CLIMATE CHANGE ISSUES FOR THE CAYMAN ISLANDS

Towards A Climate Change Policy

A Technical Report of the National Climate Change Committee

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Climate Change Issues for Cayman Islands:
Towards A Climate Change Policy

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ABBREVIATIONS, ACRONYMS & DEFINITIONS

BAU	Business-as-usual
CCCCC	Caribbean Community (CARICOM) Climate Change Centre
CCRIF	The Caribbean Catastrophe Risk Insurance Facility
CDM	Clean Development Mechanism (one of the Project-based Mechanisms under the Kyoto Protocol)
CIG	Cayman Islands Government
CPOA	Closet Point of Approach
CO_2	Carbon dioxide
COP	Conference of Parties (e.g. to the UNFCCC)
DECC	Department of Energy and Climate Change (UK)
DfID	Department for International Development (UK)
ECACC	Enhancing Capacity for Adaptation to Climate Change Project
ECLAC	Economic Commission for Latin American and the Caribbean
ENSO	El Niño Southern Oscillation
EU ETS	European Union Emissions Trading Scheme
GDP	Gross Domestic Product
GIS	Geographical Information System (spatial database)
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation (one of the Project-based Mechanisms under the Kyoto Protocol)
Kyoto	Protocol to the UNFCCC multilateral environmental agreement
LIS	Land Information System (Lands & Survey Dept's GIS)
MEAs	Multilateral Environmental Agreements
MHWM	Mean High Water Mark
NCCAWG	National Climate Change Adaptation Working Group
NOA	North Atlantic Oscillation
NGO	Non-Governmental Organisation
OTs	Overseas Territories (UK)
PEO	Public Education and Outreach
ppm	parts per million (measure of concentration)
Risk	Risk = Hazard x Exposure x Vulnerability
SIC	Special Issue Committee
SIDS	Small Islands Developing States
SLR	Sea-level rise
SRES	Special Report on Emissions Scenarios (IPCC)
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change (multilateral environmental agreement)
VCA	Vulnerability and Capacity Assessment

FOREWARD

This Green Paper Technical Report follows on from the Issues Paper produced for the Second National Consultation on Developing a Climate Change Policy held in December 2009. It incorporates stakeholders' views from the Issues Paper critique and in particular has sought to fill information gaps and correct deficiencies identified. This technical report also includes more recent studies undertaken in the region and in the Cayman Islands, such as outputs from the PRECIS regional climate model utilized by the Caribbean Community Climate Change Centre and new data gathered through the Vulnerability and Capacity Assessment of the Tourism Sector conducted by the National Climate Change Committee as a component of the *Enhancing Capacity for Adaptation to Climate Change in the UK Caribbean Overseas Territories* (ECACC) Project.

The Green Paper is perhaps the most comprehensive reference document to date on the potential implications of climate change for the Cayman Islands' economic, social and environmental sectors. It provides consensus-based adaptation interventions to address many of the adverse impacts likely to be faced by these Islands. Additionally, the Green Paper seeks to highlight areas in which the Cayman Islands can curb greenhouse gas emissions from activities that contribute to the problem of continued climate change. It identifies entry points to policies and plans where both adaptation responses and mitigation measures can be integrated into existing planning frameworks. The paper also recognises where the combined actions of responding to the inevitable impacts of a changing climate and reducing further the contributions to climate change may be cost-effective in achieving both national adaptation and mitigation goals.

This Green Paper will serve as the primary discussion document at the Third National Consultation on the Formulation of a Draft Integrated Climate Change Policy to be held in December 2010. It is hoped such a Policy will be submitted to the Cabinet in early 2011. The Green Paper is expected to provide the basis on which action plans to accompany the Policy will be developed. These plans will seek to increase the adaptive capacity to climate change at the national, sectoral and community levels, ensuring the climate-resiliency of the Cayman Islands, and will set the stage for further strategic planning toward a lower carbon future.

The National Climate Change Committee is pleased to present this consensus-based report and hopes that it will serve to foster further nation-building around a most vital issue that is currently poised to derail the sustainable development of our country. Much work is still to be done in developing a Climate Change Policy that is consistent with national development goals and shared priorities, while recognising critical areas where a departure from the status quo will be required to safeguard the survival and continued prosperity of these Islands.

The Committee stands ready to assist with the implementation of such a Policy which will require the full engagement of decision makers, stakeholders throughout the public and private sectors, associations, non-governmental organisations and communities to ensure the best possible outcome for the Cayman Islands in the 21st Century and beyond.

Gina Ebanks-Petrie
Chair, National Climate Change Committee
Director, Cayman Islands Department of Environment

1. INTRODUCTION

Climate change is not some future concept; it is happening now. There is enough evidence to move the debate beyond whether the associated global warming phenomenon is real and to what extent human actions have contributed to a more productive platform of considering appropriate adaptation and mitigation responses. In its Fourth Assessment Report (AR4) published in 2007 the Intergovernmental Panel on Climate Change (IPCC) – an assessment body of more than 3,800 scientists researching this issue since 1998 – stated that 90% of the warming effect averaged globally can be attributed to human activities such as burning of fossil fuels for power generation, transport, industrial processes and housing[1]. A 2008 survey found that over 3100 earth scientists listed in the American Geological Institute's Directory of Geosciences Departments concur with the findings of the IPCC[2].

The discourse amongst climate scientists, policymakers and the humanitarian community has now shifted to determining the tipping point for when current level of emissions will result in "dangerous anthropogenic [human-caused] climate change," which the Conference of Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) and wider international community seeks to avoid. It is estimated that this threshold is now less than a decade away[3]; the reason being the acceleration at which signs of climate changes are manifesting in the natural world as well as in economic and financial losses.

The Earth has warmed on average by 0.74˚C over the last hundred years, with 0.4˚C of this warming occurring since 1970. Globally the rate of warming averaged over the last 50 years is nearly twice that for the last 100 years. Accelerating rates of sea-level rise and global temperature increases are cause for concern worldwide and have given rise to emerging science since the IPCC AR4 which appeared to underestimate certain impacts being observed sooner than predicted[4]. The record loss of summer Arctic sea ice in 2007 compared to 2005 (relative to the 1979-2000 30-year average) is a case in point, giving rise to expert opinion on the total disappearance of Arctic sea ice in summer 30 or more years earlier than previously projected. The staggering rate of sea ice loss in recent summers suggests that this less

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[1] Solomon et al., 2007. Technical Summary. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[2] Doran, P. (University of Illinois) and Kendall Zimmer, M. http://www.sundancechannel.com/sunfiltered/tag/peter-doran/

[3] ECLAC, 2009. Review of the Economics of Climate Change (RECC): Project Document. DFID/ECLAC/ CCCCC, June 2009.

[4] Tin, T., 2008. *Climate change: faster, stronger, sooner: A European update of climate science.* An Overview of the Climate Science Published Since the UN IPCC Fourth Assessment Report. WWF European Policy Office, Brussels, Belgium.

than 1˚C rise in global temperatures may have already triggered the first tipping point of Earth's climate system. Evidence of accelerating surface melting of the Greenland Ice Sheet and more rapid collapse of the West Antarctic Ice Shelf presents a particular urgency for many low-lying countries, cities and small islands given the serious implications of untimely sea-level rise.

Based on the work of others the IPCC has concluded that climate change will impede the ability of many nations to achieve sustainable development by mid-century. The challenge now is how best to communicate to policymakers and the public the urgent need to not only take action to reduce further impacts on the climate system from additional concentrations of greenhouse gases in the atmosphere (climate change mitigation), but also to respond to the current and expected impacts of climate change in the most vulnerable countries (adaptation).

While Caribbean countries contributes less than 0.1% to global greenhouse gas (GHG) emissions they will be amongst the earliest and worst adversely affected by climate change. Their small size relative isolation, concentration of communities and infrastructure in coastal areas, narrow economic base, dependence on natural resources, susceptibility to external shocks and limited financial, technical and institutional capacity are inherent vulnerabilities of small island developing states (SIDS). Exposure to current weather-related hazards and other climate variability compound these vulnerabilities which are often linked to inappropriate development paradigms. Even countries pursuing sustainable development pathways can have their progress slowed by climate change either directly through increased exposure to adverse impacts, or indirectly through erosion of the capacity to adapt.

Changing weather patterns associated with climate change is expected to exacerbate the vulnerabilities and impacts currently experienced in the region. Heavier rainfall events are already challenging the capacity of some nations to cope, leading to more frequent flooding of settlements and infrastructure, and raising human health concerns. Longer dry spells are resulting in more frequent droughts affecting water resources needed for agriculture and human consumption. These weather extremes are likely to be accompanied by stronger hurricanes bringing the potential for increased damage and larger financial losses, greater pressure on national budgets and lengthier recovery times. Direct and indirect losses from weather-related events over the last three decades have cost the Caribbean between US$700 million and 3.3 billion[5]. In 2007 alone the region suffered US$10 billion in economic losses representing over 13% of GDP[6]. With rising sea levels,

[5] Caribbean Community Climate Change Centre, 2009. *Climate Change and the Caribbean: A Regional Framework for Achieving Development Resilient to Climate Change (2009-2015)*, May 2009.
[6] Simpson, M.C et al., 2009. *An Overview of Modelling Climate Change Impacts in the Caribbean Region with contribution from the Pacific Islands: Key Points.* United Nations Development Programme, Barbados

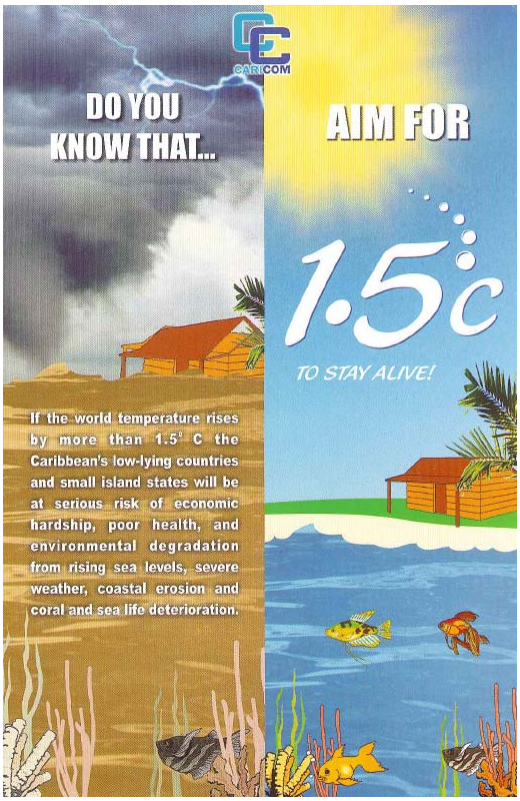
higher storm surges associated with these events will exacerbate losses from coastal erosion and flooding that impact tourism activities and the wider national economy, temporarily disrupting port operations and food security as well as access along essential roads and isolating or displacing settlements and businesses. Sea-level rise further threatens freshwater aquifers from intrusion of salt water which could impact agricultural production and quality to drinking water.

The international community gathered in Copenhagen in December 2009 to negotiate a new climate policy to succeed the Kyoto Protocol which expires in 2012. Most developed countries and rapidly developing nations share the common view that global temperatures should not rise more than 2ºC above pre-industrial levels before 2100 but made no legally binding agreements on what GHG emission reductions would be required by each Party to achieve this limit. However many scientists believe this threshold could be exceeded by 2035[7] with temperature increases of 5ºC or more by the end of the century[8]. Limiting warming to 2ºC by 2100 will mean capping the current concentration of greenhouse gases of 430 ppm at 550 ppm, or reducing global emissions by 50% on 1990 levels by 2050. The cost of action to reduce GHG emissions and stabilize atmospheric concentrations to 500-550 ppm has been quantified by Sir Nicholas Stern in *The Economics of Climate Change* (2007) to be on the order of 1% of gross global GDP, with delayed mitigation action escalating damage costs to as much as 20% of global GDP taking into account the higher losses in most developing countries. The concerted scientific opinion is that achieving this 2ºC goal will require stabilizing global carbon emissions at 1,000 Gigatons for the 2000-2050 period, however at current emission rates this limit could be reached by 2030[9]. With the atmospheric concentration of CO_2 in 2009 at 387 ppm – higher than any other time in the last 800,000 years – and increasing, the likelihood of reaching this 2°C target with peak emissions occurring well before mid-century is not encouraging.

The UNDP *Human Development Report 2007/2008* considers warming of 2°C as the threshold above which dangerous climate change will occur such that irremediable effects on human development and irreversible ecological damage will become unavoidable. This threshold is expected to be particularly detrimental to small islands, coastal communities and the poor and vulnerable worldwide. The business-as-usual (BAU) scenario or current

[7] Stern, N.H., 2007. *Stern Review: The Economics of Climate Change*. Report to the Prime Minister and the Chancellor of the Exchequer, HM Treasury, UK.
[8] ECLAC, 2009. Review of the Economics of Climate Change: Project Document. DFID/ECLAC/ CCCCC/, June 2009.
[9] Meinshausen, M. et al, 2009. Greenhouse-gas emission targets for limiting global warming to 2°C, Nature Vol. 458, pp: 1158-1162.

course of action could see global temperatures rise to 3ºC to 4ºC which will most surely spell disaster for many small islands, especially those like the Cayman Islands fringed by temperature-sensitive coral reefs upon which their present tourism economies depend and future GDP growth relies, and which provide natural storm buffering to coastal communities from the ravages of the ocean. For this reason, SIDS worldwide and the CARICOM countries have rallied together to defend a global target of stabilizing atmospheric concentration of CO_2 at 350 ppm to limit temperature well below 1.5°C which is expected to avoid the worst impacts of 21st century climate change. Disappointingly, the UK Government as part of the European Union negotiating block continues to support an agreement in which global GHG emissions are stabilized to limit warming to 2ºC relative to pre-industrial levels.



International climate policies and their potential to devastate the survival and economic prosperity of SIDS aside, the accumulated GHG emissions from past activities coupled with the long time response of the climate system has now committed the planet to a warming of 0.2ºC per decade over the next two decades. Even if all countries of the world capped emissions of greenhouse gases and aerosols to their year 2000 levels, a further globally averaged warming of 0.1ºC per decade would still occur as a result of this lag between action and reaction in the oceans, and sea levels would continue to rise for several decades or longer[10]. It is clear then that all nations must start addressing regional and localized impacts associated with this "committed warming" and long-term climate changes. Adaptation is not an option but a necessity for low-lying islands such as the Cayman Islands that are particularly vulnerable to sea level rise and have less in the way of time, resources and, at present, capacity to respond. The Cayman Islands' location in 'hurricane alley' heightens the risk of and vulnerability to more

[10] Solomon et al., 2007. Technical Summary. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

intense hurricanes spawned by hotter sea surface temperatures requiring a comprehensive plan of action to combat damaging effects.

The far-reaching effects of climate change on aspects of life as we know it give rise to several important questions including whether or not our (i) land use planning and coastal development regulations are adequate; (ii) ecological systems have been degraded beyond the point at which they can recover; (iii) public health services and agricultural policies are adequate; (iv) utilities and infrastructure are designed with sufficient robustness; (v) safety and national security become greater issues; and (vi) tourism and financial services sectors will continue to thrive. Given these and other social and economic consequences, climate change can no longer be considered "an environmental issue" requiring only a response by government scientists, natural resource managers and conservation groups. Action is required by all facets of society to preserve livelihoods and the standard of living residents of these islands have come to enjoy.

The Cayman Islands as an affluent country has typically relied on insurance and other financial safety nets (national recovery fund, government assistance programmes, access to regional or international resources), which in the past have served as effective coping mechanisms to climate variability and extremes. Tackling future climate challenges upfront before they have the potential to affect economic prosperity and subsequently derail the social development agenda is essentially the goal of adaptation. It requires a change in thinking – a departure from the BAU approaches using only economic growth (GDP) and economic well-being as measures of success and progress. Combating climate change will require commitment to exploring different approaches; a development paradigm that assesses the BAU indicators as well as places a value on environmental assets not conventionally traded through market mechanisms[11].

Speaking at the 2009 UK Overseas Territories Conservation Forum, the now Premier stated that the Cayman Islands Government recognizes that "climate change and climate variability are expected to profoundly impact small island developing states both regionally and worldwide. [These] impacts have the potential to severely disrupt life as we know it, including serious impacts to one of the mainstays of our economy – our tourism industry. I am therefore very keen to see that our country takes immediate and deliberate steps to plan ahead and develop appropriate strategies for adapting to climate

[11] ECLAC, 2009. Climate Change: Selected Economic Dimensions. LC/CAR/L.205. 10 June 2009.

change"[12]. One approach to increasing adaptive capacity is to integrate the consideration of climate change impacts into all development planning[13] .

To date the Cayman Islands Government adaptation planning efforts have principally been directed through the *Enhancing Capacity to Climate Change in the UK Caribbean Overseas Territories* (ECACC) Project, a 3-year programme funded by the UK Department for International Development (DfID) and based on an integrated planning approach developed in the Caribbean region. The project is locally managed by the National Climate Change Committee (NCCC), a multi-agency public-private sector steering committee tasked with formulating a *National Climate Change Strategy* by integrating outcomes from a series of national consultations with outputs from other project components, and utilization of local knowledge and expertise.

Whilst adaptation is clearly the focus such a strategy must take to ensure the Cayman Islands is prepared for the impacts of inevitable climate change, it is important that mitigation measures to limit further climate change by reducing our production of GHGs is successfully integrated into national strategic planning. This integrated climate policy approach to the problem of climate change has been adopted by the Caribbean region and many small island states around the world. Responding to the impacts of climate change will require making difficult policy choices and dedicating public funding and private sector resources which should not be forced to compete with the need to mitigate our contribution to future climate change. It is therefore vital that Government in concert with the private sector and communities seek to capitalize on synergies between cost-effective adaptation responses that also serve the goal of GHG mitigation. The inter-relationship between energy and water production is one example where production of potable water through desalination is a key adaptation measure but is also extremely energy intensive. Wherever this required energy can be generated through the use of fossil fuel alternatives or renewable energy should be amongst the strategic goals.

This report details the key climate change issues of concern for the Cayman Islands pertaining to the physical, social and economic vulnerabilities of local sectors identified through consultations with various stakeholder groups. It draws on international, regional, national and local studies. It includes an assessment of existing management mechanisms critical for identifying

[12] UKOTCF, 2009. Remarks from The Hon. W. McKeeva Bush, Leader of Government Business and Minister of Financial Services, Tourism and Development, for the Opening Reception of the UK Overseas Territories Conservation Forum conference "*Making the Right Connections: A conference on conservation in the UK OTs, Crown Dependences and other small island communities.*" Grand Cayman, 30th May to 5th June 2009

[13] IPCC, 2007. Summary for Policymakers. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.), Cambridge University Press, Cambridge, UK, 7-22.

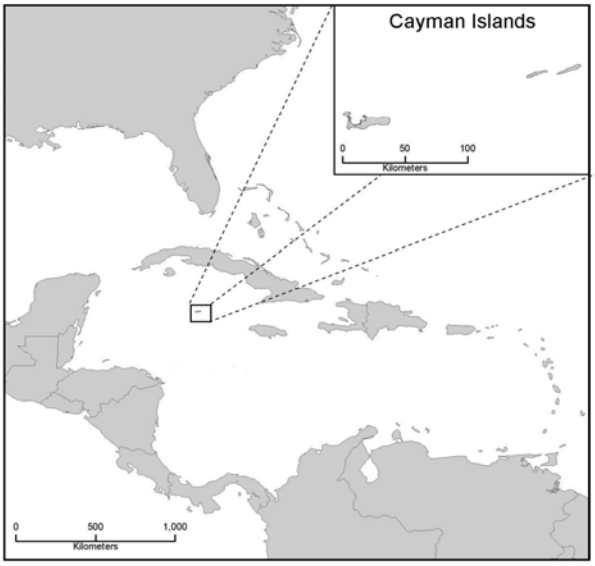
appropriate response measures, and determining their successful implementation under existing frameworks or modified structures. Discussion is offered on key adaptation interventions that address vulnerability and reduce climate-related risks in terms of common-sense policies and 'no regrets' options that would result in win-win outcomes for strengthening sustainable development and in some cases delivering greenhouse gas reductions.

2. CHARACTERISTICS OF THE CAYMAN ISLANDS

2.1 Physical Characteristics

The Cayman Islands comprise three islands, Grand Cayman, Cayman Brac and Little Cayman, located in the western Caribbean Sea (19º N 81º W) 150 miles south of Cuba, 460 miles southwest of Miami, Florida and 167 miles northwest of Jamaica (Map 1). Totalling only 102 sq miles, these low-lying islands are peaks of the Cayman Ridge which extends from the Sierra Maestra mountain range of Cuba. All three islands are separated from Jamaica by the Cayman Trench, the deepest part of the Caribbean basin at more than 4.5 miles.

Map 1 Cayman Islands Location Map



Grand Cayman

Grand Cayman is the largest island covering 76 sq miles. It hosts the capital city of George Town and district of the same name which is home to 52% of the country's population (2008). The island has an average elevation of 6 ft and maximum height rising to 93 ft in the isolated central. Roughly 79% of Grand Cayman's shoreline is afforded considerable protection from damaging waves and storm surge by fringing reefs.

The North Sound is Grand Cayman's most interesting topographic feature and is an endearing natural characteristic to its 54,287 residents and 1.8 million annual visitors (2008)[14]. A large reef-enclosed lagoon at 35 sq miles, the North Sound was originally fringed with red and black mangrove species, but these areas have given way to canal developments on the western, southern and northeast shores and interiors beyond due to extensive dredging and wetland reclamation. By 1999 approximately 70% of the upland natural wetland and forested areas within the western shores of the North Sound had been lost through alteration and correspondingly 76% of the southern shores had been altered. Within the North Sound itself some 454 acres (22.5 %) of the shallow transitional marine habitat has been altered through dredging for upland wetland reclamation. A number of very small uninhabited cays exist around the island including Sand Cay, Booby Cay and Barkers Cay. Economically and recreationally important areas within the North Sound include the fringing reef, Barkers and Rum Point/Kaibo areas, Stingray City and Sandbar.

Seven Mile Beach along the western coast of Grand Cayman is a major tourism asset. A series of pocket beaches, it is the longest stretch of white sandy beach within the Cayman Islands, which in recent years has developed erosional hot spots as a result of current weather conditions exacerbated by development pressure on storm ridges or in the dynamic zone. Other tourism assets include the historical district of Bodden Town which is home to St. James Pedro Castle, the oldest remaining stone structure in the Cayman Islands. Like George Town, Bodden Town remains one of the fastest growing districts in terms of population and development. Situated in the West Bay region, the Cayman Turtle Farm is not only a major tourism attraction, but holds particular significance for its conservation of the green sea turtle population and the provision of local turtle meat for traditional consumption. While Grand Cayman has a number of large ponds and surrounding wetland systems, only Meagre Bay Pond and Colliers Pond are officially protected as Animal Sanctuaries. Grand Cayman is also home to the Queen Elizabeth II Botanic Park, which, though small in size, showcases a variety of native habitats and floral and faunal species.

Cayman Brac

Grand Cayman is separated from its sister islands of Cayman Brac and Little Cayman by 90 miles. Cayman Brac, 12 miles long and 2 miles at its widest point, covers 15 sq miles and is so named for its central Bluff or ridge of older Cayman Formation dolostone which rises directly from the sea to 150 ft at its highest point at the Island's eastern end. The remainder of Cayman Brac's shoreline is interspersed with ironshore, sandy and rock/rubble pocket beaches typical of storm ridges created along exposed coastlines. The majority of settlements and essential services are on the coast, 18% of which

[14] ESO 2009. Ch. 11. Population and Vital Statistics and Ch. 14. Tourism. In: *Statistical Compendium 2008*. Economics and Statistics Office, Cayman Islands Government, George Town, Grand Cayman.

is protected by reef structures. However relocation of key infrastructural assets (power plant, landfill, roads) and housing developments to the Bluff is starting to occur, displacing agricultural lands and impacting some sensitive habitats and species.

Environmentally important features include Saltwater Pond at Dennis Point, the only Animal Sanctuary on this island, the Brac Parrot Reserve under the ownership of the National Trust, bluff edge habitat on the eastern end of the Island important for nesting Brown Boobies and Tropicbirds, and a variety of other environmentally significant dry forest and wetland areas. Other culturally significant features include various caves which have served as hurricane shelters for many generations of Brackers, as well as home to local species of bats and are part of the island's tourism offering.

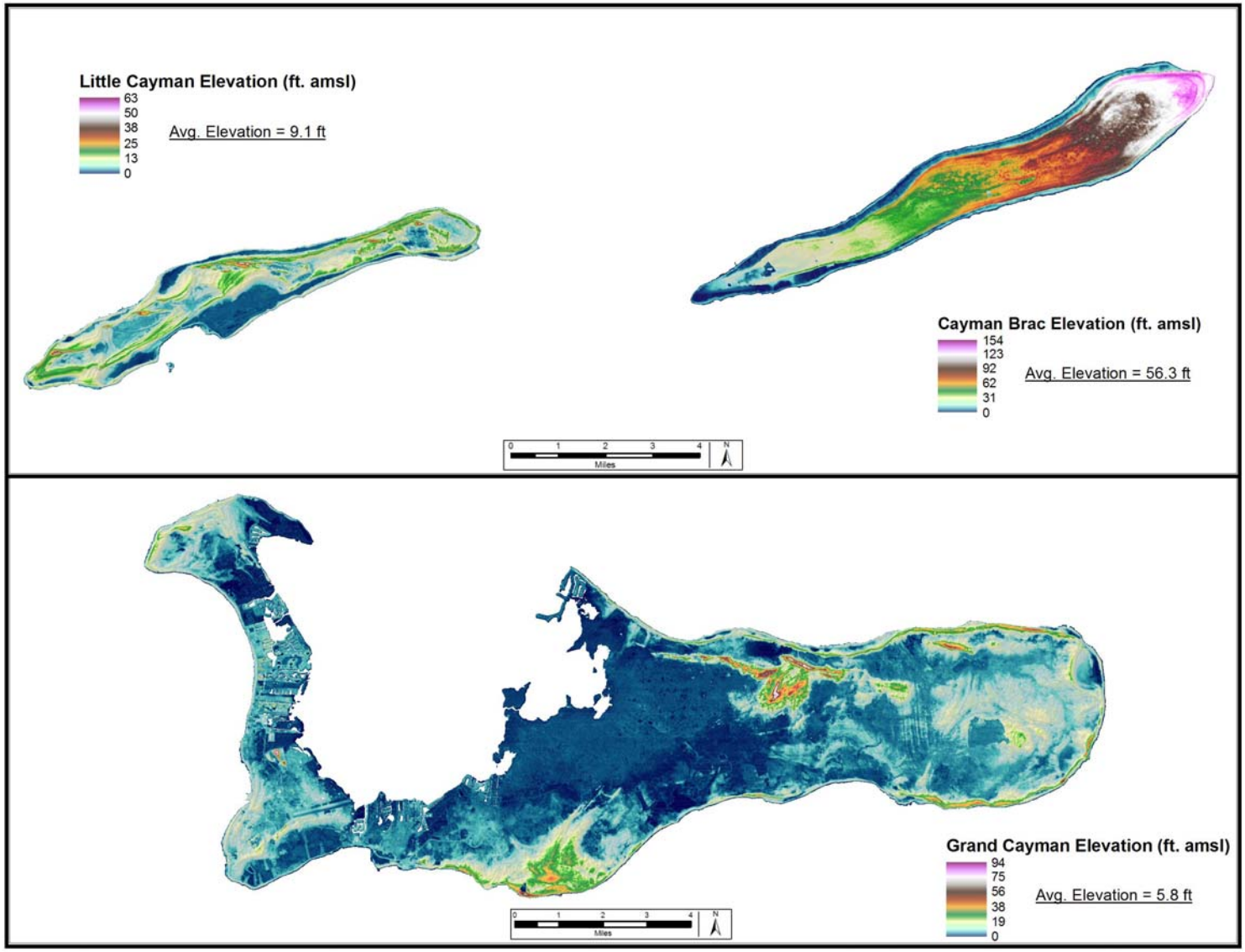
As with the other Islands, Cayman Brac has no river systems. Surface water is limited to brackish and freshwater ponds and associated wetlands. Natural freshwater resources are limited to a few isolated water lenses on all three islands. Rainwater collection for human consumption remains critical in Cayman Brac, unlike Grand Cayman where desalinisation through the reverse osmosis process provides the majority of potable water.

Little Cayman

Lying 5 miles west of Cayman Brac is Little Cayman, covering only 11 sq miles. Having geological and physical characteristics akin to Cayman Brac but with elevations in the eastern portion of the island reaching to just over 40 ft above sea level, this 10 mile long by 1 mile wide-island is the most vulnerable of all three islands with practically all settlement and services situated on the coast. Between 1989 and 1999 the population density (persons per square mile) increased more than three-fold. Blossom Village, with its charming historic church and quaintness, is the only commercial centre on the island. Approximately 76% of Little Cayman is reef-protected. Other natural buffers include beach ridges, coastal mangroves and seagrass beds that also serve to stabilize shorelines and dissipate wave energy.

Little Cayman has a series of tidally influenced coastal ponds and interconnected wetlands along the north and south coasts. The Island's largest pond, the Booby Pond, is protected as an Animal Sanctuary and is the only listed Ramsar site in the Cayman Islands. Owen Island in South Hole Sound and Point of Sand at the southeastern end of the island are two of the most unique and recreationally utilized areas of Little Cayman. Bloody Bay Marine Park near Jackson Point on the north coast is extremely popular with divers which make up the lifeline of tourism on this Island.

Map 2 Elevation of the Cayman Islands



Source: Lands & Survey Department, Map produced by Department of Environment, 2010

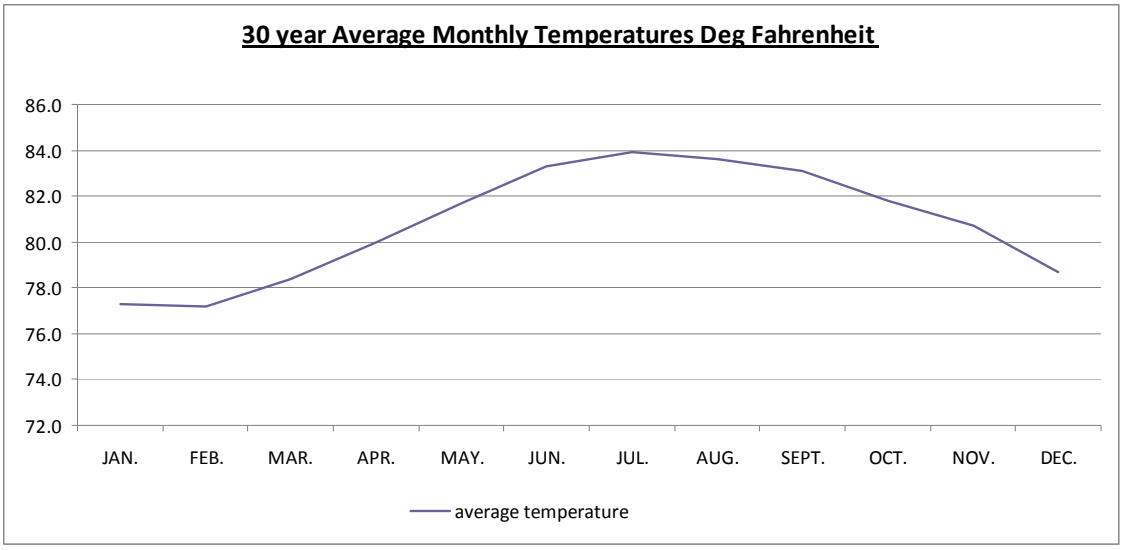
2.2 Climate and Natural Hazards

Given its small size and island status, the Cayman Islands' tropical climate is strongly influenced by the sea and prevailing winds. Seasonal variation is generally typified by two seasons: wet warm summer season from mid-May through November and a dry cool winter season from December through April.

Temperature

Air temperatures average 80.8ºF per annum with the hottest month over a 30-year average being July at 83.9ºF, and the coolest month on average is February at 77.2ºF. This information is represented in Figure 1.

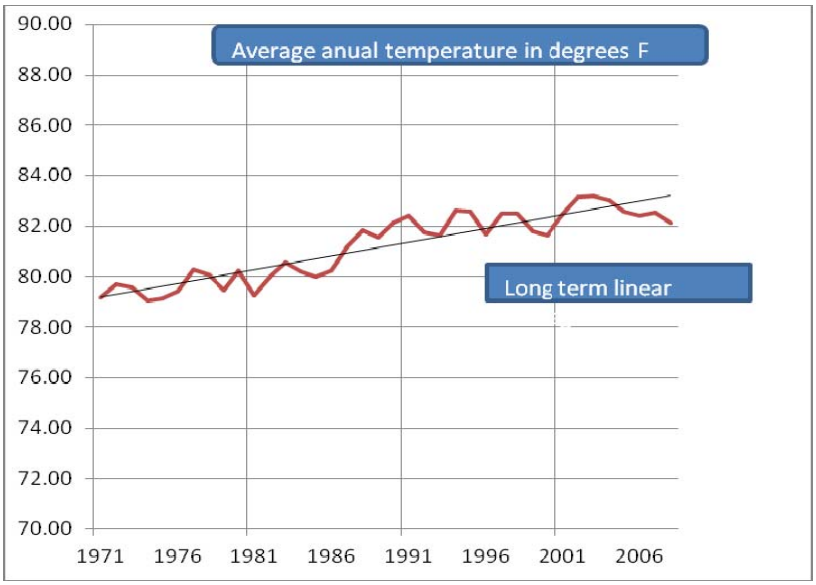
Figure 1 30-Year Average Monthly Air Temperatures



Source: Cayman Islands National Weather Service, 2010

The long term temperature trend for the past 30 years can be seen in Figure 2. The trend very clearly shows a gradual increase in temperature. Temperatures peaked in 2002 and have slowly declined but this could be a degree of variability on the long term trend.

Figure 2 Long Term Average Annual Air Temperature



Source: Cayman Islands National Weather Service, 2010

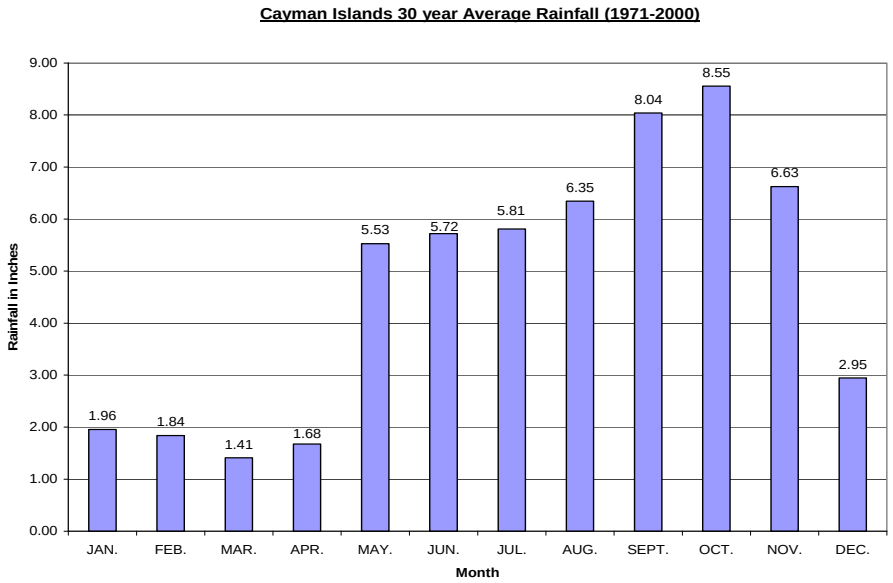
Rainfall

Rainfall averages 56.41 inches per annum. October is typically the wettest month with 8.55 inches on average over a 30-year period (1971-2000), although November – the transition from summer to winter – can see the most unsettled weather and very heavy rainfall. While March has over this 30-year average been the driest month with 1.36 inches, April – the transition month from winter to summer – has often been the driest month of the year[15].

The long term average monthly rainfall pattern can be seen in Figure 3. This bar graph shows statistics composed using data from 1971-2000, the current 30-year average utilized by the National Weather Service.

[15] Cayman Islands Weather Service, http://www.weather.ky/climate/Transition.asp

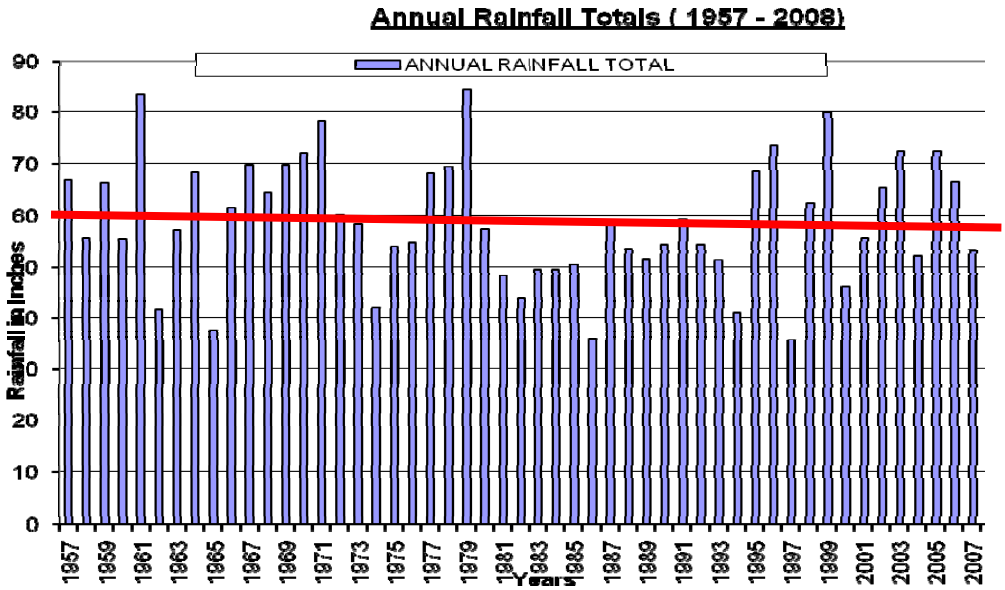
Figure 3 Long Term Average Monthly Rainfall



Source: Cayman Islands National Weather Service, 2010

The long term trend for rainfall totals show a sinusoidal pattern (i.e. has multiple maximums and minimums) as seen in Figure 4 using data from 1957-2008. The lowest annual rainfall total recorded was 35.61 inches in 1997 and the highest 84.50 inches in 1979. A downward trend in rainfall is evident over this 51-year period with 0.04 of an inch per year being the approximate rate of decrease.

Figure 4 Annual Rainfall Totals (1957 - 2008)



Source: Cayman Islands National Weather Service, 2010

Droughts

Although the 1997 lowest annual rainfall total was a significant departure from the normal it was not regarded as a drought. The Cayman Islands National Weather Service definition of a drought is less than half inch of rainfall for more than three months. Based on this definition the Cayman Islands have four noted droughts: January through March 1958; January through March 1960; February through April 2003; and December 2004 through February 2005. It should be noted that all of these drought periods have occurred during the regular dry season.

Spatial and temporal patterns

The spatial rainfall pattern shows a marked east to west disparity, with the west coast being significantly wetter than the east coast. This is especially true over Grand Cayman. This pattern is the result of the interaction between daytime heating over central Grand Cayman and the prevailing easterly wind pattern. The rainfall pattern is bimodal (i.e. has two maximums) with maxima in May/June and a second in October. November through April is the dry season. The passage of synoptic systems such as tropical waves, tropical storms, hurricanes and cold fronts as isolated events have a significant impact on the spatial and temporal patterns. Precipitation in the region is influenced by the El Niño Southern Oscillation (ENSO) and the North Atlantic Oscillation (NAO) however up until this time there has been no research to give an indication to what level.

Nor'westers

Prevailing winds are east to south from May through October and from northeast during the cooler winter months of December to April or Nor'wester season. Winter cold fronts from North America bring cooler temperatures, stronger winds and rough sea swells from the northerly quadrant. Strong winds and rough sea swells from the northwest accompany strong cold fronts, giving this weather phenomenon the local name 'Nor'wester'. These systems significantly affect the west coasts of the Cayman Islands, the George Town Harbour and other ports in the Sister Islands, Seven Mile Beach along the west coast of Grand Cayman, and boating interests throughout the Cayman Islands.

Hurricanes

Tropical low pressure systems originating from the propagation of easterly waves are experienced during the summer, the most severe of which are hurricanes (categorized on the Saffir-Simpson scale as sustained wind speeds over 74 mph). The 'hurricane season' typically lasts from June 1 to November 30 and represents the primary rainfall source in the Caribbean and the main contribution to the peak in September-October-November totals.

In a statistical analysis of the spatial distribution of return periods of tropical storm and hurricane strikes, the Cayman Islands experienced 74 total storms

over a 156 year dataset (1852-2008) (Appendix 1). Of this total, 9 major storms (Category III or higher) directly impacted the Cayman Islands: 1903 Hurricane; 1915 Hurricane; 1917 Hurricane; 1932 Hurricane; 1935 Hurricane; 1980 Hurricane Allen, 1988 Hurricane Gilbert; 2004 Hurricane Ivan; and 2008 Hurricane Paloma. This gives a return period for major hurricanes of 17 years. Records indicate that no category V hurricane has directly hit the Cayman Islands but the last four major storms have all been of category IV strength. Peak category IV Hurricane Ivan with a maximum sustained wind speed of 155 mph was the strongest direct hit.

Direct hits from hurricanes have had devastating socio-economic consequences on the Cayman Islands. Table 1 highlights damages and losses from the most costly events such as Hurricane Ivan in 2004 - locally referred to as 'Ivan the Terrible' – which severely impacted the southern and eastern coasts of Grand Cayman leaving total losses of CI$2.8 billion in its wake. This represented 183% of the country's GDP in 2003 and is by far the most devastating hurricane to hit the Cayman Islands[16]. Hurricane Paloma - the second strongest November Atlantic hurricane on record - caused total losses of CI$154 million with the passage of its eyewall over the eastern end of Cayman Brac[17]. However hurricanes do not have to directly hit the Cayman Islands to cause substantial impact. Large cyclones that produced destructive storm surges and wave action include: Hurricane Michelle in 2001 passed 130 miles west and north of Grand Cayman causing $28 million in damages; Hurricane Mitch - the strongest October hurricane since records began in 1886 – passed 190 miles south of Grand Cayman in 1998 caused extensive damage to oceanfront condo properties at Northwest Point and in Spotts, and destroyed docks along the south coast of the Sister Islands; and in 2005 Hurricane Wilma - with the lowest pressure in recorded history - passed 170 miles southwest of Grand Cayman causing extensive flooding on the south coast.

Table 1 Losses from hurricanes affecting the Cayman Islands

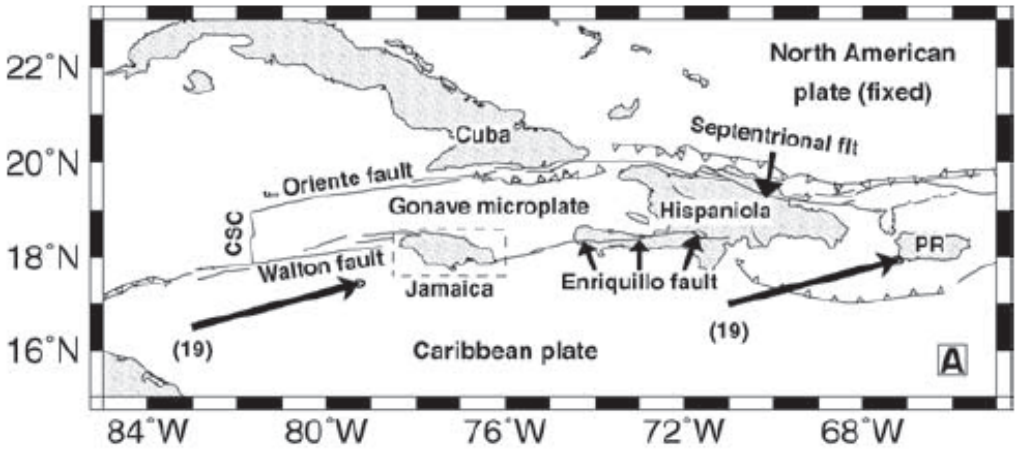
Year	Hurricane	Category	CPA (statute miles)	Loss (CI$M)	Percentage of GDP (Year)
1988	Gilbert	IV	24 GC)	16	
2001	Michelle		130 GCM)	28	
2004	Ivan	IV	22 GCM	2,800	138 (2003)
2008	Paloma	IV	9 LYC	154	7.4 (2008)

[16] ECLAC 2005. *The Impact of Hurricane Ivan in the Cayman Islands*. LC/CAR/L.25. ECLAC and UNDP, 10 January 2005.
[17] ECLAC 2009. *Cayman Islands: Macro Socio-economic Assessment of the Damage and Losses Caused by Hurricane Paloma*. LC/CAR/L.193. ECLAC and UNDP, 2 April 2009.

Earthquakes

While not a result of climate change, earthquakes are natural occurrences that have the potential to amplify the Cayman Islands' sensitivity to climate change and sea level rise. The Cayman Islands sits on the boundary between the North American and Caribbean tectonic plates which are in continuous lateral movement opposing each other (Caribbean plate traveling eastward, Map 3). While this appears to limit the size of earthquakes to under a magnitude 7 event, it is not unusual for minor tremors to be recorded. In December 2004 a quake of 6.8 magnitude rocked Grand Cayman following the devastation of Hurricane Ivan in September. The earthquake, short in duration, opened some small sinkholes but otherwise did not cause significant damage to critical infrastructure, homes or businesses. However some of the measures necessary to make these islands earthquake resilient could also serve to climate-proof them, e.g. building construction techniques and code revision or enforcement.

Map 3 Major Geologic Faults in the Northern Caribbean



Source: NDAC (2009) Preliminary Vulnerability Assessment of Grand Cayman, Cayman Islands

2.3 Ecosystems and Natural Resources

Major Habitat Classification

Habitat classifications for all three islands were recently completed under a Darwin Initiative grant and form the basis of the *Cayman Islands National Biodiversity Action Plan 2009*[18]. The following table lists the major marine, coastal and terrestrial habitats of the Cayman Islands.

[18] DaCosta-Cottam, M., Olynik, J., Blumenthal, J., Godbeer, K.D., Gibb, J., Bothwell, J., Burton, F.J., Bradley, P.E., Band, A., Austin, T., Bush, P., Johnson, B.J., Hurlston, L., Bishop, L., McCoy, C., Parsons,

Table 2 Major Habitat Classifications for the Cayman Islands

MARINE HABITATS	COASTAL HABITATS	TERRESTRIAL HABITATS
Open sea	Maritime cliffs and ironshore	Salt-tolerant succulents
Coral reefs	Sandy beach and cobble	Pools, ponds and mangrove lagoons
Lagoons	Mangrove	Dry shrubland
Seagrass beds	Invasive coastal plants	Forest and woodland
Dredged seabed	Coastal shrubland	Caves
Artificial installations		Farm and grassland
		Urban and man-modified areas

Source: DaCosta-Cottam et al (2009) Cayman Islands National Biodiversity Action Plan 2009

Mangrove forest and coastal shrubland represents 25% of Grand Cayman while tidally flooded mangroves comprise another 6%. However, only 12% and 37% respectively of each habitat is currently afforded protected status. This does not include ponds, pools and mangrove lagoons which account for 4% of the total land mass of which only 8% is protected. With the presence of the North Sound, Grand Cayman not surprisingly has the largest area of seagrass beds comprising nearly 59% of benthic lagoon habitat, nearly half of which falls within marine protected areas. Dry forest and woodland represent 15% of the island with only 7% of this habitat loosely defined as protected given the absence of legislation to establish a system of terrestrial protected areas, while dry shrubland makes up 6% of the land mass with a meagre 2% protected. Roughly 39% of Grand Cayman has been urbanized or man-modified.

The more abundant habitat (48%) on Cayman Brac is xeromorphic semi-deciduous forest, and although important nesting grounds for the indigenous Cayman Brac parrot, only 5% of this habitat is protected as National Trust lands in perpetuity for the people of the Cayman Islands. Seasonally flooded mangrove shrubland makes up only 4% of the land mass and a similar percentage of the total habitat is protected. No tidally flooded or fringing mangrove exists to afford additional storm protection. However, 23% of all lagoonal areas contain seagrass beds of which only 8% is protected. Roughly 41% of the land mass is urban or man-modified.

Dry shrubland covers 31% and dry forest and woodland 27% of Little Cayman respectively, of which not even 5% and 4% respectively is protected. Roughly 7% of the island is seasonally flooded mangrove forest and woodland while seasonally flooded mangrove shrubland covers 10%. Both types of mangroves are important for dissipating storm waves but are

G., Kirkconnell, J., Halford, S. and Ebanks-Petrie, G. (2009). Cayman Islands National Biodiversity Action Plan 2009. Cayman Islands Government. Department of Environment.

only afforded 2% and 4% protection respectively on this Island. Seagrass beds account for 25% of the benthic habitat of Little Cayman, and nearly 63% falls under marine protected area status. Although only 7% of Little Cayman has been urbanized or man-modified, the majority of this activity has taken place on the coast displacing some areas of natural buffers.

Coral reefs make up the most ecologically diverse and important marine habitats ranging from isolated shallow water patch reefs, exposed fringing reefs through to deeper spur and groove formations on all three islands and offshore banks. Fringing reefs form the most visible and perhaps physically significant of the coral reef formations as they are critical components in the natural protection and formation of the Cayman Islands' many important and attractive coastal features such as clear calm lagoons and sandy beaches. Fringing reefs surround approximately three quarters of Grand Cayman and Little Cayman's coastline, while only one quarter of the Brac is afforded protection from offshore fringing reefs. This disparity in reef protection is the principle reason for the greater presence of sandy beaches, seagrass beds and sheltered lagoons on both Grand Cayman and Little Cayman.

Various coastal habitats in all three islands have been identified as important nesting habitat for local and migratory birds, such as the tropicbird (*Phaethon lepturus*) habitat along Grand Cayman's south-central and Cayman Brac's southeastern coast, and Cayman Brac's northeastern bluff face for the brown booby colony (*Sula leucogaster*). Little Cayman's Booby Pond is the largest rookery of Red Footed Booby (*Sula sula)* in the Caribbean. Furthermore, nesting by green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) sea turtles occurs on beaches throughout all the islands. The lagoons of all three islands also support culturally important marine resources such as queen conch, spiny lobster and whelk.

Table 3 Areas, Lengths and Representation within Protected Areas for the Major Marine, Coastal and Terrestrial Habitat Classifications of the Cayman Islands, 2006

All Habitats Marine and Terrestrial 2006	Total area (ac)			Percent within a Protected Area		
	Grand Cayman	Cayman Brac	Little Cayman	Grand Cayman	Cayman Brac	Little Cayman
Coral reefs	12,197	5,094	4,617	28	18	25
Lagoons	26,984	158	1,828.	48	12	62
Seagrass beds	15,809	36	452	53	3.5	53
Dredged seabed	1,334	4	12	13	0.5	34
Maritime cliffs and ironshore	98	205	61	0.2	0	0

Sandy Beach and Cobble	124	43	55	0.7	0	0
Mangrove	16,115	43	1,184	18	0.3	3
Invasive coastal plants	335	14	8	0.1	0	0
Coastal shrubland	295	259	401	0.01	0.05	0.03
Salt-tolerant succulents	34	0	10	0	N/A	0
Pools, ponds and mangrove lagoons	1,323	87	657	11	29	25
Dry shrubland	3,131	390	2,248	2	3	5
Forest and woodland	7,536	4,559	1,927	7	6	4
Seasonally flooded grassland	100	1	50	93	0	0
Man-modified areas	7,475	3,656	403	0.2	1	1.6
	Total length (km)			**Percent within a Protected Area**		
Maritime cliffs and ironshore	6	34	0	0	0	N/A
Sandy Beach and Cobble	53	25	16	0.1	0.0	0.0

Source: DaCosta-Cottam et al (2009) Cayman Islands National Biodiversity Action Plan 2009

Protected Areas

First established in 1986 throughout the Cayman Islands, a system of marine protected areas, known locally as Marine Parks, has afforded marine resource protection to approximately one-third of the islands' total coastal shelf area. The Marine Parks system encompasses three major zones to accommodate different types and levels of use. The highest level of protection is through designation as an Environmental Zone. Only one of these zones currently exists, located on Grand Cayman. This 4,169 acre mangrove and seagrass dominated set aside area is a complete "no use" zone with no in-water activity permitted other than the passage through of boats at 5 knots or less. Of particular interest to this area, and unique to only this zone, is the extension of the protection inland by approximately 1000 feet to include tidally flooded coastal mangrove.

Marine Park Zones represent the next level of protection in which no extractive use of the coral reefs they predominantly protect is permitted for any marine resources alive or dead. Watersports activities are permitted, but anchoring of vessels larger than 60 ft is not allowed. A total of 3,677 acres of Marine Parks are found on all three islands but this protection does not extend to any of the neighbouring coastal habitats.

Replenishment Zones are essentially fisheries management zones found on all three island, encompassing a total of 12,886 acres of lagoon and shallow reef habitat. These zones provide protection to culturally important conch (*Strombus gigas*) and lobster (*Panulirus argus*) populations. For finfish there are gear restrictions and only line fishing is permitted.

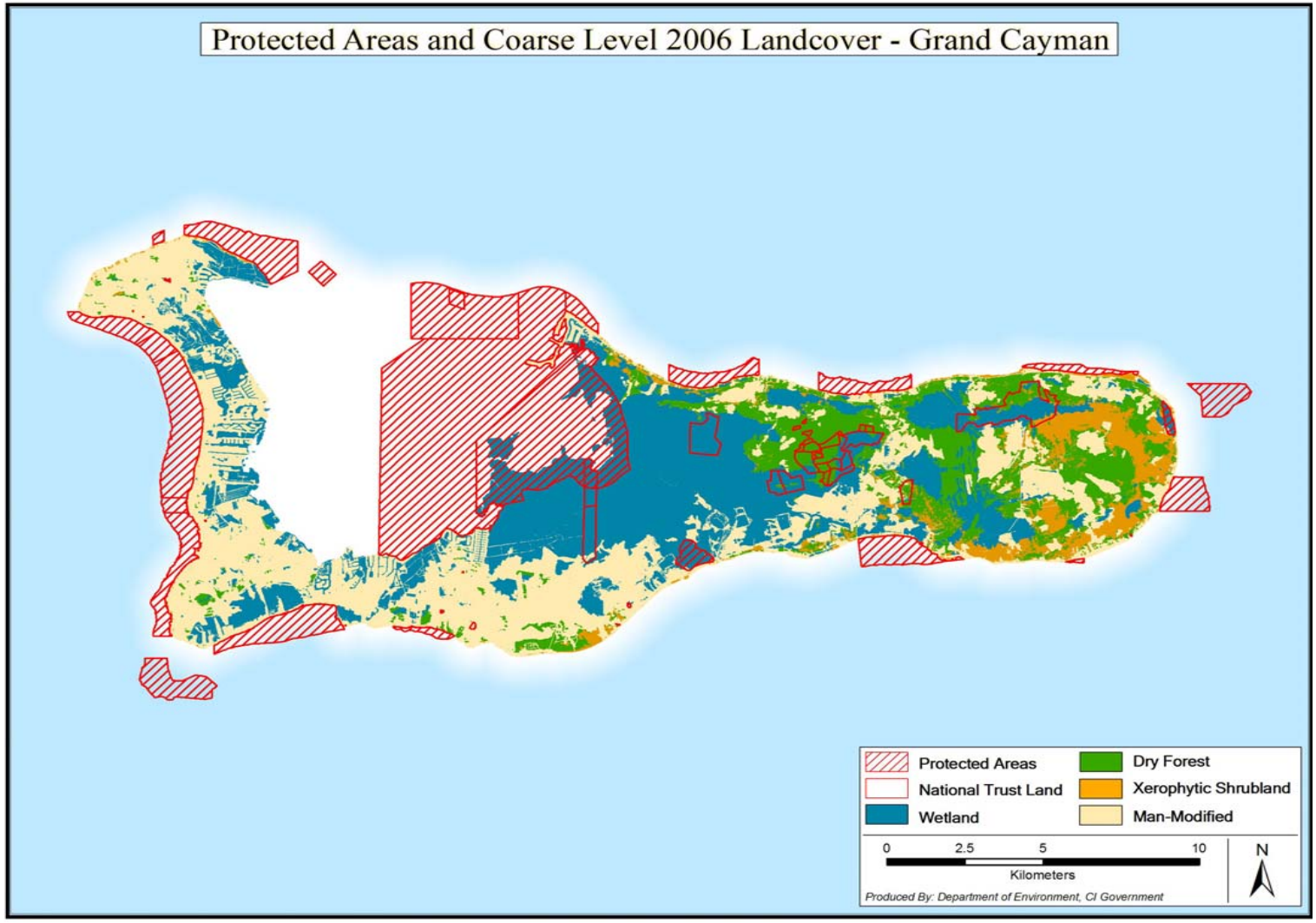
Superimposed within the Marine Parks system, Wild Life Interaction Zones and No Diving Zones have also recently been developed to address and manage user conflicts.

Important spawning aggregation sites (SPAGS) for the Nassau grouper (*Epinephelus striatus*) are also designated through the Marine Conservation Law (1978), the primary legislation that provides for marine protected areas in the Cayman Islands.

Comparatively, terrestrial protection is severely restricted due to the lack of enabling legislation and is limited to Animal Sanctuaries under the existing Animals Law (1976). Four Crown owned mangrove coastal ponds and their surrounding buffer habitat totalling 341 acres, have been declared Animal Sanctuaries, restricting activities such as hunting or collection and other forms of deliberate disturbance and littering.

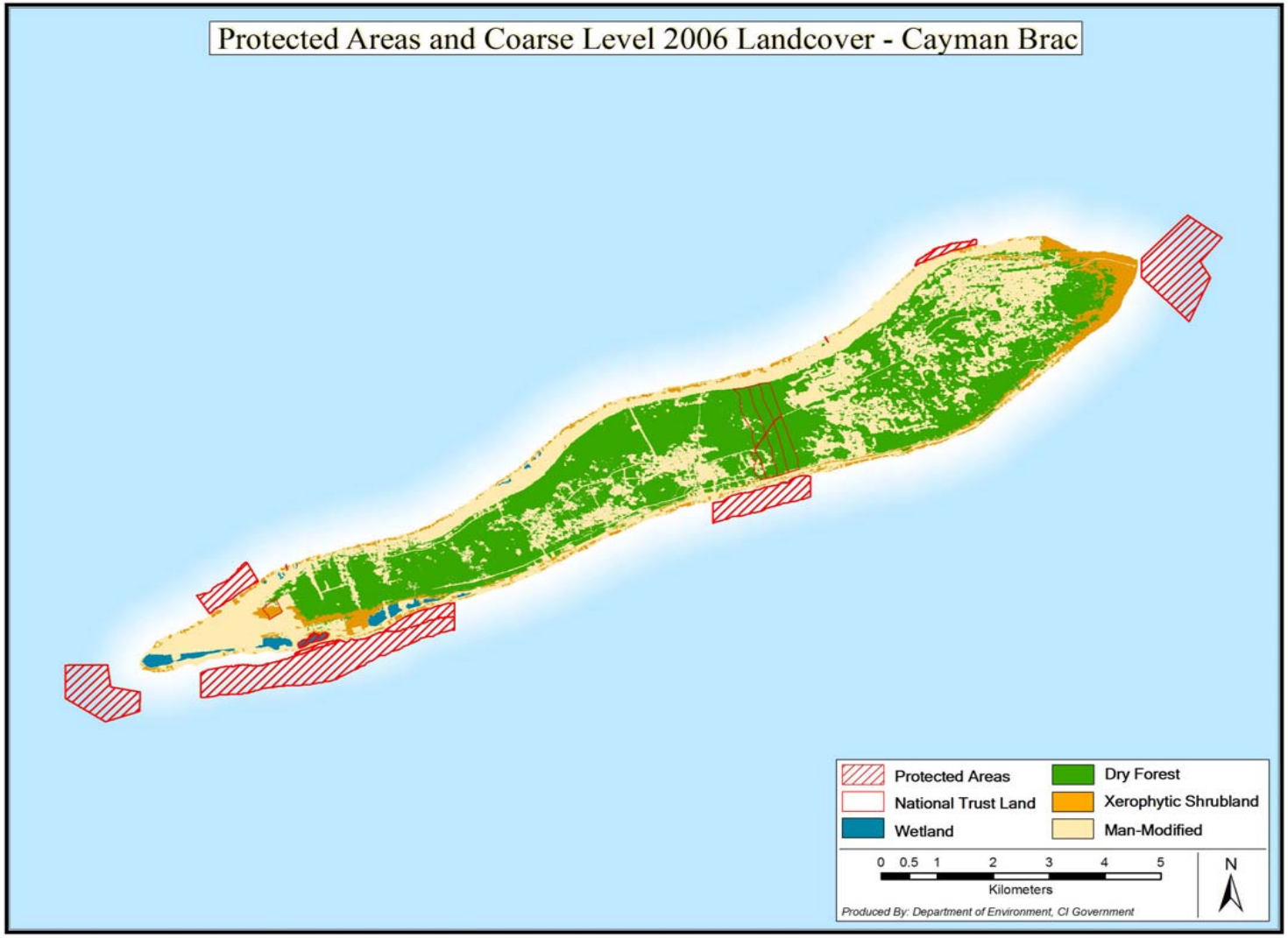
The National Trust for the Cayman Islands, under the National Trust Law (1987), has purchased or secured approximately 3,109 acres of ecologically or culturally key terrestrial areas on all three islands declaring them inalienable for the people of the Cayman Islands and indirectly affording them a measure of protection through private ownership and a commitment to manage these areas in their natural state.

Map 4 Habitat Classifications and Protected Areas for Grand Cayman



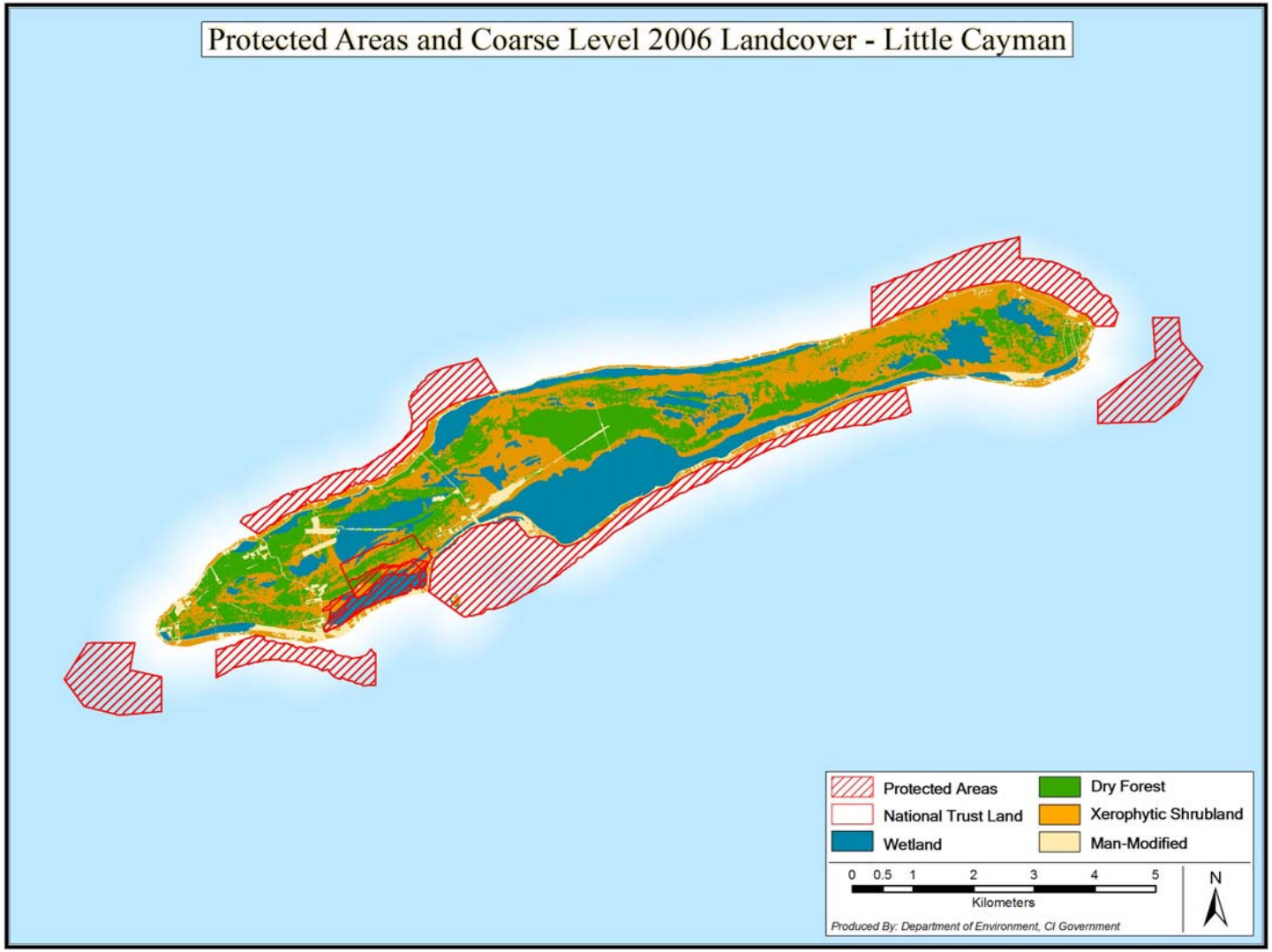
Source: Cayman Islands Department of Environment, 2010

Map 5 Habitat Classifications and Protected Areas for Cayman Brac



Source: Cayman Islands Department of Environment, 2010

Map 6 Habitat Classifications and Protected Areas for Little Cayman



Source: Cayman Islands Department of Environment, 2010

2.4 Economy

The Cayman Islands, a country of 52,830 people (2009), has enjoyed one of the highest standards of living in the Western Hemisphere with a gross domestic product (GDP) per capita of CI$44,197 in 2009 (Table 4). The Islands have witnessed tremendous economic growth from the development of financial services in the late 1960s and tourism in the early 1970s as the key foreign exchange earning sectors.

Economic success has been accompanied by rapid population growth - an annual rate of over 4% since the 1980s - due to an influx of non-Caymanians to service the finance and tourism sectors[19], which employed 10.1% and 11.4% of the total 2008 workforce, respectively[20].

Construction and real estate activities round out the main economic sectors in the Cayman Islands and are tied to both key sectors but also driven by demands from an ever growing population.

The narrow revenue base from these economic activities at the best of times must provide public services that citizens have come to expect as well as fund new capital projects made necessary by an expanding population. Like many small island developing states, recessionary periods prove extremely difficult for these Islands to withstand as they suffer diseconomies of scale and lack widespread economic diversification. The current global recession has significantly impacted all sectors of the Cayman Islands economy, with a further deepening perhaps yet to come. This will have serious implications for Government's prioritization of climate change issues amidst addressing immediate economic woes.

Financial Services

The Financial Services industry is susceptible to external shocks such as the current global economic crisis. In 2009, the number of licenses for captive insurance companies was the only sub-sector indicator which showed a moderate rise of 3 licenses, or 0.4%. The structure of the insurance industry remained as in the previous year (Figure 5) with healthcare and workers' compensation as dominant types.

The total assets registered in the Cayman Islands increased by 21.1% from 2008 at US$44.7 billion in 2009 with North America being the principal risk location comprising nearly 89.7% of total companies registered.

[19] ESO, 2009. Ch. 11. Population and Vital Statistics. In: *Statistical Compendium 2008*. Economics and Statistics Office, Cayman Islands Government, George Town, Grand Cayman.
[20] ESO, 2009. The Cayman Islands' Labour Force Survey Report Fall 2008. Economics and Statistics Office, Cayman Islands Government, George Town, Grand Cayman, April 2009.

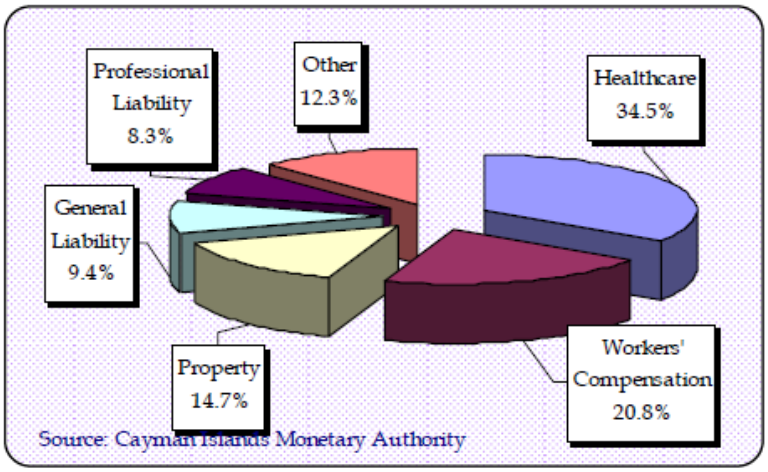
Table 4 The Cayman Islands Economic Performance: Summary Indicators

Indicators	2007	2008	2009
Real GDP ($million)	2,569.5	2,598.8	2,427.3
GDP growth in real terms (percent)	4.4	1.1	(6.6)
Real GDP per capita (in $)	48,299	46,409	44,197
Nominal GDP ($million)	2,569.5	2,704.3	2,493.0
Population (year-end)	54,986	57,009	52,830
Of which Caymanians	31,342	31,858	31,165
Population (mid-year)	54,079	55,998	54,920
Employment	36,026	37,449	33,865
Unemployment rate (percent of labour force)	3.8	4.0	6.0
Inflation rate (percent)	2.9	4.1	(1.3)
Total imports (in $million)	860.0	879.4	735.9
Total imports (percent of GDP)	33.5	32.5	29.5
Overall fiscal balance of the central government ($million)	(39.1)	(131.1)	(149.3)
Overall fiscal balance of the central government (percent of GDP)	(1.5)	(4.9)	(6.0)
Outstanding debt of the central government ($million)	210.5	354.9	512.3
Outstanding debt of the central government (percent of GDP)	8.2	13.1	20.6
Broad liquidity (money supply in CI dollars plus foreign currency deposits) [$ billion]	5.5	5.6	5.9
Stay-over tourists (in thousands)	291.5	302.9	272.0
Cruise ship passengers (in thousands)	1,715.7	1,553.1	1,520.4
Mutual funds	9,413	9,870	9,523
Insurance licenses	793	805	808
Banking and trust licenses	281	278	266
Trust companies	138	141	125
Stock exchange listings	1,748	1,579	1,312
New company registrations	14,238	11,861	7,863
Stock exchange capitalization (US$, in billion)	168.3	167.7	163.1
Building permits ($million)	446.3	502.3	355.0
Planning approvals ($million)	505.2	508.8	433.2
Property transfers ($million)	545.5	558.1	397.0
Electricity consumption (percent growth)	8.7	2.5	2.2
Water consumption (percent growth)	6.2	(0.7)	5.8
Total fixed and mobile telephone lines	136,547	134,079	144,850

* The 2007 GDP was estimated based on the System of National accounts (production approach). Figures for 2008 and 2009 are estimated using economic indicators.

Source: ESO (2010) The Cayman Islands' Annual Economic Report 2009

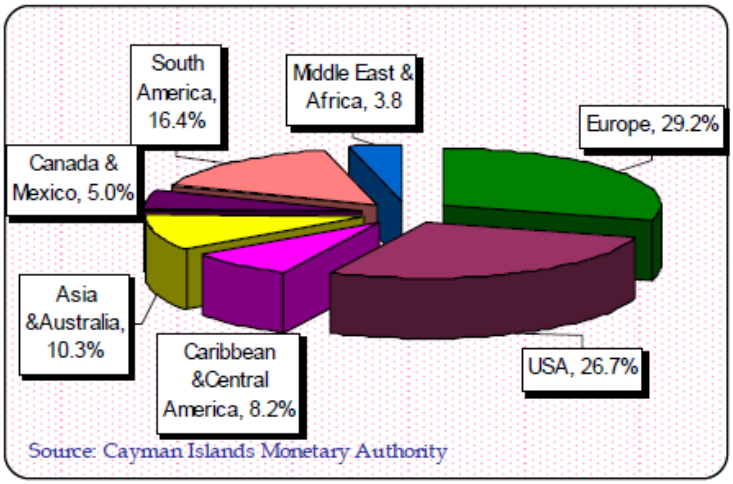
Figure 5 Captive Insurance Licences by Class of Business, 2009



Source: ESO (2010) The Cayman Islands Annual Economic Report 2009

Downturns were recorded in mutual funds registration (-3.5%), stock exchange listings (-16.9%), and new company registrations (-33.7%) while banks and trusts company registrations continued to fall, this time by 4.3%. As in previous years, banks from Europe and the United States continue to comprise the majority of the licenses (Figure 6).

Figure 6 Number of Banks by Region, 2009

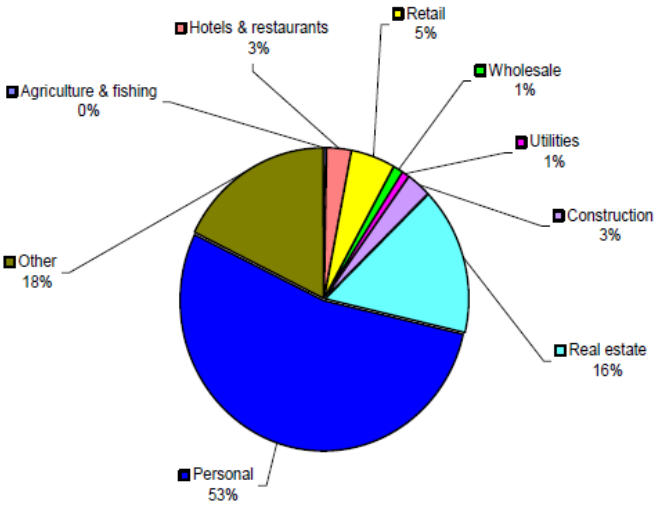


Source: ESO (2010) The Cayman Islands Annual Economic Report 2009

Banks lent or advanced some CI$2.8 billion in 2009 with personal lending continuing to represent the bulk of this activity (Figure 7). Borrowing in the hotels & restaurants, and construction sectors jumped significantly over 2008, while the retail sector showed the most dramatic reduction by over 60% in the same period[21].

[21] ESO, 2010. Ch. 6. Monetary and Financial Services. In: *Statistical Compendium 2009*. Economics and Statistics Office, Cayman Islands Government, George Town, Grand Cayman.

Figure 7 Resident Loans & Advances by Borrower, 2009



Source: ESO (2009) Statistical Compendium 2008

Tourism

The Cayman Islands has witnessed a steady year-on-year increase in both air and cruise ship passenger arrivals over the last 30 years, with the total numbers peaking at 2.2 million visitors in 2006 (Figure 8). Since then air or stay-over visitors have continued to increase while the number of cruise arrivals have declined. By 2008 the total tourist arrivals had decline to 1.86 million.

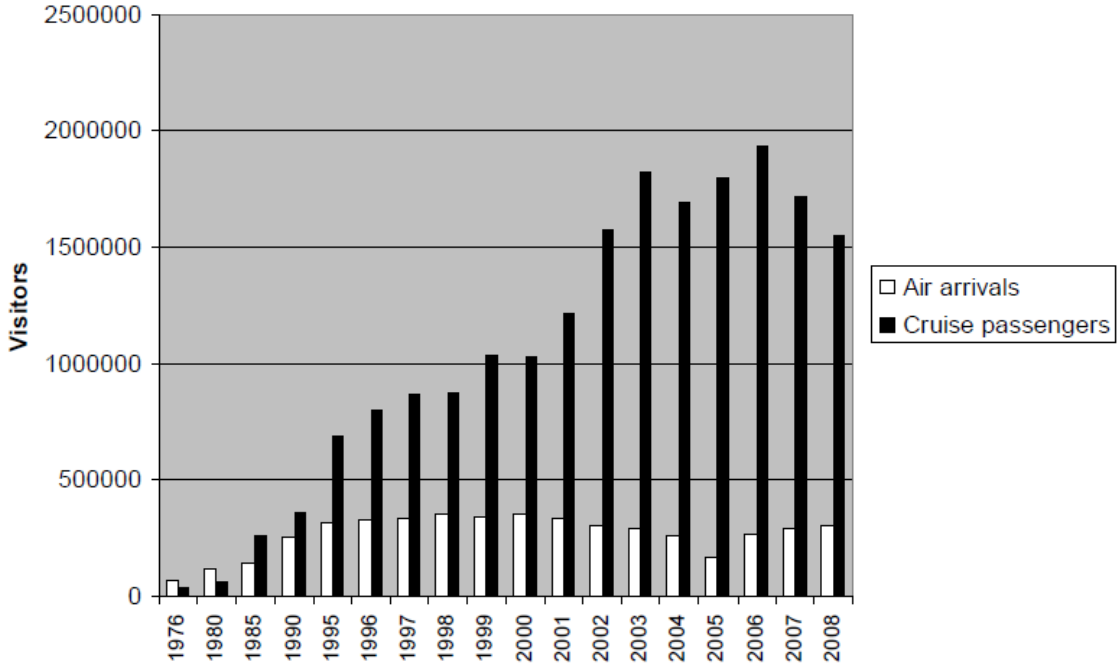
Tourism activity contracted in 2009 as air and cruise arrivals decreased by 10.2% and 2.1% respectively, to put the total visitor arrivals to 1.79 million or a decline of 3.4% relative to the previous year.

Overall, arrivals from all regions within the USA (the largest market for stay-over arrivals in the Cayman Islands) were lower. This downturn was also noted for other regions including Canada and Europe.

In contrast, the visitor expenditure from both stay-over and cruise ship arrivals in 2008 was CI$433 million, a moderate rise since 2006 (Table 5)[22]. While stay-over visitors accounted for only 16.3% of total tourist arrivals in 2008, they contributed 72.74% to total visitor expenditure and cruise ship visitors 27.26%, more that one-quarter of the total expenditure.

[22] ESO, 2010. The Cayman Islands' Annual Economic Report 2009. Economics and Statistics Office, Cayman Islands Government, George Town, Grand Cayman, May 2010.

Figure 8 Air and Cruise Arrivals to the Cayman Islands, 1976-2008



Year	76	80	85	90	95	2000	2001	2002	2003	2004	2005	2006	2007	2008
Air arrivals (000s)	65	120	145	253	316	354	334 -6%	303 -10%	294 -3%	260 -12%	168 -35%	267 +59%	292 +9%	303 +4%
Cruise arrivals (000s)	40	61	259	361	683	1031	1215 + 18%	1575 + 30%	1819 + 15%	1693 -7%	1799 +6%	1930 +7%	1716 -11%	1553 -9%

Source: The Tourism Company (2009) A Revised National Tourism Management Plan 2009-2013

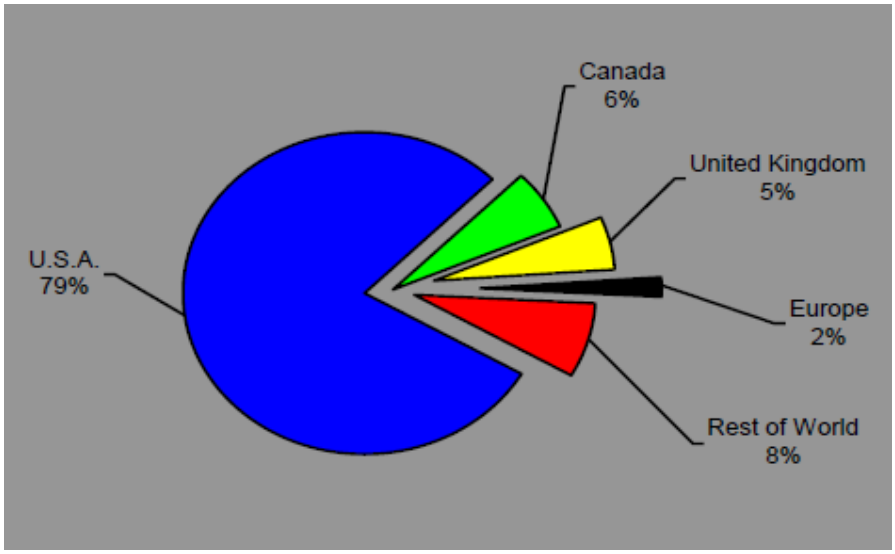
Table 5 Visitor Expenditure, 2000-2008

	2000	2001	2002	2003	2004	2005[R]	2006[R]	2007[R]	2008
Stay over visitors									
Average length of stay (nights)	6.6	6.4	5.8	6.9	6.9	7.6	6.6	6.6	6.4
Average group size	1.9	1.9	2.0	2.2	2.2	2.1	2.3	2.3	2.1
Expenditure per person per night (CI$)	191	191	169	112	111	114	160	163	162
Estimated Total Spending (CI$M)	**446**	**408**	**297**	**280**	**279**	**146**	**284**	**314**	**315**
Cruise ship visitors									
Daily expenditure	87	60	148	95	103	92	81	53	84
Actual Arrivals (000's)	1,031	1,215	1,575	1,819	1,693	1,799	1,930	1,716	1,553
Number of landed visitors (000's)	928	1,093	1,417	1,637	1,524	1,619	1,737	1,544	1,398
Estimated total spending (CI$M)	**81**	**66**	**209**	**155**	**157**	**149**	**140**	**82**	**118**
All visitors (CI$M)	**527**	**474**	**506**	**435**	**436**	**294**	**424**	**396**	**433**

Source: ESO (2010) Statistical Compendium 2009

Although stay-over numbers have rebounded to pre-Ivan levels, air arrivals and cruise passenger numbers significantly decreased in 2009, largely due to the onset of the global recession. Despite this, air arrivals from the USA grew overall, maintaining the biggest market share of 79.1%, while Canadian stay-over tourists grew slightly more, making up 6.3% of the total market (Figure 9).

Figure 9 Air Arrivals by Country of Origin, 2009



Source: ESO (2010) Statistical Compendium 2009

Construction

In 2009, this sector declined with the collapse of non-residential constructions. The total value of building permits reached $355 million (or 29.3% lower than in 2008), the lowest level since 2005.

In the non-residential sector, building permits plummeted by 56.9% from $269.1 million in 2008 to $115.9 million. Steep declines were recorded across all categories: commercial (-69.6%), industrial (-91.4%) and government (-54.0%). Construction values in the residential sector, despite losing some momentum, demonstrated growth of 2.5%. The upbeat performance was solely due to housing construction which reached $146.4 million. In all, residential building permits rose from $233.2 million to $239.2 million in 2009.

The new multi-million dollar homes and large-scale property development led building permits of houses surging by 25.6%. This increase offset the marked slowdown in the apartment/condominium category, which compared to a year ago, decreased by 20.5% to reach $92.7 million in 2009. The 'Other' category also saw phenomenal growth, when compared to a year ago, rising by 155.6 percent to settle at $35.0 million.

In terms of number, building permits rose by the 5.9%. While 1,145 such permits were issued in 2009 compared to the 1,081 in 2008, only two categories, 'house' and 'other' registered increases while the rest declined (Table 6).

Table 6 Grand Cayman Building Permits, 2006-2009

	2006	2007	2008	2009	2008-2009 % Change
Houses	517	496	503	532	5.8
Apartments	374	219	182	171	-6.0
Commercial	197	186	176	116	-34.1
Industrial	35	10	14	7	-50.0
Hotel	2	4	1	0	-100.0
Government	8	16	36	16	-55.6
Other	157	159	169	303	79.3
Total	1,290	1,090	1,081	1,145	5.9

Source: ESO (2010) The Cayman Islands Annual Economic Report 2009

The value of planning approvals also fell by 14.6% to reach $434.2 million. Most of the categories of planning approvals dropped with the exception of other, apartments and houses that rose by 29.3%, 142.% and 8.2 respectively (Table 7).

Table 7 Cayman Islands Planning Approvals, 2006-2009

	2006	2007	2008	2009	2008-2009 % Change
	Millions of CI$				
Houses	81.6	137.7	118.1	127.7	8.2
Apartments	294.3	112.8	149.7	170.9	14.2
Hotels	11.5	55.0	6.9	-	-100.0
Commercial	120.4	72.1	126.4	30.1	-76.2
Government	10.2	56.6	18.6	2.1	-88.6
Industrial	45.9	8.4	11.2	2.6	-77.1
Other	74.9	62.6	77.9	100.8	29.3
Total	638.8	505.2	508.8	434.2	-14.6

Source: ESO (2010) The Cayman Islands Annual Economic Report 2009

Real Estate

Real estate activity suffered a severe contraction in 2009 as the total volume of traded properties hit a seven-year low of only 2,287. This represents 12.4% despite a reduction in stamp duties, which made property purchase cheaper for buyers during the months of April to September.

Freehold property, the main type of traded property, declined by 10.7%. In line with global adjustment in real estate prices, traded property values shifted downwards with leasehold property plummeting from $76.2 million in 2008 to $19.5 million in 2009. This represents a reduction of 74.4%. Freehold property

values receded to $397.0 million from $558.1 million, or -28.9% recorded a year ago.

Across the different types of traded freehold properties, there were broad- based declines in average prices: 4.9% for condominiums, 8.2% for raw land and 17.7% for residential property (Table 8). Commercial and industrial properties registered the sharpest price downturns in the review period.

Table 8 Freehold Property Transfers, 2007 – 2009

Property Types	2007	2008	2009
	Number of Transactions		
Land	392	1013	915
Commercial	22	118	61
Industrial	7	3	25
Condominiums	363	713	716
Residential	124	299	235
	Average Sales Prices (CI$)		
Land	174,416	164,971	152,430
Commercial	521,873	640,631	154,736
Industrial	167,400	556,917	480,000
Condominiums	318,790	314,069	299,374
Residential	400,992	357,785	294,302

Source: ESO (2010) The Cayman Islands Annual Economic Report 2009

Utilities and Telecommunications

Utilities

In 2009, local electricity production rose by 2.0% to 608.8 megawatt hours (mWh). This was in response to a 2.2% increase in demand to 559.8 mWh in December 2009. All categories of electricity consumption expanded: commercial (0.1%), residential (4.5%) and public lighting (5.3%). Water consumption also increased by 5.8% in 2009 (Table 9).

Table 9 Utilities Production and Consumption, 2007 – 2009

	2007	2008	2009	2008-2009 % Change
Water				
Water Consumption (*millions of US gallons*)	1,657.7	1,646.1	1,741.78	5.8
Electricity ('000 megawatt hrs)				
Electricity Production (mWh)	584.4	596.8	608.8	2.0
Electricity Consumption (mWh)	534.2	547.7	559.8	2.2
• Residential	249.4	251.7	263.1	4.5
• Commercial	279.4	290.3	290.7	0.1
• Public	5.4	5.7	6.0	5.3

Source: ESO (2010) The Cayman Islands Annual Economic Report 2009

Telecommunications

In 2009, the total number of paid telecommunication minutes increased by 24.6% to 435,362. There was an increase in 'package deals' coupled with reductions in the unit cost of telecommunication during the period. Similarly, the number of telephone lines (fixed lines and mobile) also increased by 8.0% during the same period (Table 10).

Table 10 Telecommunication Sector Indicators, 2007 – 2009

Indicators	2007	2008	2009	2008-09 % Change
Fixed and mobile lines in service as of year-end	136,547	134,079	144,850	8.0
Total lines-to-household ratio[1]	5.8	4.9	5.2	6.1
Total domestic and international minutes for fixed and mobile lines ('000)	344,666	349,376	435,362	24.6

1. Using end of year number of households
2. N.B. Revised figures (for Fixed and Mobile Lines in Service and Domestic and Int'l Minutes) for periods 2007 – 2008

Source: ESO (2010) The Cayman Islands Annual Economic Report 2009

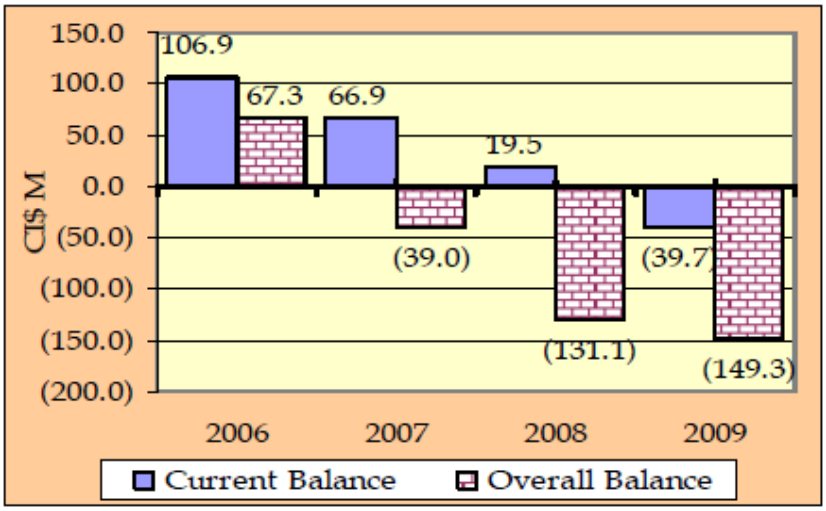
Central Government

The current global financial crisis, like past economic downturns in the US, has hit the Caribbean region particularly hard. In 2009, the Cayman Islands' overall fiscal position worsened as revenue collection declined at a faster rate than the decline in expenditure, causing increased indebtedness. The decline in expenditure was achieved primarily by significant cuts in capital expenditure and personnel costs although these were offset by increases in subsidies to statutory authorities[23].

A reduction in central government revenue coupled with high capital expenditure ignited the overall fiscal deficit to widen for the third consecutive year to settle at $149.3 million (or 6.0% of GDP) in 2009 as compared to $131.1 million (or 4.9% of GDP) a year ago (Figure 10).

[23] ESO, 2010. The Cayman Islands' Annual Economic Report 2009. Economics and Statistics Office, Portfolio of Finance and Economics, Cayman Islands Government, Grand Cayman, May 2010.

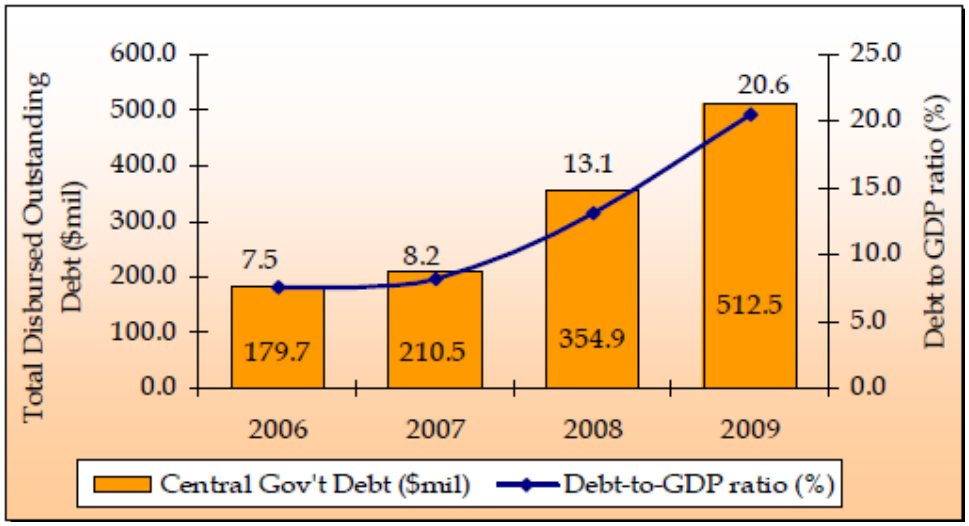
Figure 10 Central Government Fiscal Balance, 2006-2009



Source: ESO (2010) The Cayman Islands Annual Economic Report 2009

The expansion in net borrowings during 2009 resulted in an increase in the central government's outstanding debt to total $512.5 million as at December 2009 (Figure 11) from $354.9 million as at end 2008. This placed the debt-to-GDP ratio at 20.6%, higher than the 13.1% as at December 2008.

Figure 11. Central Government Outstanding Debt & Debt-to-GDP Ratio, 2006-2009



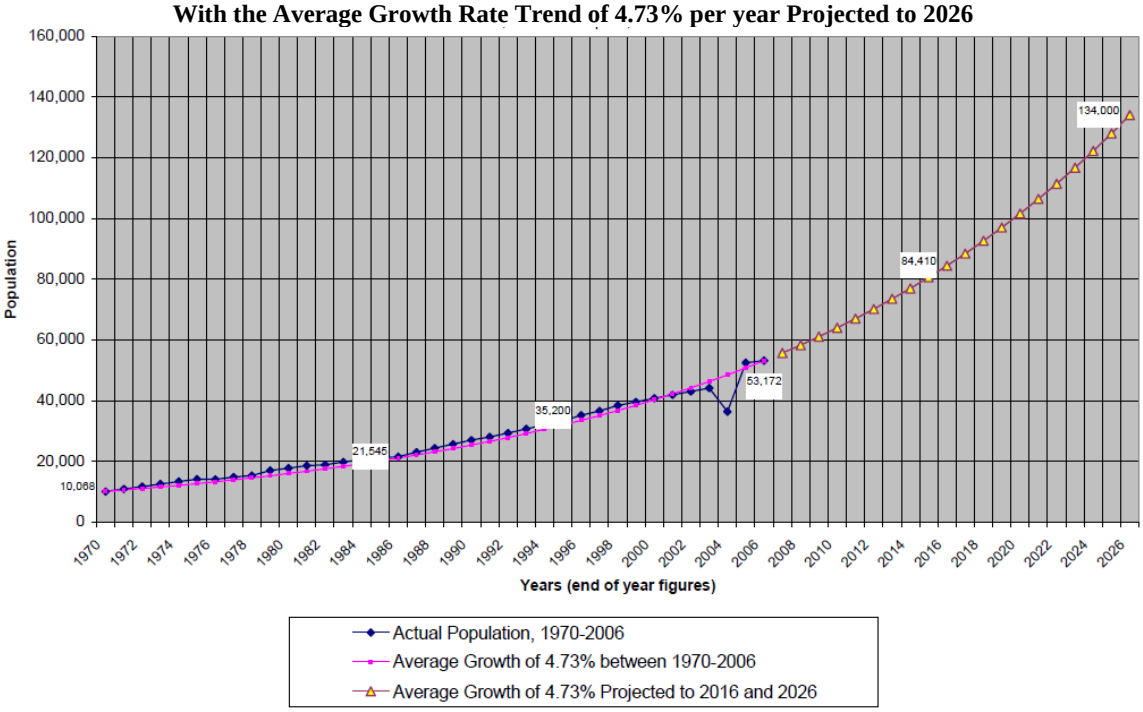
Source: ESO (2010) The Cayman Islands Annual Economic Report 2009

Record high fuel prices in summer 2008, the onset of a global recession and increased cost of borrowing are compounding problems that many small island developing states can ill afford, including the Cayman Islands which does not receive any direct budgetary support from the UK Department for International Development or The Foreign & Commonwealth Office. These factors divert scarce resources away from government's development agenda and present further challenges to funding adaptation responses that are currently at the lower end of government priorities.

2.5 Population Centres & Critical Infrastructure

Population growth in the Cayman Islands since 1970 has been at an unprecedented rate not often seen in a single generation. The Islands experienced a 428% increase in population between 1970 and 2006, at an average rate of 4.73% per year. At this rate, with all other socio-economic trends being equal, the Islands could reach a population of 134,000 by 2026 (Figure 12)[24]. This could have widespread implications for many areas of government policy including climate change adaptation: from the siting of new public infrastructure and communities to the capacity of the healthcare system to respond to various climate and non-climate related cases.

Figure 12 Population of the Cayman Islands, 1970-2006
With the Average Growth Rate Trend of 4.73% per year Projected to 2026

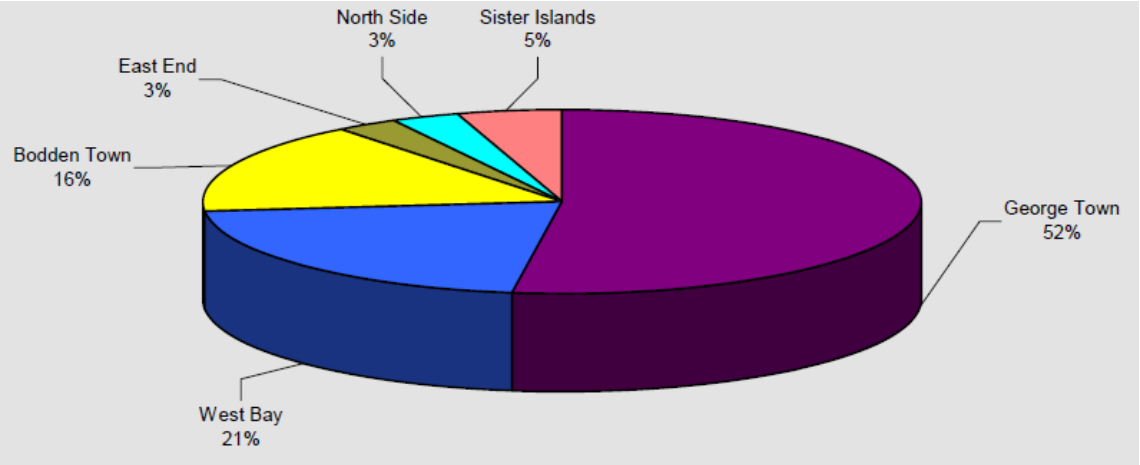


Source: Pedley (2007)

The majority of the population is concentrated in the districts of George Town, West Bay and Bodden Town (Figure 13). While the Sister Islands' population and density per square mile has increased over the same period, its share of the overall Cayman Islands population continues to decrease, much like North Side and East End districts (Map 7).

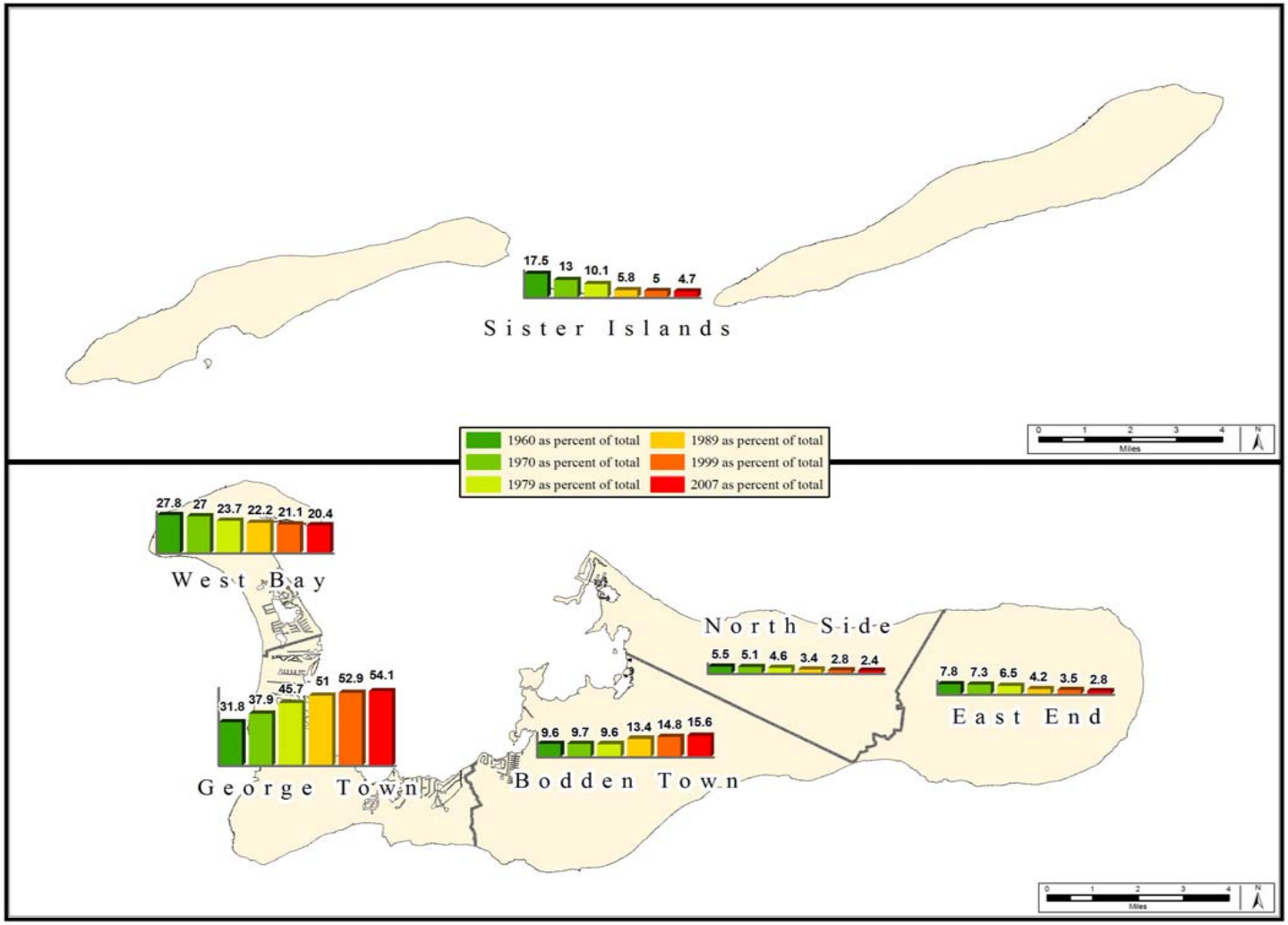
[24] Pedley, P., 2007. Population Scenarios: Past Trends and Future Possibilities. Policy Brief 05/07. Prepared for the Chief Secretary and The Portfolio of Internal and External Affairs, December 2007.

Figure 13 Population by District, 2008



Source: ESO (2009) Statistical Compendium 2008

Map 7 Population Percentage by District, 1960-2007



Source: Survey of Living Conditions (2007), Map produced by Department of Environment 2010

The National Assessment of Living Conditions (NALC) assessed the welfare of the Cayman Islands' population in 2006/2007: 3.7% of the population (1955 individuals) or 3.1% of households (575 households) were found to be living below the vulnerability line[25]. The highest level of income vulnerability is in Cayman Brac.

As with most small islands, critical infrastructure (sea ports, airports, roads, fuel terminals, utilities, emergency response and key government facilities,) and economic activities that support the main population centres have developed linearly along the coastline or within close proximity to the coast, many in hazard-prone areas. Areas on Grand Cayman vulnerable to present-day climate hazards such as flooding from hurricanes, storm surges and high winds have been identified in a preliminary vulnerability assessment conducted by the Natural Disasters Assessment Consulting Group in 2009 and ranked in relation to level of exposure of these hazards (Table 11). Map 8 is a geographical representation of the level of exposure to these hazards and the level of physical vulnerability of the critical infrastructure identified in the assessment. No similar assessments have been conducted for Cayman Brac or Little Cayman to date.

Table 11 Areas and Level of Exposure to Natural Hazard in Grand Cayman

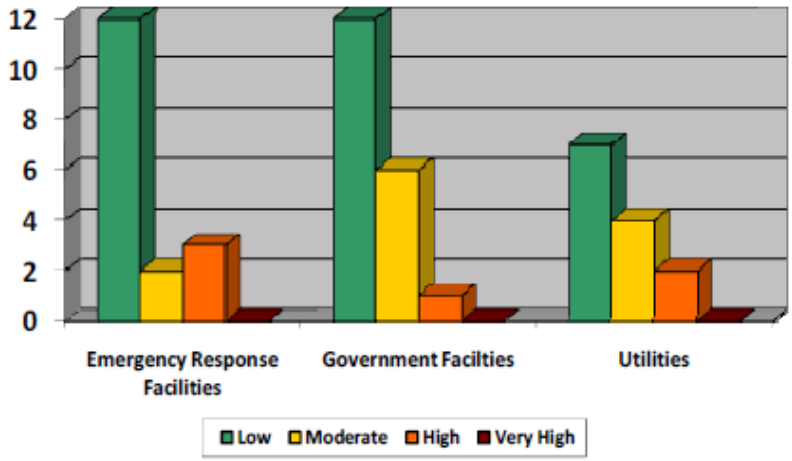
Area	Level of Exposure
Area 1: North Sound-Little Sound-Eastern West Bay	Very High
Area 2: Central Mangroves-Central Bodden Town-Central George Town and West Bay	High
Area 3: Northwestern West Bay-Western Georgetown-Bodden Town-East End-North Side	Moderate
Area 4: Remainder of the island	Low

Source: NDAC (2009) Preliminary Vulnerability Assessment of Grand Cayman, Cayman Islands

It is interesting to note that the majority of the 48 critical facilities identified have a low level of vulnerability (Figure 14). Those emergency response facilities with a high level of vulnerability include the West Bay Fire Station, Bodden Town Clinic and Bodden Town Police station. The only Government facility with a high level of vulnerability is the George Town dock and port. Two utilities are similarly categorized and are the Texaco and ESSO fuel terminals.

[25] Kairi Consultants Ltd., 2008. *Cayman Islands National Assessment of Living Conditions 2006/2007: Volume I Main Report.* Caribbean Development Bank, April 2008.

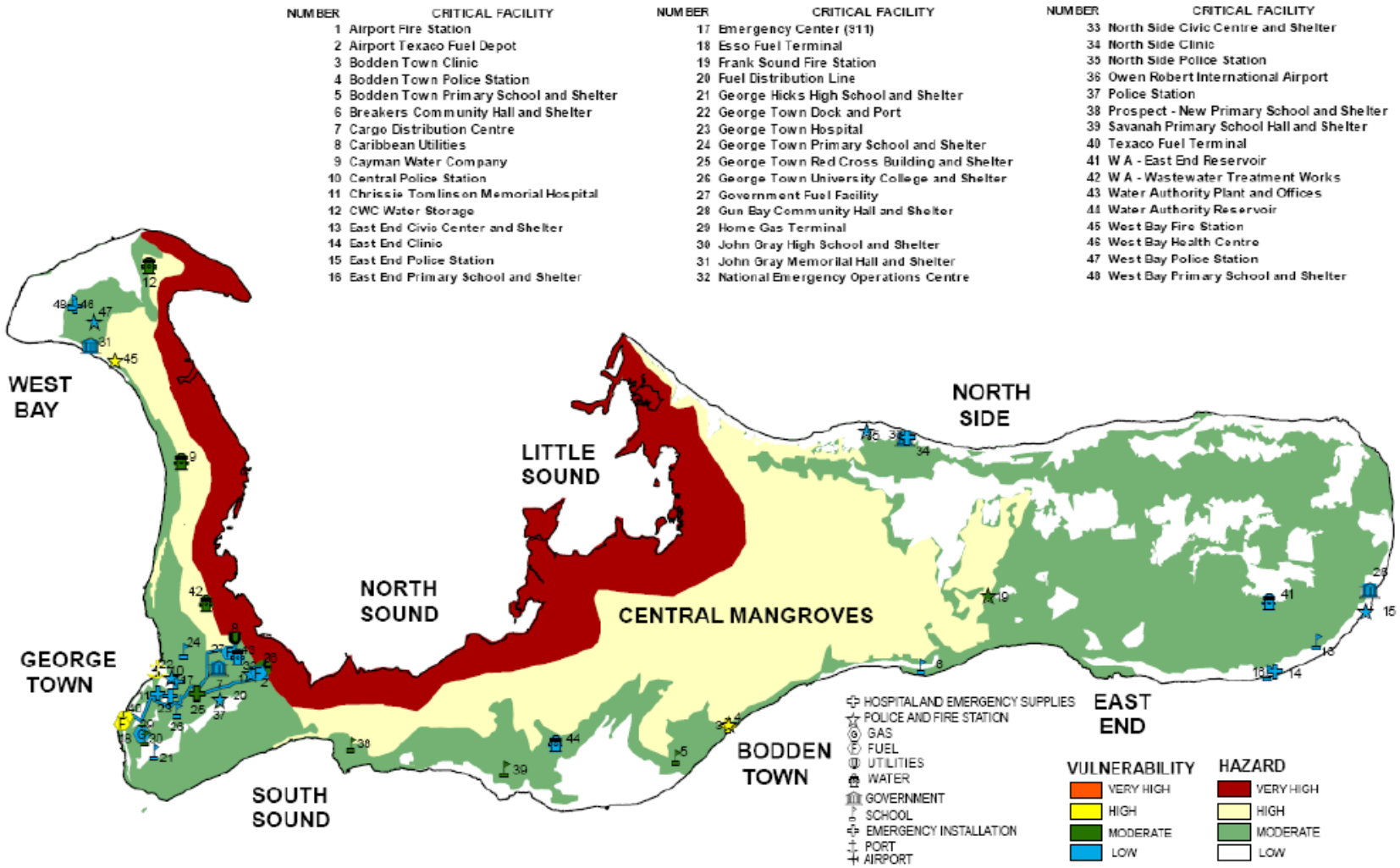
Figure 14 Percentage of the Level of Vulnerability of Critical Facilities on Grand Cayman



Low Vulnerability	Low exposure to any of the identified main hazards at the Cayman Islands. The critical facility is located inland and well above sea level.
Moderate Vulnerability	Moderate exposure to at least floods and storm surges. The facility is located in a zone that is impacted by hurricane categories 4 and 5 that take place approximately every 100 years.
High Vulnerability	High exposure to at least floods and storm surges and to a lesser degree to tsunamis. The facility is located in an area exposed to hurricanes of category 3 (and above) that hit the islands once every 9.06 years.
Very High Vulnerability	Very high exposure to floods and storm surges and to a lesser degree to tsunamis. The facilities located in a zone where coastal flooding and wave action are the highest during hurricanes of categories 1 and 2 (and above). On average these kinds of hurricanes hit the Cayman Islands every 2.23 years.

Source: NDAC (2009) Preliminary Vulnerability Assessment of Grand Cayman, Cayman Islands

Map 8 Areas showing the vulnerability and exposure of critical facilities to natural hazards in Grand Cayman



Source: National Disaster Assessment Consulting Group (2009) Preliminary Vulnerability Assessment of Grand Cayman, Cayman Islands

3. REGIONAL CLIMATE CHANGES

3.1 Observed Climate Changes

Box 1 summarizes changes and trends in climate parameters that have been observed across the Caribbean during the 20th century. While the Earth has warmed on average by 0.74˚C (ranging from 0.56˚C to 0.92˚C) over the last hundred years, the warming seen in the Caribbean of 2˚C over the same period has been well above this global mean temperature[26]. Generally wetter winter conditions have prevailed in the Northern Caribbean, which includes the Cayman Islands, compared to the southern and eastern Caribbean[27]. Trends have shown a decrease in total precipitation regionally, but an increase in rainfall intensity on rainy days. These regional trends have manifested as increased floods as well as droughts which are causing water scarcity issues in the eastern and southern Caribbean. The region also witnessed more incidences of extreme temperature-related stress events to humans, animals and plants. More frequent outbreaks of pest infestation as well as more prevalent coral bleaching have been observed[28]. Locally, the change in rainfall patterns has become a frequent topic for conversation as residents observed the seeming delay in the start of the rainy season in recent years. Further, out of season heavy rainfall events have been observed such as that of January 2003 when over 11 inches fell, well above the long term monthly average of 1.96 inches.

Hurricanes

Hurricane activity since 1995 has shown a marked increase with the number of category 3 to 5 hurricanes in recent years being twice the 1970-1995 average due to steady rise in equatorial sea surface temperatures (SSTs) (Figure 15)[29]. Between 2000 and 2009 there have been eight hurricanes reaching category 5 intensity - a number never before observed in a 10-year period[30]. The 2005 Atlantic hurricane season was the busiest on record, shattering records that have stood for decades including most named storms, most hurricanes and most category 5 storms. The season saw 28 named storms, including 13 hurricanes, of which seven were Category 3 or higher. In the Cayman Islands post-Ivan

[26] Mimura, N., L. Nurse, R.F. McLean, J. Agard, L. Briguglio, P. Lefale, R. Payet, and G. Sern, 2007. Small Islands. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. [M.L. Parry, O.F. Canziani, J.T. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.)]. Cambridge University Press, Cambridge, UK, 687-716

[27] New et al, 2001 in Sear et al, 2001. *The Impacts of Global Climate Change on the UK Overseas Territories: Technical Report and Stakeholder Survey*. Natural Resources Institute, University of Greenwich, Kent, UK and Tyndall Centre for Climate Change Research, University of East Anglia, Norwich, UK.

[28] Trotz, U.O, 2008. "Climate Change Adaptation and Mitigation in the Tourism Sector: Climate Change in the Caribbean." 1st International Capacity Building Seminar on Climate Change Adaptation and Mitigation in the Tourism Sector, Balliol College, University of Oxford, 8 April 2008.

[29] Muir-Wood, R., 2008. "Climate Change & the Cayman Islands – Building Resilience." Presentation to Cayman Business Outlook, January 17th 2008.

[30] Nurse, L. Senior Lecturer, Centre for Resource Management and Environmental Studies, UWI, Barbados. Personal communication, 23 February 2010.

recovery efforts were still ongoing when Hurricanes Arlene, Dennis, Emily, Wilma and Gamma had to be contended with during the 2005 season.

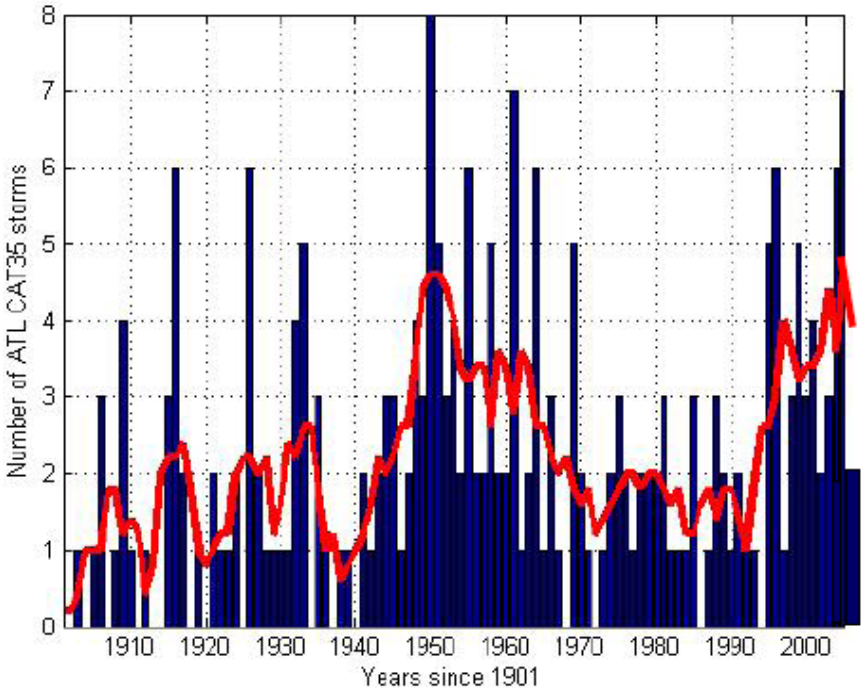
A change in hurricane tracks was observed, especially the development later in the season of systems in the western Caribbean that moved eastward. Many hurricanes, including those reaching category 5 intensity, have formed south and west of Grand Cayman and tracked north and northeastward to threaten these islands[31]. West to east tracking storms tend to move faster, testing regional early warning systems, and preparedness and response plans. Hurricanes becoming more intense in a shorter period of time have also been observed, e.g. Wilma intensified from a tropical storm to a category 5 hurricane in 24 hours[32].

Box 1 Regional Climate Change Observations over the last century

CHANGE FACTOR	IMPACT
Temperature	• 1950s to present: 2.0˚C change detected in surface air temperature for the Caribbean region or 0.5˚C per decade from 1971 to 2004 • Higher minimum temperatures, higher maximum temperatures, and a decreasing diurnal temperature range recorded • 1950s to present: number of really hot days increasing, number of cool days and nights decreasing • 1.5˚C warming of the Caribbean Sea
Rainfall	• Differences in rainfall between the north and south Caribbean • Maximum number of consecutive dry days decreasing and number of heavy rainfall events increasing • Wetter winter conditions in the Northern Caribbean (includes the Cayman Islands) • Drier summer months observed in recent decades region-wide • Frequency of droughts increased since the 1960s (especially in Cuba) • Less late season rainfall observed in El Niño years
Storms and Hurricanes	• Greater hurricane activity in 1930s-1960s compared to 1970s-1980s and first half of 1990s • Since 1995: above normal total number of hurricanes in all but two hurricane seasons (1997 and 2002 due to El Niño effects that reduce activity in the North Atlantic) • Recent extreme period may be similar in level to that of the late 19th century • Number of storms reaching category 4 and 5 intensity has increased globally since 1970
Sea Level Rise	• Global sea level rise over last 100 years: 17 cm (0.6 ft) • Mean relative sea level rise of 1 mm/yr in the Caribbean • 17 mm/decade increase recorded since 1850 in Key West, Florida • Considerable regional variation in sea level changes

[31] Trotz, N., 2008. Vulnerability and Capacity Assessment Workshop, Grand Cayman, Cayman Islands, 21-22 October 2008.
[32] Trotz, N., 2008. ProVention/ IFRC Caribbean Workshop on" Climate Change Community Resiliency in the Caribbean." Port of Spain, Trinidad, February 8 2008.

Figure 15 Category 3 to 5 Atlantic Basin Hurricanes, 1901-2005 and 5-Year Running Average



Source: Risk Management Solutions (2007) in Muir-Wood (2008)

3.2 Projected Climate Changes

Box 2 summarizes climatic and related changes expected across the Caribbean during this century. No consensus has been reached on whether the frequency of hurricanes will increase, however there is general agreement that more category 4 and 5 storms is likely to occur. While surface warming is expected to be lower than the global average, the region will likely experience temperature increases of at least 2˚C by the 2050s and up to 4.3˚C by the 2080s and beyond[33].

Rainfall

Overall, drier conditions across the Caribbean are expected, but less certainty surrounds how regional rainfall regimes will change. Regional precipitation is more difficult to project than temperature because current Atmospheric-Oceanographic Global Circulation Models (AOGCM) typically have a resolution of 200 km which is insufficient to accurately distinguish small islands from ocean surfaces. Assessments are further complicated by not well understood influences of ENSO on rainfall and climatic processes such as the Caribbean mid-summer drought. Further, tropical storm and hurricane projections from different models are often inconsistent given insufficient information on sea surface temperature changes to determine regional distribution of cyclone changes. Large deviations among models also make regional distribution of sea level rise (SLR) uncertain

[33] Brown, N, 2008. *Climate Change in the UK Overseas Territories: An Overview of the Science, Policy and You*. Joint Nature Conservation Council, Peterborough, UK.

and the number of models addressing storm surge is limited. The importance of Regional Circulation Models at high resolution (50 km and 25 km) is therefore important for meaningful regional climate prediction and the development of climate change impact scenarios[34].

Box 2 Regional Projections of Climate Change over the next century

CHANGE FACTOR	IMPACT

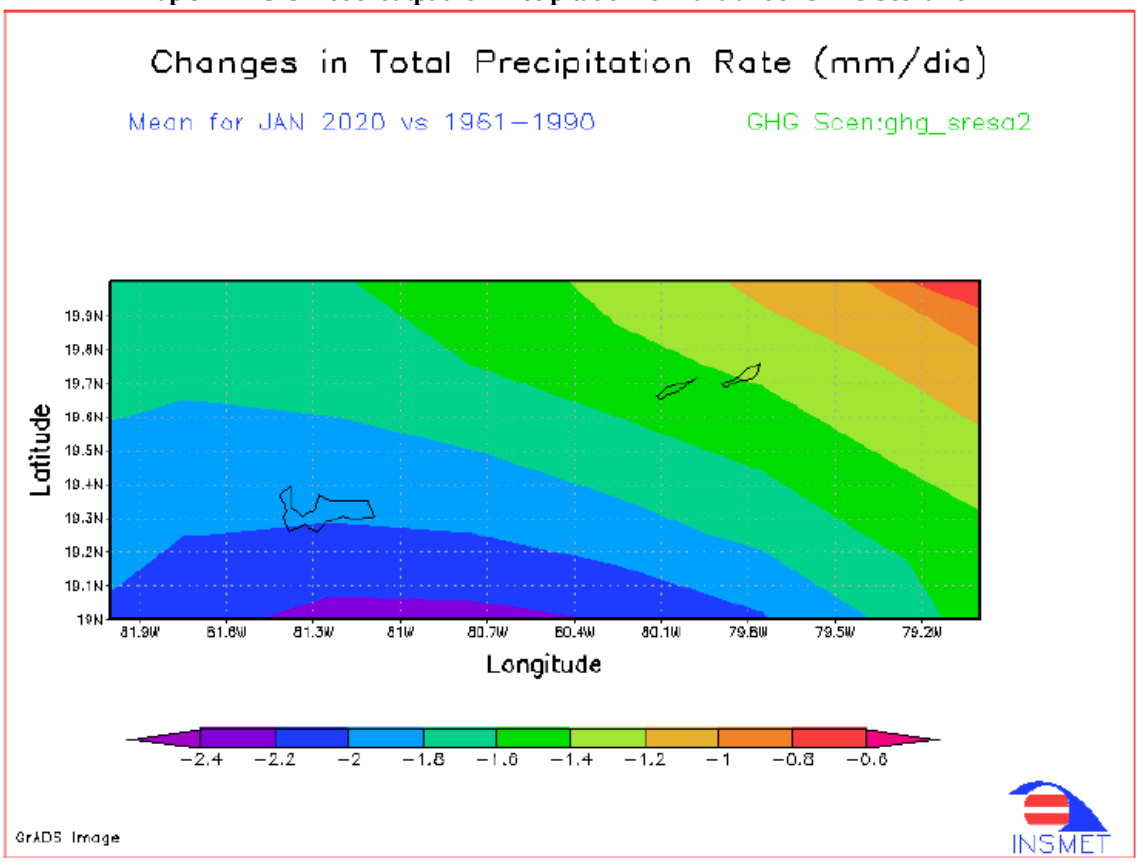
Temperature	• Rates of warming in the region expected to be lower than the global average
	  • 2050s: Increases between 2.0˚C and 2.8˚C
	  • 2080s: Increases of 3.1˚C to 4.3˚C

Rainfall	• Changes in rainfall patterns expected with generally heavier rainfall events • Regional variations expected • 2050s: decline in rainfall over the Greater Antilles • 2100: significantly less rainfall region wide in the summer wet season • Conditions likely to become more El Niño-like, i.e. drier Caribbean region
Storms and Hurricanes	• Stronger hurricanes (category 4 and 5) expected • Substantially more rainfall and peak winds intensity
Sea Level Rise	• Changes in the Caribbean expected to be near the global mean • 2100: 18 cm (low emission scenario) to 58 cm (high emission scenario) (IPCC conservative estimates) • 2100: 2 m to 3 m global sea level rise (thermal expansion of oceans and surface melting of Greenland and West Antarctic Ice Sheets)

A significant body of research on temperature, rainfall, hurricane and sea level rise projections is being undertaken by the Caribbean Institute for Meteorology and Hydrology (CIMH) based in Barbados, Climate Studies Group Mona (CSGM) at the University of the West Indies in Jamaica, Instituto de Meteorologia (INSMET) in Cuba, and the Caribbean Community Climate Change Centre (CCCCC) in Belize, as part of a regional modeling network. The PC-based PRECIS Model (Providing Regional Climates for Impact Studies) with higher resolution of 50 km and 25 km is being used by these regional institutions to provide projections for regional climate change scenarios. From this climate change impacts can be evaluated and adaptation measures identified. Map 9 illustrates the type of results that can be generated from the online version of the PRECIS model: precipitation for 2020 using the IPCC SRES A2 scenario, which represents a relatively high global CO_2 emissions future. The projection shows that by 2020 daily rainfall in January might be 1.8 to 2.0 mm less over the majority of Grand Cayman compared to the 1961-1990 average. The situation is less severe for the Sister Islands with rainfall decline per day in the same period on the order of 1.2 to 1.6 mm relative to the baseline.

[34] Trotz, U.O, 2008. "Climate Change Adaptation and Mitigation in the Tourism Sector: Modeling and Forecasting Climate Impacts in Development Countries and Small Island Developing States." 1st International Capacity Building Seminar on Climate Change Adaptation and Mitigation in the Tourism Sector, Balliol College, University of Oxford, 8 April 2008.

Map 9 PRECIS model output for Precipitation for 2020 under SRES Scenario A2



Source: PRECIS-CARIBE website, 2010

PRECIS can be used to look at a number of other meteorological variables such as temperature and higher stratosphere wind outputs to extrapolate what may happen with hurricane formation in the western Caribbean[35].

Sea Level Rise

The total 20th-century rise in sea level globally was 0.17 m or slightly more than half a foot[36]. Global average sea level rose at a rate of 1.8 mm per year between 1961 and 2003, with a marked acceleration of 3.1 mm per year between 1993 and 2003. By comparison, the Caribbean region, on average, experienced a mean relative sea level rise of 1 mm per year over the last century[37]. Regional variations exist in the rate, magnitude and direction of sea level change in response to coastal features, changes in ocean currents, difference in tidal pattern, seawater density and vertical movements of the land itself (uplift or subsistence). A 5-year satellite data series (1993-1998) indicates that mean sea

[35] Nurse, L., pers. comm, 23 February 2010.
[36] IPCC, 2007. Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
[37] Mimura et al, 2007

level in the northern Caribbean was substantially greater than for the southern Caribbean[38].

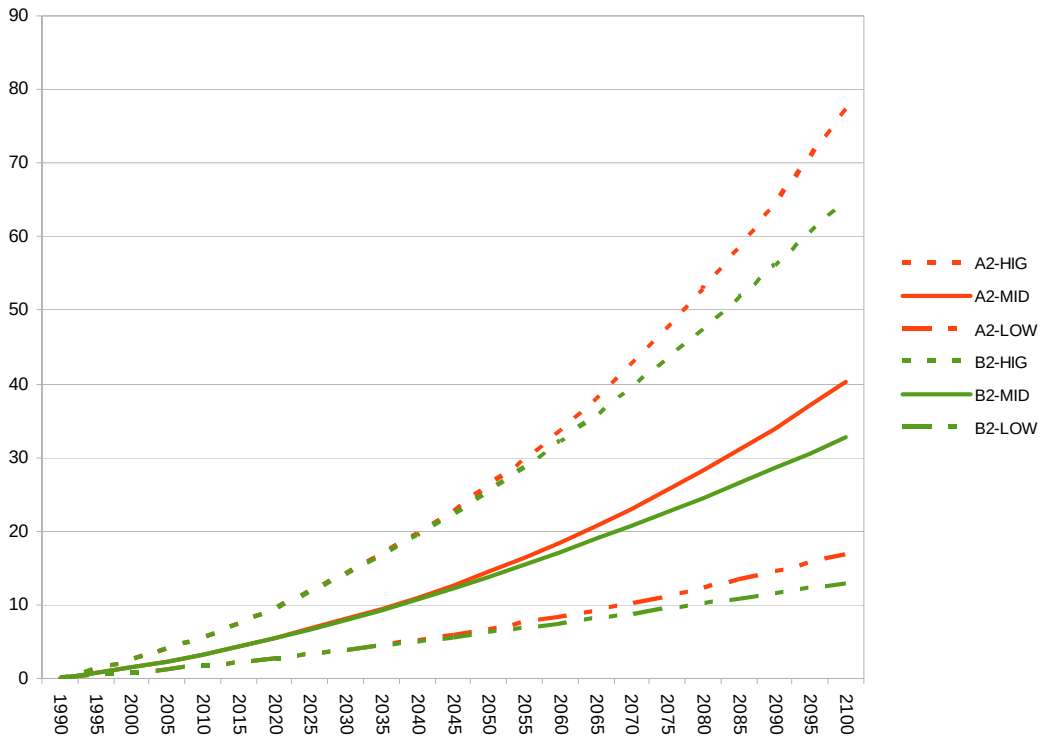
Local variations also exist: over the last century the northwest coast of Trinidad has been rising at 1 mm per year while on the southwest coast tectonic movements accounted for a 4 mm per year rate of sea level change. Annual tide values for the Cayman Islands from 1976 to 1988 reported to a global database on sea level change (managed by the Permanent Service for Mean Sea Level lab in the UK) showed correlation between locally observed and regional trends, indicating that, geologically, elevation is stable and any relative changes in sea levels are actually sea level rise, rather than land subsidence[39].

Sea level rise in the Caribbean is expected to be near the global mean of 38 cm (1.2 ft) for the period 1990 and 2080[40]; consistent with the upper range of the low emission scenario provided in the IPCC Fourth Assessment Report (AR4). The upper range for the high emission scenario is a projected globally averaged sea level rise at the end of this century of 58 cm (1.9 ft). The Cayman Islands National Weather Service, aided by the CCCCC and Cuban Institute of Meteorology, arrived at estimates of future sea level rise utilizing the Model for the Assessment of Greenhouse-gas Induced Climate Change (MAGICC). The model uses two greenhouse gas emission scenarios (SRES A2 and SRES B2) and three different climate sensitivity levels for each of these scenarios to capture the uncertainties associated with this parameter. For all scenarios and all sensitivity levels the model shows increasing sea levels. Figure 16 below shows a range of increase between 12 cm (0.4 ft) to 80 cm (2.6 ft) in sea levels or approximately 0.14 to 0.91 cm per year.

The IPCC AR4 estimates are primarily based on thermal expansion of the oceans, i.e. do not fully account for the influence of melting glaciers, ice caps and polar ice sheets, and are therefore considered highly conservative. Research published subsequent to the AR4 has refined the rates of meltwater at the base of the Greenland and West Antarctic Ice Sheets and the decay of ice shelves which are found to be accelerating. When these effects are taken into consideration, the projections for sea level rise range from 2 m (6.5 ft) to 3 m (9.8 ft) by 2100[41], some 3.5 to 5 times that of the IPCC's maximum estimate.

[38] Adapting to Climate Change in the Caribbean (ACCC) Project, 2003. *Caribbean Risk Management Guidelines For Climate Change Adaptation Decision Making*. Caribbean Community Secretariat.
[39] Burton, F.J. 2009. Personal communication, 26 Sept 2009.
[40] Brown et al., 2008
[41] Pew Center on Global Climate Change, 2009. Key Scientific Developments Since the IPCC Fourth Assessment Report. Science Brief, June 2009.

Figure 16 Sea-Level Rise Predictions under SRES A2 and B2 to 2100



Source: National Weather Service (2010) Climate and Weather Assessment for the Cayman Islands

Despite some above uncertainties, there is enough evidence to suggest a precautionary approach need be applied to the issue of climate change. The following section assesses the present vulnerability within various sectors of the Cayman Islands that is likely to be exacerbated by climate change.

4. KEY ISSUES FOR THE CAYMAN ISLANDS

The following sections discuss the possible implications of regional climate projections on the Cayman Islands in the context of existing vulnerabilities, strengths and capacity to adapt. In identifying these critical issues best judgment has been applied drawing from the growing literature on climate change impacts to and vulnerabilities of small islands and the Caribbean region, as well as local views raised during stakeholder consultations aimed at specific economic and social sectors.

4.1 Beach and Shoreline Stability

Global sea level rise projected at rates of 5 mm per year (IPCC) to 10 mm per year (Rahmstorf)[42] is more than double the local observations of an average of 2.4 mm per year from 1976 to 1988[43]. The impact on beach resources, particularly economically important assets such as Seven Mile Beach on Grand Cayman, is cause for concern, as the extent of possible beach retreat under these sea level rise and other scenarios has not been mapped. The density of recent development and inappropriate siting of structures such as seawalls, swimming pools and in some instances buildings in the active beach zone further exacerbates the problems and potential for erosion as the beaches have limited distances to retreat or flex naturally. Further, SMB is a very 'leaky' system with sand losses occurring under relatively benign conditions[44]. Existing portions of this particular shoreline from Crescent Point to Royal Palms in the south and Boggy Sand in the north already suffer significant cyclical erosion typically when summer storms bring waves from the south. The Boggy Sand area provides compelling evidence of beach retreat as sixty years ago the coastline in this area supported a church, school, market building and slipway, among other things, on land that no longer exists. Nor'westers, though destructive in terms of wave impact, facilitate replenishment of beach resources at the north end of the beach which are moved southward. The beach is relatively stable if opposing sand transport systems remain in balance. However in recent

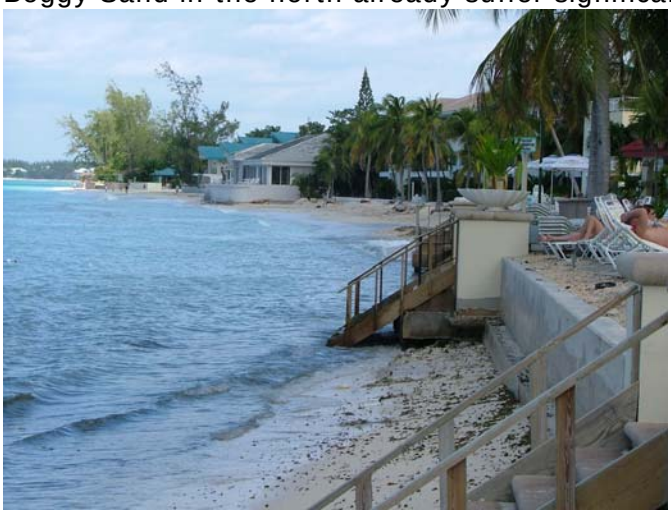


Photo 1. Beach erosion 'hot spot,' southern Seven Mile Beach, December 2003. ***Courtesy of DOE***

[42] Fletcher, C. 2008. Threats from Sea-Level Rise. In: Ka Pili Kai. University of Hawai'i Sea Grant College Program, Vol. 30 No.1 Building Community Resilience to Coastal Hazards, Spring 2008.
[43] Burton, F.J., 1994. Climate and tides of the Cayman Islands. In: *The Cayman Islands: Natural History and Biogeography*. Brunt, M.A. and Davies, J.E. (eds.), Kluwer Academic Publishers, Netherlands, pp.51-60.
[44] Seymour, R.J., 2000. Seven Mile Beach: A Natural History. Report to the Cayman Islands Government Department of Environment and the Beach Erosion Committee, 14 November 2000.

years, strong Nor'westers have been visibly absent and unusually high tides combined with more southerly winds toward the tail end of hurricane season have favoured conditions for erosion.

Beach retreat and increased erosion have far-reaching consequences for the economy, tourism especially, and recreational loss. As low-lying islands any reduction in usable land area from sea level rise and coastal inundation has real estate implications. Remaining beachfront property will either become premium with exorbitant prices or deemed undevelopable because of insufficient setbacks. The potential for user conflicts to heighten in the space remaining may require different management mechanisms from those currently in place. The adverse effects on tourism infrastructure and associated economic activities that typically rely on beach resources cannot be overstated. A study in Barbados showed beach-based tourism would be negatively affected by a 0.5 m SLR and associated beach erosion which on average could result in loss of up to 38% of the island's total current beach resources[45].

The majority of storms pass to the south and west affecting beach resources along these coasts where a large percentage of turtle nesting activity takes place in Grand Cayman. Marine turtle nesting beaches are already under threat by inappropriate coastal development (e.g. building siting and artificial lighting issues), improperly managed beach activities (e.g. obstructions such as chairs/loungers, beach cleaning/sand fluffing practices), and irresponsible vehicle use on the active beach. Rising sea levels, inundation by storms and increased rates of beach erosion only serve to exacerbate these conditions, especially where coastal development has not allowed for the migration of beaches inland. A GIS-based study in Bonaire illustrated that a 0.5 m SLR would decrease total current beach area by up to 32%, with lower, narrower beaches similar to many in the Cayman Islands being the most vulnerable, reducing turtle nesting habitat by 59%[46]. While appropriate coastal construction setbacks might mitigate human encroachment on nesting habitat made worse by sea level rise, climate change is also expected to elevate sand temperatures, the result of which may be a skewed sex ratio of hatchlings towards more females. Studies of loggerhead nesting populations in the southern USA are already female biased and expected to become ultra-biased with as little as 1˚C air temperature rise and extreme levels of mortality expected if warming exceeds 3˚C over the next century[47].

Photo 2. Green turtle hatchlings, Seven Mile Beach. ***Courtesy of Mark Orr***

[45] Uyarra, MC., I.M. Cote, J.A. Gill, R.R.T. Tinch, D. Viner, and A.R. Watkinson, 2005. Island-specific preferences of tourist for environmental features: implications for tourism-dependent states. *Environmental Conservation* (32): 11-19.

[46] Fish, .M.R., I.M. Côté, J.A. Gill, A.P. Jones, S. Renshoff, and A.R. Watkinson, 2005. Predicting the Impact of Sea-Level Rise on Caribbean Sea Turtle Nesting Habitat. *Conservation Biology*. Volume 19 Issue 2 , 482-491.

[47] Hawkes, L.A., A.C. Broderick, M.H. Godfrey and B.J. Godley, 2006. Investigating the potential impacts of climate change on a marine turtle population. *Global Change Biology*, Volume 13 Issue 5, 923-932.

The projected increase in storm intensity, storm surge and sea level will exacerbate flooding impacts and could change the shape of coastlines[48]. Such was the case along Grand Cayman's southwest coast after Ivan, where a particular beach temporarily expanded by as much as 400 ft. This, of course, has potentially serious consequences for increasing the vulnerability of any coastal development permitted in the wake of such events where setbacks are determined on the dynamic Mean High Water Mark, especially if historical data on the specific beach characteristic conditions are ignored in the planning process. More intense hurricanes also have implications for the sand budget with relies on the contribution of coral reefs. Over the long term, natural beach replenishment and shoreline stabilization may not be able to keep pace with the processes that cause beach erosion.

4.2 Marine and Coastal Ecosystems

Coral Reefs

Warming sea temperatures, rising sea levels and the threat of stronger hurricanes have the individual and cumulative potential to significantly impact marine ecosystems like fragile coral reefs and the services they provide. The total value of reef-related shoreline protection services in the Caribbean region has been estimated to be between US$740 million and US$2.2 billion per year; however depending on the degree of development, this coastal-protection benefit could range from US$2,000 to US$1,000,000 per kilometer of coastline[49]. When ecosystem services related to tourism and fisheries are added, the figure for the estimated regional total value of coral reefs climbs to US$3 billion[50].

Coral bleaching

Most coral species are sensitive to sea temperature changes. As the Caribbean Sea has warmed by 1.5°C over the last 100 years, it is no surprise that minor bleaching events have been recorded in the warmer summers with increasing frequency during the last decade, forcing corals to live at or near threshold levels on an almost continuous basis. The annual average maximum sea temperature around the Cayman Islands is 30ºC which is about the temperature threshold for regional corals. During the mass (worldwide) coral bleaching event of 1998, local water temperatures exceeded this threshold by as much as 0.8˚C for 25 days (August 9 to September 3), or 3.5 degree heating weeks (DHWs). This rise above mean monthly temperatures affected roughly 90% of all corals on Grand Cayman, particularly major reef-building boulder star coral (*Montastrea annularis*) on the deep reefs and the *Milliporines* on the shallow reef, and 10%

[48] Sear et al, 2001. *The Impacts of Global Climate Change on the UK Overseas Territories: Technical Report and Stakeholder Survey*. Natural Resources Institute, University of Greenwich, Kent, UK and Tyndall Centre for Climate Change Research, University of East Anglia, Norwich, UK.

[49] Epstein, P.R. and E. Mills (eds.) 2005. *Climate Change Futures: Health, Ecological and Economic Dimensions*. A project of the Center for Health and the Global Environment at Harvard Medical School. Sponsored by Swiss Re and the United Nations Development Programme.

[50] CANARI, 2009. Climate change in the Caribbean: the case for greater investment in research and adaptive policies. CANARI Policy Brief No.10.

coral mortality at two north coast reefs at 30 ft water depth[51]. In 2005, also one of the hottest years on record, widespread bleaching mortality was reported in the northeastern Caribbean. In 2009 September-October sea surface temperatures around the Cayman Islands have again remained elevated beyond the threshold by 35 days (5+ DHWs) which is set to exceed the intensity and severity of coral bleaching witnessed in 1998[52].

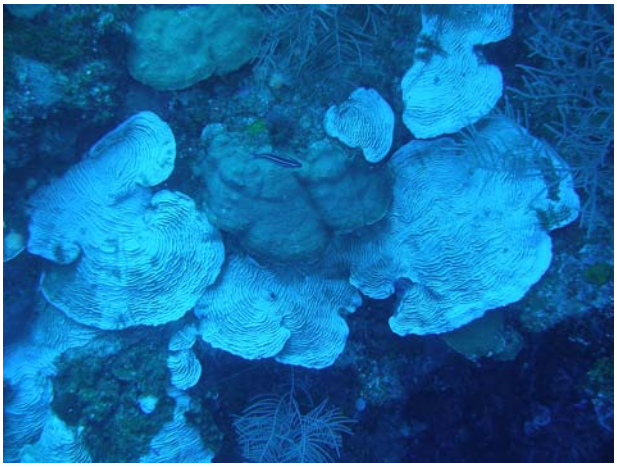


Photo 3. Coral bleaching at Andes Reef, North coast Grand Cayman, October 2009. ***Courtesy of Croy McCoy***

Coral bleaching events in the Caribbean will continue over the next 20-30 years due to committed warming from GHG emissions already in the atmosphere. Regional temperature projections least 2˚C above pre-industrial by the end of the century or sooner is expected to far exceed the current mass coral bleaching thresholds across the Caribbean. Thus without any biological adaptation, the frequency of bleaching events will outpace the rate of recovery[53]. Annual and bi-annual bleaching events are projected in the next 30-50 years or sooner if a rise in the thermal tolerance of corals of 1˚C is not realised[54]. Current research shows that a 1˚C rise in sea temperature would affect 80% of reefs throughout the Caribbean[55].

Bleaching correlates to ENSO cycles which have also been linked to coral diseases[56]. Bleached corals are known to be more susceptible to coral diseases, such as white band disease, and once dead are quickly overgrown by algae preventing new coral recruitment or overgrowth by neighbouring live coral tissue. A shift in coral community structure and reduction in cover and reef complexity over time is anticipated, with associated impacts on the diversity of fish communities and other marine species likely. It is not known if or how much revenue from diving is lost locally from mass bleaching events or what the wider ecological implications on local fisheries are. However studies in Bonaire, with a

[51] McCoy, C., 2004. An assessment in changes in benthic cover, coral colony morphology and community structure in Bloody Bay – Jackson Point Marine Park, Little Cayman, B.W.I. MSc in Marine Biology Thesis, University of Wales, Bangor, Wales, UK
[52] McCoy, C., Senior Research Officer, Department of Environment. Personal Communication, 5 October 2009.
[53] Simpson et al, 2009. An Overview of Modelling Climate Change Impacts in the Caribbean Region with contribution from the Pacific Islands, United Nations Development Programme (UNDP), Barbados, West Indies.
[54] Mimura et al., 2007. Small Islands. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.T. Palutikof, P.J. van der Linden, C.E. Hanson (Eds.), Cambridge University Press, Cambridge, UK, 687-716
[55] McWilliams, J.P., I.M. Cote, J.A. Gill, W.J. Sutherland and A.R. Watkinson, 2005. Accelerating impacts of temperature–induced coral bleaching in the Caribbean. *Ecology* 86(8) 2005: 2055-2060.
[56] Mimura et al 2007.

similar diving-based tourism economy, have shown that tourists' willingness to pay is affected by coral bleaching[57].

Hurricane impacts

While coral reefs have evolved for millennia under the influence of hurricanes, the combined threat and pace of recent climate change coupled with a host of newly introduced anthropogenic impacts including pollution, eutrophication and over-fishing may prove too rapid an onslaught for corals to adapt. Research into the role of hurricanes in the long-term decline of Caribbean coral reefs has found a 17% loss in coral cover the year after an event. More frequent or stronger hurricanes would reduce the ability of reefs to recover after each successive event, with knock on implications for fisheries, dive tourism, beach assets and shoreline protection.

Ocean acidification

Emerging science on ocean acidification – the lowering of ocean water pH (acidity) levels as carbon dioxide is absorbed from the atmosphere – reveals that it is yet another threat to coral reefs, other shell-forming organisms and plankton resulting from global temperature rise. Since the Industrial Revolution, the ocean has absorbed approximately a half of the human-induced CO_2 (or 525 billion tons) that would have otherwise contributed to global warming, and in so doing the pH has dropped 0.1 meaning the seawater has become more acidic by roughly 30%[58]. With increased acidity comes less dissolved carbonate available for calcium carbonate shell and skeleton formation which is important for corals, plankton and shellfish. A global average temperature increase of 2°C driven by 450 ppm CO_2 concentrations is expected to affect the rate at which reef-building corals form skeletons. In the long-term, ocean acidification will likely threaten biodiversity, tourism and coastal protection if indeed reef structures cease to grow and start to physically dissolve at atmospheric concentrations of CO_2 of 560 ppm as projected[59]. Similarly plankton - the basis of the food chain and instrumental in providing half of the oxygen we breathe – will find it more difficult to maintain their protective shells and the impact of this on global fisheries and food security is clear.

Impacts on reef fish communities

Physical and biological impacts on coral reefs from rising sea temperatures and tropical storms can have deleterious affects on reef fish communities and algae composition. For example, reduced habitat through loss of reef structure may lead to a decrease in important herbivorous fish such as parrotfish which are known to assist in sand production by breaking down coral substrate through digestion and therefore contribute to the sand budget of beaches. Additionally shifts in algal species composition from coralline algae such as *Halimeda* sp to fleshier macro algae will further reduce inputs to local sand sediment budgets.

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[57] Uyarra, MC., I.M. Cote, J.A. Gill, R.R.T. Tinch, D. Viner, and A.R. Watkinson, 2005. Island-specific preferences of tourist for environmental features: implications for tourism-dependent states. *Environmental Conservation* (32): 11-19

[58] Center for Ocean Solutions, Be Prepared: The Ocean in a +2°C World: A fact sheet on Climate Change and the Ocean.

[59] Pew Center on Global Climate Change, 2009. Key Scientific Developments Since the IPCC Fourth Assessment Report. Science Brief, June 2009.

Mangroves

Coastal mangroves in the Cayman Islands will be challenged to keep pace with and adapt to rising sea levels. Research in the 1990s on mangrove retreat on Grand Cayman suggests that the rate of mangrove peat formation may not be sufficient to cope with a sea level rise of 2 mm per year[60]. Given the present global mean rate of sea level rise is 3.1 mm per year, and sea level rise in the Caribbean is expected to be near the global mean, it is likely that many coastlines will experience erosion as coastal mangroves become compromised.

More severe storm surges also threaten to drown coastal mangrove systems, reducing their ability to function as natural buffers. Mangroves in Grand Cayman's Little Sound receded approximately 20 ft after Hurricane Ivan[61]. In many other areas, these systems have been dissected by coastal roads which now impede natural drainage after storms causing mangroves to drown. Examples include Tarpon Lake in Little Cayman in which the mangroves were drowned following flooding from Hurricane Gilbert in 1988 and also much of the South Sound mangroves after Hurricane Ivan. In both instances there are clear signs of recovery in some areas although extremely slow, a reminder of how long these systems take to recover from one event much less successive storms which may become more intense and more frequent.

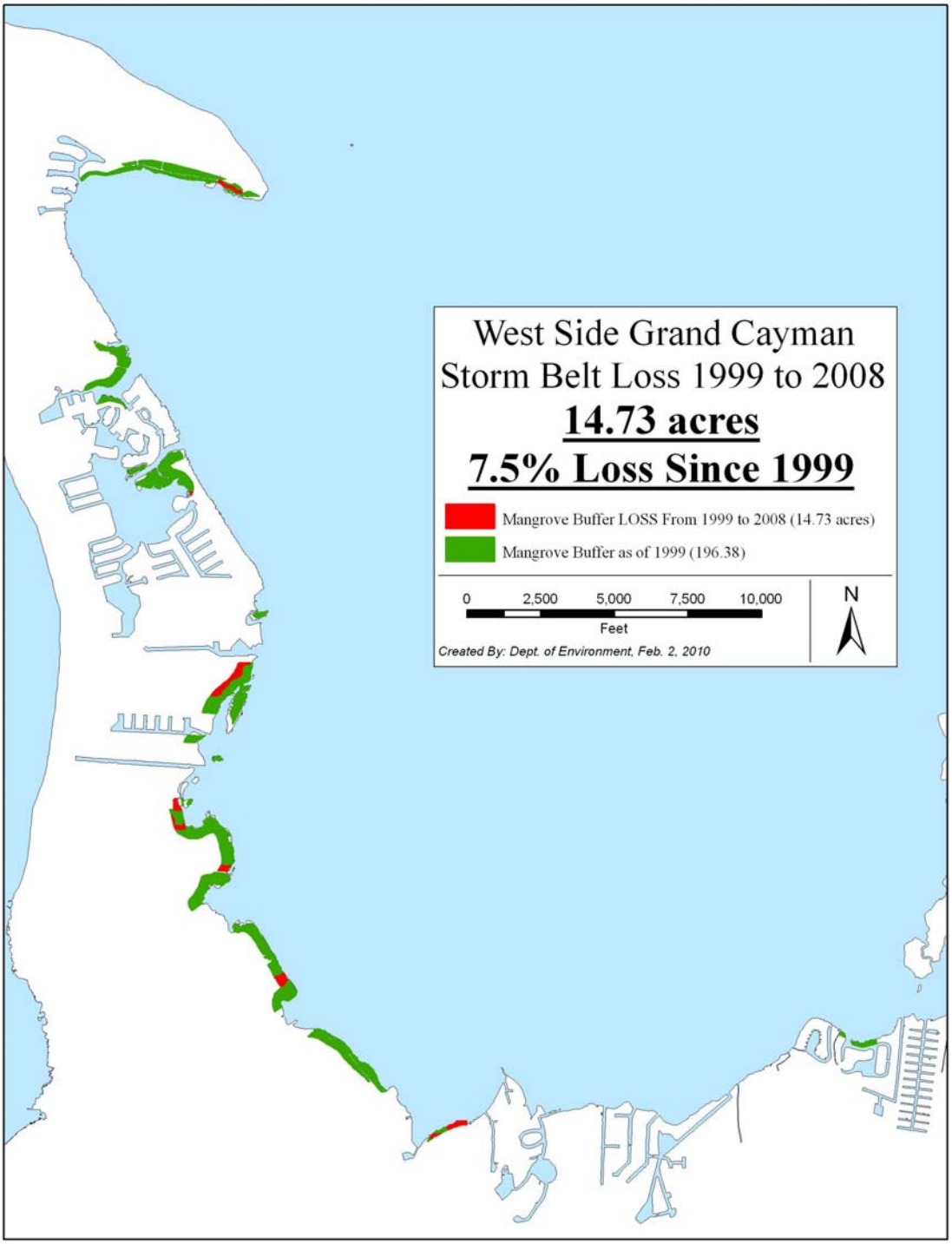
Physical impacts to mangrove communities through wind and wave induced storm damage also pose a major threat. Full recovery of mangrove communities may not be on a timescale equivalent to the more intense and frequent storms associated with climate change resulting in a net loss of coastal and inland mangrove communities. In many instances increasing development pressures on existing coastal mangroves has already severely impacted the natural resiliency of mangrove communities to withstand and recover from severe events. Map 10 shows the 7.5% loss of coastal mangroves between 1999 and 2008 alone within the Mangrove Buffer Zone – a designation in the Development and Planning Law which has been ineffective in retaining the original Storm Belt area. Several examples exist in Grand Cayman of 'Mangrove Buffers' that were too narrow to afford protection or withstand the wind and wave action during Hurricane Ivan; interestingly these areas also appeared to have fared much worse than undisturbed Buffer areas with large areas of contiguous mangroves behind them.

Photo 4. Storm-damaged red mangroves still serve shoreline stabilization function, South Sound, Grand Cayman. ***Credit: DOE***

[60] Woodroffe, 1990 in Simpson et al, 2009

[61] McCoy, M. Senior Research Officer, Department of Environment. Personal communication, 25 February 2010.

Map 10 Changes in Mangrove Buffer Zone, West Side, Grand Cayman, 1999-2008



Source: Cayman Islands Department of Environment, 2010

Seagrass beds

Coastal lagoons are typically home to ecologically important resources such as isolated patch reefs and extensive seagrass beds. Although seagrasses are

highly adapted for binding and stabilizing lose sandy substrates and dampening wave action they are not immune to the immense mechanical damage that can result from large storm events. Recovery times for seagrass meadows damaged or lost during storm activity may exceed the forecasted return period for major storms in future climate scenarios. Additionally loss of coral reefs and coastal mangroves can also result in associated impacts to closely integrated seagrass communities. Alterations to local drainage patterns and increases in rainfall can lead to higher levels of freshwater and associated nutrient-rich terrestrial run off that can have impacts on seagrass productivity, community structure and potential diseases. Additionally, increased sea temperatures can push seagrasses past their thermal tolerance threshold resulting in subsequent loss of the meadows. Rises in sea level and reductions in water clarity can have implications for seagrasses growing in deeper waters close to their minimum requirement for photosynthetically active radiation from natural sunlight.

4.3 Terrestrial Resources and Biodiversity

The Cayman Islands vegetation is characterized by dry forests, dry shrublands, seasonally flooded wetlands and extensive mangrove systems. The adaptability of these habitats to projected regional climate changes will be critical for the species they currently support.

Dry Forests

Dry forests have a relatively thin veneer of soil over karst limestone rock with the occasional deep pocket of organic material. This results in shallow root systems for some trees which topple relatively easily from high winds. While these environmental resources have evolved under the influence of historical hurricane damage, the cumulative impacts of more frequent storms of greater peak wind intensity will likely affect the adaptation responses of forests and their ability to support keystone species.

Ecological changes to dry forests may also impact key species dependent on these areas for breeding, nesting or foraging. For example the recently rediscovered white-shouldered bat (*Phyllops falcatus*) once thought to be extinct was found in the Lower Valley remnant dry forest. This indigenous bat is already extremely threatened by direct habitat loss or fragmentation and the indirect effects of residential subdivisions and roads on the forest itself. Any further changes to its dry forest habitat could cause its permanent disappearance.

Similarly, our national bird, the Cayman parrot is also subject to these stressors. Additionally, although protected, Grand Cayman Parrots (*Amazona leucocephala caymanensis*) are often shot by farmers and have their nests raided by poachers. Climate change impacts coupled with loss of breeding sites from deforestation and habitat fragmentation associated with development pressures, could lead to a rapid population decline. Hurricane Paloma, with sustained winds of 144 mph,

devastated large expanses of forest on the Bluff in Cayman Brac[62] ,including the Brac Parrot Reserve - critical breeding habitat for the Cayman Brac parrot (*A. l. hesterna*), and other rare and endemic species. In the aftermath of Paloma, the parrot population decreased by approximately 50%[63] It is feared that further deforestation and increased hurricane frequency may reduce the ability of the parrots to recover, from storm events.

Photos 5a and b Boardwalk in Brac Parrot Reserve before (July 2008) and after (November 2008) Hurricane Paloma. ***Courtesy of Kristan D. Godbeer***

The eye-wall of hurricane Paloma passed over the Eastern Bluff Shrubland, damaging roughly 90% of vegetation. The Brown booby colony on Cayman Brac and tropicbirds that favour coastal cliff habitats of these islands are also threatened by storms. More than 20 birds were lost from the Brown Booby colony as a result of Hurricane Paloma[64].

[62] Godbeer, K.D., DaCosta-Cottam, M., Bradley, P. E., Walton, R. and Sevik, T. J., 2008. Rapid Environmental Assessment (Terrestrial) of Cayman Brac Hurricane Paloma. Department of Environment, Cayman Islands Government. www.doe.ky

[63] Godbeer, K.D. and M. DaCosta-Cottam, 2009. Storm survivors. 'Flicker', The Bulletin of the Terrestrial Ecology Unit, Department of Environment, Cayman Islands Government Issue 2: 1-2. www.gov.ky.

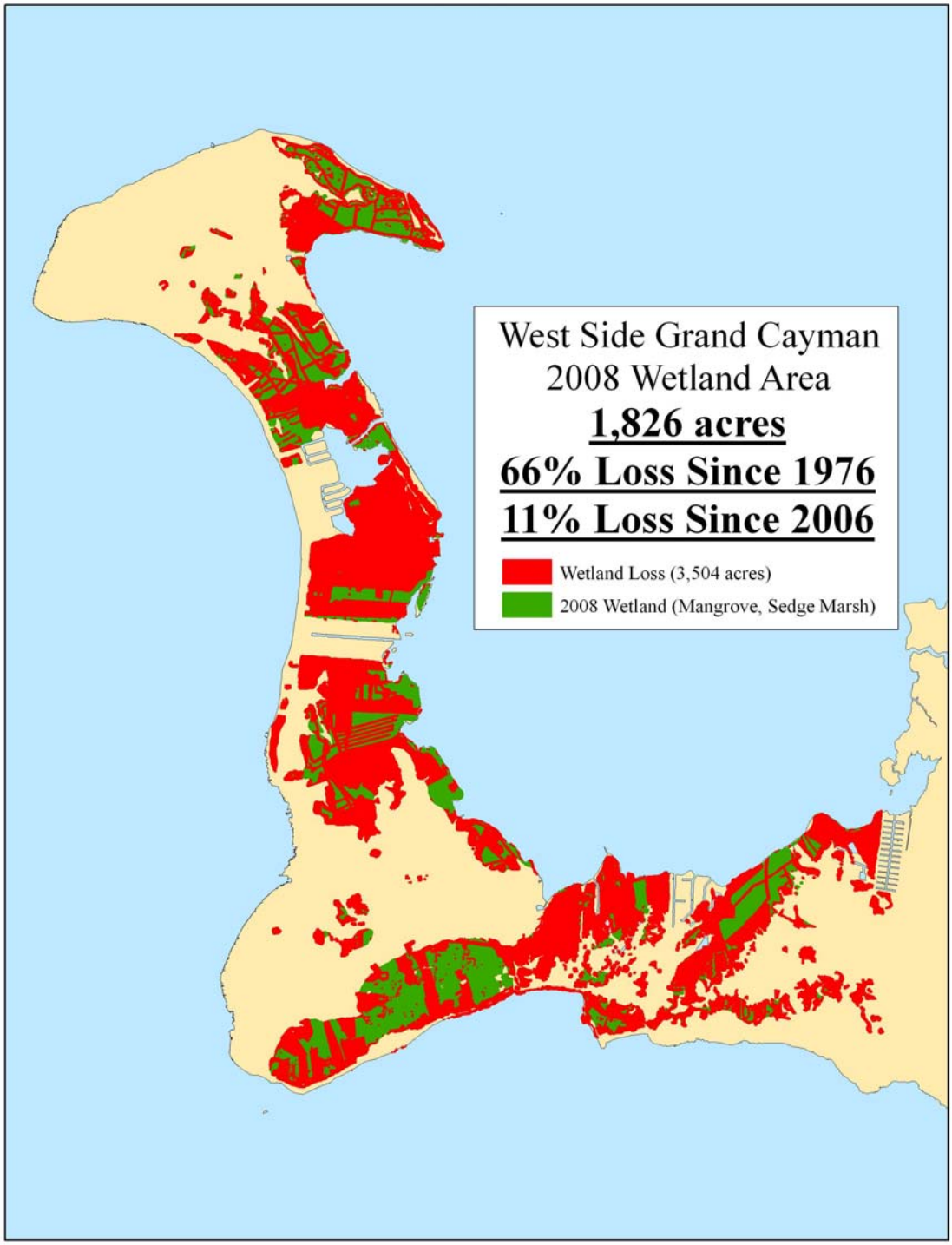
[64] Godbeer et al, 2008.

Photos 6a and b. Eastern shrubland, Cayman Brac before (February 2008) and after (November 2008) Hurricane Paloma. ***Courtesy of Kristan D. Godbeer***

Wetlands

A drier rainfall regime coupled with increased evaporation and soil and aquifer salinization could see the contraction and/or conversion of seasonally flooded fresh and brackish water wetlands. In Grand Cayman, development in low-lying areas has already significantly reduced this habitat type as well as well-established mangrove forests (Map 11). Competition for scarce resources could increase between indigenous and migratory birds for territories and foraging sites, which may be disastrous for local species already pushed to the edge of preferred habitat by development. Conversely, warmer temperate climates may alter bird migrations with many species finding similar niches farther north.

Map 11 Changes in Wetland Area on West Side, Grand Cayman, 1976-2008



Source: Cayman Islands Department of Environment, 2010

Invasive Species

The impact of invasive species of flora and fauna is already of concern in the Cayman Islands and Caribbean basin. Active border security and quarantine

measures are critical at the national and regional level to detect and prevent the spread of new invasives. To this end the Department of Agriculture is part of a regional network of government agencies focused on the threat of invasive species. Climate change may make it easier for invasive species to gain a foothold through habitat disturbance and the availability of food and water. Further species-specific research may be required to determine the socio-economic and ecological implications for protected areas and culturally important species such as the wild banana orchid (*Myrmecophila thomsoniana*), silver thatch palm (*Coccothrinax proctorii*), the Cayman Parrot (*Amazona leucocephala caymanensis* and *Amazona leucocephala hesterna*) and Grand Cayman Blue iguana (*Cyclura nubila lewisi*). In general it is essential to continue work on identifying and cataloging all native flora present in the islands.

Ensuring the resiliency of these ecosystems and species to withstand unavoidable climate shocks underscores the importance of reducing human stressors wherever possible and the need "to ensure that we take the necessary steps to set aside areas that will serve as reservoirs of the diversity of species and habitats on our islands"[65].

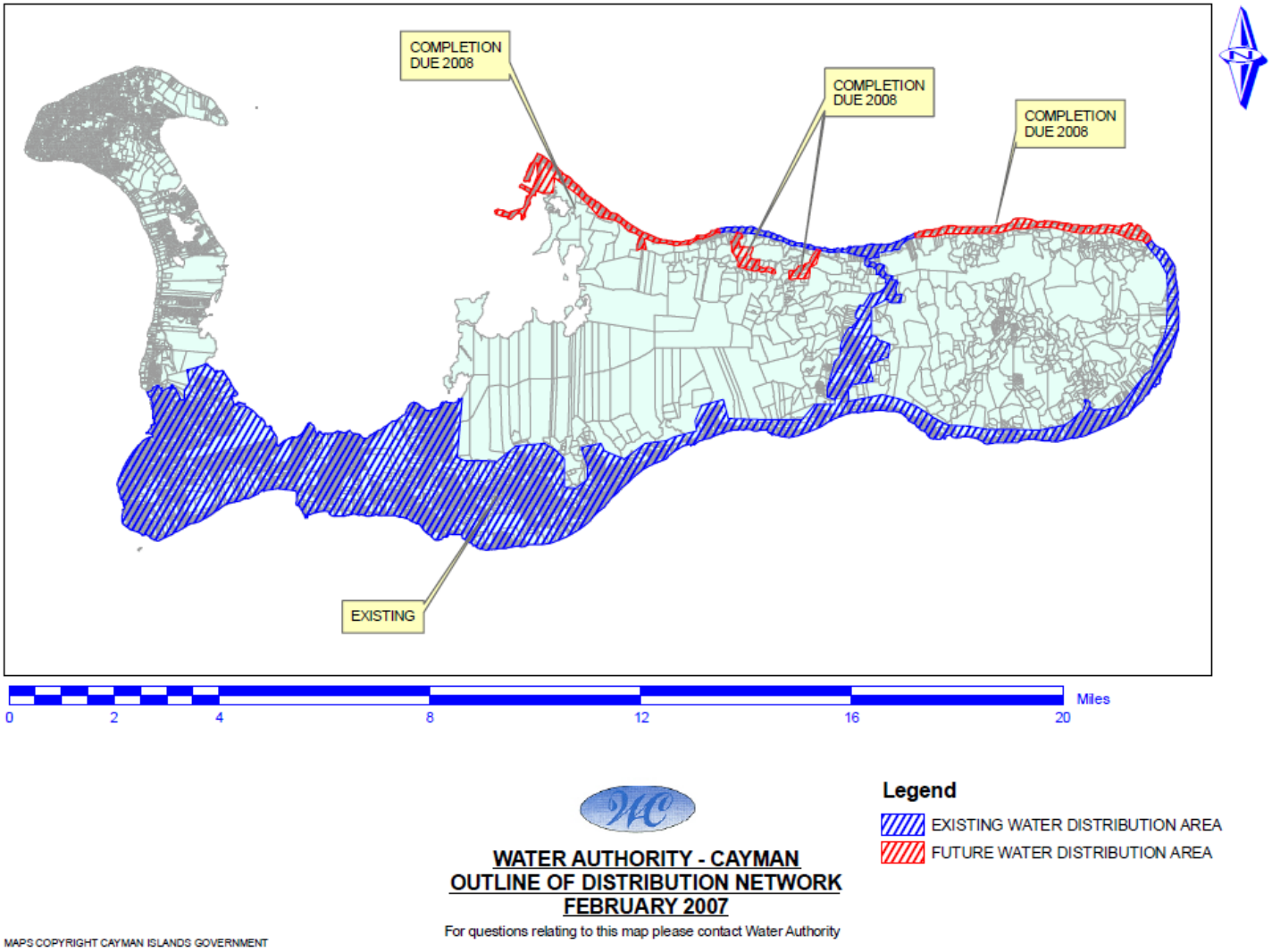
4.4 Water Resources

Water availability

Over the next century, a 25-30% drier Caribbean overall coupled with rising temperatures and increased evaporation rates could have implications for local water availability and water quality. Safe and reliable supplies of potable water for human consumption are vital for a healthy population as well as the tourism industry upon which the Islands depend. Large investments in public infrastructure have been made in Grand Cayman to meet the majority of potable water needs. Consolidated Water Company provides desalinated water to the Seven Mile Beach and West Bay areas, while the rest of the island is serviced by the Water Authority-Cayman (see Map 12), which also supplied a limited service to the tourism enclave at the West End of Cayman Brac (see Map 13). Some of the more recent or larger tourism facilities operate their own desalination plants on all three islands.

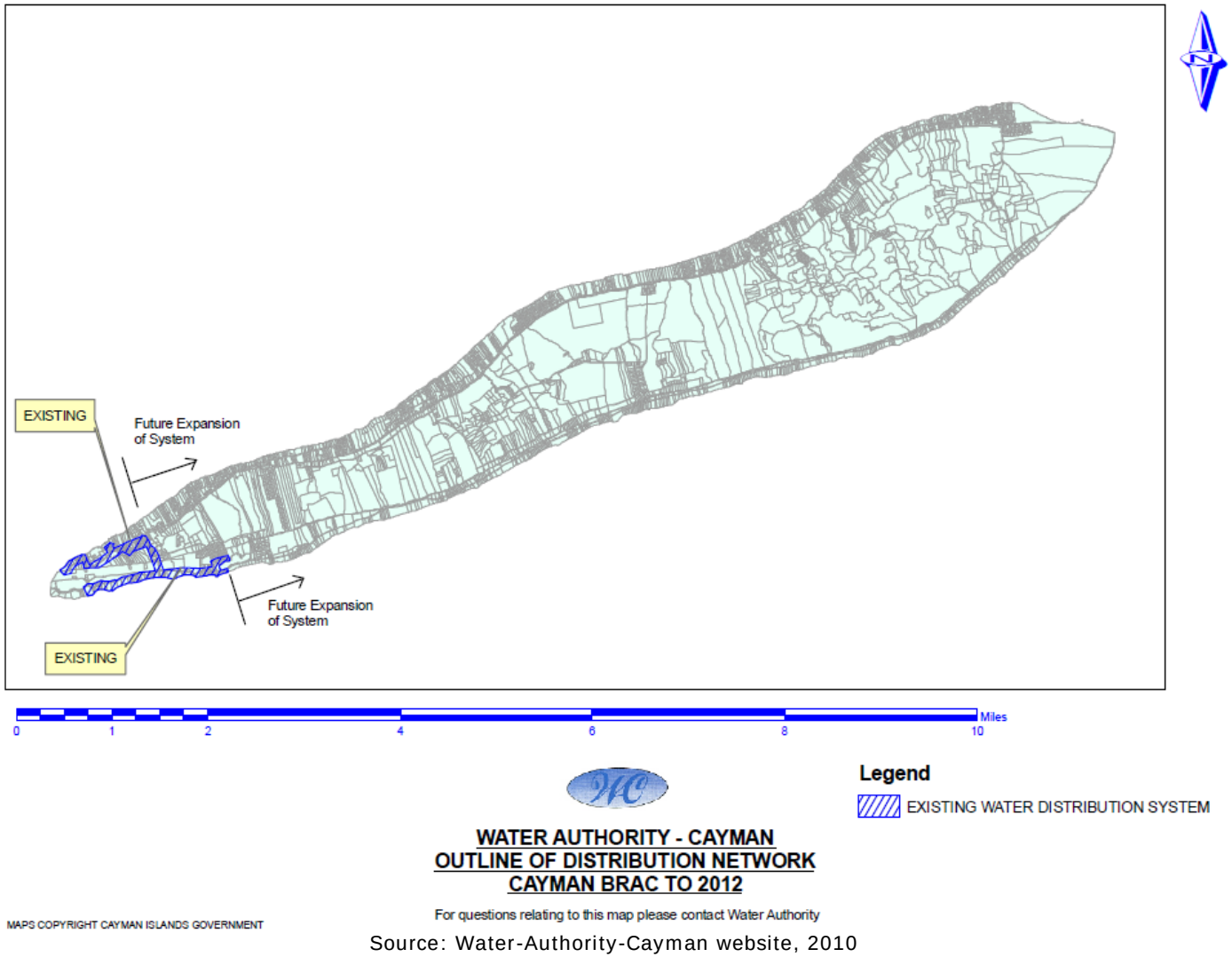
[65] UKOTCF, 2009. Remarks from The Hon. Mark Scotland, Minister of Health, Environment, Youth, Sports and Culture, for the Opening Reception of the UK Overseas Territories Conservation Forum conference "*Making the Right Connections: A conference on conservation in the UK OTs, Crown Dependences and other small island communities.*" Grand Cayman, 30th May to 5th June 2009

Map 12 Grand Cayman Water Distribution Network, February 2007



Source: Water-Authority-Cayman website, 2010

Map 13 Cayman Brac Water Distribution Network to 2012



Source: Water-Authority-Cayman website, 2010

The current climate risk to water availability appears manageable on Grand Cayman given the existing public desalination infrastructure in place. Climate change, coupled with continued population and economic growth that fuel the demand for services, has the potential to place increasing pressure on existing freshwater resources as well as intensify the need for desalination – an energy-intensive and hence costly process. This issue could become more critical for Cayman Brac and Little Cayman where the current reliance on rainwater catchment and abstraction from wells may be insufficient in future to support residential and commercial needs.

Less reliable rainfall for agricultural purposes is also a concern, particularly with drier wet seasons expected. Regional projections are for increased droughts which have historically been infrequent for the Cayman Islands (1958, 1960) until recently (2003, 2004, 2005) and have all occurred in the regular dry season– November through April. Some regional models predict a wetter dry season for the northern Caribbean which may offset these effects.

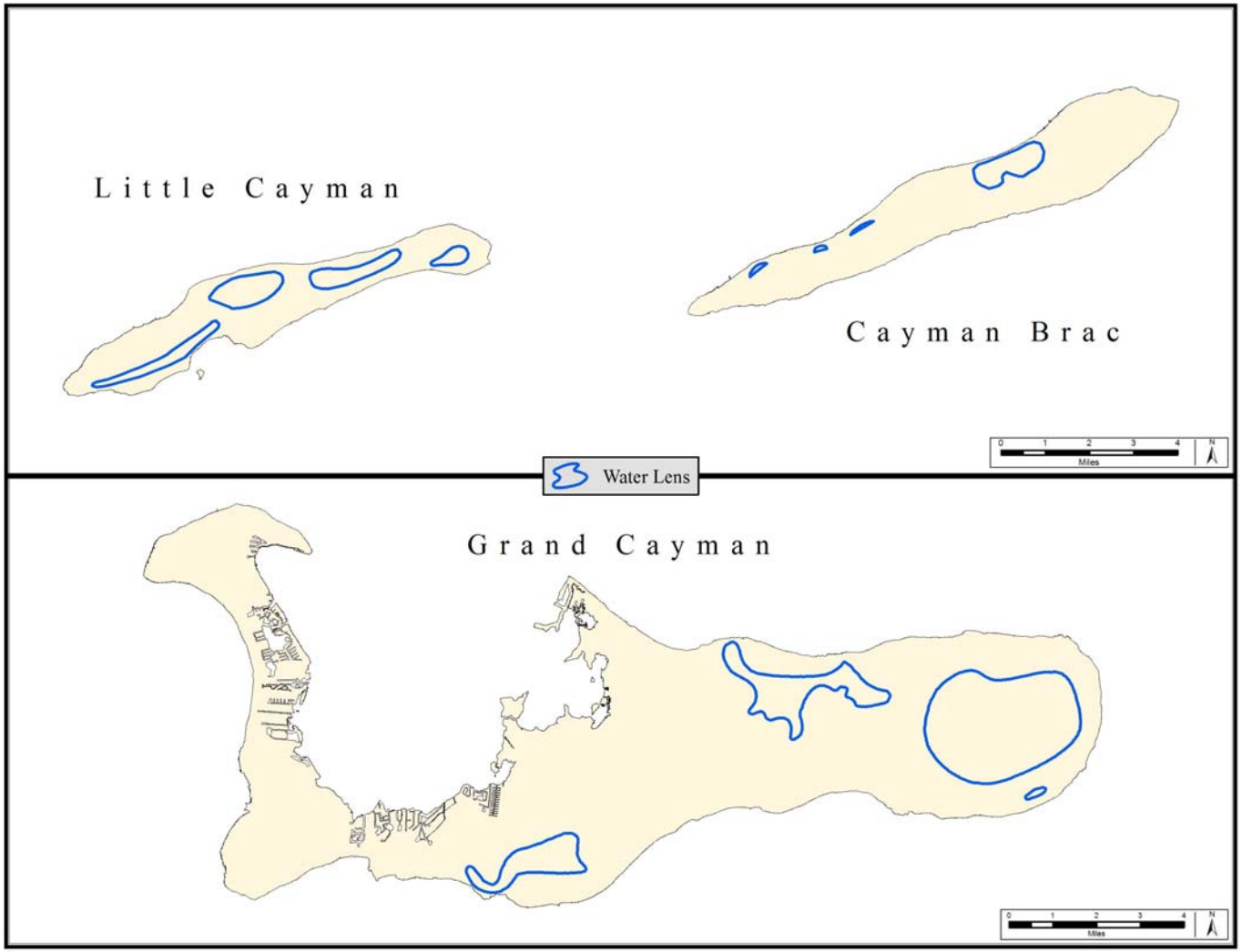
Freshwater resources

Freshwater aquifers have been identified in all three islands (Map 14). In Grand Cayman the two thinnest of the five lenses, in West Bay and South Sound, were unusable for public water supply by 1975 due to overuse and sewage contamination[66]. The remaining viable lenses are threatened by sewage contamination, reduction of recharge area, sea level rise and saltwater intrusion; these risks have implications for long term utility of these resources for human consumption, agriculture and biodiversity, especially surface ecosystems. Changing rainfall patterns strongly influenced by ENSO and North Atlantic Oscillation cycles[67] will affect water resources throughout the year and inter-annually. These phenomena can bring about longer dry periods that may increase the risk of drought and have implications for the timing and recharge rates of aquifers. ENSO years in particular will be drier with less hurricane activity, augmenting the natural mid-summer drought or diminished rainfall conditions (July-August). Water Authority-Cayman regulation of abstraction, discharge and land use activities over these lenses, including excavations and wastewater treatment, will remain critical for maintaining viable fresh water sources in the future.

[66] Water Authority-Cayman website www.waterauthority.ky

[67] Chen, A.A. and Taylor, M.A., 2008. Enabling Activities for the Preparation of Jamaica's Second National Communication to the UNFCCC: Climate Scenarios for Vulnerability and Adaptation. In Association with the Climate Studies Group Mona, University of the West Indies, Mona, August 31, 2008.

Map 14 Freshwater Lenses in the Cayman Islands



Source: Lands & Survey Department, Map produced by Department of Environment

4.5 Food Security and Agriculture

Reliance on food importation

Climate changes at other latitudes are expected to affect regional and global food production which has significant implications for small islands, especially those within the Caribbean region. In the Cayman Islands, the majority of food is imported from the United States therefore climate change impacts on US agricultural production will affect availability and price of these goods with costs indirectly borne by residents and visitors alike. It is also expected that as climate change continues to impact the Canadian grain belt, food prices world wide will increase given the widespread use of grain in a plethora of food items[68]. This problem will be further compounded by the increasing use of grains in non food uses such as bio-fuel production.

In the light of these changes, food security, defined as the access of all members of society to adequate quantities of wholesome nutritious food, is an issue of utmost importance. In the Cayman Islands like most SIDS, food security encompasses both domestic production of food and security of imported food supplies as well as ensuring access to quality nutritious foods that will help protect the health of the resident population and combat the growing problem of diet related health problems. With a local population growing at roughly 4% per annum on average and a tourism policy that emphasizes quantity of arrivals over quality, the issue is a very serious concern.

The cost of air freighting food into the islands may become an increasing factor when weather and sea conditions hamper unloading of container ships, or when ports, roadways and supermarkets are damaged by severe hurricanes resulting in long periods of downtime for rebuilding.

Impacts on local food production

Climate change also has implications for the small local agricultural sector as increased incidence of drought and flooding, unpredictable rainfall patterns, and intensifying storms exacerbate local crop damage. Throughout the Islands limited water and arable lands have kept agricultural activities to primarily small scale family operations. Cayman's rocky soils make mechanization virtually impossible and labour is expensive. Farming systems in the Cayman Islands run the gamut from traditional crop and livestock production, to intensive production systems in each sector and mixed crop and livestock farming operations. Most cropping systems focus on multiple crops planted through out the year in accordance with the seasons and market forces. Traditional crops such as bananas, plantain, yam, cassava, sweet potato, avocadoes, mangoes, breadfruit, citrus and other fruits are grown. In addition the cultivation of vegetable and herbs both in field and in shade houses continues to increase in response to niche market opportunities. Cattle is pastured in the dry season on low lands with poor, salty, but edible, grass and moved to higher land during the rainy season where the grass is better and not flooded. Other livestock activities include small ruminants (goats) and pigs.

[68] DOE, 2009. Minutes of Health Stakeholder Consultation, 22 January 2009.

Rainfall patterns

Projected climate impacts of drought and less rainfall during future El Niño years could significantly affect small scale operations with limited capital inputs for irrigation and other technologies to combat these conditions. Typically up to half of the total annual rainfall is in October-November. With 5 to 6 months of practically no rainfall for the remainder of the year, farmers are reliant on wells for irrigation, the extraction of which is regulated by the Water Authority. Already saline conditions could worsen from salt water intrusion of aquifers brought about by the slow onset of sea level rise as well as more immediate soil salinization from reduced rainfall resulting in inadequate fresh water recharging of aquifers and increased evaporation rates due to a warming climate. The CIG currently subsidizes gypsum to ameliorate salt effects in areas affected by sea water intrusion. Salt water intrusion from Hurricane Ivan storm surge resulted in flooding of the duck pond pastures which have taken several rainy seasons to become reconditioned and available for grazing again[69]. Government subsidies in animal feed is currently around CI$485,000 and this cost could rise with increased loss of pastures if frequency or magnitude of such events increase.

Storm damage

More intense storms and hurricanes are likely to devastate crop farmers, some of whom suffered great losses of banana, plantain and other fruit trees from the passage of Hurricane Charley in August 2004 which brought minimal winds of 75 mph. Ivan, a severe category 4 hurricane, destroyed 90-95% of crops, in particular, bananas, plantains, mangoes, avocadoes and other fruit trees were decimated across the Islands. Short term crops like peppers, callaloo and other vegetables were destroyed and the livestock sector severely affected both due to animal losses and damage to infrastructure[70]. When combined with fisheries, total damage and losses for this sector was CI$5.6 million. Hurricane impacts highlight the need for crop insurance for farmers, as well as the necessity to adopt risk mitigation production systems, such as routine pruning of fruit trees. Further, research into more drought tolerant varieties and cultivars is required. These adaptations could mean a shift from traditional crops and farming techniques, capacity for which would have to be built, to ensure the long term sustainability of the sector.

Challenges: Market niches and development pressures

While climate change has made local residents more aware of food costs and locally grown fresh produce which creates market opportunities for farmers, significant challenges remain for increasing food security in the Cayman Islands. Currently the biggest challenge for the agricultural sector is marketing, hence the focus on niches, such as mangoes and bananas in which the islands could be relatively self-sufficient were it not for devastating hurricanes[71] and opportunities for fresh vegetables and herbs for the resident and tourist populations. On Grand Cayman land zoned Agricultural/Residential is increasingly being used for housing schemes and aggregate mining. A situation that is further aggravated by the knock-on effect of new residences that then object to the farming activities surrounding them. Efforts to preserve Class I-III lands suitable for agricultural

[69] DOE, 2009. Minutes of Agriculture Stakeholder Consultation, 22 January 2009.
[70] ECLAC/UNDP, 2005. The Impact of Hurricane Ivan on the Cayman Islands. LC/CAR/L.25, 10 January 2005.
[71] DOE, 2009. Minutes of Agriculture Stakeholder Consultation, 22 January 2009.

purposes have been mediocre. A more critical situation exists on the Bluff in Cayman Brac where the majority of agricultural activities occur as no Development Plan is in place. These and other challenges will not be met without Government policy in a number of areas.

4.6 Fisheries

No large scale commercial fisheries exist in the Cayman Islands given the narrow shelf area and limited exploitable stocks. However, small scale commercial fishing and artisanal activities are important for livelihoods and the diet of many Caymanians and residents, especially in the Sister Islands. Even this extent of activity has had some impact on local fisheries. For example, Nassau grouper has cultural and economic importance in these islands. As in the rest of the Caribbean, aggregations around all three islands have suffered tremendously in January to February of each year due to fishing pressure to the point where a temporary ban on fishing in grouper spawning areas had to be implemented to safeguard the future of the local fishery. Other culturally and recreationally important species under specific management include queen conch, spiny lobster and whelks. To temper the pace of decline in these resources from over-exploitation due to a growing population, necessary amendments have been made in recent years to reduce conch catch limits and extend lobster closed season. The Marine Conservation Law enacted in 1978 and establishment of the Marine Parks in 1986 have been the main instruments conserving these fisheries to date. However, climate change impacts on fisheries are complex and interact with non-climate related stresses[72], creating significant management challenges locally. Curtailing man-made stressors such as over-fishing and pollution on currently threatened or endangered species will enhance their resilience in the face of future climate variability and climate change risks especially those beyond our control (e.g. rising global sea temperatures and stronger hurricanes). More stringent measures to manage man-made activities may be unpopular if what is at stake is not fully appreciated.

Impact of warming seas

There is growing recognition of changing climatic conditions and what that means for the fisheries sector. Local fishermen report that with warmer ocean temperatures the fish go deeper making them harder to catch[73]. This increasing level of effort for reduced yields is echoed in other parts of the Caribbean. While no fisheries migration data exists for the western Caribbean[74], warmer SSTs are likely to force a shift in aggregations outside of normal ranges and into cooler waters. When combined with the impacts of sea level rise, SST increases are very likely to result in significant loss of live coral cover which represents a

[72] Sear, C., M. Hulme, N. Adger and K. Brown, 2001. *The Impacts of Global Climate Change on the UK Overseas Territories: Technical Report and Stakeholder Survey.* Natural Resources Institute, University of Greenwich Kent and Tyndall Centre for Climate Change Research, University of East Anglia, Norwich.
[73] Cayman Islands Red Cross, 2007. "The Global Climate is Changing Cayman – Are you Prepared?" Video produced by Dr. Pablo Suarez with funding from the European Commission for Humanitarian Aid Office.
[74] Nurse, L. Senior Lecturer, Centre for Resource Management and Environmental Studies, UWI, Barbados. Personal communication, 23 February 2010.

serious threat to near-shore fisheries in these small islands. These impacts further affect the ability of threatened species to sustain themselves, especially with continued harvesting pressure, habitat loss and decline in recruitment potential among the vulnerabilities.

Economic importance of fisheries

Fisheries resources could be viewed as being more important to dive tourism which accounted for 34% of tourism's total revenue contribution in 1993[75] than to consumption. The economic implications of climate change for the Cayman Islands is of grave concern considering Caribbean fish diversity on a whole is not comparable to the Pacific region which may place the tourism product at a disadvantage. Noticeable decline in fish abundance and diversity, especially when coupled with bleached corals, may negatively affect visitor perception of the product, particularly among avid or repeat divers in search of pristine reefs, as in the case of Bonaire[76].

Enhancing management capacity

As regional investigations of changes in migration patterns and depth of fisheries continue, local focus on any changes in distribution and availability of key species important to sports fishing and recreational diving is needed to understand the far-reaching costs of climate change to these sub-sectors. An assessment of the marine parks system is required in order to ascertain whether the management structures in place are sufficient to ensure the viability of culturally and commercially important fisheries and the reef resources, seagrass beds and mangrove ecosystem on which they depend at various life stages. Emerging research suggests that fish communities are also negatively affected by the post-impact response of mangrove systems therefore there is a need to take steps to optimise the resilience of these systems, including the immediate cessation of harmful development practices and amendment to laws that have allowed these practices for years.

4.7 Human Health

Weather extremes can have both short and long term effects on human health, ranging from drowning, injuries, heat-stress, increased disease transmission, and even an increase in common mental disorders as coping capacities of some individuals are exceeded. These far-reaching impacts can therefore underestimate the true health burden of current climate risks[77]. The increased

[75] Madigan Pratt & Associates, 1995. Diving in The Cayman Islands: Economic Impact & Requirements for Maintaining Its Premier Status. Report to The Cayman Islands Department of Tourism, Cayman islands Watersports Operators Association, and Cayman Islands Hotel & Condominium Association, January 1995.
[76] Uyarra, M.C., I.M. Cote, J.A. Gill, R.R.T. Tinch, D. Viner and A.R. Watkinson, 2005. Island-specific preferences of tourists for environmental features: implications of climate change for tourism-dependent states. *Environmental Conservation*. Volume 32 Issue 1, 11-19
[77] Mimura et al., 2007. Small Islands. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.T. Palutikof, P.J. van der Linden, C.E. Hanson (Eds.), Cambridge University Press, Cambridge, UK, 687-716

frequency and severity of extreme weather events will result in more frequent need to respond to humanitarian emergencies, particularly those affecting high-risk areas such as the coastal zone or vulnerable sectors of the population. Regionally, a rise in heat extremes could result in an increased number of deaths among those with existing health conditions (e.g. heart disease and asthma), the very young, the elderly, the ailing and disadvantaged communities with inadequate infrastructure.

Incidence of Communicable Diseases – Dengue Fever & Malaria

Changing weather patterns, as well as increased tourism and migration, have raised the prevalence of mosquito borne diseases such as dengue fever in the Caribbean by 11% between 2006 and 2007[78]. While dengue is the primary threat to the Cayman Islands, imported cases of malaria (particularly from Honduras) are also of concern. Typically 2 to 3 imported cases of dengue fever and malaria have been reported annually as the Cayman Islands is not endemic for these diseases (Table 12)[79].

Table 12 Selected Public Health Diseases, 2004-2009

Disease	2004	2005	2006	2007	2008	2009
Ciguatera	7	16	16	22	21	26
Dengue	1	2	1	9*	2	2
GE < 5 yrs	447	237	448	367	343	335
GE >=5 yrs	952	628	1,092	848	897	776
Influenza	310	290	3,208	4,328	4,195	7217**
Malaria	3	2	1	1	1	1

GE – Gastroenteritis Influenza - includes all Upper Respiratory Track Infections
* Indicates all cases were imported as there was an outbreak of Dengue in the region
** Indicates that there was a world wide Influenza Epidemic due to the H1N1 strain

Source: Public Health Department, Health Services Authority, 2010

However, warmer temperatures expected in future will hasten the larval stage of mosquitoes and reduce the incubation period for the parasite that causes dengue. The projected 2°C increase in temperature by 2050 could result in a three-fold increase in the rate of transmission of dengue fever in the Caribbean[80]. Studies in Jamaica show extended ranges of dengue vectors in terms of increased mosquito breeding and biting resulting from warmer temperatures that shorten incubation periods and create the potential for higher transmission rates[81]. Increased incidence of dengue fever during the warm years of ENSO cycles and the year after an El Niño year (El Niño+1) will have implications for vector control programmes especially in the wet season.

[78] Marino, J., 2007. "Dengue fever epidemic hits Caribbean and Latin America," Reuters, October 5, 2007.
[79] McLaughlin-Munroe, T., Public Health Surveillance Officer/Deputy National Epidemiologist, Cayman Islands Heath Services Authority. Personal Communication, 23 April, 2010.
[80] Brown et al, 2008
[81] Heslop-Thomas, C., W. Bailey, D. Amarakoon, A. Chen, S. Rawlins, D. Chadee, R. Crosbourne, A. Owimo and K. Polsom, 2006. Vulnerability to dengue fever in Jamaica. AIACC Working Paper No. 27, May 2006.

Locally, the Mosquito Research and Control Unit (MRCU) has also seen a change in vectors and distribution of the local yellow fever (*Aedes aegypti*) mosquito which lives in the same vectors as the imported Asian Tiger (*Aedes albopictus*) or dengue mosquito, especially since Ivan which saw a fourteen-fold increase in the former and a ten-fold decrease in the latter. These "domestic mosquitoes" favour areas of human habitation and poor environmental conditions such as garbage and debris piles left in the wake of a natural disaster or within enclaves of substandard housing such as central George Town (Scranton, Rock Hole, Washington Boulevard, Dog City) and parts of West Bay (Birch Tree Hill, Boatswains Bay)[82]. The breeding sites for the malarial vector, *Anopheles albimanus*, are permanent and semi-permanent vegetated fresh water bodies, do not show up in light traps and therefore are difficult to monitor. Changing temperature and rainfall patterns could similarly magnify the breeding potential for *Anopheles albimanus*. It then comes down to economics and resources to affect decent control[83].

The reliance on migrant workers from within the region and general travel of people from dengue or malaria affected countries (Mexico, Honduras, Nicaragua, Dominican Republic, Cuba) would increase the threat of importing either the vector and/or disease into the Cayman Islands. In turn the cost of increasing vigilance and on additional control for those vectors would inevitably rise. Should the situation also arise where locally transmitted diseases are seen on a regular basis, it may also be the case that faster (local) lab testing and confirmations are required. This may have inherent costs in setting up and manning specific lab testing equipment to obtain quick information and a rapid response. This of course depends on the severity of the threat.

Adaptive responses across a full range of management measures in terms of early warning systems, surveillance, enforcement, public health services and public education are critical to reducing future threat of these diseases. Currently MRCU's budget supports port disinsection services, larvicide programmes, aerial spraying, physical controls and spot treatment for known or suspected dengue vectors in Grand Cayman with much reduced programmes in the Sister Islands. The work effort of this Unit in respect of disease versus the traditional nuisance issues has steadily increased but not in budget terms. An increase in disease vectors from climate change and climate variability will require greater allocation of resources to this Unit. A good portion of MRCU's budget has traditionally been used to control nuisance biting (swamp) mosquitoes which except for West Nile Virus are not disease vector mosquitoes, but from time to time infringe on the quality of life of citizens. Warming, tidal changes and precipitation might amplify emerging populations of these nuisance mosquitoes which in turn escalate control costs. For both the disease vectors and the nuisance biting mosquitoes it is also the case that an escalation of dengue/malarial cases and/or an increase in nuisance biting mosquitoes will definitely have an adverse effect on tourism (i.e. tourists will either leave or might not choose this as a destination with

[82] Hurlston, L-A., 2007. Minutes of interview with Dr. William Petrie, Director of Mosquito Research and Control Unit, Cayman Islands National Assessment of Living Conditions, Institutional Analysis, 15 May 2007.
[83] Allen, F., Research Manager, Cayman Islands Mosquito Research and Control Unit. Personal Communication, 27 November, 2009.

information at hand) if adequate resources for surveillance and control are not provided[84].

Other Communicable Diseases

Changing rainfall patterns of shorter but stronger intensity (e.g. 1-in-50 year events) produce flooding with large areas of stagnant water and contaminated freshwater resources – conditions ideal for the spread of water-borne diseases like schistosomiasis, cryptosporidium etc. These events are experienced in Guyana almost annually and have been linked to insurgence of new diseases such as cholera and dysentery in some of the poorer communities lacking proper waste disposal and stormwater run-off, as well as increases in leptospirosis. These cases are not currently common in the Cayman Islands. On a weekly basis an average of 10 to 20 cases of Gastroenteritis (GE), defined by diarrhea and vomiting, is reported. While small outbreaks have occurred they are mostly due to Rota Virus in children 5 years and younger, Norwalk virus in both children and adults, of food borne bacteria like Salmonella, Shigelloses and Ecoli; however, the vast majority is diagnosed as viral in nature. Incidents of Gastroenteritis due to flooding are negligible as most residents in the Cayman Islands have access to clean and safe drinking water[85].

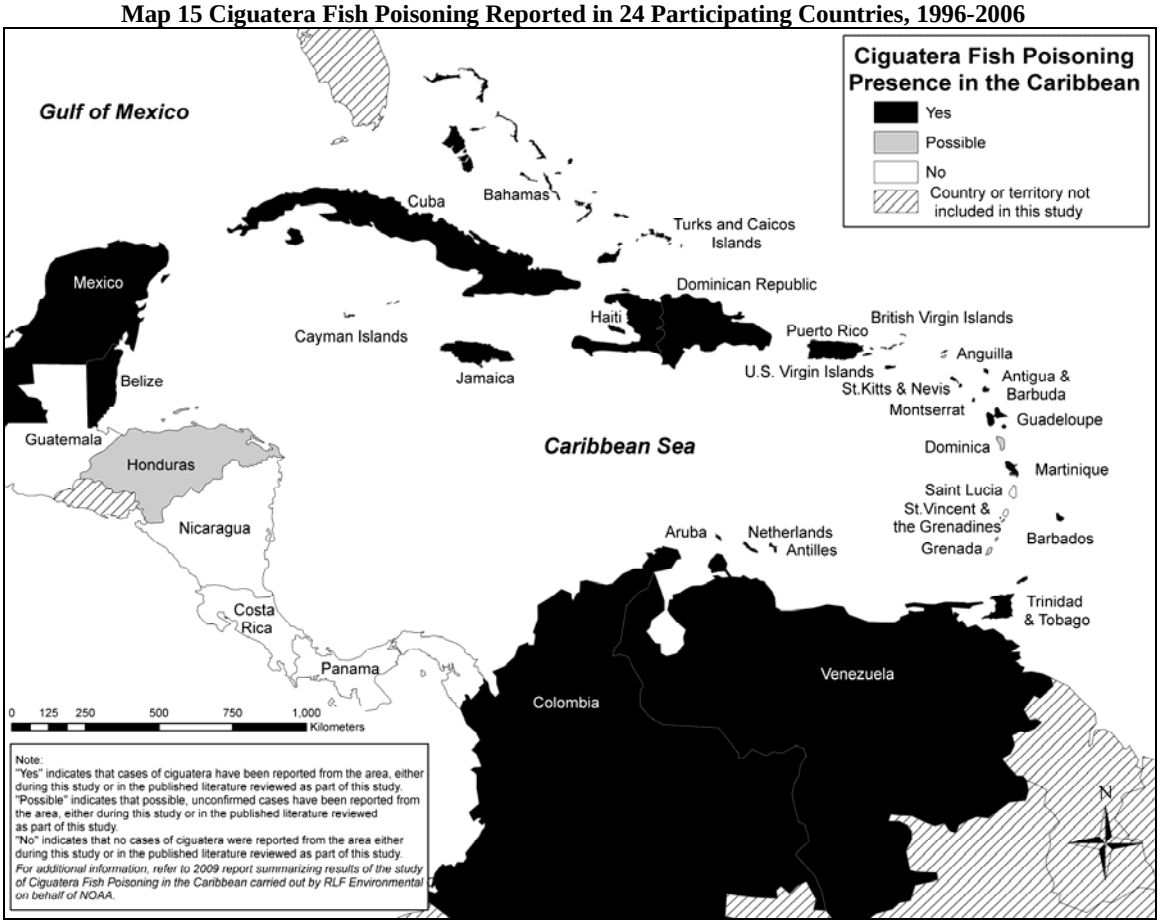
Heavy rains and severe hurricanes bring the potential for increased mosquitoes breeding sites. Many broken septic tanks after Hurricane Ivan caused an increase in breeding sites for *Culex quintefasciatus*, known as the Southern House mosquito in Florida. While not a disease vector, it is however the known vector of filarial worms, which is not common in the Caribbean and has a vaccine[86].

Fish poisoning

Increases in ciguatera poisoning from fish in the northeastern Caribbean from warming seas has been observed. Map 15 shows the distribution of ciguatera fish poisoning between 1996 and 2006 across the Caribbean region and includes the Cayman Islands amongst those countries that have reported such incidents. As sea temperatures around the Cayman Islands can reach some of the hottest in the Caribbean basin, traditional consumption of some fish species susceptible to ciguatera could be threatened by the continued rise in water temperatures. While long-term data do not exist, there appears to be an upward trend in ciguatera occurrences recorded in the Cayman Islands since 2004 which is thought to be seasonal and occur in some years more than others (Table 12).

[84] Allen, F., Research Manager, Cayman Islands Mosquito Research and Control Unit. Personal Communication, 27 November, 2009.
[85] McLaughlin-Munroe, T., Public Health Surveillance Officer/Deputy National Epidemiologist, Cayman Islands Health Services Authority. Personal Communication, 23 April , 2010.
[86] Hurlston, L-A., 2007. Minutes of interview with Dr. William Petrie, Director of Mosquito Research and Control Unit, Cayman Islands National Assessment of Living Conditions, Institutional Analysis, 15 May 2007.

Map 15 Ciguatera Fish Poisoning Reported in 24 Participating Countries, 1996-2006



Non-Communicable diseases

The Cayman Islands is seeing an increasing trend in chronic non-communicable diseases, mainly from life style issues, such as high blood pressure, hypertension, heart disease and diabetes in adults. With 22% of school children overweight and the prevalence of Type II diabetes amongst children increasing[87], treatment costs are escalating as their coverage is typically free unless covered under their parents' health-care plan. While health insurance coverage extends to 80% of the Cayman Islands' population, the cost of chronic illnesses treated through overseas referrals is incurring huge costs for government (with tertiary health care at overseas institutions costing CI$10 million and CI$750,000 in loans for Overseas Medical Advances for the uninsured in the 2009/2010 Budget)[88]. Lifestyle diseases are primarily linked to poor nutritional habits, and these problems could be further compounded if rising food prices increase the consumption of cheap nutritionally poor, processed foods over healthy fresh food choices; reinforcing the importance of access to quality food whether produced locally or imported.

[87] CaymanNetNews.com, 2009. "Obesity Looms – Officials," Cayman Net News, January 6 2009.
[88] Cayman Islands Government, 2009. 2009 / 10 Budget. Annual Plan and Estimates For the Year Ending 30 June 2010.

These vulnerable segments of the population may have reduced capacity to respond to stress in times of severe weather, and in emergency situations. Additionally, an unhealthy population puts higher than normal demands on the health care delivery system[89]. The Cayman Islands are fortunate that communicable diseases have been kept in check as this would have implications for the allocation of resources. However, this may be a future consideration as warming temperatures and water-borne diseases could further impact the future health of the population, particularly certain at-risk cohorts, with a currently unknown associated cost[90].

Nutrition

Adequate nutrition as it relates to food security has been linked to a critical climate change issue, especially for the Caribbean. A further 1ºC warming of SSTs will affect migration of fisheries out of range of artisanal fishers which in turn impacts on the protein intake traditionally derived from seafood[91]. While the Cayman Islands is a major importer of food, some groups reliant on subsistence fishing activities could be vulnerable.

Heat stress

The effects of increased incidences of heat stress worldwide have received much attention since the 2003 heat wave in Europe claimed some 52,000 lives directly and indirectly. While the local population will generally be more resilient, with perhaps the exception of the elderly, children, and those with pre-existing health conditions, however tourists are likely to be at greater risk. Currently the Public Health Department does not keep records for heat strokes or heat stress for either residents or visitors so the present vulnerability is not known. Those exposed to heat as a result of occupation, e.g. construction workers, road crews, farmers, fishers, dive industry personnel and charter boat operators, may also be at risk.

Asthma and Respiratory Illnesses

Air-quality respiratory illnesses and allergies due to the effect of rising temperature on surface level ozone have been reported in a Cuban study by INSMET, the results of which have been translated into the country's national policy for the health sector (e.g. an early warning system based on best practices). In the Cayman Islands admissions and outpatient visits with the diagnosis are reported; however it is not known what percentage of patients get sick due to change in climate, as it is usually not a protocol for documentation by the physician, hence not always documented. Findings in local records suggest that the onset of symptoms may be due to anxiety, allergies to animal coat/feathers, plants, food, living conditions/environment, post-exercise-sports related, etc. However during some months of the year (May, July, October,

[89] Clarke, J., G. de Romilly and U.O. Trotz, 2009. Enhancing Capacity for Adaptation to Climate change in the Caribbean UK Overseas Territories: Inception Mission Report, February 24, 2009.
[90] DOE, 2009. Comments by Leonard Dilbert. In: Minutes of Ministry of Health Stakeholder Consultation, 22 January 2009.
[91] Trotz, U.O, 2008. "Climate Change Adaptation and Mitigation in the Tourism Sector: Climate Change in the Caribbean." 1st International Capacity Building Seminar on Climate Change Adaptation and Mitigation in the Tourism Sector, Balliol College, University of Oxford, 8 April 2008.

November - not all rainy season) a significant increase in admissions with diagnosis of respiratory diseases including asthma is noted; but this increase cannot necessarily be attributed to climatic change (humidity) (Table 13). In an analysis of admissions by age group for the year 2009, patients less than 15 years old made up 65.5% (263 cases) of total admissions (400 cases). The majority in this age group were to young children. Overall (all ages), there were 72 asthma cases (18%) of all cases (400); Females and males cases were 33 and 39 respectively. The remainder (82%) of cases refers to other diseases of the respiratory system[92].

Table 13 Frequency of Admissions by Month – Respiratory Disease, 2009

Frequency of admissions (by month) to patients with a diagnosis of Respiratory Disease - C.I. Hospital & Faith Hospital (CY 2009)

Count of PA.ALIAS		MONTH												
Inp/Oup	**P_SEX_DISP**	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Grand Total
	Female Total	**17**	**22**	**18**	**8**	**22**	**16**	**15**	**10**	**7**	**23**	**24**	**12**	**194**
	Male Total	**18**	**11**	**15**	**11**	**16**	**12**	**23**	**12**	**23**	**22**	**24**	**19**	**206**
Inp Total		**35**	**33**	**33**	**19**	**38**	**28**	**38**	**22**	**30**	**45**	**48**	**31**	**400**
Grand Total		35	33	33	19	38	28	38	22	30	45	48	31	400

A grand total of 400 admissions for respiratory difficulties; 164 females with 194 (48.5%) admissions and 171 males with 206 (51.5%) admissions.

A total of 335 clients with an average of 1.2 admissions per client. It is noted that there were approximately 1 dozen (12) clients with multiple admissions from 2 to 4 and 1 client with 7 admissions.

Source: Public Health Department, Health Services Authority, 2010

Health care facilities

As in other sectors, climate-proofing health care facilities from a structural standpoint will be needed. The Bodden Town Clinic has been identified in a preliminary vulnerability assessment as being "highly vulnerable" given its location only 150 yards from the seashore[93]. The main hazard is from storm surge that inundates this area, such as was witnessed during hurricane Ivan which took this critical facility out of commission for two months afterward. While the Clinic now has an adequate contingency plan to move to Bodden Town Primary School under threat of hurricane, personnel recognize that not all equipment can be relocated. The resiliency of the physical health care infrastructure needs to be accompanied by a similar risk management approach on the primary health care system itself. The Ministry of Health and Human Services aimed to finalize a programme by mid-2009 to get health care in districts improved with an emphasis on preventative health care, including

[92] Kelly, C., Statistics Division, Cayman Islands Health Services Authority. Personal communication, 23 April, 2010.

[93] Natural Disasters Assessment Consulting Group, 2009. Preliminary Vulnerability Assessment of Grand Cayman, Cayman Islands. Presented to the Government of the Cayman Islands, June 2009.

wellness[94]. Applying tools such as the WHO study on Methods for Assessing Human Health Vulnerability and Public Health Adaptation could provide invaluable information. Canada used this methodology which informed the decision to decentralize health care facilities[95]. A similar VCA for the Cayman Islands health sector would be useful in communicating climate change issues to Cabinet and the wider populace as it provides credible information that is current and relevant to the local context.

4.8 Settlements

Settlements and urban centres situated along the coast and in low-lying areas inland are currently impacted by damaging winds and coastal flooding from tropical storms and hurricanes, and heavy or prolonged rainfall events which cause isolated but often extensive inland flooding. These effects are likely to worsen under future climate scenarios where exposure to major hurricanes (category 3 and above) carrying stronger peak winds and heavier rainfall may become the norm. The present extreme high water levels under storm surges, storm tides and waves would be attained more frequently due to projected sea level rise, causing significant increases in the areas threatened with inundation[96].

Sea-level rise

The immediate concern most residents have in relation to climate change and these extremely low-lying islands is the impact of sea level rise on personal property, communities and businesses. Land movement of the islands appears to be stable in geologic terms therefore relative sea levels around the Cayman Islands are close to sea surface levels[97]. As noted earlier, an increase in sea level between 0.12 m (0.4 ft) and 0.80 m (2.6 ft), or roughly 0.14 to 0.91 cm per year, by 2100 is estimated for the Cayman Islands. Map 16 shows a SLR of 0.25 m (0.8ft), which exceeds the low range anticipated, affects less than 0.5% of all buildings constructed or permitted in 2010 on Grand Cayman. By the high range of SLR expected, only 5% of all buildings on the island would be impacted in some way. However, an additional rise of 0.25 m represented by the 1 m (3.3 ft) SLR scenario shows a sizable increase to 14.3% of total buildings affected when compared to the previous scenario[98].

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[94] DOE, 2009. Comments by Leonard Dilbert. In: Minutes of Ministry of Health Stakeholder Consultation, 22 January 2009.

[95] DOE, 2009. Comments by George de Romilly. In: Minutes of Ministry of Health Stakeholder Consultation, 22 January 2009.

[96] Nurse, L.A. and G. Sem, 2001. Small Islands. In: *Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, UK.

[97] Simpson, M.C., N.B., Robson and D. Smith, 2009. Sea Level Rise and its Impact on the Cayman Islands. Produced by The Cayman Institute for the Government of the Cayman Islands and the British Foreign and Commonwealth Office, May 2009.

[98] Hurlston-McKenzie, 2010. Vulnerability and Capacity Assessment of Climate Change and Sea-Level Rise on the Cayman Islands' Tourism Sector: A Report by the Department of Environment to the National Climate Change Committee, ECACC Technical Report, November 2010.

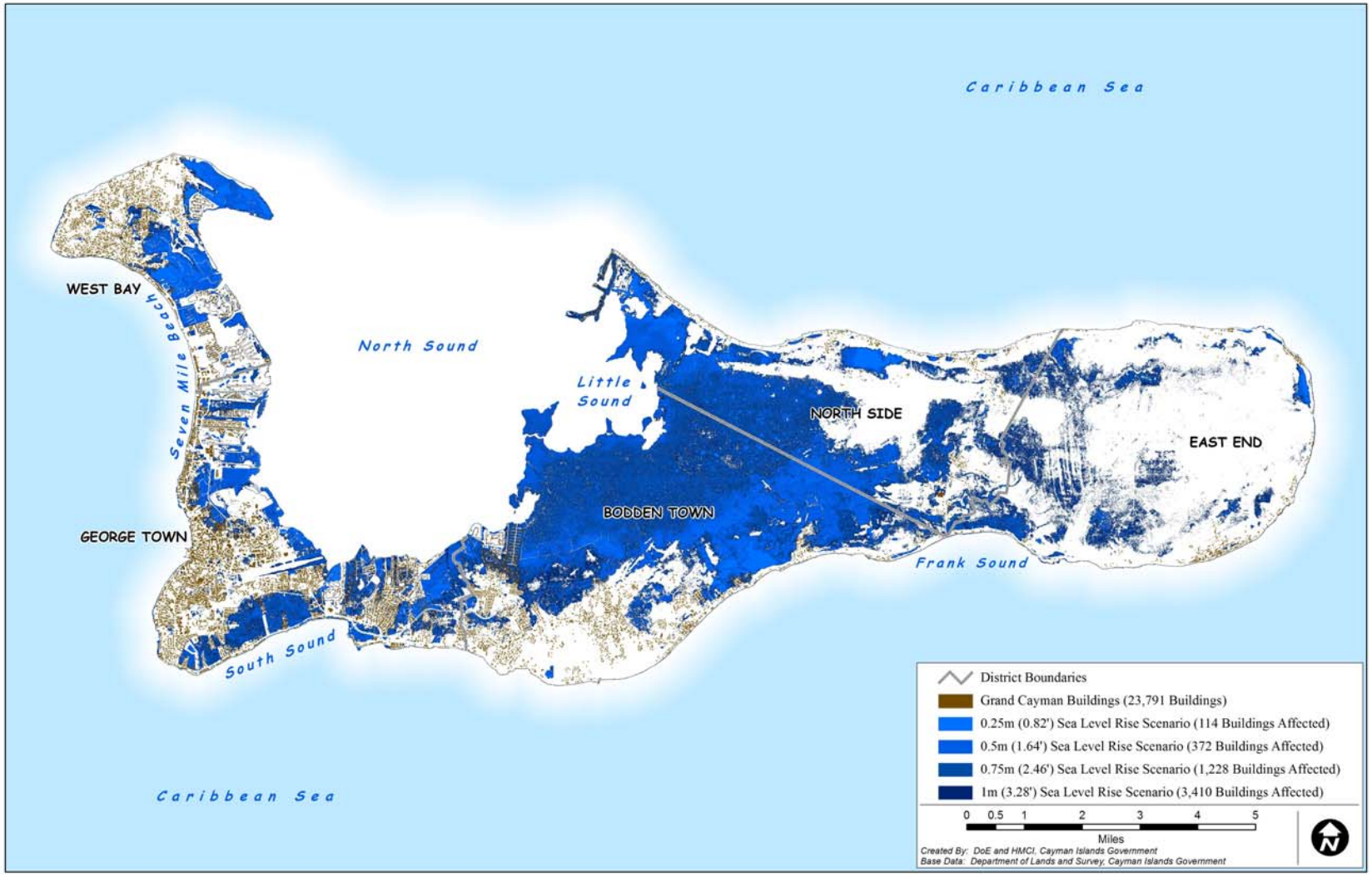
In 2008, the Lands & Survey Department estimated total building values in Grand Cayman between CI$5.4 and $7.4 billion. The estimated damage or loss buildings affected in 2008 by a 0.25 m (0.8ft) SLR range from over $21.6 to $32 million (Map 17). An analysis by building class indicates at least one apartment/condo valued between CI$19.4 and $29 million would be damaged or lost, in addition to three residential properties with a combined value of CI$646,340 to $888,050. As would be expected, a SLR of 0.75 m (2.5 ft) shows a significant increase in the number of buildings affected, representing a ten-fold raise in the total value of damages or loss. Not surprisingly, the majority of these buildings are in the residential and apartment sectors, representing damages between CI$77 and $108 million and CI$33 and $54 million, respectively. Three times the amount of damage to the residential building stock is expected as a result of an additional 0.25 m rise in sea level represented by the 1 m (3.3 ft) SLR scenario and a six-fold increase in the number of educational and religious structures affected.

However should sea levels around the Cayman Islands more closely coincide with the global mean projected, the islands would experience between 2 m (6.6 ft) to 3 m (9.8 ft) rise by the end of the century. Map 18 produced by the Cayman Islands Lands & Survey Department is a representation of a 2 m (6.6 ft) sea level rise overlaid on the Cayman Islands' land mass. In this scenario 47% of the building stock at the time the exercise was conducted is affected – the majority of the West Bay peninsula, George Town, Bodden Town and Cayman Kai on Grand Cayman and the coastal and low-lying areas of Cayman Brac and Little Cayman (save for the eastern ends and a few isolated sections of coastline). Map 19 shows that under a 3 m (9.8 ft) SLR scenario 71% of the existing building stock would be under threat. It is clear that in many cases current coastal setbacks are not sufficient and relocation of entire settlements would be an incredible feat.

These depictions do not account for the additional building stock likely to be in place by 2100 which should be more prudently sited using these types of assessments and refined SLR projections for the region as planning aids. These maps also do not capture the additional effect of storm surge on top of the average sea level rise which increases exponentially, thus the resultant inundation under various storm conditions could be much more extensive than represented. With present-day sea level, use of the TAOS (The Arbitrator of Storms) model storm surge analysis to inform coastal construction setbacks is wise as the Cayman Islands has this current ability with good bathymetric data collected by the Lands & Survey Department[99].

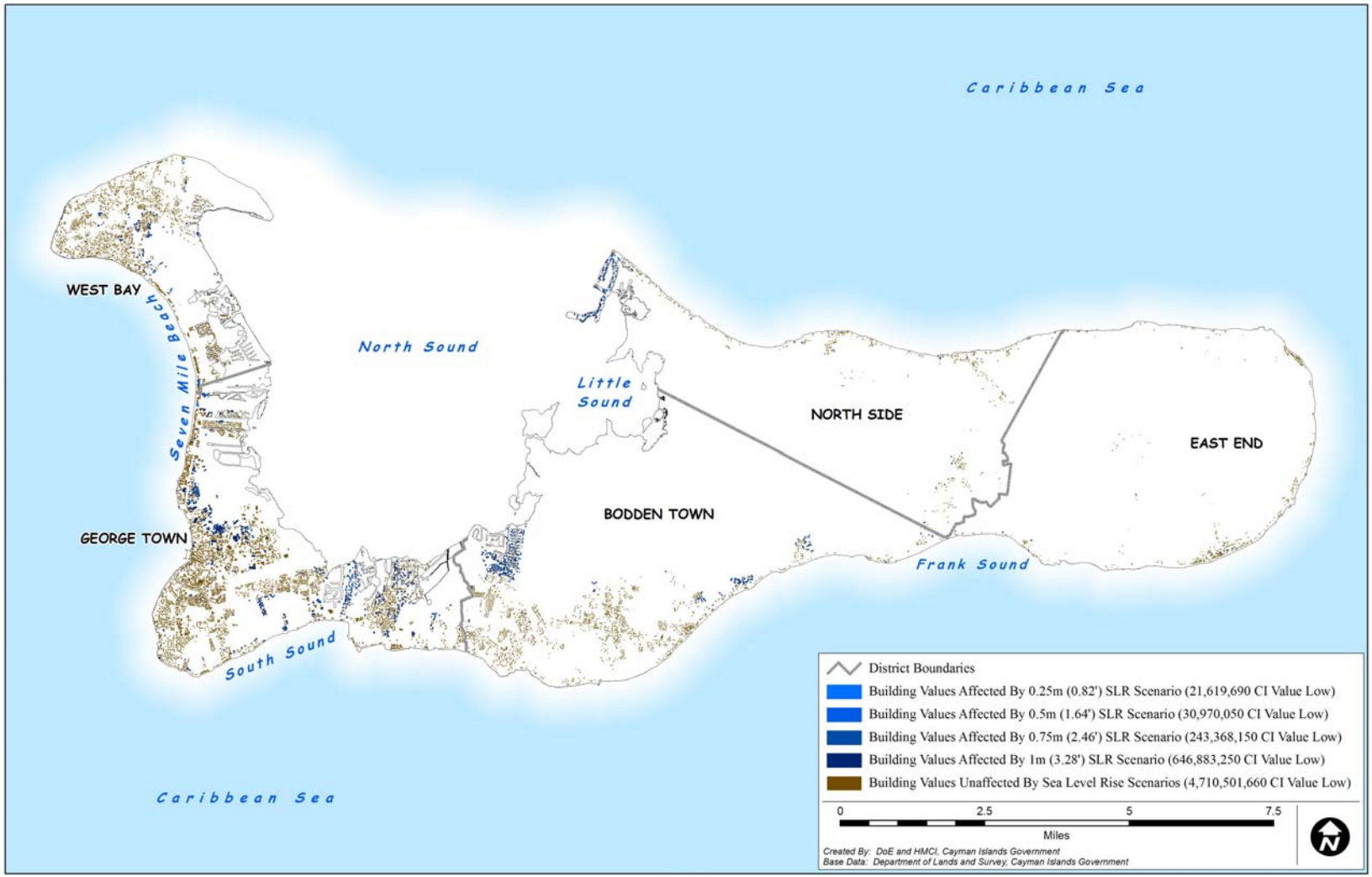
[99] Nurse, L., pers. comm.., 23 February 2010.

Map 16 Buildings Affected by 0.25m-increment Sea-Level Rises, Grand Cayman



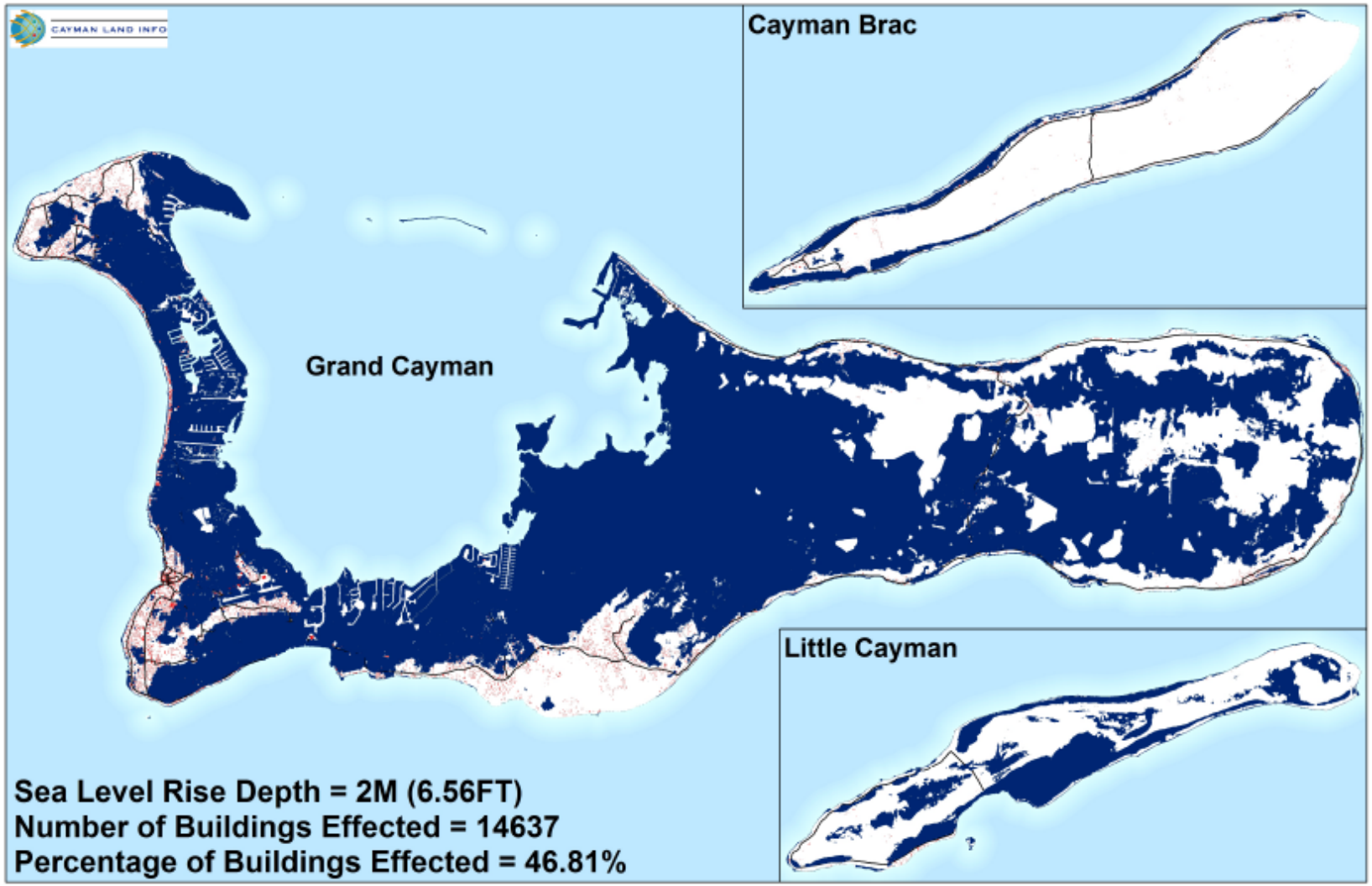
Source: Department of Environment, 2010

Map 17 Building Values Affected by 0.25m-increment Sea-Level Rises, Grand Cayman



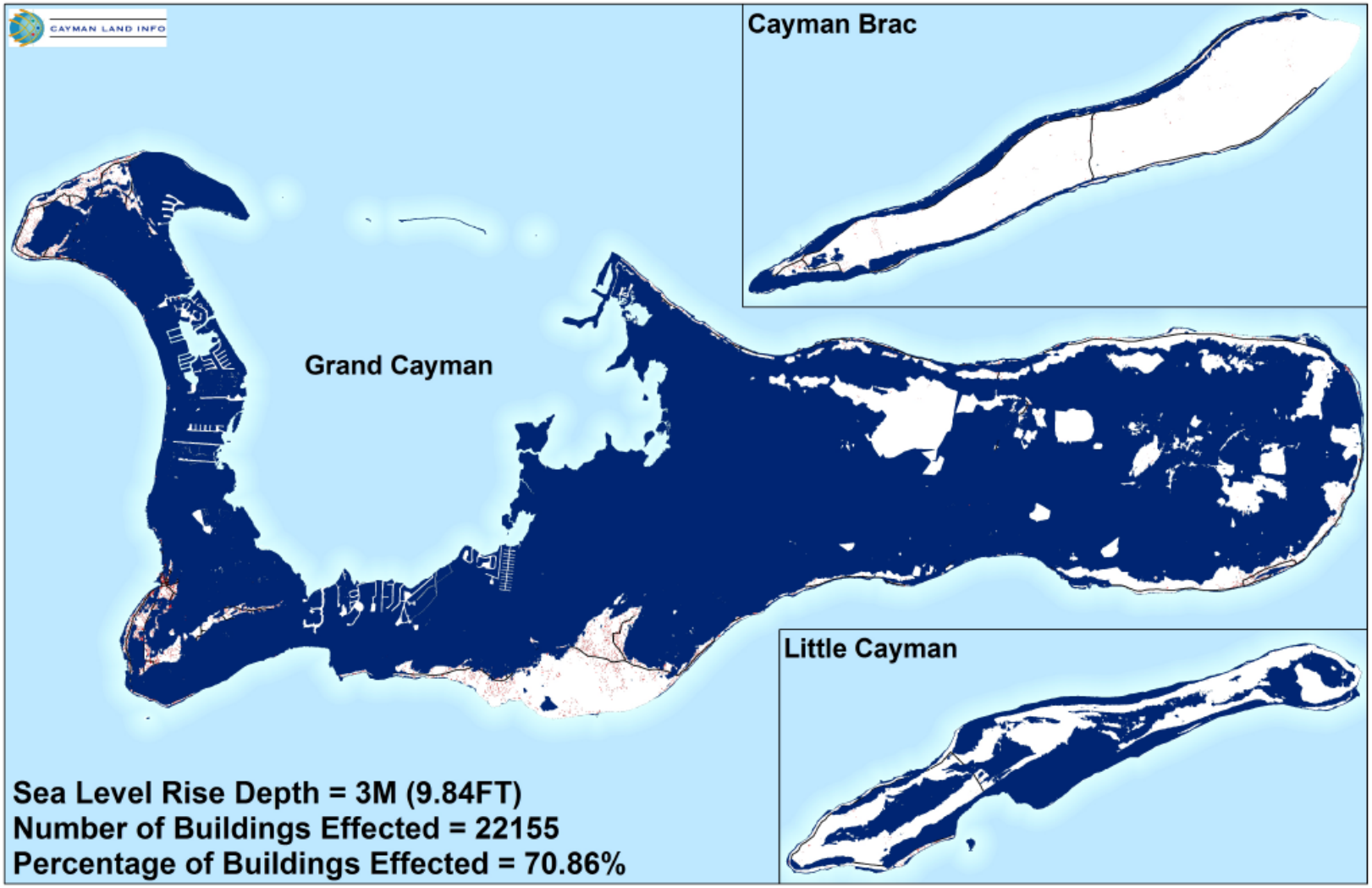
Source: Department of Environment, 2010

Map 18 Overlay of 2 metre Sea-Level Rise on the Cayman Islands



Source: Simpson Robson & Smith, 2009

Map 19 Overlay of 3 metre Sea-Level Rise on the Cayman Islands



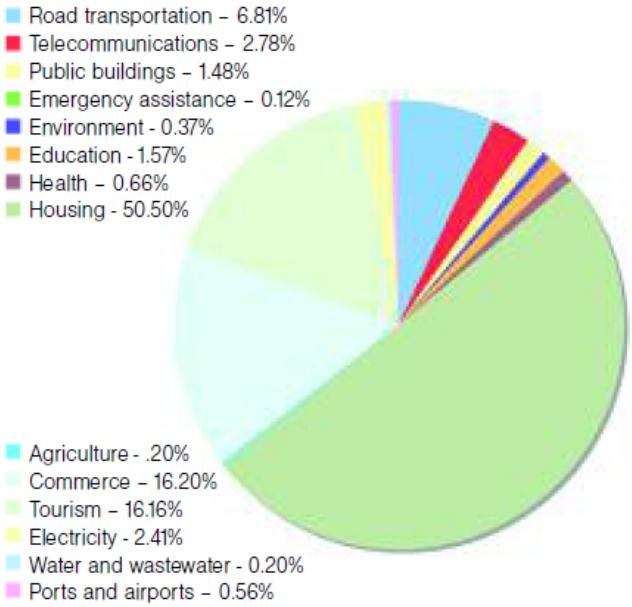
Source: Simpson Robson & Smith, 2009

Hurricane damage to building stock

Indelible in the minds of all residents is the extensive wind and flooding impacts caused by Hurricane Ivan in 2004. The housing sector was the most severely impacted, sustaining more than 50% of the total damages and losses to all physical assets (Figure 17). Ivan damaged or destroyed 83% of the total housing stock on Grand Cayman, incurring CI$1.4 billion impact to the economy. Historical analysis suggests Ivan was a 100-year storm in terms of hazards, but various factors suggest that the economic impact equivalent to Ivan may be more frequent[100].

According to Young and Gibb (2005), the severity of impact was due to Grand Cayman being under an increasingly intense outer eyewall which allowed for increasing wind speed. Sustained winds of 135 mph (a low to moderate Category 4 storm) and gusts to over 165 mph caused catastrophic structural damage to old, poorly designed, long-spanned galvanized roofs or other roof types with flawed design or construction. Homes and commercial buildings built to code weathered hurricane winds very well. However it must be borne in mind that with maximum wind speed increases of 5%, 10%, 15% (corresponding to 1, 2, and 3°C sea-surface temperature rises respectively) insured losses from hurricanes increase exponentially (Clark 1997), e.g. if maximum wind speeds were 15% higher, insured wind losses would have more than doubled.

Figure 17 Damages and Losses in the Cayman Islands from Hurricane Ivan, 2004



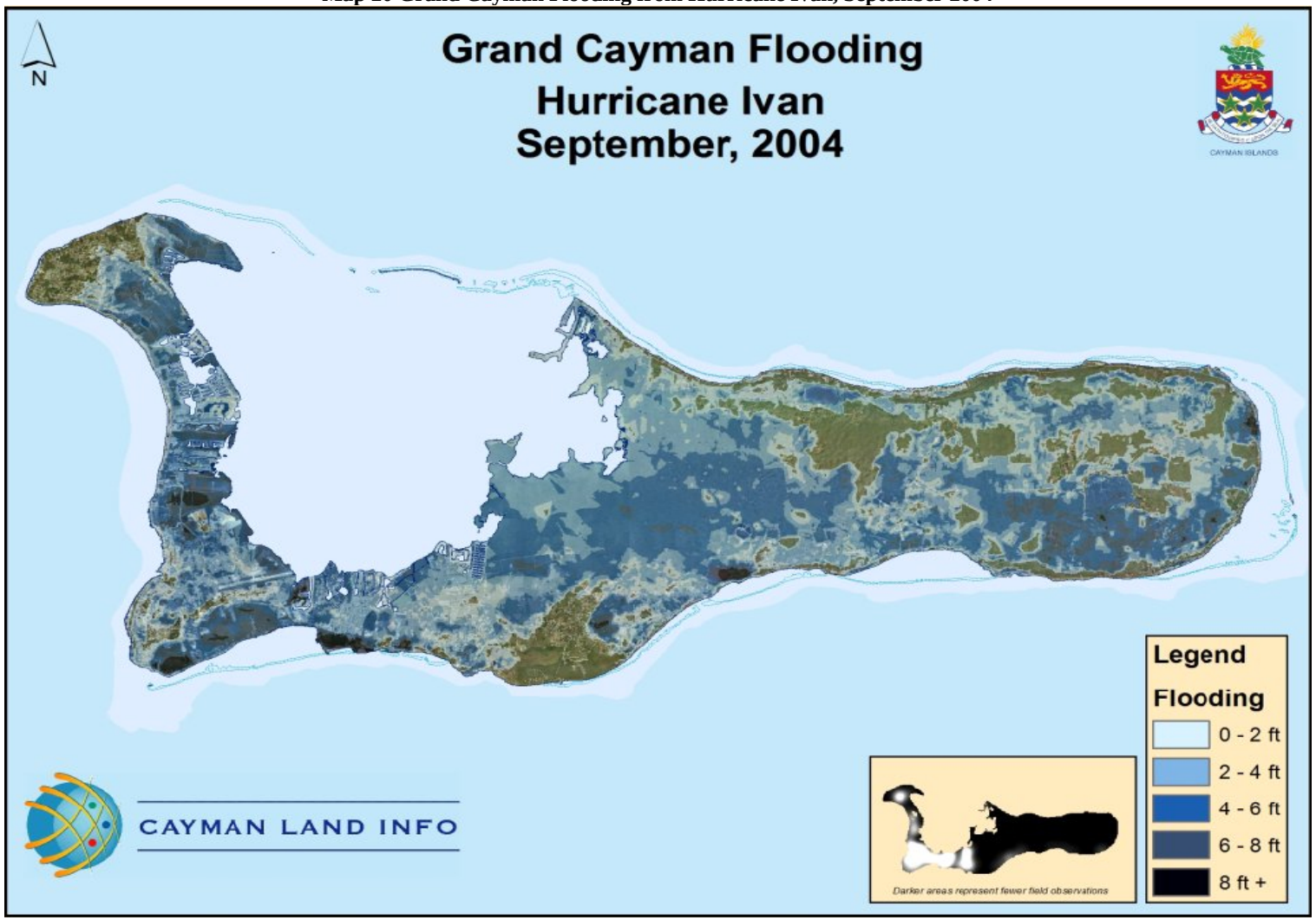
Source: Brown (2008)

[100] Young, S. and T. Gibbs, 2005. Impact of Hurricane Ivan in Grand Cayman: A technical review of the hazards and their effects. Prepared for the UK Department for International Development, 18 February 2005

The monetary loss from Ivan water damage far outstripped that for wind damage. Flood damage was not catastrophic but widespread, with over 70% of Grand Cayman flooded from a few inches to as much as 10 ft (Map 20)[101]. Inland and coastal flooding occurred across the housing sector: from sub-standard housing on Watlers Road and Washington Boulevard to luxury homes along the coasts. Ivan was an unusually slow moving hurricane (5 nm per hour) by the time it reached Grand Cayman, dumping 16.5 inches of rain at a peak rate of 1.5 inches (38 mm) per hour. Many low-lying areas could not handle the deluge. More significantly, storm surge flooding reach 9 ft above sea level. Wave damage at 20 ft above sea level where no reef protection existed was catastrophic (e.g. at Mariner's Cove and Ocean Club)[102].

[101] Simpson, Robson & Smith, 2008.
[102] Young and Gibbs, 2005.

Map 20 Grand Cayman Flooding from Hurricane Ivan, September 2004



Source: Simpson, Robson & Smith, 2009

However, it is not just the direct strikes that are of concern, but the frequency with which the Cayman Islands might experience Category 4 and 5 hurricanes developing and passing south and west of Grand Cayman. With large and powerful hurricanes from this direction even a 'wide miss' can do significant damage[103]. Many will recall Hurricane Michelle's impact on the Cayman Turtle Farm which forced the relocation and redevelopment of this facility to the other side of Northwest Point Road.

Photo 7 Flooding in Newlands from overtopping waves during Hurricane Wilma, October 2005. ***Credit: Unknown***

Inundation of the Savannah Gully area from storm surge and waves overtopping the bluff during of the passage of Hurricane Mitch some 200 miles away in 1998 and again during Wilma in 2005 some 170 miles away shows an increasing threat from coastal flooding even to high elevation settlements well inland. "Breaching" of the sea from south to north in this location also occurred during the passage of Hurricane Gilbert in 1988 and historical documents repeatedly reference similar incidences[104]. Clearly vulnerable communities can no longer be considered only those on narrow or shallow gradient sandy beaches or within canal developments.

The mere smallness of the Sister Islands makes communities even more vulnerable. The recent experience of Hurricane Paloma devastated communities on Cayman Brac, in particular damaging 90% and destroying another 7% of that island's building stock, 30% of which pre-dated 1970 construction and 48% had outer walls of wood and timber[105]. The extent of damage speaks to building code issues: small, traditional type buildings withstood Paloma winds of 140 mph better than shingle roofed concrete structures[106]. Cayman Brac has applied lessons from Ivan with 76% of new construction not sited on the beach. This not only protects the building stock but also helps with reducing pressure on disaster risk reduction and management resources as those with resilient housing on the Bluff will not need to go to shelters. The new road network on the Bluff linking shelters and other critical infrastructure supports these overall risk reduction goals. Hurricane Paloma also demonstrated the need for the Sister Islands to be in a position to operate for a certain amount of time independent of Grand

[103] DOE, 2008. Comment by John Tibbetts. In: Minutes of the 2nd Meeting of the NCCAWG, 18 January 2008.
[104] Burton, F.J. 1994. Climate and Tides of the Cayman Islands. In: *The Cayman Islands: Natural History and Biogeography*. [Brunt, M.A. and Davies, J.E. (eds.)]. Kluwer Academic Publishers, Netherlands, pp.51-60
[105] ECLAC, 2009. Cayman Islands: Macro Socio-economic Assessment of the Damage and Losses Caused by hurricane Paloma. LC/CAR/L.193, 2 April 2009.
[106] DOE, 2009. Comments by Ernie Scott. In: Minutes of Ministry of Planning Stakeholder Consultation, 22 January 2009

Cayman. In particular, they have to be prepared for when forecasts do not bear out, such as when the path of a hurricane and area of impact changes[107].

The majority of houses in the Cayman Islands are less than 30 years old and have been constructed to a high standard in terms of wind resistance. However with design standards now at 150 mph, there is likely to be increased costs associated with climate-proofed homes in the short-term. New construction technology now in use such as Insulated Concrete Forms (ICF) blocks are twice the cost of regular concrete blocks (although they provide an insulating factor as well as structural strength), increasing upfront construction cost by 10% and having a 12-year payback at present[108]. Bringing the cost of such technology to where it is affordable by most will require Customs duty concessions or increased taxes[109]. Other players can provide breaks, such as banks making mortgage rates more attractive for new construction and building retrofits, which is in their interests to secure these assets[110]. The banking sector could also be encouraged to offer Energy Mortgages as is done in other jurisdictions and Government could look at incentivizing climate-resilient building through stamp duty waivers for young/new Caymanian homeowners[111].

Photo 8 Hurricane Paloma damaged houses, Cayman Brac, November 2008. ***Credit: Stuart Turpin***

Hurricane preparedness

How socio-economic drivers of vulnerability to existing climate variation are managed in planning for hazards and reducing economic losses will be important for dealing with future climate change[112]. Research conducted prior to the 2004 hurricane season, i.e. pre-Ivan, showed that socio-demographic factors appeared to be driving preparedness for current weather hazards and could have implications for future vulnerability of communities and associated economic losses. The study concluded that income was not a relevant driver of long term preparedness behaviour. Whilst those who could afford to do so shuttered

[107] DOE, 2009. Comments by Ernie Scott. In: Minutes of Ministry of Planning Stakeholder Consultation, 22 January 2009

[108] DOE, 2009. Comments by Sam Small. In: Minutes of Real Estate and Construction Stakeholder Consultation, 23 January 2009.

[109] DOE, 2009. Comments by Kenneth Ebanks. In: Minutes of Critical Infrastructure Stakeholder Consultation, 23 January, 2009.

[110] DOE, 2009. Comments by George de Romilly. In: Minutes of Real Estate and Construction Stakeholder Consultation, 23 January 2009.

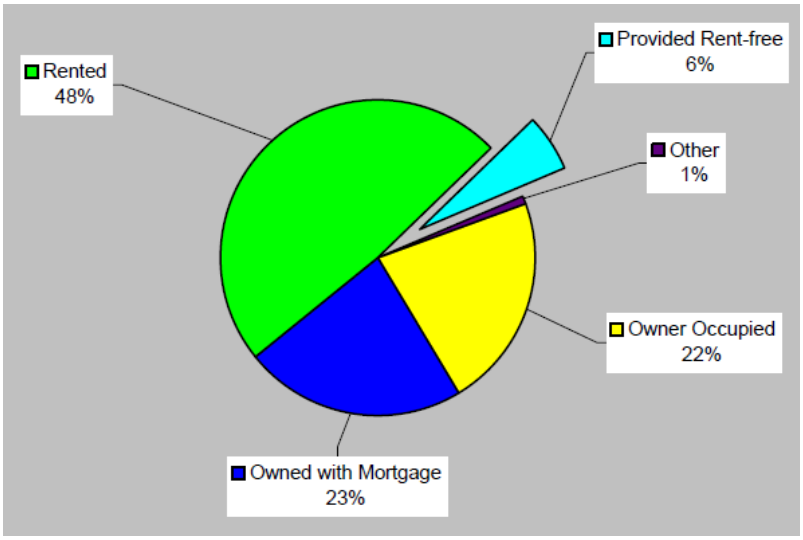
[111] DOE, 2009. Comments from Sam Small and George de Romilly. In: Minutes of Real Estate and Construction Stakeholder Consultation, 23 January 2009.

[112] Tompkins, E.L., 2006. Factors affecting economic losses in the Cayman Islands. In: *Climate change and Disaster Losses. Understanding and Attributing Trends and Projections – Workshop Report* (Eds., Höppe, P. and Roger Peilke, J. Centre for Science and Technology Research, Boulder, CO, pp.212-217.

windows and doors and braced roofs, income did not play a major role in decisions to install hurricane straps, make evacuation plans or move inland. This may be because for those who had been badly affected by past storms, preparedness was prioritized irrespective of income[113].

Those less likely to have prepared for hurricanes in the short term (through shuttering or evacuation) were the same as for those unlikely to make preparations in the medium (installing roof braces and wall ties) and long term (moving inland). These were young, childless, internationally mobile migrants, in rented accommodation, living on the coast (55% of expatriate residents surveyed), likely to not have developed ties to the island or experienced a major hurricane. Surprisingly, this profile of a 'disaster risk ignorer' included the expatriate coastal resident who does not engage in risk reduction activities[114]. This is particularly worrying if the profile still holds true post-Ivan as non-Caymanian residents made up 44% of the Islands' population in 2008 and as illustrated in Figure 18, almost half the households in 1999 were under rental agreement. The number of condo developments along the Seven Mile Beach corridor actually expanded post-Ivan as developers capitalized on a 2003 revision to the Development and Planning Regulations allowing seven stories in place of conventional three storey buildings[115]. As the supply of coastal properties continues to feed the demand of increasing numbers of new migrants wanting to live on the coast, these very activities are increasing the vulnerability of settlements, households and individuals to coastal hazards with implications for human life, property damage and related insurance premiums, and overall economic losses for the country.

Figure 18 Tenure of Households, Census 1999



Source: ESO (2009) Statistical Compendium 2008

[113] Tompkins, E.L., L-A. Hurlston and W. Poortinga, 2009. Disaster Resilience: Fear, Friends and Foreignness as Determinants of Risk Mitigating Behaviour in Small Islands. SRI Paper No. 18, Sustainability Research Institute, School of Earth and Environment, University of Leeds, Leeds, UK.
[114] Tompkins, E.L., L-A. Hurlston and W. Poortinga, 2009. Foreignness as a constraint on learning: The impact of migrants on disaster resilience in small islands. Environmental Hazards 8 (2009): 263-277.
[115] ESO, 2006. The Cayman Islands' Annual Economic Report 2005. Cayman Islands Government Economics and Statistics Office, Portfolio of Finance and Economics, Grand Cayman, June 2006.

Since hurricane Ivan community level capacity building in hurricane preparedness and future climate change adaptation has been heighten. The Red Cross has worked with communities on Grand Cayman (Goat Yard, West Bay; Washington Boulevard, George Town; Belford Estates, Bodden Town; Seaview Drive, East End) to train and develop Community Disaster Response Teams (CDRT). These CDRTs assist the vulnerable in their communities to shutter homes, evacuate to shelters and make any other preparations necessary for response and recovery[116]. While some communities have accomplished more than others, these efforts from 2006 have spawned other community redevelopment projects not geared specifically at climate change adaptation but with overall aims of reducing their physical and socio-economic vulnerability. Since Ivan government assistance programs for hurricane preparedness such as supplying plywood for shutters has become commonplace.

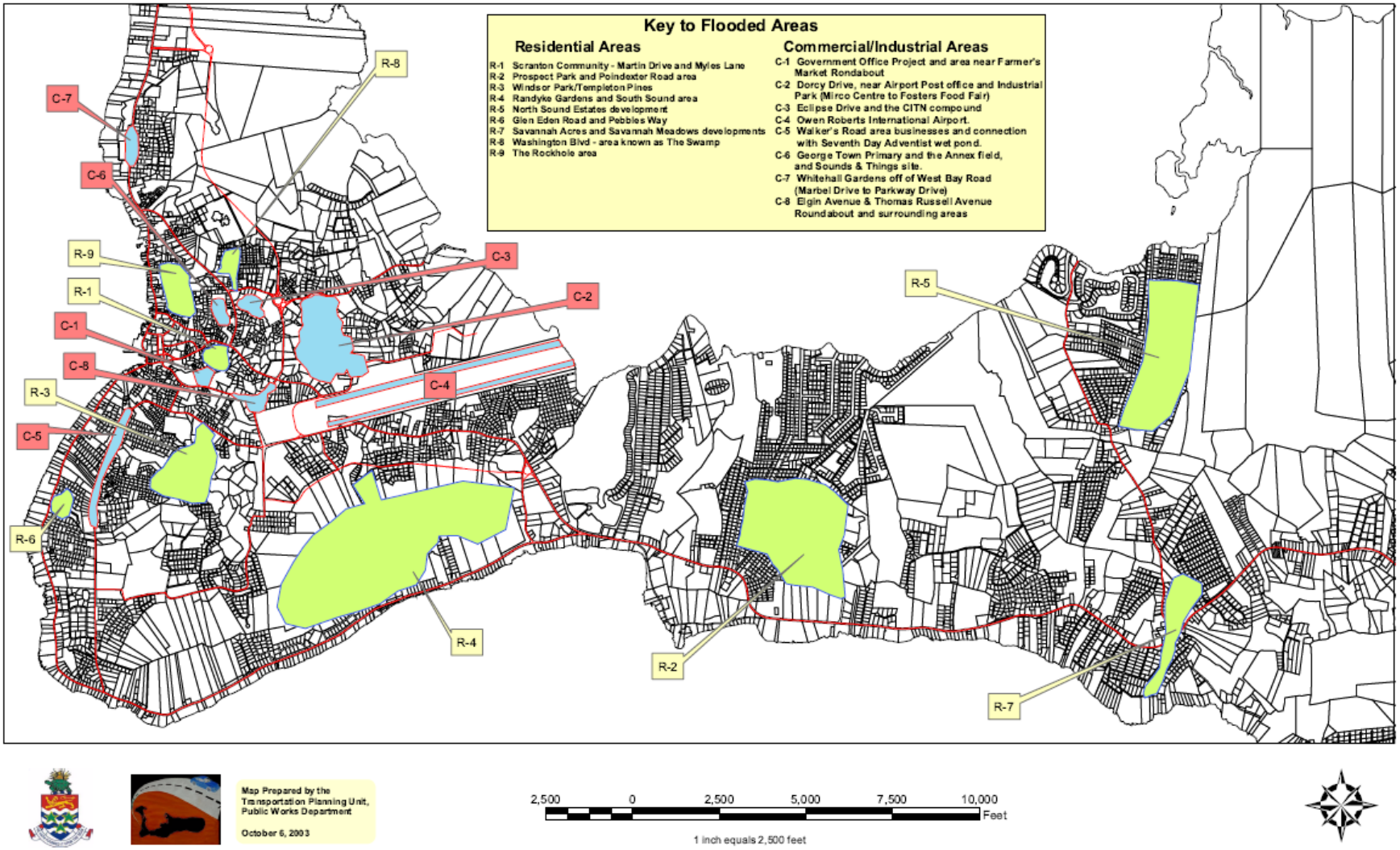
Stormwater management

Stormwater management must be considered as a basic public service requirement in maintaining a high standard of living, disease prevention, and protection of people, property and the natural environment. Due to the loss of wetlands and other surface water storage areas such as pastureland and natural ponds to development, heavy rainfall events in George Town often lead to recurrent flooding of some major roads which disrupts traffic and businesses, commercial areas and residential neighbourhoods, many of which have been identified by the Stormwater Management Committee since 2003 (Map 21). While some of these areas are along hurricane evacuation routes, others coincide with pockets of sub-standard housing, hot spots of dengue vectors and communities identified by the NALC as among the most economically vulnerable. Some of these vulnerable households may have benefited from regular government assistance when temporary evacuations have become necessary or for home repairs post-flooding.

Cumber Avenue in Bodden Town is another area where ongoing problems have resulted from the conversion of wetlands by the filling of entire parcels for new development well above older neighbouring properties and disruption of natural drainage in the area by the construction of the bypass road. Residents of this neighbourhood contended with or were displaced by flooding in 2007, during hurricane Gustav in 2008 and again during hurricane Paloma a few months later. With each successive event, more water accumulates and remains stagnant for a longer period of time, causing rodent infestations, ringworm in children, increased sinus problems and heightened stress levels among those in the community regularly affected. Residents have taken to constructing individual walls around their homes to prevent future flooding, recognizing that this act will likely cause problems for their neighbours who do not take similar measures[117]. This is a clear case where stormwater management on a regional or catchment basin scale is needed.

[116] Balgobin, H. Disaster Manager, Cayman Islands Red Cross. Personal communication, 16 October 2008.
[117] Robbins, S., 2009. "Hope washed away: The long, slow drowning of Bodden Town's Cumber Avenue," The Observer on Sunday, 1 March 2009.

Map 21 Key Flooding Areas of Grand Cayman Identified by the Stormwater Management Committee, 2003



Source: Transportation Planning Unit, Public Works Department (2003) Report of the Stormwater Management Committee

Typically where management practices have existed at all, vertical deep wells and dykes have been the predominant means of stormwater control both on public roads and within newer subdivisions. It is now widely accepted that this engineering technique is inadequate in dealing with the quantity of stormwater in low-lying areas with water tables near the surface. This mechanism is also ineffective in addressing stormwater quality as it does not treat runoff before it enters the ground, potentially contaminating groundwater resources with hydrocarbons, fertilizers and other chemicals, and sediments from urbanized areas. More intense rainfall events associated with climate change will increase the rate of overland flow resulting in greater magnitude of runoff to be handled by these means. The initial cost to drill and install deep wells is on average $3,000 per well, and maintenance outlay to keep wells and drains clear is significant owing to high water tables and rapid ground saturation rates. With greater rainfall accumulation expected more frequently or over longer periods these costs will likely escalate. The 2009/10 Budget allocated CI$100,000 for stormwater management – particularly remedial stormwater solutions for a specific site in Grand Cayman – as well as for mitigation of tidal inundation. Resources on a larger scale will be needed to reverse chronic flooding in multiple areas using more appropriate and cost-effective technologies and techniques.

This is now the case with Cumber Avenue. Deep wells simply will not solve the problem any longer. One remedy that addresses the high water table dilemma is to construct a shallow trench under roads to convey water to the sea via a pumping station, perhaps as part of a larger national stormwater system of pumping stations and pipes common in other jurisdictions. This could be prohibitively expensive, and concerns exist over the environmental impact to receiving waters into which large volumes of rapidly flowing untreated stormwater would be discharged. (Coastal and marine habitat loss and tannin stained water in the South Sound replenishment zone as a result of drainage culverts installed to relieve the flooding of Randyke Gardens is a prime example). Another costly solution and perhaps less palatable to homeowners is to relocate residents to a less vulnerable area of the district. Public funding is also needed to improve the situation in other affected locations which is simply not sufficient at this time. A widely accepted belief is that developers should be held responsible for avoiding these flooding situations in the first instance by incorporating the cost of proper stormwater management into their business plan otherwise the general public pays later for fixing the problem after the fact which is much more difficult and costly.[118]

Inland flooding will not be resolved unless the risk due to areas in which buildings are sited and stormwater management at inception of subdivision design become material considerations in the planning process[119]. New subdivisions continue to be sited in wetlands and low-lying areas which are still relatively cheap to purchase. Planning permission granted for major and minor developments by the Central Planning Authority is subject to stormwater management plans (SWMP) reviewed by the National Roads Authority (NRA). Most often these plans do not adhere to the Guidelines for Stormwater Management Plan Preparation provided by the NRA's Transportation Planning

[118] Robbins, S., 2009 "Storm water drainage is national problem," The Observer on Sunday, 1 March 2009.
[119] DOE, 2009. Comments from George de Romilly. In: Minutes of Real Estate and Construction Stakeholder Consultation, 23 January 2009.

Unit, which describes the content of what a SWMP should contain[120]. These guidelines encourage the use of grass channel and swale conveyance systems, limits of disturbance of stormwater treatment practices, and site reforestation or re-vegetation as part of a complementary landscape plan. Developers have been slow to integrate these stormwater management measures into new developments, opting to only meet drain well requirements that address the volume of runoff from roofs, parking lots and other impervious surfaces to prevent flooding of public roadways and neighbouring properties.

The NRA has also produced a more comprehensive Stormwater Management & Design Guidelines for Grand Cayman which contains several other methods for addressing surface runoff. While this document has Water Authority backing it has not been endorsed by the Planning Department as it is deemed too complicated and a far departure from the status quo. Furthermore, stormwater management taking a wider catchment area approach for well designed conveyance is still not common practice. Better flood prevention measures will be needed to protect vulnerable communities and public infrastructure from the costly and disruptive impacts of heavier or prolonged rainfall events, especially those associated with slow moving hurricanes.

4.9 Critical Infrastructure

Critical infrastructure that supports these communities is likewise threatened by similar climate hazards. Hurricane Ivan for example caused damage and losses totaling CI$407 million in the infrastructure sector or 14% of the total impact of the disaster. Increasing the resilience of these utilities and services must go hand in hand with augmenting the future resilience of communities overall to climate impacts, which may mean less reliance on these services and more self-sufficiency at the household level.

Electricity supply

The following tables illustrate the type of lighting and cooking fuel most used by households in 2007. The table on left shows that a significant portion of households throughout the islands (94%) rely on electricity provided by the two power generation companies, Caribbean Utilities Company (CUC) in Grand Cayman and Brac Power & Light in Cayman Brac. Not surprisingly, private-generator use for lighting was more common amongst the richest households, and renewable energy use is almost non-existent. The table on the right also reflects a high reliance (57%) on public service providers for cooking purposes, although a large portion of households (42%) – mainly the poorer cohorts - utilize LPG/cooking gas.

[120] Thibeault, D. Assistant Director, Transportation Planning Unit, National Roads Authority. Personal communication, 4 May 2010.

Table 14 of Lighting Sources and Cooking Fuels Used Most in the Cayman Islands

Lighting Used Most	Per cent
Electricity (CUC, Brac Power)	93.7
Electricity-Private Generator	4.9
Other	0.8
Not Stated	0.6
Total	100

Cooking Fuel Used Most	Per cent
Gas/LPG/Cooking Gas	41.8
Electricity	56.7
Other	0.5
Not Stated	0.9
Total	100

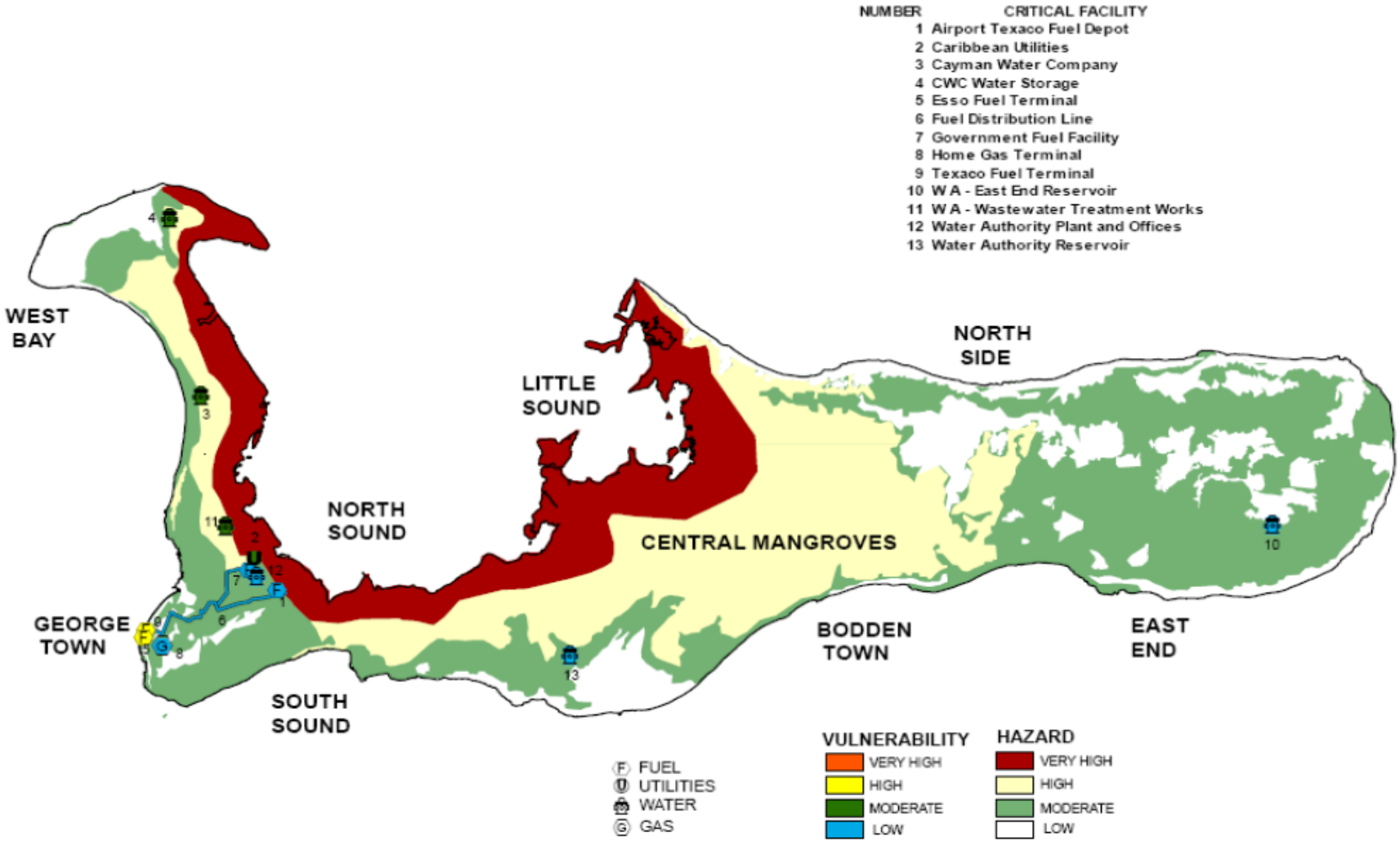
Source: ESO, Selected Statistics from the Survey of Living Conditions, 14 April 2009

The physical vulnerability of power generation facilities to existing climate hazards can affect reliability of electricity supply. A preliminary assessment of the physical vulnerability of utilities on Grand Cayman found that CUC's generation facility is located in a zone that is impacted by hurricane categories 4 and 5 producing flooding and storm surge hazards of a moderate exposure levels, giving it a moderate level of physical vulnerability overall (Map 22)[121]. The study did not assess the vulnerability of the CUC's overhead transmission and distribution (T&D) system. However Ivan - a low to moderate category 4 hurricane - tested the long-standing practice of erecting light poles and power lines, and illustrated the vulnerability of these systems to intense wind hazards likely to be experienced more often in the future. Concrete poles faired far better than wooden poles. Ivan caused the loss of approximately 20% of CUC's T&D system[122]. Many households, particularly in the eastern districts of Grand Cayman, were without access to electricity and resorted to other coping mechanisms to carry out day-to-day activities. CUC successfully completed restoration of service to all reconnectable customers on November 30, 2004, which was within the 90-day period the company projected following the hurricane.

Photo 9 Downed transformers , poles and lines obstructing West Bay Road, September2004. ***Credit: Unknown***

[121] Natural Disasters Assessment Consulting Group, 2009.
[122] Caribbean Utilities Company Ltd., 2008. 2007 Annual Report: Celebrating 40 Years in Paradise.

Map 22 Level of Vulnerability of Utilities on Grand Cayman



Source: NDAC (2009) Preliminary Vulnerability Assessment of Grand Cayman, Cayman Islands

CUC received overseas man-power to assist with the restoration efforts and, although insured against hurricane losses, still had to apply a Hurricane Ivan Cost Recovery Surcharge to all electricity bills to help offset the cost of recovery. Whilst the Cayman Islands Government negotiated the removal of the surcharge in 2008, the skyrocketing fuel prices in the summer of 2008 has meant that the cost of this service remains high and many households struggle to pay bills.

The cost – both monetary and in terms of disruption borne by utility providers and their customers alike - associated with future hurricanes of wind intensity comparable to Ivan's strength or greater supports the need to increase the resilience of this infrastructure. Other infrastructure providers such as Cable & Wireless have introduced risk reduction measures through buried telecommunication lines - a good example of adaptation and illustrates the avoided costs of damage to this infrastructure that have not been passed on to consumers. However, CUC has found it cost-prohibitive to place its infrastructure underground in some areas mainly as a result of the low concentration of customers and the high cost of underground construction owing to the high water table on the island; nevertheless, the company has looked at business projections for placing lines underground[123]. CUC owns and maintains the poles that other telecoms lines are attached to in Grand Cayman and was responsible for the replacement of these poles after hurricane Ivan. Currently the typical average price of constructing underground electrical distribution networks is over 500% of the cost of constructing overhead electrical distribution networks.

The current practice is for developers to put in the civil infrastructure (e.g. pipes) and for CUC to put in the cable. While some believe costs should be borne by utilities and not the developer or homeowner with legislation to support this[124], there are other cost-sharing arrangements that can be explored. In Canada the utility companies, developers and homeowners now share underground installation as studies on maintenance costs of above ground installations over the longer term have shown to be considerably higher[125]. Grand Cayman's high water table and high costs of construction results in significantly higher costs for underground utilities compared to Canada.

CUC has adapted its transmission and distribution system over the years to become more resilient to hurricanes by utilizing indoor concrete encased substations, utilizing submarine cables to loop its transmission system and to utilize reinforced concrete transmission poles all of which were very resilient to the wind and flooding experienced during hurricane Ivan. Since Ivan CUC has taken the decision to design its critical generation and transmission system infrastructure to 150 mph and super critical infrastructure to 200 mph. Raising critical infrastructure to +10 ft above the mean sea level has resulted in a drop in premiums; the previous standard was +8 ft based on historical data. A Government mandate to raise all future development to +7 to 10 ft through

[123] DOE, 2009. Comment by David Watler. In: Minutes of Critical Infrastructure Stakeholder Consultation, 23 January 2009

[124] DOE, 2009. Comments by Dalkeith Bothwell. In: Minutes of Critical Infrastructure Stakeholder Consultation, 23 January 2009.

[125] DOE, 2009. Comments by George de Romilly. In: Minutes of Critical Infrastructure Stakeholder Consultation, 23 January 2009.

revision of 30-year old Planning legislation is also considered necessary[126]. CBP&L has taken advantage of the high bluff elevation and relocated its diesel generation facility to this area. Plans for wind-powered generation are also in the works as the bluff provides a good position for siting such installations.

Action on the part of utilities should be coupled with increasing the adaptive capacity of households and businesses to withstand long terms without power. Climate-proofing buildings and communities would include designing structures using passive cooling techniques to take advantage of prevailing winds and cross-ventilation so longer periods without air conditioning would not be an issue. Further, extended periods without power can be offset with the use of small-scale solar and wind energy technologies. If such systems can be used post-disaster, they can be scaled appropriately for regular use as is done in Florida and elsewhere. There may be a need for the Electricity Regulatory Authority in consultation with the utility provider to revise the Customer Owned Renewable Energy (CORE) net billing programme, specifically rates for selling/receiving credit for renewable energy generated in-situ to achieve higher conversion rates to these low-carbon alternatives. Also incentivizing the installation of these systems which are still considered expensive despite their duty free status is needed through joint programmes with the utilities and equipment providers. These measures should be set in clear policy, such as a National Energy Policy, supported by a new energy building code and other policies.

Water supply and wastewater

Table 15 shows that more than 84% of households in 2007 had piped water ("city water' or desalinated water) as their primary potable water source. The low figures for cisterns and wells (roughly 7% respectively) demonstrate the departure 30 years ago from utilizing these traditional water harvesting techniques when constructing new homes. On the one hand, the extensive investment in a public water supply since the mid-1970s in Grand Cayman and more recently in Cayman Brac bodes well for the country's adaptive capacity to regional water scarcity concerns associated with climate change. On the other hand, the limited piped water supply system and use of desalination, and greater reliance on wells and catchment of rainwater in cisterns in the Sister Islands, suggests they are presently more vulnerable than Grand Cayman to the slow onset changes expected for this sub-region in terms of a reduced amount of rainfall in the rainy season and less annual rainfall overall.

Hurricane Ivan showed that the heavy reliance on piped water by the majority of the population can result in no access to fresh water for quite some time following such an event, slowing clean-up efforts vital to maintaining healthy sanitation levels which curb the onset of disease.. Water service was restored to 67% of reconnectable customers by 29 September and to 90% by 1 October. Some officials believe that "we have become our greatest enemy with not continuing to build cisterns and relying on Water Authority"[127]. Incentivizing cistern-building through bank mortgages, the insurance sector and an enhanced

[126] DOE, 2009. Comment by David Watler. In: Minutes of Critical Infrastructure Stakeholder Consultation, 23 January 2009

[127] DOE, 2009. Comment by Ernie Scott. In: Minutes of Ministry of Planning Stakeholder Consultation, 22 January 2009.

building code are all measures that could be taken which comes at the issue of ensuring reliable water supply in future from different angles[128].

Table 15 Water Supply Sources and Sewerage System Types

Main Source of Water Supply	Per cent
Mains (city water or desalinated)	84.2
Cistern, Rain or Truck	7.2
Well	7.6
Other	0.2
Not Stated	0.9
Total	100

Type of Sewerage System	Per cent
Mains (West Bay Road)	13.1
Sewerage Treatment Plant	10.1
Septic Tank or Cesspool	72.0
Deep Well	2.1
Not Stated	2.7
Total	100

Source: ESO, Selected Statistics from the Survey of Living Conditions, 14 April 2009

The physical vulnerability of water utilities on Grand Cayman to hurricane-related flooding and storm surge has been assessed by the Natural Disasters Assessment Consulting Group in 2009[129]. Consolidated Water Company plant and water storage facilities are both exposed to a relatively high degree of hurricane-induced flooding and moderate storm surge, but overall their physical vulnerabilities are considered moderate (i.e. impacted by categories 4 and 5 hurricanes every 100 years) (Map 18). This was borne out during Ivan where the plant and equipment sustained heavy damage totaling CI$1.3 million not including spare parts inventories or rebuilding costs[130]. Of all Water Authority's physical infrastructure, the main plant and office, and reservoirs at East End and Lower Valley have a low vulnerability to a moderate level of hazards given their location further inland and well above sea level. Whereas the wastewater treatment works next to the landfill is more exposed to flooding from hurricanes and therefore has a moderate level of physical vulnerability (Map 18). Despite this, some CI$3.6 million in estimated damages to plants, buildings and equipment were reported by the WAC after Ivan. As with other utilities that run alongside coastal roads, the water lines are vulnerable to storm surge and subsequent coastal erosion. Over 2,000 metres of pipeline was exposed during Hurricane Ivan and had to be replaced due to rupture or concerns over structural integrity.

While regulations enacted in the late 1980s made it mandatory to connect new developments in Grand Cayman to the public sewerage system or construct on-site treatment plants, the majority of households throughout the islands have septic tanks (Table 10). All types of onsite treatment systems installed at or below grade can be inundated during extraordinarily heavy rainfall events and storms. In addition, given the flat terrain, pump stations are required in many areas to convey wastewater to a treatment system. These too can be inundated and in the event of a power outage, will overflow. These scenarios all pose a significant risk to public health and the environment. While hurricane Ivan caused the wastewater collection system to flood with seawater and damaged

[128] DOE, 2009. Comment by George de Romilly. In: Minutes of Ministry of Planning Stakeholder Consultation, 22 January 2009.
[129] Natural Disasters Assessment Consulting Group, 2009. Preliminary Vulnerability Assessment of Grand Cayman, Cayman Islands. A Report to the Government of the Cayman Islands, June 2009.
[130] ECLAC/UNDP, 2005. The Impact of Hurricane Ivan on the Cayman Islands. LC/CAR/L.25, 10 January 2005.

Photo 10 Water lines along coastal road exposed and damaged. ***Credit: ECLAC 2005***

the electrical components of 90% of the pumps, hindering disposal and treatment of wastewater for days, no discharged to roads or properties occurred. Through the use of portable pumps and sewage vacuum trucks the WAC was able to convey wastewater to the treatment facility during the period the island was without power.

Ground Transportation Network

Grand Cayman has a network of primary, secondary, unclassed, access and unpaved roads totaling 337 miles. In 2001 the asset value of this network was estimated at CI$180 million excluding land value. A 2009 assessment of the existing network found hurricane Ivan damage to be a good benchmark of the road sections most vulnerable to present-day climate hazards. The areas of greatest damage and deemed most exposed are north, northeast and southwest sections of East End, Breakers-Bodden Town road, Spotts-South Sound-West Bay section and Rum Point Road[131]. These areas sustained CI$146.2 million in damages or destruction of assets in terms of roads cut or reduced in width, asphalt carpeting removed or severely damaged, drainage structures eroded or silted, or coastal protections destroyed[132].

Entire sections of road infrastructure were washed away in some areas where storm surge of 5 m to 6 m (16.5 ft to 19.6 ft) came inland by as much as 500 m (1640 ft). Thousands of cubic metres of sand buried extensive road sections, beyond the typically affected areas of sand deposition on West Bay Road and in South Sound. In some cases even homes and residential complexes where ripped from their foundations and laid to rest along major arterials. These impacts severely hampered mobility throughout the island after the hurricane until road crews with heavy equipment could clear the sand and debris. This made life difficult to transport much needed supplies and reconstruction materials to devastated areas.

Similarly, flooding from heavy rains or storm surge from even distance storms has forced frequent road closures at various locations around Grand Cayman. Severe events have created cut-off points in the road network such as wave overtopping and flooding of the Savannah Gully after hurricane Mitch, which left several feet of seawater within the Savannah-Newlands basin and made the Tall Tree junction completely impassable for days. Whilst some residents passed the time jet-skiing these flooded streets, the disruption of traffic was costly to many businesses in George Town whose workers from the eastern districts could not physically get to work. In such situations telecommuting capabilities would have allowed for business continuity and reduced losses due to decreased productivity.

[131] Natural Disasters Assessment Consulting Group, 2009
[132] ECLAC/UNDP, 2005

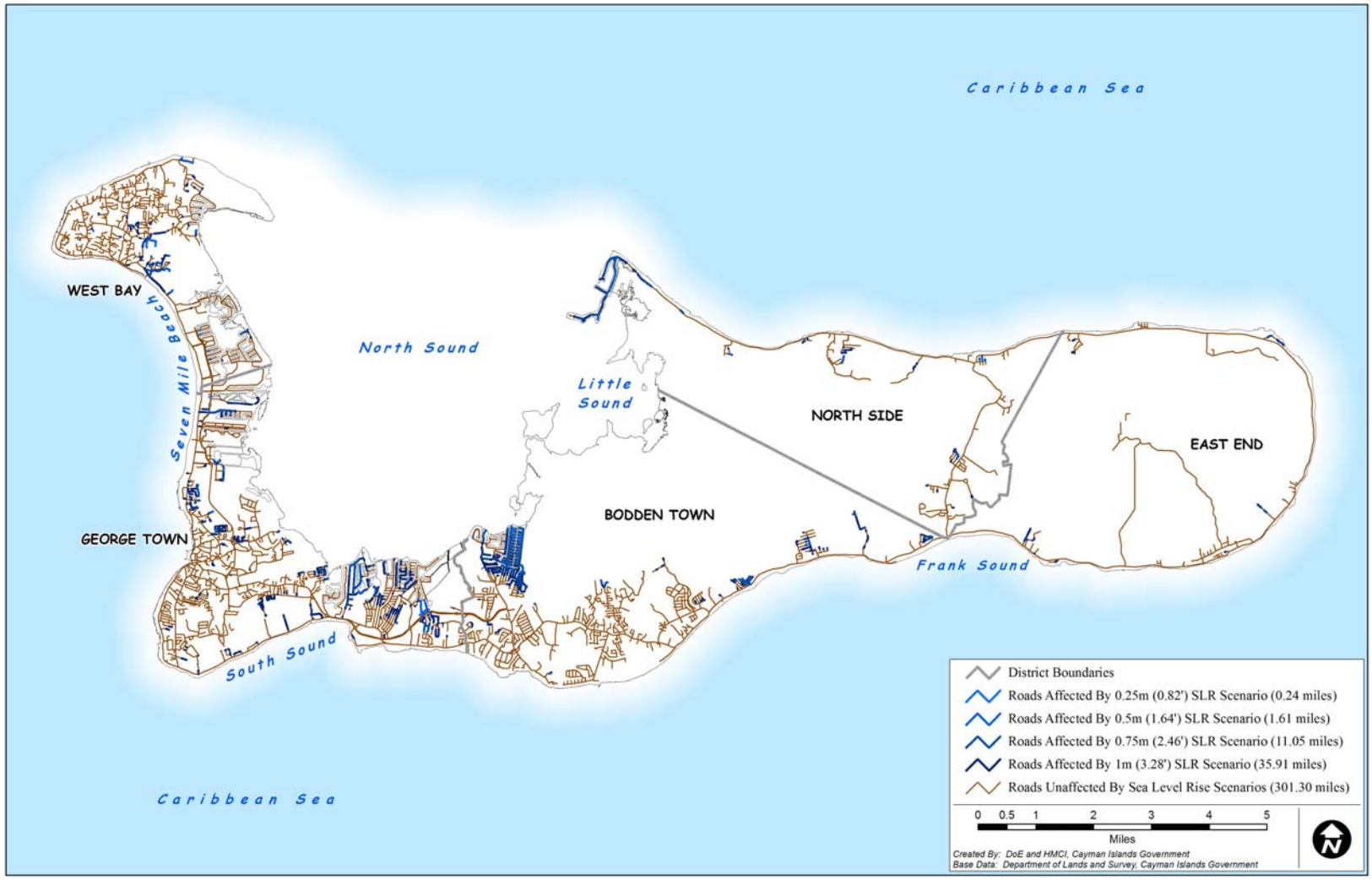
An estimation of ground transport infrastructure affected by 0.25 m to 1 m sea-level rise was conducted in 2010 as part of the *Vulnerability and Capacity Assessment of Climate Change Impacts and Sea-Level Rise on the Cayman Islands' Tourism Sector*. The study found that the road infrastructure will cope with a 0.5 m (1.6 ft) SLR with only 0.5% of all Grand Cayman roads affected. At 0.75 m (2.5 ft), near the upper end of the expected SLR (2.6ft), the affect of this rise starts to have a more significant impact on the island's transportation network, with just over 3% of all roads inundated, primarily in North Side and Bodden Town. However, there is a considerable increase in the amount of infrastructure impacted between the 0.75 m and 1 m SLR scenarios, with almost 11% of the current (2010) road infrastructure affected by the a 1 m (3.3 ft) rise. East End roads not affected by SLR below 0.75 m, and less than 2.5% affected by 1 m SLR. The greatest impact will be experienced in Bodden Town and North Side with nearly 15% of roads in each district affected by 1m rise in sea level. An additional 1 m sea level will cause just over 11% of roads in George Town – the district with the largest amount of road infrastructure – to be impacted. Slightly less than 6% of the West Bay network and almost 2.5% of the East End network will be affected in some way if seas rise to 1 m or 3.3 ft above present level. Map 23 shows the distribution of impact across the various SLR scenarios.

Governments over the years have considered the relocation of some sections of this infrastructure inland to reduce further damages and losses from storms. This is prudent given the amplified hurricane intensity and hurricane storm surge on top of average sea level rise that are likely to take place, necessitating the construction of new roads in accordance with better standards to mitigate these potential effects. Efforts to reduce the inevitable increased costs to the National Roads Authority for repair and reconstruction of older roadways due to SLR and augmented storm damage are needed as well[133]. Options are very limited in some areas on Grand Cayman, as development has now confined certain road corridors to the coast; in the case of Cayman Brac retreat of coastal infrastructure is restricted to the base of the Bluff. However many new roads are being constructed on the Bluff top spawning new housing development and support services in previously inaccessible lands. New cross-island roads in Little Cayman are also emerging - some of which are in environmentally sensitive areas - that could function as alternate routes should the coastal roads become periodically impassable.

On Grand Cayman, the preliminary vulnerability assessment recommended that in addition to a quantitatively assessing the physical and socio-economic impact of natural hazards on the road transport system be undertaken, upgrades to the road infrastructure with larger drainage pipes to better handle floodwater and protection from surge should be undertaken as well as construction of alternate routes to prevent communities in the eastern district from being isolated during emergencies and after severe storms.

[133] Lansley, C., 2009. Training Safety Environmental Specialist, Caribbean Utilities Company. Personal communication, 17 December 2009.

Map 23 Grand Cayman Road Infrastructure Affected by Sea-Level Rise Scenarios



Source: Department of Environment, 2010

Sea ports and Airports

Not surprisingly the sea ports are inherently vulnerable to present hurricanes and nor'westers given their coastal locations. There is no option to relocate these facilities which serve as infrastructural lifelines for the Islands. When structural damage or operational disruptions arise at the ports, this affects food security and access to other vital commodities necessary for recovery and reconstruction which otherwise have to be flown in at greater expense. Table 16 shows the number of "Days Unable to Work" as a result of weather or forced closure of the Port due to activities in central George Town [134]. These typically coincide with the passage of tropical storms, hurricanes or strong nor'westers.

Table 16 Days Unable to Work at George Town Port, 1977-2008

Year	Days Unable to Work	Weather System
1977	19	
1980	8	Hurricane Allen
1983	10	
1987	12	
1988	11	Hurricane Gilbert
1990	15	
1994	18	
1996	13	Nor'wester, Hurricane Lili
1998	17	Hurricane Mitch
2001	11	Hurricane Michelle
2002	10	Tropical Storm Lili
2003	8	
2004	8	Hurricane Ivan
2005	12	Hurricane Wilma
2007	8	Hurricane Dean
2008	13	Hurricanes Gustav & Paloma

This underscores the need for maintaining and increasing the resiliency of the port buildings, equipment and operation plans to flooding and physical damage from storm surge and wave action. Operational vulnerability at the George Town port has been reduced using lessons learned from the Ivan experience and other recent hurricanes. However, an increasing number of days when the port is inoperable due to unsettled weather, damaging hurricanes from the southwest tracking NNE, or even storm surge from major hurricanes some distance away may be future scenarios that residents and businesses will have to contend with. The country may have to gear itself to absorb the increasing costs of mitigating damage to existing port facilities and operations from storms and SLR which, depending on the instruments used (e.g. taxes, fees), may raise the cost of living. New cruise ship and cargo facilities currently under consideration must be designed using best available projections on regional SLR and storm surge risk.

There are also situations elsewhere beyond our control that could have serious implications for us locally. Other major sea ports such as Miami or Jamaica, where the majority of commodities to the Cayman Islands are shipped from or through, are also at risk from SLR and damaging hurricanes. Lack of response to

[134] Port Authority of the Cayman Islands, 2009. Cargo Summary 1977 to 2008.

such climate risks by port authorities or Governments in these countries could have knock on effects for many small islands in the region.

Roughly 200 yards from the coast, Owen Roberts Airport is susceptible to flooding and storm surge, and impacts by hurricane categories 4 and 5 which these islands will likely experience at least once every 17 years (consistent with local historical record) or possibly more frequently as a result of climate changes. That Grand Cayman's airport was operable within a day of the passage of a severe category 4 hurricane such as Ivan speaks to the coping mechanisms of measures and systems already in place, which undoubtedly could be improved using lessons learned from that experience. As with the proposed cruise and cargo facilities, a new airport terminal in Grand Cayman must be designed and operated with and expected hazards from climate change in mind. This could be costly as securing loans becomes problematic or insurance underwriting these risks becomes more expensive. Again, airports authority will be seeking to recoup or offset costs wherever they can, perhaps through increased fees.

Fuel terminals

Fuel storage and distribution systems are equally critical to energy security and continued economic prosperity of the country. The high physical vulnerability of the ESSO and Texaco fuel storage terminals is not surprising given their coastal locations with high exposure to flooding and storm surges associated with category 3 and above hurricanes[135]. The fuel distribution lines have a low vulnerability to natural hazards due to their buried nature (Map 16). Similarly, the Home Gas terminal much further inland and well above sea level has a low vulnerability when faced with the same level of hazards from hurricanes. However with more customers are turning to propane appliances (stoves, water heaters, clothes dryers) and therefore the continued operation of this facility is increasingly important. Given that fuel is the life blood of economic and social activities, these facilities need to ensure their hazard preparation and response plans are up to date, regularly tested and refined.

4.10 Energy Security

The Cayman Islands needs a reliable and affordable supply of energy in order to prosper. To make these supplies sustainable, they also need to be delivered in an environmentally responsible manner and utilised as efficiently as possible. The Cayman Islands faces a number of challenges in meeting its energy needs however, which will only be exacerbated by climate change.

In line with economic and population growth, electricity demand has steadily increased in the Cayman Islands year-on-year. With the exception of the aftermath of Hurricane Ivan in 2004, electricity consumption increased an average of 5% per year from 1990 to 2007 during which time the population grew from 25,355 (1989) to 54,986 (2007) while average household size decreased from 3.1 to 2.5 persons (ESO). Total electricity consumption increased by a striking 160% over this period, reaching just under 600 GWh in 2007.

[135] Natural Disasters Assessment Consulting Group, 2009.

The US Energy Information Agency (EIA) estimated the energy intensity – that is, the amount of energy consumed per unit of GDP - of the Cayman Islands as 2,296 Btu/US$ of GDP in 2006. Although lower than most other Caribbean countries, when compared to European nations with similar service economies and the US, this figure is relatively high considering the difference in geographic area and population. In terms of energy intensity per capita, or per person, in 2006 the EIA estimated the Cayman Islands' total energy consumption per capita as 130.7 MBtu. Energy use per capita in the Cayman Islands is over twice that of the average energy use per capita for Central and South America, in which the Caribbean is classed, is just higher than the Middle East, and only 19 MBtu below the average for European countries. Energy is therefore used intensively on the Cayman Islands, perhaps unsurprisingly considering the electricity needs of the tourism and financial services industries and the high standard of living, and demonstrates that there is certainly much room for improvement in terms of decoupling economic growth from energy use.

Almost all of this energy consumed is created through the burning of diesel oil in the Cayman Islands. It is this fossil fuel that is used almost exclusively in the generation of electricity and for transport. It is also used indirectly in the production of potable water, 99% of which in Grand Cayman is produced through desalinisation[136], a process run using electricity. The Water Authority has found that it takes 3.6 kWhr to produce and supply 1 m^3 of desalinated water using reverse osmosis[137]. Currently (2010) all desalination plants use reverse osmosis technology. The Water Authority owns 4 plants in Grand Cayman and 1 plant in Cayman Brac and Cayman Water Company owns 4 plants in Grand Cayman.

This dependency on oil and high demand for electricity makes the country extremely vulnerable to price fluctuations on the global energy markets, which are then fed into electricity prices here in the Cayman Islands. Oil prices topped US$147 per barrel in 2008, a record high and a price that has since fallen, but is now on the rise once again. Electricity prices in the Cayman Islands, which are high in the first instance, especially in the Sister Islands, are therefore susceptible to dramatic changes as a result of this. These high oil prices will not only make electricity supply considerably more expensive however, but as much of the islands' potable water supply is also produced using electricity, the cost of providing this utility will also increase, as well as the cost of transportation for every citizen. There are therefore a number of energy related services that will be affected, which will have serious implications for the economy of the Cayman Islands and some social sectors. With housing and utilities constituting nearly 40% of total household expenditure, compounded by escalating costs of local goods, it is likely the number of service disconnections may increase, especially among disadvantaged households. This situation is unacceptable in such an outwardly affluent society.

An oil-based economy also leaves the Cayman Islands dependent on imports of energy. Petroleum products and gas were 12% of all imports in 2009. There is

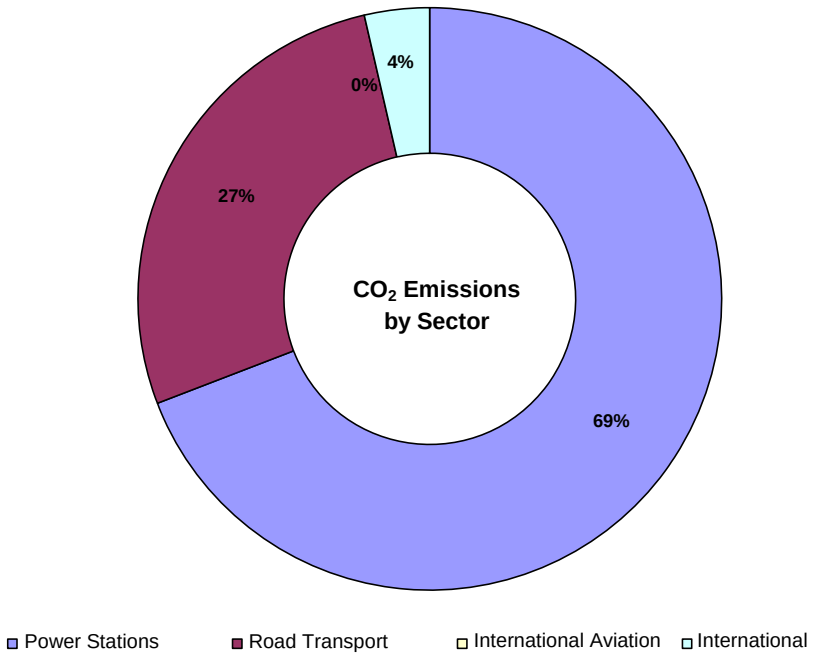
[136] ESO, 2010. Ch. 16 Utilities, in *Statistical Compendium 2009*.

[137] Van Genderen, H-J, 2010. Explanatory notes for GHG emission inventory for water production and supply October 2010

currently very little utilisation of indigenous renewable sources of energy, such as solar and wind power. This in turn means the islands are not only vulnerable to prices, but also vulnerable to the political vagaries affecting supply and availability of supply. There is also the ever more pressing issue of how much longer global oil supplies can continue to sustain increasing global demand. Projected impacts from climate change such as increased intensity of storms could affect imports by disrupting supply, through increasing the number of instances when the port and fuel terminals have to be shut, or affect the extraction or refining of crude oil in other regions. These will in turn increase the cost of fuel if supply is regularly restricted. Small businesses are particularly susceptible to price fluctuations with energy costs increasingly being passed on to their customers. It is not unreasonable to expect even the price of diving and excursions (e.g. to Stingray City) to increase.

The burning of fossil fuels is the largest contributor of carbon dioxide (CO_2) emissions into the atmosphere. It is this rise in CO_2 emissions from human activities such as electricity generation through the combustion of fossil fuels that is leading to global warming. The energy sector is therefore the area which needs most attention in the effort to reduce carbon dioxide and other harmful greenhouse gas emissions. In 2008 the bulk of CO_2 emissions from the Cayman Islands energy sector was attributed to power generation, with road transport accounting for over a quarter of total emissions (Figure 19).

Figure 19 Cayman Islands Carbon Dioxide Emissions by Sector, 2008

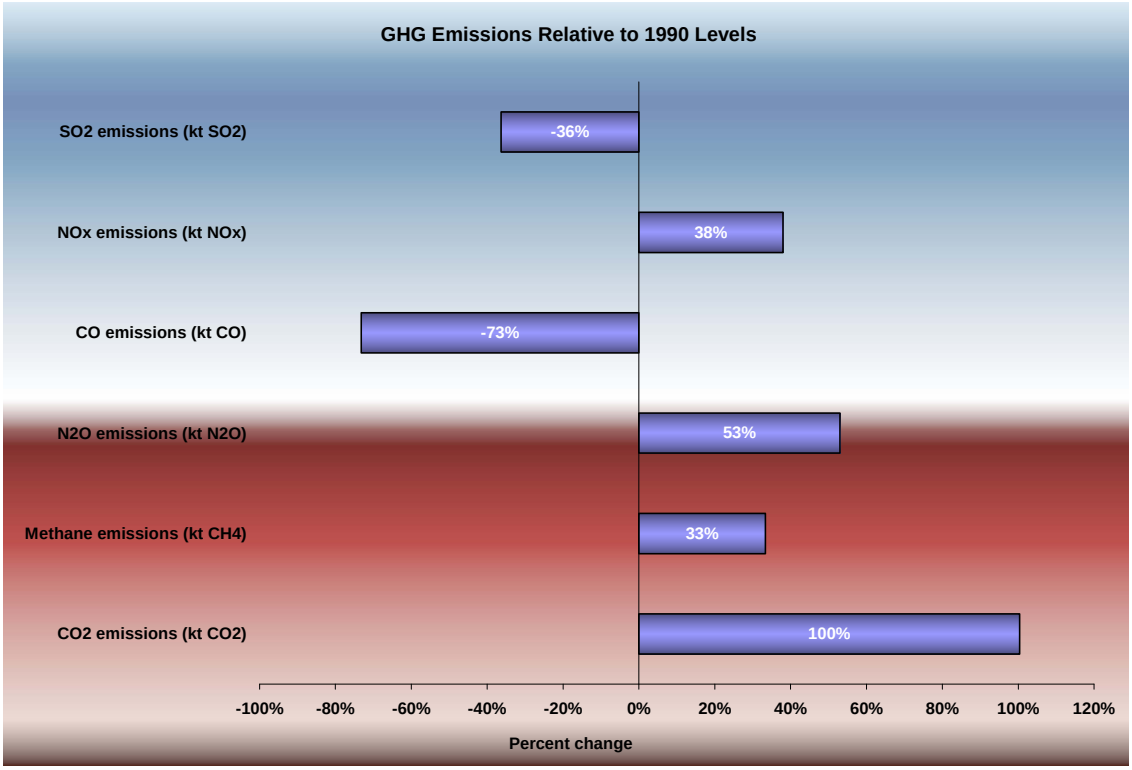


* Data for International Aviation emissions currently unreliable or too small to register

Source: AEA Technology, plc, 2010

In terms of total greenhouse gas emissions for the Cayman Islands, CO_2 emissions saw a doubling between 1990 and 2008, which is not unexpected since the population more than doubled during this period (from 26,969 to 57,009). Nitrous oxide (N_2O) emissions grew by over 50% no doubt a result of vehicles in use which increased 243% between 1992 and 2008, as well as growth in the use of synthetic fertilizers. Since 1990 carbon monoxide (CO) emissions have decreased significantly (73%), likely a result of industry-wide introduction of catalytic converters in vehicles and use of lower octane fuel, making tailpipe exhaust less polluting. A one-third reduction in sulfur dioxide (SO_2) emissions is probably attributed to an increase in supply side electricity efficiency and lower sulphur content diesel use over this period.

Figure 20 Cayman Islands GreenhouseGas Emissions 2008 relative to 1990



Source: AEA Technology, plc, 2010

In demonstrating its commitment to global climate change, the Cayman Islands Government requested the UK's ratification of the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol be extended to the Cayman Islands, which took effect in March 2007. Under the UNFCCC multilateral environmental agreement the islands have committed to implement GHG reducing policies and measures as well as to put in place an adaptation plan to respond to climate change related issues. Being among the most affluent islands in the Caribbean region, the Cayman Islands also has a certain responsibility to take a leading role in the area of environmental stewardship and the fight against global warming. A National Energy Policy would put in place a framework for incentivising a cleaner, less carbon-intensive energy mix and more

efficient energy consumption which will lead to a more sustainable and environmentally responsible use of energy resources in the Cayman Islands. This in turn will effect a reduction in national CO_2 emissions and potentially mitigate the environmental costs associated with climate change. Such a policy is currently under development with targeted action to 2030 and is expected to be in place by 2012.

Energy issues are inextricably linked with and critical to economic development. A sustainable energy policy will promote measures that will inevitably stimulate and diversify local economic sectors with associated growth in employment, through renewable energy and energy efficiency initiatives funded domestically and by way of direct foreign investment. Many energy and carbon reduction measures have adaptation co-benefits and less national expenditure allocated to providing energy needs results in more resources available locally for adaptation.

4.11 Construction and Real Estate

The construction industry forms a significant economic sector in the Cayman Islands as it supports other sectors such as tourism, real estate and the provision of public infrastructure. It is also a major employer of local as well as migrant workers. How the industry currently responds to weather-related hazards and extremes are important considerations for how it will fare under future climate regimes. The industry relies on adequate weather conditions for many aspects of its work, from site survey and foundation pouring, to roofing, rendering and well drilling. Delays in any one or more of these and other activities caused by unusually heavy or extended rainfall, or even extremely high water tables, are costly to the client. Exposure to intense hurricanes mid-construction could be detrimental to structures or projects if significant damage is sustained requiring unscheduled repairs prior to proceeding with the programme. Man-hours lost to heat stress and the potential for increased work-related accidents are also likely.

The construction industry plays a vital role in increasing the physical resiliency of the country against current climate variability and weather-related impacts such as flooding, coastal erosion, subsidence, and impacts to drainage systems, which all require new building techniques and materials to withstand adverse weather conditions[138.] Building to or exceeding code and industry best practices speak to climate-proofing new and existing development, which may affect project financing initially, but avoid future costs in business interruption and exorbitant insurance. Further, building industry initiatives can influence the insurance sector to put systems in place to discount climate change-related risk mitigation.

Undoubtedly this industry benefits from reconstruction requirements after a major hurricane as post-Ivan economic activity demonstrated. The reconstruction boom led to some 6,500 additional people in the workforce[139]. With proper adaptation planning and climate-resiliency incorporated in building codes,

[138] Kruse, C., 2004. IIGCC Briefing Note: Climate Change and the Construction Sector. ISIS Asset Management, June 2004.
[139] ESO, 2006. Labour Force Survey Fall 2005. Cayman Islands Government Economics and Statistics Office, Portfolio of Finance and Economics, Grand Cayman, 5 April 2006.

development plans, critical infrastructure planning, etc., post-disaster recovery should be shortened and require less reconstruction unless unanticipated threats reduce preparedness capabilities and predicted damages are exceeded. The explosion of contractors and construction companies post-Ivan also led to concerns about the quality of reconstruction. The Builders Law 2007 and accompanying regulations should address this concern and serve to prevent actions that are counterproductive to enhancing climate-resiliency of the built environment.

After devastating hurricanes the real estate sector will likely suffer initial shock to housing and commercial sales because of reduced building stock, with substantial offsets in the rental market as was the case after Ivan. Post-Ivan reconstruction works presented new development opportunities, especially along SMB as noted previously. Record sales of raw land - presumably inland locations - were recorded with active listings rising by 20% in 2005 over the previous year. Purchases of pre-built townhomes also increased in the outskirts of George Town away from the coast[140]. While hurricanes no doubt present the most immediate and widespread impact on the real estate sector, more extreme rainfall events exacerbating frequently flooded areas or impacting new ones will likely reflect in property values and resale potential. Practices in selected jurisdictions should be adopted locally, such as valuation reports that include risk assessment which insurance companies should require as policy[141], and the UK's 'Buyer Beware' practices where home purchasers must be given a risk assessment of property as part of full disclosure at the time of purchase[142].

CIREBA believes that the sector needs to make preparations for adapting to impacts from warmer seas, in particular hurricanes that track from the southeast to northwest. Preparation would be assisted by the generation of scenarios based on projected SLR and storm surge using historical data to determine the appropriate building elevation under a revised code. There is recognition that building elevations (and setbacks) cannot be uniform for all areas of Grand Cayman, and that treatment on a sub-national level will be required especially to avoid persistent flooding issues (e.g. Savannah Gully). Buildings constructed to code at +5 ft were flooded during Ivan so a change in code to +6 or 8 ft, and siting far enough away from the sea is required, particularly if the Cayman Islands will experience more hurricanes of Ivan's intensity. Government must do likewise and install more resilient public infrastructure by building roads higher.

Additionally there is a need to address regulations that discourage good practices, e.g. South Shore Coves redeveloped coastal property damaged in Ivan by placing the buildings on pilings, however planning permission restricted ground floor height to 6'6" because it would be considered another habitable space otherwise. The real cost of these measures augment the growing cost of construction in the Cayman Islands and must be passed on to the customer/new home owner. However in the long term these measures can save on insurance

[140] ESO, 2006. The Cayman Islands' Annual Economic Report 2005. Cayman Islands Government Economics and Statistics Office, Portfolio of Finance and Economics, Grand Cayman, June 2006.
[141] DOE, 2009. Comment by Willie Forsythe. In: Minutes of Insurance and Banking Stakeholder Consultation, 23 January 2009.
[142] DOE, 2009. Comment by George de Romilly. In: Minutes of Insurance and Banking Stakeholder Consultation, 23 January 2009.

premiums even though there is no incentive at present because a differential rate system is lacking[143].

Government incentives to encourage new home builders to construct safe rooms from flooding and wind damage (e.g. building a small multi-purpose room in the house that is +10 ft above MSL and with a concrete roof and reinforced doors) should be considered, as the number of shelter spaces on the Islands is currently insufficient given the local population.

4.12 Insurance

As late as 2006 the reinsurance industry was still largely ignoring climate change at its own peril but a shift in 2007 saw the industry recognize its ability to influence attitudes towards climate change and risk reduction. By 2008 climate change moved from a niche to mainstream topic featuring regularly on reinsurance conference agendas with discussion on ways in which the industry can confront climate change and further exploring risks as well as opportunities[144]. Reinsurers such as Swiss Re and Munich Re have climate policies that seek to better manage risk from present-day climate and future risk, and are actively pushing the insurance and banking industries to put similar measures in place[145]. Insurance companies closely monitor hurricane activity in the Atlantic Basin, as well as climate projections of future cyclone intensity and frequency. The relatively quiet disaster period in the 1990s, during which insurers adequately covered damages caused by storms, appears to be over with a marked increase in activity and intensity since 1995. In the decade 1998-2007 there have been five Category 5 hurricanes: 1998 Mitch, 2004 Ivan, 2005 Wilma, 2007 Dean and Felix.

Cayman Islands Risk Profile

Hurricane or catastrophe insurance in the Caribbean is deemed to be high price with low risk transfer[146]. Throughout the Caribbean the risk profile for insurance premiums is not very well defined – falling under the Gulf Coast risk profile partly due to lack of information for the Caribbean - and reinsurance as a safety net is not adequate. This means governments have to step up their disaster management funds[147] or significantly lower risk within the jurisdiction.

The risk in the Cayman Islands is termed low frequency, high severity, meaning a lower chance of the perils occurring but a high chance that should a peril occur,

[143] DOE, 2009. Comments by Kel Thompson. In: Minutes of Real Estate and Construction Stakeholder Consultation, 23 January 2009.
[144] Global Reinsurance website http://www.globalreinsurance.com/issueIndex.asp?issueCode=1089
[145] DOE, 2009. Comment by George de Romilly. In: Minutes of Insurance Stakeholder Consultation, 23 January 2009.
[146] Pollner, 2001 in Tompkins, E.L., L-A. Hurlston and W. Poortinga, 2009. Foreignness as a constraint on learning: The impact of migrants on disaster resilience in small islands. *Environmental Hazards* 8 (2009) 263-277.
[147] DOE, 2009. Comments by Dr. Neville Trotz, Project Technical Team Coordinator. In: Minutes of the 7th Meeting of the National Climate Change Adaptation Working Group, 21 January 2009.

the losses will be high[148]. The Cayman Islands, like many small islands, already suffer the cost of remoteness through high freight insurance, and are exposed to the hazards that trigger increases in other insurance premiums (property, motor). With the Islands located in the Northwest Caribbean - considered to be a Category 5 hurricane 'hot spot' because seawater temperatures are the warmest in the Caribbean, and the warm layer is deep[149] – the exposure to severely damaging and costly natural hazards is even greater. The relatively shorter tropical storm and hurricane return periods for the Cayman Islands' location is an underlying risk factor, and so too is the low-lying nature of the Islands which extends risks from the coast to farther inland. The extent of damages in the Cayman Islands has drastically increased: Hurricane Gilbert damage exceeded CI$16 million in 1988 while Ivan damage and losses totaled CI$2.8 billion (138% of 2003 GDP). Claims have also increased causing local premiums to similarly rise in the short-term. Gross domestic written premiums for property was CI$65.7 million in 2004, jumped to CI$104.6 million in 2005, and now stood at CI$146.7 million in 2008[150]. The frequency of other extreme events (droughts, floods) is also expected to increase, perhaps requiring new types of coverage not typically accessed, e.g. insurance for farmers.

Avoiding Future Insurability of the Cayman Islands

According to climate change and insurance experts, the Cayman Islands could potentially face a future of uninsurability. Many properties on Grand Cayman in particular are currently close to the 'limit of insurability,' having risk characteristics similar to coastal areas of North Carolina or Queen's Cove canal estate in Grand Bahama which are now insurable[151]. Queen's Cove suffered extensive flooding damage from Hurricanes Floyd, Frances and Jeanne which left homeowners of inexpensive apartments to seaside mansions with massive repairs and reconstructions. Banks have not extended mortgages to properties now ineligible for insurance which has resulted in incomplete repairs and in some cases abandonment of homes[152].

[148] Bowyer, L., personal communication, December 3, 2009
[149] Muir-Wood, R., 2008. "Climate Change & the Cayman Islands – Building Resilience." Presentation to Cayman Business Outlook, January 17th 2008.
[150] ESO, 2009. Monetary and Financial Services. In: Statistical Compendium 2008. Cayman Islands Government, Grand Cayman.
[151] DOE, 2008. Presentation by Dr. Robert Muir-Wood, Lead author of Climate Change and Insurance for IPCC Fourth Assessment Report and Chief Researcher at Risk Management Solutions, to the National Climate Change Adaptation Working Group. In: Minutes of the 2nd Meeting of the NCCAWG, 18 January 2008.
[152] Schwab, T. 2006. "A new, uninsured reality," The Freeport News, Friday, November 10, 2006.

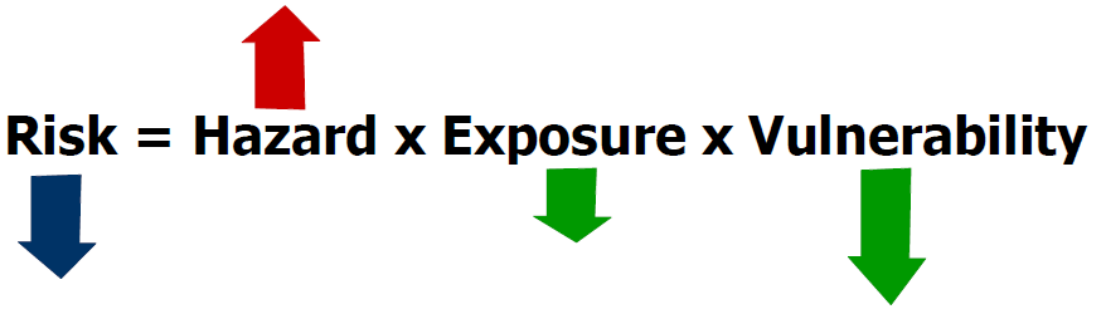
Photo 11 Queen's Cove canal estate, Grand Bahama; properties sitting 2-3 ft above sea level, flooded three times in 10 years by storm surges. ***Credit: Risk Management Solutions.***

Three factors could tip the situation over the edge in the Cayman Islands as well. Firstly, the occurrence of another Ivan-type event could play a major role, the losses from which in the Cayman Islands were $70,000 per insured – the highest per capita category loss for any country – with up to 15,000 property claims and 10,000 motor vehicle claims covered by 10 locally licensed insurance companies and over US$1 billion paid by reinsurers[153]. Secondly, evidence suggests in the long term that these Islands and the region may face increasing exposure to more intense hurricanes. Thirdly, continued acceleration of sea level rise to the 2020s and beyond exposes more areas inland to storm surge flooding, affecting property and vehicles. However it is not simply the climate risk posed by hurricanes and associated increases in insurance claims. More frequently occurring flooding due to heavy rains will also increase the amount of claims in the jurisdiction and could make the overall risk associated with the Islands too great to be insured.

The ability to influence reinsurers regarding the risk in the Cayman Islands is not straightforward. The process to negotiate reinsurance is rather antiquated, although some reinsurers are taking a proactive approach to climate change and seeking to encourage risk mitigation (Munich Re and Swiss Re). In general the market is too large for one small nation to lobby. Nevertheless, the Government and business community urgently need to demonstrate through an effective plan that the Cayman Islands can and will reduce its current high risk status which might give reinsurers renewed confidence in these Islands.

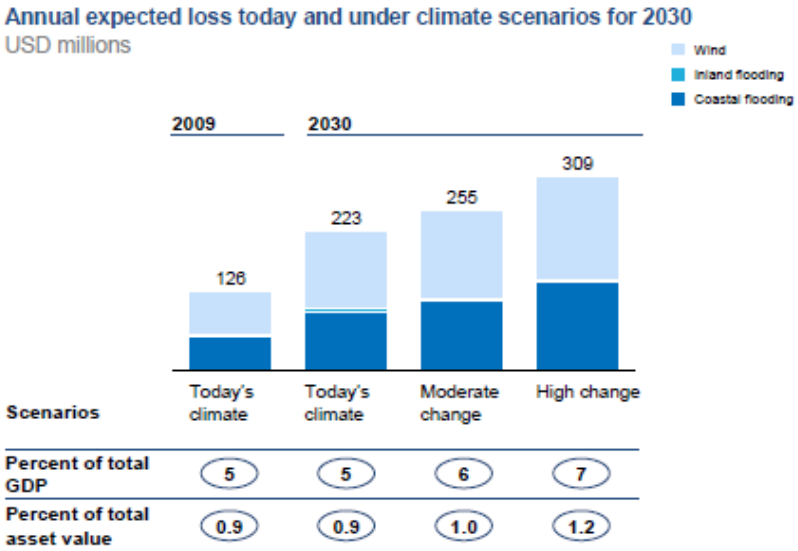
To reduce its current risk to climate hazards and those that are expected to be amplified, the Cayman Islands must reduce the level of exposure to these hazards and the degree of susceptibility of each element exposed.

[153] Twohey, N. Insurance in the Cayman Islands Following Hurricane Ivan, October 30, 2004.



The Cayman Islands was included in a study on the *Economics of Climate Adaptation* undertaken by the CCRIF and McKinsey Group in partnership with the CCCCC and UN ECLAC in August 2010[154]. The current and future expected losses from climate risks - hurricane-induced winds, coastal flooding from storm surge and inland flooding from both hurricanes and tropical systems - for three climate scenarios using global and regional circulation models based on IPCC SRES A2 were assessed. The potential loss was then estimated using an approach similar to that applied for calculating insurance premiums. The current climate risk for the Cayman Islands is already high - 5% of local GDP - with expected losses of up to 7% in the high climate change scenario by 2030 (Figure 21). Comparatively, this is one of the highest loss jurisdictions of all the Caribbean countries studied (Figure 22). While the contribution of coastal flooding from storm surge remains at about 45% of the total damage potential across all scenarios, expected loss nearly triples by 2030 (US$126 to US$309 million).

Figure 21Annual Expected Loss from Climate Risks 2009 and 2030

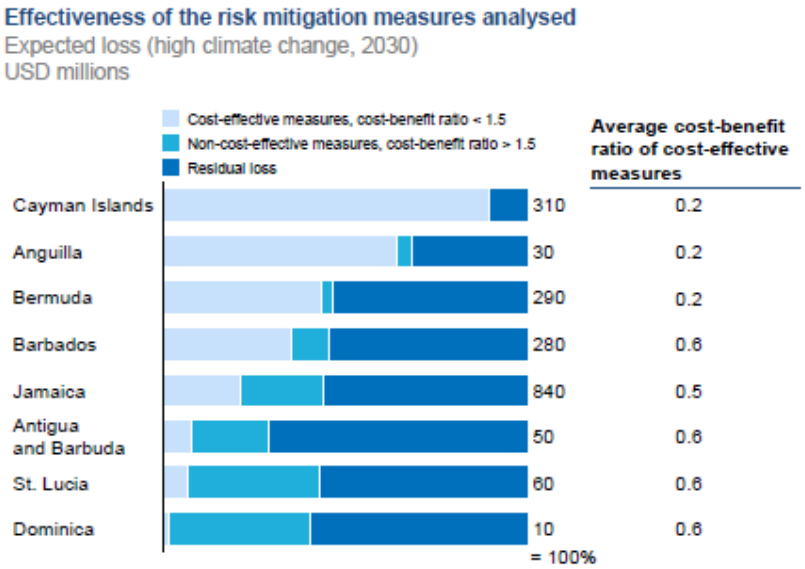


Source: CCRIF (2010)

[154] CCRIF, 2010. Enhancing the Climate Risk and Adaptation Fact Base for the Caribbean: An informational brochure highlighting the preliminary results of the ECA Study., CCRIF, Grand Cayman, Cayman Islands

The most compelling reasons for adaptation is shown in Figure 22 which demonstrates that the Cayman Islands can avoid up to 89% of the expected loss by implementing cost-effective adaptation measures (Figure 23). The benefits – that is, the averted losses – and the costs were quantified and a cost-benefit ratio was computed, which accounted for cost of capital, investment costs and operating costs. Measures with a cost-benefit ratio below 1.5 were considered to be cost effective across all countries. With an average ratio at 0.2, it is clear that the Cayman Islands is in a good position to cost-effectively avert significant loss through risk mitigation measures, with the small residual risk addressed through the purchase of risk transfer solutions.

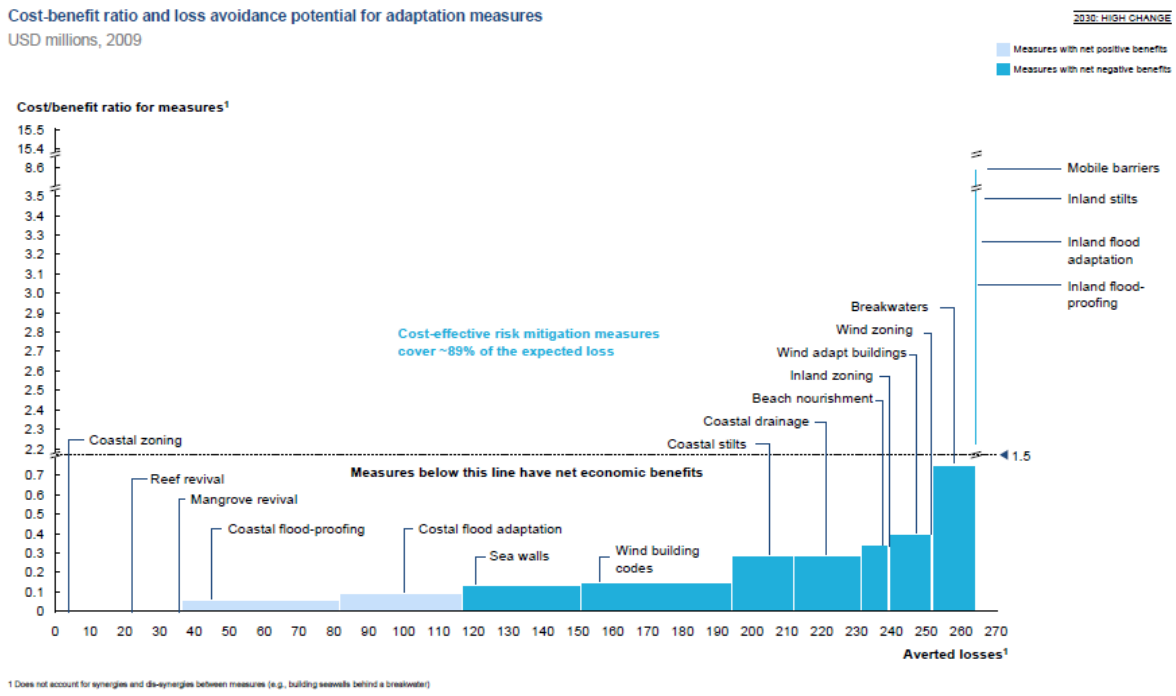
Figure 22 Cost Effectiveness of Adaptation in the Cayman Islands



Source: CCRIF (2010)

The types of risk mitigation measures and the loss avoidance they would achieve are shown in Figure 23. These range from environmental rehabilitation, land use planning and building regulation, to hard and soft engineering solutions. Coastal flooding and coastal flood adaptation measures have net positive benefits as they address the majority of the climate threat and total damage to these very low-lying islands.

Figure 23 Loss Avoidance Potential of Adaptation Measures



This information should now motivate Government to enact the wider policies and legislation needed to reduce current and future risk with the aim of avoiding uninsurability. This action would provide the necessary framework for the local banking and insurance industry to incentivize and reward risk reducing behaviour.

Uninsured Public Infrastructure and Utilities

Like many small islands, most critical infrastructure is located on the coast, and risk cannot be easily avoided, especially primary coastal roads that are too costly to relocate or where relocation is now not an option due to surrounding development. This option also does not exist for ports. The business reality for the Cayman Islands is that certain marine assets such as docks and ports have not been insurable for some time due to events like Hurricanes Andrew and Katrina, and the 2004 Indian Ocean tsunami. This has put greater emphasis on designing public infrastructure and tourism projects for risk reduction, however best data only allow design to certain thresholds[155]. Integration of climate projections into project designs and ensuring construction standards can withstand the expected impacts from climate-related weather hazards (e.g. high wind speeds, wind-borne debris, water damage from hurricanes, and flooding from both storm surge and heavy rainfall events) is still not a common practice. While Government policies may have shifted in terms of planning, design and siting new public sector assets using risk engineering studies[156], the application

[155] DOE, 2009. Comment by Gloria McField Nixon. In: Minutes of Ministry of Tourism Stakeholder Consultation, 23 January 2009.
[156] DOE, 2009. Comment by Rick Quittell. In: Minutes of Finance Stakeholder Consultation, 23 January 2009.

of such policies to every new project has not been consistent. Nor has Government employed the proper use of environmental impact assessments and the integration of climate change considerations into such processes which is now standard procedure worldwide for planning or funding of capital projects.

CUC practice - which is common industry practice for utilities in the Caribbean - is to maintain adequate levels of hurricane insurance for buildings, substations and generating facilities[157]. In 2007 CUC had a similar insurance coverage as in 2004 when Hurricane Ivan hit: property insurance of $100 million, $55 million in business interruption coverage and $15 million in machinery breakdown insurance with major international insurers costing a premium of $3.2 million[158]. Coverage was adequate to deal with the CI$33.9 million in damages and $35 million in business losses. All T&D assets outside of 1,000 ft from the boundaries of the main plant and substations are excluded, as the cost of such coverage is not considered economical[159]. The industry practice within the Caribbean and Florida in regards to insuring and financing overhead T&D infrastructure is to have predefined mechanisms to recover uninsurable replacement costs for overhead infrastructure. These mechanisms generally involve a cost recovery surcharge to customers over a 3 to 5 year period and to ensure the utility maintains adequate lines of credit and financing capability to invest in such repair costs. This has been successfully done in Cayman, Florida and Jamaica over the last 10 years. Some utilities also maintain a hurricane savings fund to cover some of the replacement costs associated with hurricane related damage to uninsurable overhead infrastructure. However, the disadvantage with this method is that customers have to pay higher utility rates now to invest in such a fund instead of paying for the replacement costs when the hurricane related damage occurs.

Similarly the Water Authority's reverse osmosis plants are insured against hurricane threats however its underground pipeline distribution system is not insured. While pipelines can be insured, the Authority has made the conscious decision that the costs outweigh the benefits. For example, WAC lost 2% of pipelines in Ivan, with a deductible of anywhere between 2% to 5% of insured value of the entire underground pipeline systems, it would not have had any insurance claim. Like other utilities self-insurance is built into its business model. In the Hurricane Ivan example, the cost recovery for damaged water mains was not passed on by WAC to the customer, unlike the hurricane surcharge of CUC[160].

In other jurisdictions, utilities and other infrastructure providers that find it difficult to or currently do not insure certain assets have entered into self-insurance pools. Locally such schemes for critical infrastructure may need to be facilitated by Government. A comparable framework already exists for the

[157] Watler, D. Vice President, Production, Caribbean Utilities Company. Personal communication, 16 December, 2009.
[158] ECLAC/UNDP, 2005. The Impact of Hurricane Ivan on the Cayman Islands. LC/CAR/L.25, 10 January 2005.
[159] Caribbean Utilities Company Ltd., 2008. 2007 Annual Report: Celebrating 40 Years in Paradise.
[160] Crabb, C. Senior Development Control Technologist, Water Authority-Cayman. Personal communication, 10 December, 2009.

captive health insurance industry[161] which has not been affected by the financial downturn because parent companies are still fairly liquid[162].

Lack of Industry Incentives

Similar to the health sector, the increased cost of homeowners and commercial property insurance will either occur in the industry itself and passed on to customers, or borne by government and supported indirectly by taxpayers. Therefore it is vital that risk mitigation measures are put in place now to alleviate these costs for the wider society, lessen the public sector burden and avoid an uninsurable future. Some risk-reduction measures have been seen to take place in the absence of public policy or industry incentivization, such as filling building footprints to higher elevations, constructing buildings on pilings with wash-through ground floors, installing hurricane shutters at the completion of new construction, and retrofitting with metal seam roofing. However, policy holders have seen their deductibles increase from 2% to 5% and remain frustrated over the lack of differential rates in the Cayman Islands which have been applied in other jurisdictions to the risk reduction measures demonstrated. This is because insurance premiums in the Cayman Islands are not tied directly to local impacts as reinsurance markets are strongly affected by global disasters (e.g. 9/11, multiple hurricanes affecting the US and Caribbean in 2004). Further, government has not set in place policy mechanisms and legislation (e.g. use of insurers risk models in the planning process, enact flood resilient building code) that incentivize risk reduction action by the insured majority hence the local industry has been slow to respond with restructured rates.

Some local insurers have started to link local risk to insurance rates and offer limited incentives, e.g. Island Heritage lowers rates for installation of hurricane shutters. However this only addresses hurricane wind hazard and not flooding. Not placing structures in hazard-prone or highly vulnerable areas in the first instance where this can be avoided is not part of national planning policy or legislation, nor part of current insurance industry practice to risk reduction. Using the planning process as the early entry point for risk management is critical[163]. This provides for climate-proofing of infrastructure and projects through the structural integrity of designs and appropriate siting at the outset so as to minimize risk and ensure eligibility of assets for insurance coverage at reasonable rates. However planning policies and buildings codes need to work in concert with insurance industry action in order to affect a broader change in behaviour and construction practices. Puerto Rico provides a good case study for how the introduction of construction techniques was used to achieve one of the lowest insurance rates in the region[164]. The 'mitigation credit' system pioneered in Florida is an example of incentivizing adaptation through insurance pricing[165].

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[161] DOE, 2009. Comments by Ronnie Dunn. In: Minutes of Finance Stakeholder Consultation, 23 January 2009.
[162] DOE, 2009. Comments by Willie Forsythe. In: Minutes of Insurance and Banking Stakeholder Consultation, 23 January 2009.
[163] DOE, 2009. Comment by Dr. Trotz. In: Minutes of Ministry of Planning Stakeholder Consultation, 22 January 2009.
[164] DOE, 2008. Comment by Dr. Robert Muir-Wood. In Minutes of the 2nd Meeting of the NCCAWG, 18 January 2008.
[165] Muir-Wood, 2008.

Coverage for Agriculture Sector

In agriculture the lack of any form of crop insurance is a major impediment to increased production as persons are hesitant to invest. More frequent stronger hurricanes and adverse whether events and less recovery time between events, without any financial support network, will result in further production losses, as has already been seen in the significant reduction of domestic banana and avocado production.

Caribbean Catastrophic Risk Insurance Facility

Reducing risk in hurricane or flood-prone areas, especially where vulnerable groups are located, is paramount given that additional forms of risk transfer currently sought by CIG may not be reliable as once thought. A case in point is the Caribbean Catastrophic Risk Insurance Facility (CCRIF), a regional parametric insurance fund for earthquake and hurricane coverage in which the Cayman Islands participates with 15 other countries. The Cayman Islands was not able to benefit from the CCRIF after hurricane Paloma devastated Cayman Brac because the damaged area did not account for the majority of the population or asset holdings of the country. Damage criteria refinements are perhaps needed for this evolving facility. Government is currently reviewing the annual premium of CI$1.68 million contributed with respect to terms of coverage and whether a reduced premium should be paid on only the portion of coverage the country is likely to receive under the current criteria. An economic assessment of predicted climate risks to the Cayman Islands as well as an analysis of cost-effective risk mitigation measures for Government and key national assets should assist in reducing this premium and avoid future uninsurability.

4.13 Financial Services

The financial services sector generated CI$1.2 billion in GDP in 2007, representing 55% of the Cayman Islands economy based on the latest Economics and Statistics Office estimates of total GDP and 40% of all government revenue in 2007[166]. The sector directly employed 5,723 persons in 2007 in hedge funds management, offshore banking, offshore securitization and structured finance, captive insurance and high-net worth private trusts. When downstream impacts are included, financial services generated employment of 12,603 representing 36% of all employment in the country. Nearly 60% of these employees are Caymanian. Over 419 bank and trust companies alone were registered in 2008, (although down from 580 in 2000[167]), with the majority of these company activities concentrated in George Town. The sector's physical infrastructure is vulnerable to current extreme weather events and tropical cyclones which cause major structural damage to buildings from high winds and flooding, downed electricity lines and telecommunication networks and restricted access by management and staff to offices from outer districts.

[166] The Cayman Financial Review, 2009. "CIFSA: Economic Impact Study – putting a hard number to it," 17 April 2009.
[167] ESO, 2009. Ch. 6. Monetary and Financial Services. In: *Statistical Compendium 2008*. Economics and Statistics Office, Cayman Islands Government, George Town, Grand Cayman.

However, unlike other sectors, the financial services sector did not sustain significant direct damage, showing a high level of resiliency when tested by hurricane Ivan. This allowed for rapid recovery post-storm - some companies even maintained operations during the storm – having little affect on certain sub-sectors such as company registration, which actually increased during September 2004[168]. Effective contingency planning and supporting information technology systems played important roles in re-routing business through other jurisdictions where staff had been efficiently placed either before or immediately after the hurricane. Though reliant on a resilient telecommunications network and airlift services, the adaptive nature of the sector lends itself to a higher level of climate resiliency than tourism. However the very mobility of the financial services sector means that businesses can relocate some or of all of their services permanently as a result of climate or other risks perceived in this jurisdiction. While Hurricane Ivan served as a catalyst for expanding business continuity services and other risk management consulting opportunities which will clearly assist the sector and other commercial interests in addressing climate-related risks, it also increased operating costs in terms of travel expenses for staff and families, and use of alternative communications and utilities services. The threat of stronger hurricanes from climate change could necessitate similar responses in future, the cost of which will likely be borne by clients, and is among the risks to this sector.

Despite its apparent resiliency, the banking sector in particular is not without risks to its own assets. Increased frequency of flooding to homes mortgaged under their portfolios will affect bottom lines and lending capabilities of local banks if the uninsured risk becomes too large. However the sector is in a favourable position to assist with facilitating national adaptation by ensuring risk is reduced at the outset of loans or fully underwritten through its lending policies. Further, the banking sector in other jurisdiction has been instrumental in providing the means for home owners and businesses to retrofit their properties with energy efficient equipment through a host of measures including energy saving mortgages. A similar mechanism could be used for investments in adaptation measures at the household and small business levels.

The issue of climate change is repositioning the financial services industry globally. Banks have been recognized for the role they play in society's adjustments to climate change through financing and investment decisions, credit risk management policies and lending practices, and the development of risk mitigation products[169]. Leading international banks now incorporate climate change considerations into their due diligence for project financing and lending policies through credit underwriting criteria that address the specific climate change risk of a particular loan. Dresdner Bank, Barclays Capital, Fortis and ABN Amro have well-articulated climate change policies which have provided these banks the opportunity to widen the scope of services to their clients that have become subject to those procedures. The concept is not new; environmental considerations in lending has been practiced for some time by the World Bank and over 40 of the major financial institutions through the adoption of the

[168] ECLAC, 2005. The Impact o f Hurricane Ivan on the Cayman Islands. LC/CAR/L.25, 10 January 2005.
[169] Allianz Group and WWF, 2005.). Climate Change and the Financial Sector: An Agenda for Action, June 2005.

Equator Principles, an industry standard for environmental and social management within project financing that requires an environmental impact assessment for projects totaling more than US$10 million in capital costs. Financial institutions such as JPMorgan Chase are working with their clients to identify and mitigate GHG emissions and climate-related risks associated with specific projects[170].

Types of climate change-related risks and opportunities for banks are suggested in the table below.

Table 17 Important Climate Change-Related Risks and Opportunities for Banks

Banking class	Examples of risks	Examples of opportunities
Corporate banking and project financing	• Reduction in competitiveness of GHG-intensive business clients due to higher mitigation costs • Higher costs for consumers of energy due to new mitigation policies • Price volatility on carbon markets and carbon-related products • Reputational risks due to investments in controversial energies projects (e.g. large dams, nuclear power)	• Risk management services for clients affected by the EU ETS • Carbon trust services (administration and custody of client's emission allowances account) • Carbon project finance services (JI/CDM)
Investment banking and asset management	• Investment in immature technologies • Additional costs due to changes in weather patterns e.g. in the utilities sector	• Trading services in the EU ETS • Offering weather derivatives • Set up of carbon fund and fund custody
Retail banking	• Direct losses due to drought, precipitation, soil erosion, flood • Policy change, e.g. termination of subsidies for renewable energies	• Microfinance for climate-friendly activities • Advisory service in the field of loans for small sized renewable energy projects

Source: Allianz Group and WWF, (2005). Climate Change and the Financial Sector: An Agenda for Action, June 2005.

Climate change considerations are starting to pervade through the chain of responsibility of asset management. Investors who have been following socially responsible investment strategies for years now view climate change as a strategic factor in portfolio performance. Institutional investors groups that have acknowledged climate change as a material impact on their investments include the Institutional Investors Group on Climate Change (IIGCC) in Europe and the Investor Network on Climate Risk in the US. Those institutional investors and fund managers are building capacity to evaluate climate change impacts on or enhancement of investment values using tools to assess climate change risk in

[170] Davis, C. A. Joroff and C. Jenks. "Climate Change Strategies for the Financial Services Industry." Godwin Procter Environmental and Energy Advisory: An update on law, policy and strategy, January 4, 2007.

their portfolios such as World Resources Institute reports, the Carbon Disclosure Project and in-house Socially Responsible Investment specialists. Other reputable guides on investment published by the United Nations Environment Program Finance Initiative (UNEP FI) include[171]:

"The Principles of Responsible Investment"
"Unlocking Value: The scope for environmental, social and governance issues in private banking"
"Demystifying Responsible Investment Performance"
"Fiduciary responsibility – Legal and practical aspects of integrating environmental, social and governance issues into institutional investment"
"The materiality of climate change – How finance copes with the ticking clock"

There are many other guides related to lending and insurance.

A key issue is that fund manager performance is measured based on short-termism (quarterly corporate performance) primarily within hedge funds, which is contrary to the long-term nature of climate change. Fund managers and financial analysts will need to build capacities to make informed decisions on climate change risks and opportunities related to clients' assets and meeting clients' expectations. Across the spectrum recognition that international climate policies and legislation are set to widely influence future global capital markets and ultimately shareholder value is paramount[172].

Companies within the sector worldwide face reputational and competitive risks based on their response to climate change issues. Increasing pressure to improve corporate governance on business risks and opportunities posed by climate change and greater disclosure is being applied within the sector by groups such as CERES (Coalition for Environmentally Responsible Economics – a network of institutional investors, environmental and public interest groups working to address global climate change), as well as the Investor Network in Climate Risk (representing some US$4 trillion in assets). Externally there is pressure by the public and stakeholders on the sector to address activities at corporate level to reduce their own GHG emissions, and good environmental performance has been linked to good financial performance. Many are incorporating the use of the Global Reporting Initiative, the de-facto international standard used by over 1300 companies for corporate reporting on environmental, social and economic performance, and/or the GHG Protocol, the standard for accounting and reporting company GHG emissions. Financial institutions that find themselves without credible climate policies that address the reduction of GHGs and now increasingly social responsibility goals aimed at climate change adaptation can be at a competitive disadvantage from the perspective of customers and investors. They risk poor reviews by climate-focused advocacy groups and loss of confidence by institutional investors[173]. These risks and pressures are likely to increase as awareness of climate change and its impact particularly on extremely vulnerable communities and small islands becomes more widespread.

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[171] Bowyer, L., personal communication, December 3, 2009
[172] Allianz Group and WWF, (2005). Climate Change and the Financial Sector: An Agenda for Action, June 2005.
[173] Davis, C. A. Joroff and C. Jenks. "Climate Change Strategies for the Financial Services Industry." Godwin Procter Environmental and Energy Advisory: An update on law, policy and strategy, January 4, 2007.

4.14 Tourism

Travel and tourism directly and indirectly contributed CI$523 million in GDP in 2007, equivalent to over 24% of total GDP of the Cayman Islands economy. In the same year those directly and indirectly employed in travel and tourism activities were 8,600 persons, representing nearly 28% of total employment. In 2010 the tourism economy is expected to contract by 0.4% from 2009 to CI$515 million in GDP with a corresponding decline in jobs by 0.2% to 8,200 persons. The economy is forecast to achieve annualized real growth by 2020 of 3.1% to CI$909 million with roughly the same percentage of employment contribution as in 2007, equivalent to 9,500 jobs[174]. Given the large expatriate workforce in this and other sectors, the Islands have now become a source for remittances to populations in countries around the world.

Economic impact of hurricanes

Tourism managers foresee decreased economic capacity given the increased threat of storms and resultant damage to the tourism plant, and the need for Government to partner with others to share future risk[175]. Visitor expenditure in the year of Ivan was CI$435 million which dropped to CI$294 million the following year, demonstrating the hurricane's devastating impact on this sector. By 2006, visitor revenue injected CI$424 million back into the Cayman Islands' economy, a testament to the resiliency and rapid recovery of the sector and its key businesses. However, the Ivan experience is sobering considering this level of exposure to severe category 4 and 5 hurricanes may become the norm (in La Niña years). Ivan caused CI$281.5 million in damages to hotels and condos from storm surge-induced flooding (75% of the damage cost) and wind damage, permanently withdrawing room stock as some properties have not reopened or have been diverted to other uses, e.g. residential housing [176]. Indirect damages from reduced cruise tourism include loss of port fees and visitor expenditure during closure of port facilities and the rebuilding of tourism infrastructure (ground transport, restaurants, attractions, etc.). No cruise ships visited between 9 September and 1 November 2004 as a result of direct damages to the port and facilities that support cruise ship activities, resulting in CI$25 million lost revenue from cruise tourism.

The indirect impact of hurricanes in terms of lost revenue starts with preparation activities and continues through down time for rebuilding. In the case of Ivan, loss of stay over tourism in 2004 was CI$72 million which extended into 2005. While hotels have loss of business insurance to compensate for lost room rentals during this time, few condos, apartments and guesthouses have such a safety net which, coupled with a high level of underinsurance affecting the ability to undertake repairs, could lead to permanent business closures[177]. Many tourism properties have strata arrangements which can further delay reopening due to

[174] World Travel and Tourism Council, 2010. Travel and Tourism Economic Impact 2010: Cayman Islands.
[175] DOE, 2009. Comment by Gloria McField-Nixon. In: Minutes of Ministry of Tourism Stakeholder Consultation, 23 January 2009.
[176] ECLAC, 2005. The Impact of Hurricane Ivan in the Cayman Islands. LC/CAR/L.25, 10 January 2005.
[177] ECLAC, 2005.

insurance settlement and reconstruction issues. The next major hurricane has implications for insurance coverage, particularly with the possible threat of uninsurability looming over the Cayman Islands. The ability to spread catastrophic risk for tourism plant and other critical infrastructure like roads through regional programmes may not be an adequate safety net. While Government's risk management concerns are to protect its own assets and those of sectors which cannot get/afford coverage, there is a need to reduce the risks and associated damages through measures within our control, such as appropriate siting and design of new facilities and redevelopment projects. Running scenarios using local insurance, tourism and geographical information systems data inputs to identify existing vulnerabilities and levels of risk has been suggested. In terms of future tourism development, guides now exist for integrating EIA – a natural starting point in the design of a project to explore weather hazards and related risk - with climate change adaptation utilizing projections for the Caribbean region. This is a departure from using historical data for all planning[178].

Damage to Tourism Product

As the Cayman Islands tourism product is primarily built around 'sun, sand and sea' and thus reliant on natural attractions such as beaches, coral reefs and fisheries, the degradation or loss of these assets from beach erosion, coastal land loss and coral bleaching is of tremendous concern. For years a few properties at erosion 'hot spots' on Seven Mile Beach have had to contend with temporary and sometimes extensive beach losses, and the cost of continually rebuilding damaged facilities (e.g. seawalls, swimming pools, cabanas) located too close to the sea. The Beach Review and Assessment Committee (BRAC) Report 2003 addressed beach nourishment needs and requisite contingency planning for Seven Mile Beach specifically in relation to continued beach retreat resulting from sea-level rise or major hurricanes. Despite Government and the tourism sector being aware (via representation on the Committee and tabling of the report) of the extent of lost revenue from serious beach erosion on SMB, to date no funding sources have been identified to draft and implement contingency plans which identify sources and stockpile locations of equivalent beach quality sand, appropriate placement methodology, etc.[179]. Cancun after hurricane Wilma is a good example of huge beach nourishment efforts that will likely have to be continued on a regular basis, and the situation may be similar for SMB[180]. If that is the case then funding sources for this and other adaptation and contingency measures need to be identified sooner rather than later.

Public-private commitment and resources are needed to address this issue. Possible Government funding sources include taxes derived from travel although there is a need to clarify how these funds are utilized, which requires dialogue with the Portfolio of Finance[181]. However climate change is admittedly not a high priority; when it comes to budgeting it is the first to be cut in terms of financing

[178] DOE, 2009. Minutes of Ministry of Tourism Stakeholder Consultation, 23 January 2009.
[179] DOE, 2009. Comments by Gina Ebanks-Petrie. In: Minutes of 2nd Meeting of the NCCAWG, 18 January 2008.
[180] DOE, 2009. Comment by Dr. Robert Muir-Wood. In: In: Minutes of 2nd Meeting of the NCCAWG, 18 January 2008.
[181] DOE, 2009. Comment by Gloria McField-Nixon. In: Minutes of Ministry of Tourism Stakeholder Consultation, 23 January 2009.

programmes[182]. For effective adaptation Government must get away from viewing climate change as a "programme" but rather a fact of life, otherwise the budget dilemma will be resolved through the cost of inaction[183]. A Stern-type review for the OTs would be useful to finance departments and budget managers in translating the risks and impacts from climate change science into dollars and cents.

Product quality tied to environmental conditions that do not meet visitors' expectations has been assessed in other Caribbean tourism destinations. A study in Barbados showed tourists' reduced willingness to pay for erosion-impacted beaches[184]. Similarly, willingness to pay for diving on coral-bleached reefs decreased in Bonaire[185]. Currently overall customer satisfaction with the scuba diving, snorkeling and fishing products in the Cayman Islands rates highly (3.61, 3.52 and 3.12, respectively out of 4)[186]. It is not known if or how much revenue from these activities may be lost locally from severe bleaching events like that witnessed in 1998 and 2009 or from the wider ecological implications on local fisheries. However, it is clear that without proper management of diving pressure, nutrient loading and other anthropogenic stressors on these systems, the quality and rating of marine attractions will decline[187] – a risk the Cayman Islands can ill afford even without the threat of climate change.

Other attractions and tourism activities at risk include Stingray City-Sandbar tours which are currently affected by unsettled weather conditions and more frequent closures of these sites for safety reasons. While these occurrences primarily affect lost revenue to charter boat operators, there are knock-on effects for ground transport and other sub-sectors. Structural damage or temporary closures to some land-based sites are climate risk factors. Hurricane Ivan badly affected natural features in some areas of the Botanic Park and devastated the great house at Pedro St. James which did not open for some time. As with the accommodation sector, delays due to insurance settlements and difficulties in finding qualified contractors to start repair work is a concern, particularly for the very vulnerable National Museum building which requires specialists in historical building conservation and rehabilitation.

[182] DOE, 2009. Comment by Ronnie Dunn. In: Minutes of Ministry of Finance Stakeholder Consultation, 23 January 2009.
[183] DOE, 2009. Comment by Gina Ebanks-Petrie. In: Minutes of Ministry of Finance Stakeholder Consultation, 23 January 2009.
[184] Uyarra, M.C., I.M. Cote, J.A. Gill, R.R.T. Tinch, D. Viner, and A.R. Watkinson, 2005. Island-specific preferences of tourist for environmental features: implications for tourism-dependent states. *Environmental Conservation* (32): 11-19.
[185] Uyarra et al, 2005.
[186] Deloitte, 2008. Water Sports Market Assessment, November 26, 2008.
[187] Deloitte, 2008.

Table 18 Potential Climate Change Impacts on Tourism Infrastructure and Amenities

Attraction at Risk	Effect of Climate Change	Impact on Attraction
Stingray City / Sandbar	• Sea level rise • Increased storminess; change in wind patterns	• Deeper sites, ability to stand at Sand Bar reduced • Reduced no. of trips due to sea state conditions
Beaches	• Sea level rise	• Reduced area, overcrowding, user conflicts
Dive tourism	• Sea level rise • Increased storminess • Stronger hurricanes • Increased sea temperatures	• Deeper sites • Reduced no. of trips • Physical damage to reefs • Coral bleaching, die-off or disease
Botanic Park	• Increased drought • Wind damage • Increased temperature	• Irrigation issues • Reduced site attractiveness • Risk of heat stress to visitors
Blow Holes	• Sea level rise	• Submerged cavities, no dramatic pictures
Hell	• Increased rainfall intensity	• Flooding
Pedro St. James	• Increased storm intensity, wind and rainfall	• Flooding, wind-borne debris, damage to structures & property • Event cancellations
Cayman Turtle Farm	• Increased storm intensity, wind and rainfall • Increased temperature	• Flooding, damage to structures & exhibits • Water quality affected within turtle & other enclosures
CI National Museum	• Sea level rise, increased storminess, storm surge and hurricanes	• Damage to structures & property from flooding and wind-borne debris
Pirates Weeks Festival	• Increased storminess, rainfall	• Event cancellations
Maritime Heritage Trail	• Stronger hurricanes, wave action • Change in wind patterns	• Destruction, dislodgement or burial of historic shipwrecks and artefacts
Heritage Sites (Lighthouses, Mission House)	• Increased storm intensity, wind and rainfall • More intense rainfall events • Higher temperatures	• Wind and water damage • Flooding • Terminate, deterioration of structures

While product diversification has started to take place, which is a good adaptive measure, some of the niche tourism being explored is still very weather dependent, e.g. weddings and the hosting of world class sports, music and culinary events, especially if large indoor facilities do not exist to accommodate them. In recent years event postponements or cancellations have become more common, with the annual Pirates Week festival now held in November instead of October due to rainy weather, Taste of Cayman postponed for months for similar reasons, and Art@Governors 2009 postponed by one month due to wind conditions associated with a Nor'wester. While resorts are already targeting the off-season traveller looking for a better experience at an attractive rate, the hotter days, heat waves and unpredictable extremes of this time of year may affect comfort levels of visitors to the region or their health whilst here placing increased demands on the health care system.

Some tourism managers fear the Caribbean is being perceived as an unsafe destination for weather hazards and believe that regional tourism interests will have to collaborate to address this perception in key markets[188]. Even those who do travel to the region can become a liability. As travel insurance does not cover "acts of God," some costs were borne by overseas tour operators to fly tourists back home during Hurricane Ivan[189]. Government's capacity to continue expensive airlift operations before and after a storm is becoming stretched, especially in an economic decline. The Ivan experience has also shown that sectors such as tourism and financial services which employ significant numbers of expatriate workers need to participate in shelter and evacuation planning processes, and develop a coordinated plan to cover this activity with the national emergency agency in future events[190].

Impact of external climate mitigation policies

The Cayman Islands tourism sector's resilience is owed to a loyal repeat visitor base during the high season, mostly from North America. However there is potential for this market share to be eroded due to circumstances beyond local control, namely rising airfares coupled with threats of reduced air service to the region as a result of climate change mitigation regulations and policies to safeguard the aviation sector against deepening economic recession. Moves are well advanced to bring aviation emissions from international flights landing in the European Union under regulation and into the formal carbon market by 2012. EU aviation emissions account for 3% of its total CO_2 emissions, and are estimated to double within a decade if not capped. US air carriers Delta and United are thought to have the highest carbon shortfalls under this cap and trade system (the total being 200 million tonnes of CO_2) with 3.5 and 3.3 million tonnes respectively[191]. Airlines that can afford to do so could purchase additional permits from the European market or invest in clean development mechanism projects to offset their carbon shortfalls. Although no similar US regulation is presently proposed, US-owned airlines might have to raise prices generally to cover cost of flying into European cities.

The Cayman Islands has traditionally been an expensive destination to access and could see a downturn in air arrivals as consumers opt to travel to less expensive destinations through short-haul flights or using "greener" modes of transport (car or train). Further, more frequent warmer mid-latitude winter temperatures could see even loyal repeat visitors chose cheaper vacations closer to home. Local tourism managers are also concerned that if an aviation tax is not tied to specific project funding, informed consumers will find this objectionable and their choice of a more transparent destination will affect revenue for local programmes. Thus Governments pursuing transitions to low-carbon economies should find other mechanisms to curb consumer behaviour apart from taxation[192]. While the Cayman Islands is actively looking both at Central America

[188] DOE, 2009. Comment by Gloria McField-Nixon. In: Minutes of Ministry of Tourism Stakeholder Consultation, 23 January 2009.
[189] BBC News Online. "Travel firms count cost of Ivan," 12 September 2004
[190] McCarthy, G., 2005. "Resilience Through Recovery." A Presentation by the Hon. Chief Secretary of the Cayman Islands to the Deputy Governors and Chief Secretaries Conference, Bermuda, May 2005.
[191] Voosen, P., 2009. "Airlines will be first US industry to confront cap and trade," Greenwire, 12 August 2009.
[192] DOE, 2009. Comment by Gloria McField-Nixon. In: Minutes of Ministry of Tourism Stakeholder Consultation, 23 January 2009.

(specifically Panama) and eventually South America as secondary markets[193], this could have implications for the spread of malaria and dengue from inter-regional travel.

Opportunities for Tourism Product

Opportunities are emerging for the Caribbean tourism sector to appeal to the global eco-sensitive traveller by positioning and branding the sector as "carbon neutral," while simultaneously achieving self-sufficient funding streams for regional Governments to build climate resilience in this sector through adaptation and mitigation projects. Energy security is a growing concern in the region and locally. Utility costs are 15-20% of total revenue locally compared to 7.3% for the average Caribbean property or 3.6% in comparable US resorts. Potable water derived through reverse osmosis is very energy intensive and expensive to produce and deliver, and like electricity is even more costly when damage to these utilities from hurricanes is passed on to consumers. Finding win-win arrangements that address the need for measures around resilience, economic stimulus and the move towards a green economy should be undertaken within a cohesive framework of long-term commitments to address climate change and sustainable development[194]: Positioning the Cayman Islands as a leader in climate change mitigation through participation in high-quality carbon offset programs and pilot projects that allow for tourism facilities to transform to carbon neutrality would achieve these goals. Further, this would complement ongoing efforts through the Cayman Islands Environmental Project for the Tourism Sector (CEPTS) that seeks to institute best environmental practices and prepare tourism businesses for certification in internationally recognized "green tourism" programmes (e.g. Green Globe).

Local tourism managers see the need for the sector to respond to the challenge of reducing GHG emissions not only for the moral imperative to do so but also because of the economic necessity[195]. It has been estimated that the likely costs to the Caribbean's tourism sector from global inaction on climate change could range from US$0.4 billion to $2 billion by 2025[196]. For the Cayman Islands the costs associated with increased hurricane damages, loss of tourism revenue, and infrastructural damages due to sea level rise (exclusive of hurricane damages) by 2025 is 8.8% of current GDP, 20.1% of GDP by 2050, and 53.4% of GDP by the year 2100[197]. Since 1990 the Cayman Islands has had hurricane damages averaging 10-15% of GDP. Global inaction coupled with shorter return periods for hurricanes[198] that affect the Cayman Islands and the reminder of Ivan's total impact on the economy which sits at CI$2.8 billion (183% of 2003 GDP), leaves

[193] Knipp, S., 2009. "Tourism sector cautiously optimistic," Cayman Net News, February 20, 2009.
[194] UNWTO Tourism Resilience Committee: "Roadmap for Recovery." http://www.unwto.org/trc/index.php?lang=E
[195] DOE, 2009. Comment by Gloria McField-Nixon. In: Minutes of Ministry of Tourism Stakeholder Consultation, 23 January 2009.
[196] Bueno, R., C. Herzfeld,E. Stanton and F. Ackermon, 2008. *The Caribbean and Climate Change. The Costs of Inaction*. Stockholm Environment Institute, US Center and Global Development and Environment Institute, Tufts University, May 2008.
[197] Bueno et al, 2008.
[198] US National Climatic Center storm track data analysis by Clark (1988) estimated hurricane strike return time for Grand Cayman alone at 9.2 years for the passage of the eye over the island and at 3.7 years for the passage of the eye within a 50-mile radius. Since then direct hurricane hits is once every 9.06 years and 2.23 years for the islands to be affected or brushed by hurricanes (Caribbean Hurricane Network)

little doubt that climate resilience has to be built into the sector to address the expected impacts of climate change.

5. PRIORITISING CLIMATE CHANGE IMPACTS

5.1 Identification of Priorities

As with many SIDS, the Cayman Islands simply cannot address every climate change issue all at once as constraints exist with inadequate data or information and technical capacity for timely and effective adaptation planning; weak institutional capacity; and limited financial resources[199]. Therefore climate change responses will have to be prioritized.

The key climate change issues identified in the previous chapter were prioritized using established criteria during stakeholder consultations held December 2009 (Box 3). This risk-based approach to prioritization of issues across and within sectors required consideration of the significance of impacts to the social, environmental, economic and cultural dimensions of the country, with threats impacts to all four dimensions (i.e. a score of 1) rated the highest. Stakeholders were also asked to consider the likelihood and magnitude or scale of the threat given current and future climate-risk exposure and levels of vulnerability of various groups or sectors to the threat or impact; and finally the urgency or rate of onset of the climate change impact.

Box 3 Criteria used by Stakeholders to Prioritize Climate Change Issues

National Significance *(Social, Environmental, Economic, Cultural Dimensions)*
1=Four dimensions 2=Three dimensions 3=Two dimensions
4=One dimension 5=No dimensions

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)*

Total scores across all criteria were calculated for each issue area and threat. Table 19 shows the results of this scoring, starting with the issues ranked highest in priority (those having the lowest overall score) and in need or policy interventions to those considered less threatening following in descending order.

Chapter 7 takes the top priority issues (scores of 5 to 8) and suggests appropriate responses to enhance existing coping mechanisms or develop future adaptive capacity and mitigation responses.

[199] UNFCCC, 2005. Climate change, small island States. Climate Change Secretariat (UNFCCC), Bonn, Germany.

Table 19 Climate Change Issues Prioritized by Stakeholder Groups

Climate Change Issue Area	Climate Change Impact	National Significance	Certainty	Severity of threat/ impact	Urgency	Sum
Immediate Priority Issues *(total score of 5 across all priority indicators)*						
Marine & Coastal Resources	Impact on turtle nesting and breeding patterns from beach erosion (habitat loss), periodic inundation and elevated sand temperatures (skewing of sex ratio)	1	1	1	2	**5**
Insurance Sector	Higher insurance premiums as damages from natural disasters increase and sea level rises	2	1	1	1	**5**
Short Term Priority Issues *(total score of 6 across all priority indicators)*						
Marine & Coastal Resources	Increased beach and shoreline erosion and land loss from stronger hurricanes, storm surges, and sea level rise	1	1	2	2	**6**
	Impact on fisheries & reef health from physical destruction by hurricanes and degraded reefs from warming seas, resulting in changing range of tuna & grouper	1	1	1	3	**6**
Energy Security	Increased energy costs to consumer from increased electricity and gasoline prices	2	1	2	1	**6**
Short-to-Mid Term Priority Issues (*total score of 7 across all priority indicators)*						
Marine & Coastal Resources	Corals reefs impacted from warmer sea temperatures (coral bleaching), ocean acidification, sea level rise	1	1	2	3	**7**
	Increased mangrove loss from hurricanes, drowned by storm surge and impoundment, outpaced by sea level rise, resulting in loss of natural storm buffers & protection for coasts	1	1	2	3	**7**

Terrestrial Resources	Loss of biodiversity, especially games birds and culturally important species, e.g. parrots	1	1	1	4	**7**
	Increase of invasive species of flora and fauna	1	1	2	3	**7**
Water Resources & Hydrology	Increased occurrence of inland flooding in chronic areas and newly impacted areas	1	2	2	2	**7**
	Increased costs for desalinated water as the price of fossil fuels rise in response to climate change and depleting resources	2	1	2	1	**7**
Critical Infrastructure & Human Settlements	Higher insurance premiums or eventual future of uninsurability	1	2	2	2	7
Food Security	Local food security – local food production and availability affected by crop damage, soil salinization, drought conditions and competition from imported produce and development pressures on scarce, good quality arable land.	1	2	2	2	**7**
Medium Term Priority Issues *(total score of 8 across all priority indicators)*						
Water Resources & Hydrology	Loss of groundwater resources from annual rainfall decrease and saltwater intrusion associated with sea level rise	1	1	3	3	**8**
Critical Infrastructure & Human settlements	Increased flooding of homes, critical facilities, roads and developable lands (both inland and in low-lying coastal areas)	2	2	2	2	**8**
	Increased operational disruptions to critical services (airports, sea ports, utilities, waste management) from weather extremes and rebuilding after significant damage	2	3	1	2	**8**
Food Security	External food security – increased food costs and incidents of disruption to food supply as climate change impacts other regions and supplies disrupted when sea ports damaged or inoperable	2	2	2	2	**8**

Energy Security	Increased demand for electricity and gasoline as warmer temperatures trigger increased demand for cooling of buildings and cars	2	1	4	1	**8**
Tourism	Facilities at risk from sea level rise, stronger hurricanes, storm surges and flooding	2	2	1	3	**8**
	Impact on product as more extensive coastal erosion degrades beach amenities, damage local attractions, and more frequent coral bleaching events impact dive tourism	2	1	2	3	**8**
Insurance Sector	In ability to obtain insurance for current risk factors	2	2	1	3	**8**
Mid-to-Long Term Priority Issues *(total score of 9 across all priority indicators)*						
Marine & Coastal Resources	Economic and social impact from impacts on fishery stocks – dive tourism revenue, subsistence fishing	3	2	1	3	**9**
	Increased user conflicts for land space	1	1	3	4	**9**
Terrestrial Resources	Sister Islands nature tourism product impacted	1	2			**9**
Water Resources & Hydrology	Viable water lenses threatened by sea level rise – salt intrusion and higher water tables	1	2	3	3	**9**
	Impact on water quality, quantity and availability and long term utility for human consumption, agriculture and biodiversity	2	2	3	2	**9**
Critical Infrastructure & Human Settlements	Impact to electricity distribution system from flooding, damage to power lines	2	3	2	2	**9**
	Increased damage to transportation network, sea ports and fuel terminals along coast from stronger hurricanes/surges	2	3	1	3	**9**
Food Security	Increase in pests, weeds, diseases and invasive species	2	2	2	3	**9**
Energy Security	Electricity infrastructure more vulnerable to floods, stronger hurricanes and storm surges	2	3	1	3	**9**

	Switch to smarter energy production and consumption patterns as the cost of importing fossil fuels increases driving pressure to "go green"	1	2	5	1	**9**
Tourism Sector	Erosion of market share – image of tourism product, perception of unsafe destination, warmer temperate winters or external climate mitigation policies (aviation emissions regulation) erode mainstream market share	2	3	2	2	**9**
	In the short term rising energy, water and food costs for the industry	3	2	2	2	**9**
Finance Sector	Increased loss due to damage to vulnerable property underwritten by finance sector (mortgages, loans, insurance)	3	1	2	3	**9**
Long Term Priority Issues *(total score of 10 or higher across all priority indicators)*						
Critical Infrastructure & Human Settlements	Increased cost for storm protection (sea defences) and to compensate for (temporary) displacement from homes	3	3	3	1	**10**
	Increased incidents of social and economic disruption from inland flooding from heavier rainfall	3	2	3	2	**10**
	Increased failure of existing storm water management practices	2	3	3	2	**10**
Human Health	Increased incidents in vulnerable groups – amongst high blood pressure, heart disease & hypertension sufferers; children; elderly; construction, landscaping & emergency response workers	3	3	2	2	**10**
	Increased costs and impact on capacity of local health control & surveillance programs	3	2	3	2	**10**
Food Security	Soil degradation from salt-water intrusion and soil erosion / leaching	2	3	2	3	**10**

Finance Sector	Permanent relocation of business to less risk-prone jurisdictions (direct impact or indirect increased cost)	1	4	1	4	**10**
Marine & Coastal Resources	Loss of storm protection services (mangroves & reefs)	2	3	3	3	**11**
Terrestrial Resources	Increased incidents of damage to dry forests, shrubland and coastal cliff habitats from wind damage associated with more intense (and cumulative) storms	3	2	3	3	**11**
	Contraction/conversion of seasonally flooded fresh & brackish wetlands from drier rainfall regimes, increased evaporation rates and soil & aquifer salinization	2	2	3	4	**11**
Water Resources & Hydrology	Increased maintenance costs of commercial and residential property damage	3	1	5	2	**11**
Human Health	Increased incidence of dengue and malaria due to wider distribution of vector and warmer temperatures affecting higher transmission rates	2	4	2	3	**11**
	Damage to physical infrastructure (hospital, district clinics)	3	3	2	3	**11**
	Increased risk of diarrhoea and other water, food and rodent borne illnesses	3	3	2	3	**11**
	Greater threat of epidemics and pandemics as warmer temperatures and changing rainfall patterns trigger the spread of pathogens into new regions	2	3	2	4	**11**
Marine & Coastal Resources	Loss of beach building resources	2	3	3	4	**12**
Water Resources & Hydrology	Increased maintenance costs of deep water wells and roads from more frequent and intense rainfall events	3	1	5	3	**12**

Critical Infrastructure & Human Settlements	Impact on coastal land values	2	3	3	4	**12**
	More costly damage to buildings, roads and electricity and communication systems due to stronger hurricanes	3	3	3	3	**12**
Human Health	Increased incidence of respiratory illnesses and heat stress in visitors	3	3	3	3	**12**
Finance Sector	Increased strain on banking system – potentially higher interest rates to cover increased inherent risk	3	3	2	4	**12**
Critical Infrastructure	Increased incidents of structural damage from stronger peak winds	3	3	4	3	**13**
Human Health	Higher occurrence of ciguatera (fish poisoning) from warmer sea temperatures	2	4	4	3	**13**
	Increased cost of service delivery locally & overseas referrals	3	4	4	3	**14**
Finance Sector	Physical infrastructure owner by finance sector vulnerable to hurricanes (buildings, infrastructure)	2	4	4	4	**14**
Human Health	Reduced protein intake as fish catches decline	2	4	4	5	**15**
	Risk of heat waves as temperatures potentially rise by up to 10.4°F by 2100	1	5	4	5	**15**

6. INSTITUTIONAL AND LEGAL ARRANGEMENTS FOR RESPONDING TO ISSUES

Addressing climate change in the Cayman Islands will necessitate the involvement of both public and private sector institutions, as well as community-based organizations and at the household and individual levels. A preliminary assessment of the capacity of a portion of tourism businesses to adapt to the unavoidable impacts of climate change was captured in the *Vulnerability and Capacity Assessment on Climate Change Impacts on the Cayman Islands' Tourism Sector*. Extensive research on the adaptive capacity of Government, the private sector and individuals was conducted by Tompkins and Hurlston prior to hurricane Ivan. The Knowledge Attitude and Perception Survey conducted under the ECACC Project provides some updated insights to the present capacity of those working within the tourism sector to respond to climate change. The following section looks specifically at the national response capabilities of the Government.

6.1 National Institutions, Their Roles and Capacities

The myriad of issues associated with climate change cuts across all facets of Government policy, with each of the five Ministries and their affiliated Departments and Statutory bodies having an integral role in adaptation and mitigation planning. Therefore the collaborative effort required in the public sector to effectively respond to the adverse impacts of climate change and curb future contribution to this global problem cannot be understated. Appendix 2 provides an overview of the key functions of agencies currently responsible for environmental and coastal management, physical development planning, disaster risk reduction and management, and those peripherally involved with climate change mitigation. Many of these agencies are not sufficiently equipped to address the challenges brought by climate change in their fields as most still struggle to successfully handle current issues given limited staff and technical capacity, or lack of policy direction, legislative underpinning and funding. This is particularly the case with agencies involved with the sustainable use and management of the coastal zone which is critical for staving off future climate change impacts on small islands.

The Department of Environment's Sustainable Development Unit (SDU) has significantly advanced the Cayman Islands' climate change adaptation research and policy agenda in a very short timeframe. The DOE generally holds a good deal of knowledge on climate science and like the Lands & Survey Department has regionally enviable datasets resulting from smart investments in technology, staff training and programmatic planning. Many view the DOE as the primary climate change entity within the Cayman Islands' Government given that the National Climate Change Focal Point heads the SDU and the DOE chairs the National Climate Change Committee. Whilst this may all sound encouraging for the Cayman Islands, it is feared that the capacity of other government agencies is not being sufficiently built for adaptation purposes, and there are many more aspects of climate change that extend beyond the capabilities and current

mandate of the DOE. Narrowing of knowledge gaps and strengthening of capacities throughout the public sector is essential if effective and timely adaptation is to occur.

Capacity building under the ECACC Project

The DfID-funded ECACC Project has not only focused national adaptation planning and mitigation efforts, but through the agencies represented on the National Climate Change Committee which manages the project and benefits from planned activities, has strengthened the institutional capacity of the Cayman Islands Government. Appendix 4 details the involvement of various CIG agencies and non-governmental organizations in the national consultations, workshops and meetings held under the auspices of the ECACC Project from inception in November 2007 to February 2010. The Department of Agriculture benefitted from a regional workshop on climate change impacts on agriculture in the Caribbean held in Guyana in April 2008. Additional training of National Weather Service personnel took place in August 2010 as institutional strengthening for the preparation of the Climate and Weather Assessment for the Cayman Islands, a vital component of the *Vulnerability and Capacity Assessment of Climate Change Impacts on the Cayman Islands' Tourism Sector*.

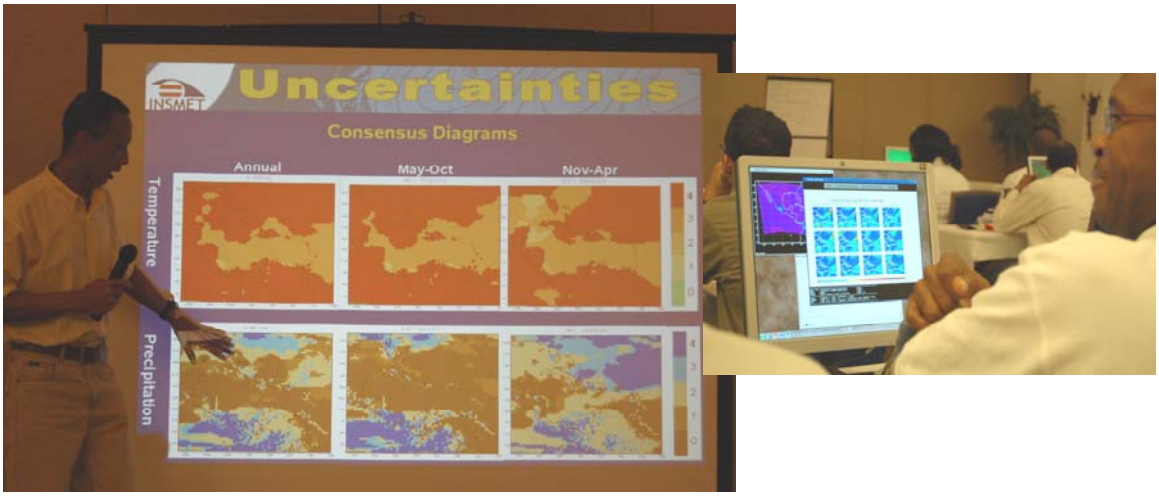

Photo 12 Abel Centella, INSMET, presenting at the PRECIS Model training workshop for the Overseas Territories, Grand Cayman, February 2010. Inset: Workshop participant using PRECIS Caribe Online. ***Photos courtesy of John Bothwell.***

Adaptive Management and leadership roles

Previous research on the Government's ability to increase adaptive capacity to respond to climate change provides encouragement. Tompkins and Hurlston[200] found that many lessons for climate change adaptation can be learned from the CIG successfully responding to tropical cyclones since the passage of hurricane Gilbert in 1988. The role of collective group action and the creation of new

[200] Tompkins, E.L. and L-A. Hurlston, 2003.*Report to the Cayman Islands Government: Adaptation lessons learned from responding to tropical storms by the Cayman Islands Government, 1998-2002.* Tyndall Centre Working Paper No. 35, September 2003.

institutional forms (e.g. NHC) to manage risk from existing environmental hazards were among the lessons. Identification of risk, proposing and testing solutions (e.g. National Hurricane Plan), re-evaluting and re-testing is all a process of adaptive management which allows institutions to prepare for hazards. How ministries and departments that typically have rigid organisational structures work together to enable adaptive management is a key function of an adaptation framework and must an integral component of the National Climate Change Policy. However, it is clear that a central coordinating entity must lead the charge.

To date the NCCC, greatly assisted by the DOE, has elevated the issue of the need to adapt to climate change. However neither of these agencies has statutory backing. The appropriate agency or entity and supporting framework for implementing the *National Climate Change Policy* will have to be designed for effective and efficient adaptation to occur. Similarly, a variety of climate mitigation action has been driven by the DOE in the last 5 years and other departments, but efforts have been severely hampered without the supportive regulatory framework. More recently the Ministry of Works has clearly established itself as the lead agency on energy issues, raising expectations that the climate mitigation agenda will become a Government policy priority.

6.2 Legislation Provisions, Policies and Plans

Climate change adaptation and mitigation planning in the Cayman Islands is set within a framework of international treaty obligations, bilateral agreement commitments, national policies and plans, implementing projects, and budgetary allocations. In general however, the national policy framework and supporting legislation for addressing adaptation and mitigation are inadequate to meet current vulnerabilities presented by climate variability as well as the challenges posed by continued climate change. This is particularly the case with fragmented and deficient environmental management legislation, weak physical planning and enforcement laws, and lack of regulatory standards for and reporting of air emissions and pollution.

International Legal Framework

United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC, officially extended to the Cayman Islands in March 2007, is one of many multilateral environmental agreements (MEAs) to which the Territory is Party through the UK. Mainstreaming adaptation responses and mitigation action into existing national policies and plans underpinned by new enabling legislation where necessary is among the Cayman Islands' obligations under the UNFCCC. The implementation of a *National Climate Change Policy* will place the Cayman Islands in good stead in this regard, as currently the jurisdiction is policy deficient and institutionally disjointed in its treatment of responses to climate change impacts and has no comprehensive plan to address GHG emissions associated with its current activities or future economic growth.

Environment Charter

The Environment Charter, an oft-forgotten bilateral agreement signed by the Governments of the UK and the Cayman Islands in 2001, commits the Cayman Islands to effective implementation of: relevant MEAs; responsive environmental management and biodiversity and species conservation legislation, including environmental impact assessments; institutional capacity building for integrating environmental considerations in decision making; and appropriate mechanisms for public consultation on plans of national importance. Importantly, the Charter also obligates the Cayman Islands to develop and implement a National Sustainable Development Strategy (by 2005), which in concert with similar efforts by other nations would reverse the current trends in the loss of environmental resources at both the global and national levels by 2015 as part of the International Development Targets on the Environment. In the national context, these measures would create a strong foundational framework for effectively addressing climate change adaptation and mitigation.

National Policy and Legislative Framework

Active incorporation of climate risk into existing policies and updated plans and legislation under review is essential to increase the coping capacity of the islands and ensure long term sustainable development. Climate Change Adaptation and Mitigation became a Specific Outcome under the broader outcome goal of 'Conserving the Environment' in the People Progressive Movement's Strategic Policy Statement for the 2009/10 financial year. This has carried through as a Key Strategic Policy in the United Democratic Party's 2010/11 Annual Plan and Estimates under the Broad Outcome of 'Addressing Energy and the Environment.' However national planning efforts under this outcome remain disjointed with no call for a comprehensive policy or legislative review to identify critical gaps or entry points were mainstreaming of climate risk and mitigation action should occur. Appendix 3 provides a summary of relevant existing and proposed policies, plans and legislation governing environmental and coastal management issues and development control, as well as those related to energy management and promotion of renewable energy technologies for which entry points for adaptation and GHG mitigation should be sought. The following are instruments that have failed to achieve national integrated planning but through critical re-assessment have the potential to realize CIG's current adaptation and mitigation outcomes.

National Environmental Policy Framework

To meet the goal of effective MEA implementation and address current environmental issues, the 2002 National Environmental Policy Framework was developed and contained strategies critical for achieving sustainable development. Key determinants for successful climate change adaptation and GHG mitigation included in the Framework were enabling conservation and environmental management legislation and the promotion of renewable sources of energy. The policy draws on commitments articulated in the Environment Charter but currently serves no useful function by policy makers or decision bodies.

National Sustainable Development Framework (NSDF)

As noted above, the Cayman Islands was meant to formulate and start implementation of a National Sustainable Development Strategy by 2005 in accordance with the Environment Charter. The NSDS would be based on a shared national vision of social and economic development in balance with the environmental capacity of these islands and in recognition of their unique biodiversity attributes. It would serve to integrate existing policies and plans for better management of natural resources and long term economic prosperity, and provide an overarching policy framework for future decision making. New strategies such as those addressing climate change adaptation or nationa energy issues would tie into this framework. In 2006 the DOE's Sustainable Development Unit was created to advance the NSDS for the Cayman Islands and by 2007 a workable framework and programme of action emerged, however even after gaining widespread public sector support, no traction for this approach was sustained despite its consistent appearance as a specific outcome of every budget since. It is hoped that policy integration can be galvanized around the threat of climate change and need for incorporating adaptation and mitigation into existing policies, and that government entities swiftly build a culture of delivering outcomes in this much needed integrated fashion.

National Conservation Law

This proposed piece of legislation serves to help meet a number of obligations under the various MEAs to which the Cayman Islands is Party, such as the provision for EIAs, which is fundamental to integrating climate change considerations in development planning. The draft Law includes a very consultative mechanism for the establishment of a system of protected areas which would facilitate the preservation of ecosystems vital for carbon sequestration as well as enhancement of natural storm buffers that increase adaptation of the coastal zone. Other entry points for both adaptation and mitigation are present throughout this legislation.

National Energy Policy

Another initiative currently underway that presents opportunities for adaptation whilst curbing GHG emissions is the establishment of a National Energy Policy (NEP). Among the goals of this policy are the reduction of the Cayman Islands' carbon footprint in line with national targets to be agreed, development of renewable energy sources and the promotion of energy conservation and efficiency in all sectors. The formulation of the NEP runs concurrent to the developing of the *National Climate Change Policy*, offering ideal circumstances for policy integration and efficiency in the delivery of strategic outcomes from each. The NEP is expected to be implemented by 2012 while the aim is to have the climate change policy in place by 2011.

Development Plan 1997

The primary objective of this plan is to maintain and enhance the quality of life in the Cayman Islands by effectively directing development so as to safeguard the economic, cultural, social and general welfare of the people, and subject thereto the environment. As currently stated this objective is counterintuitive to climate change adaptation and sustainable development generally as environmental considerations and their implications to the other factors are clearly not equally weighed in development planning. This policy framework has led to the systematic erosion of the Mangrove Buffer Zone and other natural storm buffers

and a host of other deficiencies in terms of climate change adaptation. That the Development Plan is meant "to define and develop a planning strategy for the Islands which is flexible enough in concept and implication to accommodate individual requirements, special circumstances and changing conditions"[201], has on the one had allowed for too much discretionary decision making and unsustainable practices, but on the other hand now offers entry points for responses to changing environmental conditions to occur at the individual home owner level to large-scale adaptation projects. A legislative requirement to review this plan every 5 years provides opportunity for constant re-evaluation of climate change adaptation policies and practices.

National Tourism Management Plan (2009-2013)

Another 5-year plan that affords multiple entry points for increased climate-resiliency and GHG emission reductions in a particular sector is the NTMP. This plan builds on the previous one prepared in 2003 but is more focused on tourism initiatives that better serve to achieve long term sustainable development within the Cayman Islands. It also recognizes the implementation problems surrounding the earlier plan and offers lessons such as a different framework needed for the execution of the climate change policy which similarly requires a fully integrated process.

Maladaptive Legislation and Policies

Actions or policies that exacerbate the effects of climate change by inadvertently increasing vulnerability. These are often termed climate change 'mal-adaptations' can be one or more of the following actions[202]:

- Inefficient use of resources compared to other options (e.g. unnecessarily displacing development funds away from other concerns)
- Ineffective (e.g. relying on scenarios of future climate risks that are not subsequently realized and actions that have no other benefits)
- Inequitable reductions in vulnerability (or shifting vulnerability from one group to another)
- Inflexible decisions or investments that may reduce the possibility for future adaptation

The following table highlights examples of current misaligned legislation or policies that are counterproductive to the goal of reducing coastal vulnerability to weather and climate hazards.

[201] The Development Plan 1997

[202] McKenzie Hedger, M., Mitchell, T., Leavy, J., Greeley, M., Downie A. and Hoorocks, L. 2008. Desk Review: Evaluation of Adaptation to Climate Change from a Development Perspective. A study commissioned by the Global Environment Facility Evaluation Office and financed by DFID, Institute of Development Studies, August 2008.

Table 20 Examples of current policies that may exacerbate climate change impacts

Policy Choice	Effect	Recommended Improvements
Lack of comprehensive coastal zone management and planning.	Piece meal management of the coastal zone contributes to loss of beach resources from coastal erosion, sand mining, improper filling and siting of structures, loss of public access.	Various recommendations in Beach Review and Assessment Committee Report and Environment and Coastal Zone Management Special Issue Committee Report.
Systematic reduction of Mangrove Buffer zoning and coastal mangroves not in this zone through rezoning and past planning approvals.	Reduced storm protection, exposing coasts and shorelines to flooding and coastal erosion from battering waves and sea level rise.	Increase Mangrove Buffer zone inland and to other coastlines; apply hurricane evacuation/risk exposure zones to these and other general zoning designations; Specially Vulnerable and No Build Zones
Property ownership to and definition of MHWH on mangrove coastlines in Land Survey Regulations combined with development approvals for filling.	Increased exposure of settlements by removal of natural buffers and development to property boundary.	Revise MHWM definition to revert mangroves standing in water to the Crown; no clearing of mangroves within development setbacks; increased protection for all remaining coastal mangrove.
Measurement of coastal construction setbacks from MHWM – a dynamic feature.	Intrusion of and damage from storm surge especially if setbacks not tied to sea level rise projections	Revise benchmark for measuring setbacks to line of permanent vegetation; develop setback category maps and storm atlases for long term planning; use site-specific setbacks for planning approvals
Reluctance to enact environmental impact assessment legislation as a decision support tool	Potential for maladaptive decision making	Pass National Conservation Law; integrate climate change into EIA processes

The lack of EIAs and other decision support tools could seriously hamper effective climate change adaptation efforts. In Jamaica, as part of the normal planning process, plans for developments go to the disaster agency for review as well as during an EIA process[203]. By integrating weather, climate and hazard information into physical planning processes national development plans and individual projects will stand a better chance of being climate-proof[204]. Further, the Cayman Islands has MEA obligations that speak to having EIA processes in place, namely the Convention on Biological Diversity (CBD) and Convention on Wetlands of International Importance especially for Waterfowl (Ramsar). Environmental assessment processes will also be a requisite under Specially Protected Areas and Wildlife (SPAW) Protocol, the extension of which to the Cayman Islands has been requested of the UK. A regional study supported by DfID on the integration of climate change into EIA processes was recently conducted. The Cayman Islands and other OTs could benefit from a similar study to ensure that climate change considerations take prominence in national decisions, particularly related to large-scale capital projects where significant resources are committed or those projects deemed to have readily identifiable current adverse effects.

[203] Carby, B. Personal Communication, 22 January 2009.
[204] Tompkins, E.L., Nicholson-Cole, S.A., Hurlston, L-A, Boyd, E., Brooks Hodge, G., Clarke, J., Gray, G., Trotz, N., and Varlack, L. 2005. *Surviving Climate Change in Small Islands: A Guidebook*. Tyndall Centre for Climate Change Research, University of East Anglia, Norwich, UK.

6.3 Integrating Climate Change and Sustainable Development

Climate change has the potential to impede the ability of small islands to achieve long-term social and economic development, and likewise pursuing a deliberate path towards sustainable development lessens the pressure on natural resources and addresses the challenges posed by climate change. Like many SIDS, the Cayman Islands is challenged by setting national development priorities aimed at sustaining economic growth, maintaining a sustainable population and alleviating poverty. National priorities have not typically included addressing climate change in the medium- and long-term or integrating it into national legislations, pursuing economic strategies such as sustainable energy development, creating synergies with other environmental objectives such as biodiversity conservation, or developing institutional arrangements for integrating sustainable development. Some key needs and barriers to integrating climate change and sustainable development in the Cayman Islands are discussed below.

Needs: Capacity-building at a systematic level for policy integration

The nature and handling of both climate change and sustainable development require multi-faceted approaches at all levels including comprehensive policy integration. The Cayman Islands is skilled at generating sectoral plans through national stakeholder consultations and public-private sector collaboration, however it falls short in implementation of these plans. Often time there is a void in higher level policy development and integration of sectoral plans. This need for greater coordination and integration among departments and ministries in the development of policies or implementation of plans was among the recurring problems highlighted for improvement by Vision 2008 stakeholders and formed the basis for numerous roundtable action plans[205].

Creating the enabling environment for the policy integration and implementation remains a significant challenge despite recent institutional advances in government, namely the formation of the Cabinet Office. This office was formed to assist Cabinet decision-making on plans and policies that are cross-governmental in scope. Whilst a Policy Coordination Unit exists within the Cabinet Office, it monitors international policy developments and provides technical support and advice to the Cabinet in these matters[206]. Thus, national policy disconnects and conflicts still occur, as do complete policy voids in some areas. Improvement in CIG performance in this regard is needed to not only achieve anticipated sustainability outcomes under various funded plans but also to be in a position to successfully and cost-effectively respond to climate change. The constitutional arrangements of the Cabinet Office and its role in organizing Chief Officer interaction should underpin the coordinated implementation of climate change policy through various Ministry programmes[207].

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[205] *The Key to the Future: A Guide to the National Strategic Plan 1999-2008*. Central to the policy guidelines the community wished to see was a policy of Integrated Growth Management covering the environment, economy, infrastructure, human resources development and social policies.
[206] http://www.cabinetoffice.gov.ky/portal/page?_pageid=1774,3504308&_dad=portal&_schema=PORTAL
[207] DOE, 2009. Comment by Gloria McField-Nixon. In: Minutes of Ministry of Tourism Stakeholder Consultation, 23 January 2009.

Fundamental barriers to integrating climate change and sustainable development

Major barriers to increasing adaptive capacity and achieving greater sustainability are that climate change is considered a phenomenon that can be addressed in the future when the effects are more clearly evident, and the concept of sustainable development generally and its long term benefits are not well understood in the Cayman Islands. A public education and awareness strategy to support the development and implementation of a national climate change policy is anticipated to address some of the issues associated with the former. In the Cayman Islands sustainable development is not regarded in the sense intended by the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992 and adopted by globally:

"The principle of sustainable development ...includes preserving natural resources for present and future generations, exploiting such resources in a sustainable manner, balancing one State's use with the needs of others in an equitable manner, and integrating environmental considerations into economic, social and development issues"[208].

Instead it is an approach thought to limit rather than sustain balanced and equitable development. This is because the "environment" is narrowly defined as natural resources and ecosystems, and the ecological services provided by the latter in enhancing or maintaining social well-being and economic prosperity are rarely appreciated or form national dialogue unless tied to a specific (controversial) proposal of national concern. An ecosystems approach to planning has not been adopted although past exposure to and experience of recovering from damaging storms has raised the general awareness of mangroves and reefs as natural buffers that provide storm protection functions. The environment is essentially viewed as the domain of the DOE, which is perceived by some interest groups as being anti-development. These groups, and often policymakers and constituents, are reluctant to see beyond the short-term to longer planning horizons needed for truly successful economic and social development outcomes whereby the environmental costs and benefits are considered at the time decisions about these plans are being made. The challenges posed by climate change not only require this long-term planning perspective but also moving the environment out of the box where it has been traditionally relegated and placed on equal footing with social and economic dimensions of the development agenda.

Interestingly, a similar sentiment is heard from the risk reduction community: the need for a more integrated approach and the cessation of viewing risk reduction as an add-on rather than integral to various decision processes. Short-term thinking of external institutions does not help either: the UN Central Emergency Response Fund, of which the former head of HMCI is a board member, struggles to operate beyond the short term goal of saving lives towards

[208] UNFCCC, 2005. *Sustainable development and the integration of climate change concerns into medium- and long-term planning*. Sixth compilation and synthesis of initial national communications from Parties not included in Annex 1 to the Convention. Twenty-third session of the Subsidiary Body For Implementation, Montreal, 28 November to 6 December 2005, FCCC/SBI/2005/18/Add.1, 25 October 2005.

a longer term planning mode. HMCI hopes that local and regional politicians and policymakers will have a change in thought process soon[209].

Linkages between climate change and sustainable development are evident. Similar requirements are needed for both enhancing adaptive capacity and promoting sustainable development. The state of a country's development and access to resources affect its ability to adapt to climate change impacts. Co-benefits of sustainable development and enhancing adaptive capacities of communities or systems are possible if measures and investments are properly designed[210]. Capturing synergies between climate change and sustainable development is part of an effective climate change policy discussed in the following chapter.

[209] DOE, 2009. Comments by Dr. Barbara Carby. In: Minutes of Hazard Management Cayman Islands Consultation, 22 January 2009.

[210] Munasinghe, M. et al (Eds.), 2003. *Integrating Sustainable Development and Climate Change in the IPCC fourth Assessment Report*. Proceedings of the IPCC Expert Meeting held in Colombo, Sri Lanka, 5-7 March 2003, Published for the IPCC by Munasinghe Institute for Development (MIND), Colombo, Sri Lanka.

7. TOWARDS A CLIMATE CHANGE POLICY

Setting a national agenda for responding to climate change has now been put in motion which will be complete when a climate change policy and collection of action plans emerge from this process. Implementing long-awaited measures to enhance ecosystems and biodiversity protection and improve natural resource management generally, while meeting objectives of disaster risk reduction and sustainable development will result in a triple dividend[211]. Addressing once and for all significant issues already affecting the physical development and quality of life of residents will in turn position these islands in a more climate ready state for the next few decades. Climate change adaptation and mitigation do not have to be an 'either or' choice, and in fact addressing the two together will be more effective and less costly in the long term. These are among the principles guiding the recommended policy framework. Funding of the policy will be challenging and may require further examination of specific responses, their cost and when they should be implemented. While this and other constraints presently exist, they are not insurmountable. Indeed, climate change presents many opportunities for the Cayman Islands to embrace, some of which have been identify previously in other national planning initiatives and by past political directorates, and others are simply waiting to be pursued.

7.1 Regional Framework for Climate Resiliency

The Cayman Islands response to climate change has been guided by the expertise at the CCCCC, the regional institution that has spearheaded the majority of the climate change programs in the region over the past decade, and has prepared a regional strategy for CARICOM Governments as a roadmap for continuing to build resilience to the impacts of global climate change in their states[212]. The following strategic elements of the strategy set the tone for many of the adaptation options proposed for the Cayman Islands' own policy:

- Mainstreaming climate change adaptation strategies into the sustainable development agenda - investing in resilience-building is investing in sustainable development. Strengthen institutional capacity, build the knowledge base and deepen awareness and participation amongst government, the private sector, citizens, regional organizations, CCCCC and the international development community.
- Mitigation is an essential part of adaptation in the region – promote actions to reduce greenhouse gas emissions through fossil fuel reduction and conservation, and switching to renewable and cleaner energy sources.
- Promote actions to reduce the vulnerability of natural and human systems to the impacts of a changing climate.
- Promote actions to derive social, economic and environmental benefits from the prudent management of standing forests.

[211] Brown, N. 2008

[212] CCCCC, 2009. *Climate Change and the Caribbean: A Regional Framework for Achieving Development Resilient to Climate Change (2009-2015)*, Caribbean Community Climate Change Centre, May 2009.

Another important regional development is the Liliendaal Declaration on Climate Change and Development[213], signed by CARICOM Heads of Governments in July 2009, which clearly states the position of the Caribbean with respect to a number of climate change issues. Out of this Declaration was born the "1.5°C to Stay Alive" slogan, song and campaign to raise awareness within the region and amongst the wider international community of the plight of these small islands in the face of climate change and action that is expected to be taken by regional governments and their global counterparts as part of a Copenhagen agreement. The UK OTs have drawn inspiration from this, and in light of disappointing results at Copenhagen, developed an Overseas Territories Declaration on Climate Change to be discussed with the UK Government that endorses this regional position, calls upon the UK and international development partners to undertake more decisive action, and commits to responsive strategies within our Territories.

7.2 Developing a Cayman Islands Climate Change Policy

Policy Development Process

The Cayman Islands' National Climate Change Policy has been nearly three years in the making. Starting with the development of an *Issues Paper* on national concerns related to a changing climate derived from previous country vulnerability profiling work undertaken by the Department of Environment and an initial series of consultations with all government ministries and most departments, private sectors representatives and associations, key non-government organizations and local research institutions. This paper underwent a full critique during another consultation at which the issues where further considered and prioritized by an array of stakeholders using a national lens. This *Green Paper Technical Report* emerged from that consensus-building process and contains a suite of possible policy interventions and response options. The report will be the subject of further discussions to reach agreement on a *draft National Climate Change Policy*, forming a White Paper to be submitted to Cabinet for approval after the concluding round of national consultations.

It is expected that the policy will be welcomed by Cabinet and work on its implementation will start immediately. To ease this next phase, a Public Education and Outreach Strategy – 3-year plan – has been designed to support the policy's endorsement by Cabinet and national acceptance, as well as bolster its implementation.

Policy Focus Areas

National policies set the backdrop for specific plans of action or strategies. The *Stern Review on the Economics of Climate Change*[214] identified four key areas

[213] http://www.lcds.gov.gy/component/content/article/45-information-documentation/118-liliendaal-declaration-on-climate-change-and-development.html

[214] Stern, N.H., 2007. *Stern Review: The Economics of Climate Change*. Report to the Prime Minister and the Chancellor of the Exchequer, HM Treasury, UK.

where governments can establish policy to promote adaptation responses by individuals and businesses in the medium and long term. These coincide with key themes raised over the course of the national consultations.

1. ***Provision of high quality climate information and tools for risk management, including regional storm and rainfall predictions.***

The Cayman Islands have some of the longest time series of meteorological and environmental data in the region. Through the CCCCC, the Cuban Institute (INSMET) utilized a 30-year local data set in regional climate models to derive outputs helpful for more accurately characterizing future climate impacts on the Cayman Islands and sub-regionally. This information has been used in the Vulnerability and Capacity Assessment for the Tourism Sector and will continue to serve in planning processes for other sectors.

2. ***Land use, infrastructure and building planning and permitting regulations that take climate change into account.***

Stakeholders in national consultations on climate change adaptation and other planning initiatives readily recognize the urgent need to revisit land use planning and development controls particularly in the coastal zone and inland areas with chronic flooding issues. Many plans for advancements in these areas exist, and over the years some of the same recommendations have been made time and time again as the political will to implement changes has not been there.

3. ***Long-term polices for climate-sensitive public goods, including natural resources protection, coastal protection and emergency preparedness.***

The Cayman Islands is often used as a model for hurricane preparedness. Lessons learned from responding to hurricanes can be applied to climate change adaptation, particularly institutional structures and the successful use of public-private partnerships. Whilst the system of marine parks established in the Cayman Islands is also emulated across the region, the same proactive approach has not been adopted in preserving valuable and effective natural coastal protection measures such as mangroves and beach ridges which seems incongruous with the islands' disaster response reputation and widely understood coastal vulnerabilities to current weather hazards. In fact, it has been observed that the amount of accountable damage from Ivan pointedly signals that environmental assets and their services do not receive adequate valuation[215]. While some CI$0.4 million was allocated in the 2009/10 budget for coastal protection (seawalls), CI$0.3 million must be split between projects that preserve the natural environment and places of historic significance.

4. ***A financial safety net for the most vulnerable to impacts and least able to afford protection (insurance).***

While the country continues to invest heavily in disaster preparedness and other risk reduction measures, insurance as a financial safety net is critical. The

[215] ECLAC, 2005. "Hurricane Season 2004 in the Caribbean: Some Facts, Figures and Preliminary Conclusions and Lessons Learned." Report

Cayman Islands typically has a high level of insurance and hence the capacity to rebuild, albeit in the case of Ivan with a shortage of immediate resources and a consequence on government's budget and cash flow[216]. Hurricane Ivan's $75,700 per person damage estimate - the highest ever encountered in the region – taxed Government resources and demonstrated the need for disaster reserves. The National Recovery Fund, a public-private initiative, has served the immediate needs of those badly affected by Ivan and more recent events but is now winding down. CIG budgetary appropriations of CI$3.5 million for Hurricane Paloma Relief have been made in fiscal year 2009-10 as the CCRIF did not provide the expected recovery safeguard. A suite of solutions may be required such as building a domestic disaster fund, renegotiation of CCRIF terms and engagement of the local and regional insurance industry to avoid uninsurability and ensure access to regional or international funds is available when needed.

7.3 Adaptation and Mitigation Response Options

Guiding Principles for the Policy

The following principles have guided the selection of policy responses and adaptation options.

1. Manage the unavoidable

The planet is committed to decades of warming before a slowing in the changes to the climate system will take effect. Therefore the Cayman Islands must managing the inevitable impacts and respond to the projected effects of climate change. An array of potential adaptation responses[217] have been proposed for the Cayman Islands, including:

- Very large, purely technological (e.g. sea defences)
- Behavioural (e.g. altered food and recreational choices)
- Managerial (e.g. altered farm practices)
- Policy (e.g. strengthening cross-governmental policy coordination)
- Regulatory (e.g. revised planning regulations)

2. Reduce vulnerability by reducing other stressors

Vulnerability to climate change can be exacerbated by other human-caused stressors which reduce the resiliency of natural and socio-economic systems even further. Activities that impact these systems and further diminish their abilities to cope or rebound after frequent events or perturbations should be avoided,.

[216] Ibid. 165

[217] IPCC, 2007. Summary for Policymakers. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of the Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.), Cambridge University Press, Cambridge, UK, 7-22.

3. Reduce vulnerability at all levels

Responses that seek to reduce personal vulnerability to natural hazards and increase adaptive capacity of businesses and key economic sectors should require less Government resources for national disaster recovery. Energy independence of individual households over time would also decrease pressure on national coffers to support an economy reliant on foreign reserves of fossil fuels.

4. Guard against maladaptations

Avoid actions or policies that exacerbate the effects of climate change by inadvertently increasing vulnerability. This includes ensuring that initial recovery activities post-disaster do not increase vulnerability which is a guiding principle used in OECS countries to guard against maladaptation.

5. Learn from experiences

Valuable lessons for adapting to climate change can be learned from past experience of Government institutions in responding to the threat of tropical storms and hurricanes in these Islands[218]. While Hurricane Gilbert led to better national hurricane preparedness Ivan punctuated improvements needed in recovery plans[219] which, concomitant to climate change, must take into account scenarios substantially worse than Ivan. The disaster risk reduction and climate change agendas are closely aligned as both aims to build a culture of resilience, therefore efforts to maximize these linkages should be pursued.

6. Integrate adaptation into existing national planning frameworks

Reviewing existing plans and policies through an 'adaptation lens' to identify opportunities for interventions that will make sectors or processes more climate-resilient is the recommended approach[220]. Capitalizing on current planning initiatives developed through consensus means not having to start from scratch. Early integration of adaptation into national development planning will guard against the slowing or derailment of sustainable development goals by increasing resiliency and adaptive capacity across multiple sectors. It is imperative that the current National Planning Initiative and all Development Plan reviews are aligned with the National Climate Change Policy. Use of hazard vulnerability assessments and EIAs at the project level to assess the potential impacts of the proposal on the environment as well as consider the climate risks on the project itself should make future development more climate-resilient[221].

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[218] Tompkins, E.L. and L-A. Hurlston, 2003. *Report to the Cayman Islands Government. Adaptation lessons learned from responding to tropical cyclones by the Cayman Islands Government, 1988-2002*. Tyndall Centre for Climate Change Research, Norwich, UK.

[219] McCarthy, G., 2005. "Resilience Through Recovery." A Presentation by the Hon. Chief Secretary of the Cayman Islands to the Deputy Governors and Chief Secretaries Conference, Bermuda, May 2005.

[220] McKenzie et.al., 2008

[221] CARICOM Adapting to Climate Change in the Caribbean (ACCC) Project, 2004. Guide to the Integration of Climate Change Adaptation in to the Environmental Impact Assessment Process. September 2004.

7. Seek adaptation and mitigation synergies to achieve multiple benefits

Integrating mitigation and adaptation goals requires an integrated policy and implementation framework underpinned by legislation. Tourism and finance are two obvious entry points for energy-related measures that offer long term cost savings even if initial outlay is high as the climate-change losses averted are often higher[222]. Protection and enhancement of natural buffers offers immediate co-benefits. Their shoreline protection services derive avoided damage costs to coastal properties and infrastructure that, in the case of the Cayman Islands, have been shown to outweigh the cost of implementing protection and enhancement measures, which may include compensation from change in land use regulations, land purchases, or restoration activities. Further benefits are realized when their greenhouse gas mitigation role in terms of carbon uptake is considered.

Adaptation options can be categorized by five basic types (Box 4)[223]. These categories provide a context within which to view adaptation strategies and activities, and have proved helpful to decision makers in other jurisdictions in prioritizing and funding action.

Box 4 Categories of Climate Change Adaptation Options

Category	Type of Action
Accept Loss	Implement no vulnerability measures and bear the burden of loss
Spread Loss	Distribute the burden of loss through property insurance, government emergency relief or other measures
Prevent Loss	Reduce vulnerability to climate change through engineering or other measures
Change Activity	Replace current activities with more sustainable ones
Relocation	Shift current activities or structures to another location

Table 21 includes the use of these adaptation option categories in rationalizing responses for the Cayman Islands to the issues of greatest priority determined at the December 2009 stakeholder consultations.

Consensus around these responses and developing more specific options and action plans will be the focus of further discussion at the Green Paper consultation to be held in December 2010. However, it is likely that many of these will be viewed as common-sense, 'no-regrets' solutions that achieve the desired sustainable development outcomes and therefore are in the interest of the country to pursue irrespective of climate change adaptation benefits. It is expected that these suite of options will form the basis of Action Plans to the *National Climate Change Policy*. Other action plans should perhaps be developed for the remaining issues identified in section 5.1 that did not rank as highly as those that follow.

[222] UN Foundations/Sigma XI, 2009. *Confronting climate change: Avoiding the unmanageable and managing the unavoidable.* Scientific Expert Group Report on Climate Change and Sustainable Development, Prepared for the 15th Session of the Commission on Sustainable Development. Executive Summary, February 2007

[223] d'Auvergne, C., A. James and D. Barrows, 2001. St. Lucia Country Paper on National Climate Change Issues. Towards the Implementation of CPACC Component 4: Formulation of a Policy Framework for Integrated (Adaptation) Planning and Management, January 2001.

Table 21 Possible Adaptation Responses for the Cayman Islands

PRIORITY CLIMATE CHANGE ISSUES	Adaptation Category	ADAPTATION OPTIONS (INCLUDING MITIGATION)
Priority Issues to be addressed Immediately *(total score of 5 across all priority indicators)*		
ISSUE AREA ***Marine & Coastal Resources*** **IMPACT** **Impact on turtle nesting and breeding patterns from beach erosion (habitat loss), periodic inundation and elevated sand temperatures (skewing of sex ratio)**	Accept Loss	Accept loss of some nesting beaches to sea-level rise identified in local vulnerability study.
	Prevent Loss	Continued monitoring of threats to nesting populations and identification of nesting locations and conditions threatened by climate risks (especially sand temperatures), sea level rise and human activity (e.g. coastal development) which could be mitigated. Implement engineered solutions (e.g. beach nourishment) on selected nesting beaches particularly vulnerable to beach erosion to support long-term nesting activities Pass the National Conservation Law to support efforts under an action plan developed for this Issue Area/Impact and relevant aspects of the Habitat and Species Action Plans under the *National Biodiversity Action Plan 2009* (NBAP) Implement *Species Action Plan 2009* for marine turtles, and conduct periodic evaluation measures against increasing climate change threat
	Change Activity	Locate new coastal development away from nesting areas under threat supported by regulations to increase coastal construction setbacks Implement necessary measures to reduce current level of poaching and disruption of breeding patterns by human activities
	Relocation	Relocate nests vulnerable to inundation from high storm surges and impending hurricanes to less risk-prone beaches or to incubation facilities at the Cayman Turtle Farm.
ISSUE AREA ***Insurance Sector*** **IMPACT**	Prevent Loss	Reduce vulnerability of building stock in all categories: • Ensure all existing buildings are constructed in accordance with existing Building Codes • Identify appropriate risk analytical tools (e.g. Geographical Information Systems, Reinsurance industry climate models, risk assessments) and use outputs in all

Higher insurance premiums as damages from natural disasters increase and sea level rises		Government decision making procedures and planning • Develop holistic policy mechanisms to incentivize risk reduction and set targets for risk reduction in all sectors • Measure and report progress on risk-mitigation targets
	Change Activity	Update Building Codes for new construction to withstand at minimum 150 mph winds and water hazards from a Category 5 cyclone and expected sea-level rise. Policymakers and relevant Government entities must engage the Insurance and Banking sectors to: • Set differential insurance rates to reward risk-mitigation behaviour in all sectors • Encourage corporate risk management in the banking and insurance sectors to protect their industries' businesses and reputation (e.g. insurance companies should require as a policy valuation reports that include risk assessment) • Adopt a 'Buyer Beware' program where home purchasers must be provided with a risk assessment of the property as part of full disclosure at the time of purchase • Establish workable lending mechanisms and financing frameworks for homeowners and businesses to retrofit buildings to reduce their climate risk and current premiums • Develop niche market for adaptation and mitigation financing • Through business licensing, condition all companies to file an entity Corporate Social Responsibility (CSR) type statement to report its impact upon the environment and its plans for reducing the impact (e.g. carbon reduction) and contribution towards adaptation • Pass appropriate legislation to establish a reinsurance market in the Cayman Islands
	Relocation	Identify Government assets located in risk-prone areas or those with highest premiums and develop plans to relocate them where possible.
	Spread Loss	Work with regional governments and insurance sector to better define the Caribbean Region risk profile for the reinsurance industry so that it is a separate insurance zone from the Gulf Coast or United States
Priority Issues to be addressed in the Short Term *(total score of 6 across all priority indicators)*		
ISSUE AREA ***Beach & Shoreline Stability*** **IMPACT**	Accept Loss Prevent Loss	Accept loss of some beaches to sea-level rise identified in recent vulnerability studies. Improve beach monitoring programs to: • Develop a comprehensive inventory of erosion-sensitive beaches

Increased beach and shoreline erosion and land loss from stronger hurricanes, storm surges, and sea level rise		• Map beach-erosion hazards at each location • Determine long-term beach erosion/accretion trends for individual beaches Develop coastline stabilization plans for select beaches using appropriate techniques and state of the art technology: • Undertake properly planned and designed beach nourishment activities in areas susceptible to high economic losses, important for tourism and critical turtle nesting habitat. • Enhance islands-wide mangrove replanting programs using a variety of techniques suited to particular locales (e.g. soft engineering solutions). • Increase protection for coral reef systems, especially those fringing and providing buffering services to vulnerable beaches, and implement other recommendations contained in the Coral Reef *Habitat Action Plan 2009*. • Use Reef Balls and other proven technology as artificial reefs for underwater wave attenuation to slow erosional forces along selected beaches as determined by experienced coastal engineers and environmental professionals. • Installation of more substantial sea defences and shoreline stabilization structures (e.g. hard engineering solutions) Implement Sandy Beach and Cobble *Habitat Action Plan 2009* Implement recommendations from the *Beach Review & Assessment Committee Report 2003* and *Environment & Coastal Zone Management Special Issue Committee Report 2003* to reduce beach erosion and facilitate enhancement of natural beach sand accumulation rates and renourishment processes, including: • Use annual erosion rates for specific beaches to establish site-specific coastal construction setbacks taking into account sea-level rise atop storm surge using existing and periodically updated Storm Surge Atlas • Revise measurement of coastal setbacks from the High Water Mark to the line of permanent vegetation • Amend Development and Planning legislation to reflect recommendations made in an action plan developed for this Issue Area/Impact • Enforce revised coastal construction setbacks and new regulations on redevelopment and reconstruction within the coastal zone • Revise Development and Planning compensation statue for refusal of new applications not in accordance with the action plan developed for this Issue Area/Impact • Undertake a review of the Planning regulation that currently permits the taking of ballast from shore and increase fines for exceeding the stated quantity. Ensure violations are prosecuted to the fullest extent of the Law to discourage further illegal activity.

	Change Activity Supporting Activities Relocation Spread Loss	• Reduce illegal sand mining and other extractive activities through increased enforcement of such activities. • Promote alternatives to beach sand use in the construction sector and other activities in which it is traditionally used. Review recommendations of the Beach Review & Assessment Committee (BRAC) on artificial beach nourishment, which includes maintaining an adequate supply of beach quality sand, and develop a proper strategy for efficient implementation when such activities are needed. Relocation or removal of structures impeding natural renourishment as recommended by the BRAC Compensation to land owners significantly affected by the new coastal redevelopment policy or regulations
ISSUE AREA ***Marine & Coastal Resources*** **IMPACT** **Impact on fisheries & reef health from physical destruction by hurricanes and degraded reefs from warming seas, resulting in changing range of tuna and grouper**	Accept Loss Prevent Loss	Accept a certain degree of loss of coral reef structures and fish colonies from ever-increasing hurricane intensities. Increase resiliency of coral reef systems and fish populations by reducing human-caused stresses and unsustainable practices. • Participate in or keep abreast of regional climate research in this area and incorporate findings into local fisheries management ensuring buy-in from local fishers. • Monitor land-based sources of pollution on reef systems and in fish populations to determine if these are compounding problems. Enforce existing or enact new relevant regulatory controls for reducing harmful pollutants. • Expand monitoring of fish stocks of key species, including the use of anecdotal sources, to detect any significant changes in abundance or distribution. • Ensure sufficient financial and human resources exist to monitor and control overfishing of certain reefs. • Implement the *Habitat Action Plan 2009* for Coral Reefs, including legislative requirements to increase protection of these systems against anthropogenic stressors, and conduct periodic evaluations to determine the success of this plan against the climate threat. • Implement the *Species Action Plan 2009* for Nassau grouper, including stricter legislative requirements if necessary to safeguard already fragile populations, and conduct periodic evaluations to determine the success of this plan against the climate threat. Pass the National Conservation Law to support efforts under an action plan developed for this Issues area/Impact and relevant aspects of the Habitat and Species Action Plans under the

	Spread Loss Change Activity	*National Biodiversity Action Plan 2009* (NBAP) Provide compensation or other means of support to subsistence fishermen and anglers reliant on these target species. Utilize Cayman Sea Sense sustainable seafood program to raise awareness of plight of grouper and other species from climate change and human over-consumption to foster buy-in for stronger protection measures and encourage a switch in consumer preference for less vulnerable species. Offset any declines in these target species by encouraging sustainable aquaculture in other fish species for consumption by residents and within the restaurant trade. • Review and amend Aquaculture Policy accordingly to include incentives and proper environmental controls of these activities or construct an appropriate regulatory framework if necessary. • Provide training and financial assistance for ready uptake of these activities.
ISSUE AREA ***Energy Security*** **IMPACT** **Increased energy costs to consumer from increased electricity and gasoline prices**	Change Activity	Formulate a National Energy Policy (NEP) aimed at reducing energy dependence on foreign imports of fossil fuels, increasing use of indigenous sources of renewable energy (solar, wind, ocean water) through incentivized programmes and improving efficiencies in the use of energy across all sectors. A host of policy measures should include: • Strengthening foreign exchange reserves and bilateral agreements • Alternate sourcing of fuel products and fuel switching to cleaner cheaper options • Focus on recycled biodiesel not purpose-grown biofuel • Creating an attractive environment for independent power producers of non-fossil fuel based electricity generation • Development of Waste-to-Energy facility for Grand Cayman using clean, start of the art technology and appropriate regulatory controls for air emissions, noise, groundwater contamination, etc • Increasing supply side as well as demand side efficiencies • Introduce off-peak rates for tourism facilities • Adoption of an energy conservation code for new buildings and supporting legislation, e.g. installation of solar water heating systems on all new residential buildings, insulation values • Adoption of efficiency standards for appliances (e.g. Energy Star), equipment (e.g. air conditioning systems), building products and materials (e.g. R-value), and vehicles • Incentives to increase buy-in by vehicle owners, importers and providers in all sectors for fuel efficiency and alternative energy vehicles

	Supporting Activities	A range of strategies and measures to support the NEP and keep down the cost of energy use in all sectors include: • Evaluate performance of duty waiver on RETs program for residential sector and creation of additional incentive measures in other sectors • Review of CORE Program, including the current Feed-In Tariff, and/or develop new programs to increase uptake in the use of renewable energy technologies by all sectors, including the implementation of a Net Metering policy to allow Independent Power Producers to sell unused electricity back to the grid and offset their purchase of utility-produced electricity at other times • Use of demonstration projects to showcase new construction technologies and techniques for climate-proofing and reducing the energy cost of operating buildings (e.g. a model ICF home), and other micro-projects that illustrate energy cost savings through GHG-mitigation practices • Use of energy audits to secure financing and attractive insurance rates for new builds, and to acquire energy saving mortgages for retrofit of existing building stock • Development of green jobs as expertise needed to conduct home energy audits, local assembly or production of RETs used in the Cayman Islands or exported regionally, etc. • Public Education & Outreach Strategy on various aspects of the NEP targeted at all sectors, including changing attitudes regarding electricity usage • Promotion of mixed-use development to facilitate pedestrian and other non-motorized activities
	Prevent Loss/ Relocation	Climate-proof existing and planned fuel terminals and electricity distribution systems to reduce vulnerability to climate threats, extent of future damage, and reconstruction/recovery costs passed on customers; test and update safety measures and hurricane contingency plans; and other major adjustments to critical infrastructure including relocation to less risk-prone areas (e.g. CBP&L generation plant moved to bluff, CUC submarine cable across North Sound)
Priority Issues to be addressed in the Short-to-Mid Term *(total score of 7 across all priority indicators)*		
ISSUE AREA ***Marine & Coastal Resources*** **IMPACT** **Corals reefs impacted from warmer sea temperatures (coral bleaching), ocean**	Accept Loss Prevent Loss	Accept a certain level of loss from global activities that have caused increased sea surface temperatures beyond the threshold of some Caribbean corals to survive and ocean acidification. Enhance existing long term coral reef monitoring programs and provide additional resources for research specifically related to detecting climate change impacts Implement the *Habitat Action Plan* for Coral Reefs which details action on: Policy & Legislation,

acidification and sea level rise		Safeguards & Management, Advisory, Research & Monitoring, and Communication & Publicity. Complete the ongoing review of marine parks system, the framework for which dates back to 1986, and implement recommendations to enhance protection of these marine resources and reduce anthropogenic stressors so as to facilitate optimal resiliency of these systems to unavoidable climate risks. Pass the National Conservation Bill to support recommendations in an action plan developed for this Issue Area/Impact
	Change Activity	Review all other relevant national legislation and policies that have the potential to impact coral reefs and seek to align policies to avoid or minimize vulnerability-enhancing practices.
	Spread Loss	Utilize the Environmental Protection Fee Fund to enhance conservation and management of coral reefs
IMPACT **Increased mangrove loss from hurricanes, drowned by storm surge and through impoundment, outpaced by sea level rise, resulting in loss of natural storm buffers and protection for coasts**	Accept Loss	Accept temporary and long-term loss of fringing and coastal mangroves to serve hurricanes and impoundment of sea water by coastal roads.
	Prevent Loss	Pass the National Conservation Bill to support recommendations in an action plan developed for this Issue Area/Impact Implement *Habitat Action Plans* for Mangroves and Pools, Ponds and Mangrove Lagoons. Implement relevant recommendations *Environment & Coastal Zone Management Special Issue Committee Report 2003*, including increased protection for remnant mangrove on Grand Cayman's coastline not currently designated Mangrove Buffer. Establish appropriate coastal construction setbacks for mangrove shorelines not included in the Mangrove Buffer Zone. Enforce construction setbacks and development behind these buffers to allow for landward migration of mangroves. Undertake timely drainage of impounded mangroves, particularly black mangroves, along the coast to prevent permanent drowning of stands and forests. Expand mangrove replanting program undertaken by the Department of Environment and provide support to other non-government organizations that periodically undertake such efforts

	Change Activity	Adopt Florida Department of Environmental Protection Mangrove Trimming Guidelines and encourage pruning of coastal mangroves rather than outright removal.
	Spread Loss	Utilize the Environmental Protection Fee Fund to enhance management of protected areas and purchase additional areas for conservation
ISSUE AREA ***Terrestrial Resources*** **IMPACT** **Loss of biodiversity especially game birds and culturally important species (parrots) due to impacts on habitats (dry forests, black mangrove) that support these species**	Accept Loss	Accept a certain attrition rate of biodiversity loss from unavoidable climate risks
	Prevent Loss	Conserve the range and variability of existing habitats and species by enacting the National Conservation Law in order to: • Protect IUCN Red List threatened and critically endangered endemic species currently without protected status • Allow for the creation of networks of protected areas and wildlife corridors • Facilitate the implementation of the *Cayman Islands National Biodiversity Action Plan 2009* which includes *Habitat Action Plans* for mangroves, forests and woodland and *Species Action Plans* for the Cayman parrots • Facilitate the implementation of the *Environment & Coastal Zone Management Special Issue Committee Report* recommendations, including standard conditions of approval on vegetation clearance and retention of primary habitat • Reduce or prevent threats not linked to climate change such as species loss and habitat fragmentation from current land use practices and other development pressures
		Enhance early warning programs, including conducting rapid assessments after major perturbations (e.g. hurricanes), to determine impact on bird populations and need to initiate response measures
	Change Activity	Continue to collect specimens under the Seed Bank Project in concert with Kew Gardens, UK.
	Supporting Activities	Provide investments in and garner political and public support for reforestation and rehabilitation projects, especially after the passage of damaging hurricanes.
		Investigate opportunities to participate in international carbon offsetting schemes or support the development of local measurable and verifiable projects to facilitate the protection of in-situ forests and finance reforestation efforts
		Greater financial support the Botanic Park Native Tree Nursery to allow for expansion of species cultivated for the landscape trade and reforestation programs

		Technical capacity building and manpower to perform a wider array of bird population surveys
IMPACT **Increase of invasive species of flora and fauna**	Accept Loss	Accept that some endemic species may be lost to invasive species that emerge from favourable climate change circumstances.
	Prevent Loss	Expand monitoring and reporting efforts to identify new invasive species. Implement relevant *NBAP 2009 Habitat Action Pans* and *Species Action Plans*, especially for invasive coastal plants Develop strategies or refine protocols for addressing invasive species and prioritorize action plans: • Actively remove invasive species deemed particularly harmful to endemic species • Find alternative uses for invasive species considered of lower threat to native flora and fauna, e.g. Leucania good for fodder.
	Change Activity	Implement more stringent regulations and sourcing practices related to importation of aggregate, soil, non-native plants and produce.
	Supporting Activities	Public Education & Outreach Campaign to support efforts of Government agencies and non-governmental partners. Develop technical capacity and manpower
	Spread Loss	Utilize the Environmental Protection Fee Fund or other taxes collected for conservation purposes to enhance invasive species eradication programs
ISSUE AREA ***Water Resources & Hydrology*** **IMPACT** **Increased occurrence of inland flooding in chronic areas and newly impacted areas**	Prevent Loss	Develop comprehensive plans to alleviate current flooding problems at areas identified by the Stormwater Management Committee and National Roads Authority using appropriate suite of hard and sort engineering methods Increase investment in stormwater management programs to prevent reoccurring and future problems, including: • More frequent maintenance of drainage systems along primary and secondary roads and within subdivision networks • New roads designed and constructed outside of flood-prone areas and using methods appropriate to high water table environments

	Change Activity Spread Loss	• Identification of techniques and conveyance systems that do not involve untreated and high velocity stormwater run-off entering the marine environment, particularly in Marine Protected Areas (e.g. South Sound) • Identification and mapping of areas where it would be unwise to continue to develop and declare these 'no build' zones Develop comprehensive regulations for proper stormwater management to supplement the use of conventional drainage systems (deep wells) that are inadequate in many cases, which include the use of EIAs or other environmental site assessments to ensure proper design and impact mitigation Implement a program of catchment and wetland restoration Implement relevant Habitat Action Plans under the *National Biodiversity Action Plan 2009* to support other measures in an action plan developed for this Issue Area/Impact Revisit MRCU Law and Planning policy to fill entire parcel in reclaimed areas to a consistent 4'0" above mean sea level Strengthen provisions for retaining in-situ vegetation on development sites within the Planning regulations as use of the Land for Public Purposes provision and Landscaping Guidelines have been effective Require new developments in wetland areas to retain a percentage of in-situ wetland, particularly freshwater habitats, by incorporation as landscape features and public amenities Require new developments to minimize the extent of impervious surfaces by incorporating technologies designed to facilitate and increase infiltration (e.g. Grasscrete, porous concrete) Use of Infrastructure Fee Fund to compensate land owners for land within 'no build' areas or properties needed for capital projects to alleviate flooding
IMPACT **Increased costs for desalinated water as the price of fossil fuels rise in response to climate change and depleting resources**	Change Activity	Increase energy and equipment efficiencies throughout all desalination plants to reduce fuel use and production costs Incentivize the water sector to invest in renewable alternatives to fossil fuel-based production systems such as solar powered desalination technology Develop water conservation programs to reduce demand on desalinated production systems and

	Spread Loss	agree with key stakeholders implementation of more stringent measures at critical thresholds (e.g. onset of drought as determined by the National Weather Service) Revise Water Authority regulations to allow use of grey water for irrigation, especially at hotels, golf courses and other large-scale development, as well as reuse in buildings for toilet flushing Investigate Insurance Pool scheme as alternative to self-insurance of water production infrastructure
ISSUE AREA ***Critical Infrastructure & Human Settlements*** **IMPACT** **Higher insurance premiums or eventual future of uninsurability**		See action items under Insurance Sector
ISSUE AREA ***Food Security*** **IMPACT** **Local food security – local food production and availability affected by crop damage, soil salinization, drought conditions and competition from imported produce and development pressures on scarce, good quality arable land.**	Accept Loss Prevent Loss	Abandonment of unproductive lands or flooded areas Develop a Food Security and Nutrition Policy with a target to increase domestic food production by 10-20% and to include strategies contained in an action plan developed for this Issue Area/Impact Expand domestic food production through existing niche market opportunities and the development of new niche markets designed to reduce imports. Establish land use and zoning policies to protect agricultural land: • Protect Class I and II agricultural lands and in particular water lenses essential for agriculture • Show these areas and Agricultural Buffer Zones critical for preserving agricultural enterprises and developing the sector on the Development Plan and amend planning regulations accordingly • Revisit use of designating orders in zoning decisions. • Protect farmers' rights of use of land Maintain or increase yield through:

	Change Activity	• Use of climate change data to facilitate production and ensure distribution of information to farmers. • Expand the use of adapted production systems, new crop varieties and cultivars • Initiate use of more efficient controlled environment production systems, e.g. shade houses • Introduction and expansion of the use of risk mitigation production systems, including rigorous fruit tree pruning, use of wind breaks and modifications to infrastructure • Use of compost collected at central landfill to offset fertilizer requirements and costs • Testing of integrated management approaches Combat issues related to salinzation of soils, ground water resources and irrigation wells through: • Use of subsided supplies of gypsum to counteract salt intrusion effects • Use of composting to help rebuild soil structure and other soil management practices • Introduction of more salt tolerant varieties of crops and pasture grasses Combat issues related to water scarcity affecting crops and livestock by: • Protecting aquifers for farmers • Investigating drought tolerant crops • Implementing better soil and water management, e.g. use of mulch to reduce evaporation rate and retain moisture; use of drip irrigation systems; install water catchment/covered storage system Monitor and implement measures to address invasive species, e.g. policies on quarantine, control and pesticide use Rehabilitation of degraded lands Encourage more ‘backyard’ gardening: greenhouses, grow boxes, home and commercial composting, etc Expand linkages with the tourism sector and promote and encourage the use of local agricultural products as substitutes for imported alternatives both to reduce dependency on imported food and enhance the visitor experience. Address population growth rate and consider policy on overall number of tourists
	Supporting Activities	Streamline planning application and approval processes for agricultural projects Financial assistance from DEFRA and other UK agencies required

	Spread Loss	Monitoring & Data Collection – Early warning systems to identify potential problems with corrective action and policies Public Education & Outreach programs developed to support various initiatives to change behaviours and achieve domestic food production targets Increase capacity of farmers to access and utilize climate research and equip them with the necessary tools Establish locally funded crop insurance or a crop recovery fund financed by a cess on both domestic production through fees on inputs and on imported food by a small import tax. Payouts would be linked to a parametric system and would be for commercial farming operations. Establish other lines of credit for farmers.
Priority Issues to be addressed in the Medium Term *(total score of 8 across all priority indicators)*		
ISSUE AREA ***Water Resources & Hydrology*** **IMPACT** **Loss of groundwater resources from annual rainfall decrease and saltwater intrusion associated with sea level rise**	Accept Loss Prevent Loss Change Activity	Abandonment of unproductive catchments, lenses and wells Enforce development controls over water lenses, including especially quarrying and clearance practices Tighten regulations and monitoring of abstraction from aquifers Continue to expand storage and distribution infrastructure in Cayman Brac and determine need for similar investments in Little Cayman Ensure state of the art leak detection system and metering in place Restrict surface area of quarries and open water bodies to reduce evaporation rates Enhance monitoring of groundwater contamination and salinity levels as part of early warning systems, and implement corrective measures Reforestation of catchments to promote infiltrate and increase recharge rates Encourage water conservation and rainwater capture at the household level

	Supporting Activities	Incentivize efficiency measures, equipment replacement and the development of reservoirs in water-intensive activities (agriculture, tourism) Public Education & Outreach programs developed to introduce and encourage support for new water management practices and more stringent measures Address regulatory framework and infrastructural requirements to facilitate public supply of treated greywater and stormwater
ISSUE AREA ***Critical Infrastructure & Human settlements*** **IMPACT** **Increased flooding of homes, critical facilities, roads and developable lands (both inland and in low-lying coastal areas)**	Accept Loss Prevent Loss	Some loss of coastal areas for development and infrastructure, and temporary or permanent displacement of some households in low-lying areas Develop or implement remediation plans for chronic flooding 'hot spots' identified by the Stormwater Management Committee in 2003 and more recently the National Roads Authority - identify means of financing and work with these communities on implementation Wisely utilize the compulsory acquisition provisions of the Roads Law to initiate remedial plans in communities and for critical infrastructure most adversely affected by intense or prolonged rainfall events Revise Planning regulations & building codes to include provisions for reducing flood risk: • Coastal construction setbacks based on flood risk mapping and measured from the line of permanent vegetation • Building on pilings and other construction techniques to raise ground floor • Wash-through ground floors • Road side drainage and other sustainable drainage systems (SUDS) in all new development • Minimal land clearance and retention of wetlands to assist with stormwater capture and release • Vegetated buffer zones and other land use or stormwater run-off controls between existing communities and planned developments of varying site elevations Identify existing properties most vulnerable to coastal flooding and in conjunction with land owners/stakeholders determine the appropriate national response, e.g. coastal drainage, mangrove revival, beach nourishment, construction of professionally engineered coastal defences Use the Preliminary Vulnerability Assessment for Grand Cayman and the Tourism Vulnerability &

	Change Activity	Capacity Assessment to identify road sections and other public critical infrastructure currently vulnerable to sea level rise and: • undertake a quantitative assessment of the physical and socio-economic impact of natural hazards on the road transport system • upgrade the road infrastructure with larger drainage pipes to better handle floodwater • protect critical sections of the road network from surge with the necessary sea defences • construct alternate routes to prevent communities in the eastern district from being isolated during emergencies and after severe storms Implement measures to enhance natural buffers (e.g. mangroves, beaches) Identify risk-prone areas through the development of flood risk maps based on 100-year storm event, rainfall outputs from PRECIS Regional Climate Model, regional sea-level rise projections, local Storm Surge Atlas and other hazard vulnerability assessment tools Determine highest-risk areas and designate as 'no build' zones Locate new development and infrastructure away from the coast and flood-prone areas wherever possible, and provide incentives for developing outside of wetland areas or at higher elevations Integrate hazard vulnerability and risk assessments into development planning processes and utilize environment impact assessments to assist with decision making Regional watershed/catchment basin planning integrated in all future review of the Development Plan Rehabilitation of wetlands to increase storage capacity in flooding 'hot spots' Design, cost and phase implementation of a national level sewerage system with appropriately located pumping stations and treatment facilities
	Relocation	Use the Tourism Vulnerability & Capacity Assessment and other hazard mapping tools to identify road sections and other public critical infrastructure (shelters, clinics) that will require relocation to less risk-prone areas where feasible
	Supporting Activities	Economic and Fiscal measures to promote appropriate behaviour, e.g. construction of multi-purpose safe rooms with concrete roof and reinforced doors that is +10 ft above MSL or well above locally determined flood line)

	Spread Loss	Adopt a 'Buyer Beware' program (similar to that in the UK) where home purchasers must be given a risk assessment of the property, including previous flooding incidents, as part of full disclosure at the time of purchase Ensure adequate home owners property insurance and provide support to or means of coverage for those currently un/under-insured Use of Infrastructure Fee fund and other revenue to finance investments in remedial stormwater infrastructure, wetland rehabilitation to increase catchment storage capacities, compensation for land acquisitions and relocation of the most vulnerable groups. Ensure adequate insurance for critical infrastructure and investigate insurance pool schemes for portions of infrastructure not currently insurable (e.g. distribution systems)
IMPACT **Increased operational disruptions to critical services (airports, sea ports, utilities, waste management) from weather extremes and rebuilding after significant damage**	Accept Loss Prevent Loss	Recognize some infrastructure, particularly road sections, will be temporarily impassable Design new public buildings (schools, civic centres) that serve as hurricane shelters and other critical infrastructure (hospitals, clinics) for passive survivability, i.e. to function as liveable refuges in the event of a natural disaster or temporary loss of energy, water, waste collection and public sewage systems: • Rainwater harvesting systems for potable water use, toilet flushing, bathing • Solar electric (PV) systems • Solar water heating systems • Back-up power at municipal sewage treatment plants and pumping stations and installation of one-way valves to prevent back up into buildings • Distributed infrastructure (power, water communications) provided through renewable strategies • Bury all new electricity and telecommunications infrastructure for added protection • Adequate shelters provided for growing population and appropriately distributed and sited • Major arterials (primary roads, bypasses) upgraded to withstand Category 5 storms • Emergency access for use as assembly areas, distribution points and helicopter land areas designed in all schools, hospitals and recreation areas Design and build all new critical infrastructure to withstand Category 5 hurricane winds, comply with earthquake code, at ground floor level between +7 to 10 ft above MSL. Require underground utilities in new all developments.

	Change Activity Spread Loss	Implement plans to flood-proof or re-site infrastructure if possible and plan new routes to minimize disruption Enhance maintenance program for stormwater drains to minimize blockage at critical times of intense rainfall accumulation and high saturation rates Incorporate appropriately designed retention/detention ponds into regional catchment management and rehabilitation plans as well as individual project proposals for new development Review Disaster Management Plans for district landfill sites, and ensure design and operation of future facilities consider climate change impacts on sector Ensure Disaster Management and Emergency Response plans at all critical services are tested and upgraded regularly Seek cost-sharing arrangements amongst utilities, developers and home owners to ease compliance with new requirements to bury infrastructure in all future developments
ISSUE AREA ***Food Security*** **IMPACT** **External food security – increased food costs and incidents of disruption to food supply as climate change impacts other regions and supplies disrupted when sea ports damaged or inoperable**	Prevent Loss Change Activity	Harden ports, road networks and other critical infrastructure and services (e.g. supermarkets) to reduce down time resulting from rebuilding. Secure alternative sources of food supplies and expand bilateral linkages with non-traditional suppliers particularly with regional producers in the Caribbean and Central America (e.g. Nicaragua where there are Caymanian-owned interests)
ISSUE AREA ***Energy Security*** **IMPACT** **Increased demand for**	Change Activity	Encourage architectural design of homes and other buildings that incorporates both active (HVAC, lighting) and passive strategies for cooling and lighting (e.g. natural ventilation, shading and day lighting) Develop a Building Code aimed at increasing energy efficiency in new buildings across all sectors,

electricity and gasoline as warmer temperatures trigger increased demand for cooling of buildings and cars		with particular focus on efficiency requirements for cooling systems (i.e. highest industry approved SEER rating) Provide incentives for the importation and use of building materials, products and technologies that result in higher energy efficiency Set energy efficiency standards for a range of appliances and equipment imported Encourage development and use of solar air conditioning, geothermal and district cooling systems and provide the appropriate financial incentives for uptake of these technologies, especially in large residential and commercial projects Require solar water heating systems for all new buildings and provide appropriate vehicles for financing purchase and installation of systems in order to reduce overall electricity demand across all sectors. Ensure compliance through building permit process. Ensure all new Government buildings, including affordable housing, are designed and built utilising LEED rating systems for energy efficiency, and develop a reasonable schedule for retrofitting the existing public building stock Work with local electricity generation companies to: • Develop Smart Grid systems for energy management and energy efficiency • Develop plans for fuel switching to cheaper alternatives if this proves cost-effective • Replace conventional energy sources with renewables in an agreed timeframe Work with local utilities to create a suit programs (rebates, tax breaks, fee reductions, price disincentives) to encourage greater water and energy conservation and efficiency practices in the residential and commercial sectors and increase the use of renewable technologies Develop programs with the tourism sector to: • Conduct energy audits of the Cayman Islands tourism plant • Reduce overall energy use from facility operations, especially demand for cooling • Provide financial incentives and technical assistance to achieve reductions, with particular emphasis on retrofitting lighting and cooling systems and installing renewable energy alternatives, e.g. solar water heating • Encourage tourists to conserve energy at their hotel or tourism facilities and attractions visited • Provide opportunities for tourists to offset carbon emissions associated with their hotel stay

	Supporting Activities Spread Loss	or activities which benefit on-site or local energy conservation and efficiency programs or renewable energy initiatives Incentivize and encourage: • the importation and use of smaller, more fuel efficient vehicles • the conversion of existing vehicle stock to use biodiesel where feasible • the importation and use of hybrid, electric and alternatively fuelled vehicles • vehicle licensing fees tied to carbon emissions or fuel efficiency Promote the development of the burgeoning local biodiesel industry Work with local fuel providers to source the most cost-conscious fuel products for the needs of the Cayman Islands Develop a series of Public Education & Outreach campaigns gear at, including but not limited to: • Making the motoring public more efficient drivers and responsible vehicle owners • Energy conservation and energy efficiency in the home and office, including the importance of systems maintenance to increase efficiencies • Increasing support for a national public transport system Work with the valuation sector to incorporate of carbon intensity of buildings in property valuation and the marketability/salability of high-performance, energy efficient, and self-sufficient homes A domestic carbon trading scheme utilizing allocations or a quota system should be explored to kick start activities in increasing energy efficiency and use of renewable energy sources across all sectors to effect national GHG emission reductions. The pitfalls and successes of other domestic and regional programs can provide useful lessons in designing an appropriate national scheme. Use of Infrastructure Fee Fund or other revenue taxes and measures to assist existing home owners and businesses retrofit their buildings in compliance with new Building Codes and standards
ISSUE AREA ***Tourism*** **IMPACT** **Facilities at risk from sea level**	Prevent Loss	Implement recommendations from the Vulnerability and Capacity Assessment for the Tourism Sector to reduce the present risk of existing facilities, including: • A review of current Tourism zoning in areas highly vulnerable to sea level rise, stronger storm surges and flooding and determining whether any of these area should be established as ‘no build’ zones

rise, stronger hurricanes, storm surges and flooding		• Re-evaluate evacuation routes and reliance on other critical tourism infrastructure which may affected • Ensure property valuations are current and used to secure adequate coverage in the event of damages • Encourage facilities to develop, implement and test disaster management and business continuity plans • Encourage tourism businesses to invest in risk-mitigation activities and assist those that are too small or otherwise challenged
	Change Activity	Construct sea defences and implement soft engineering solutions to reduce the vulnerability of selected facilities Develop low-density/low-impact tourism facilities and attractions that have little or no infrastructure vulnerable to climate risks, including not siting development in or over Crown seabed (e.g. villas on stilts) Identify synergies between actions for maintaining Green Globe Certification amongst certified properties at risk from climate change and reducing hazard vulnerability, and provide assistance for these measures to be implemented Increase the climate resilience of the tourism plant through: • Proper siting and development of facilities using integrated EIA processes to ensure hazard vulnerability and risk reduction factors are considered in the planning approval process • Improved building codes and development control setbacks • Enforcement of building codes and land use regulations
	Relocation	Relocate hotels and critical tourism infrastructure away from coastal areas where feasible
	Spread Loss	Encourage facility owners to have adequate property insurance, including business continuity coverage provisions Assist the most vulnerable facilities to acquire group insurance if this is deemed more cost-effective Establish public-private Disaster Recovery Fund for the tourism sector; encourage sector-specific insurance

IMPACT **Impact on product as more extensive coastal erosion degrades beach amenities, damage to local attractions, and more frequent coral bleaching events impact dive tourism**	Prevent Loss	See action items under Beach & Shoreline Stabilization related to reducing beach erosion and enhancing coastal environments See action items under Coral Reefs related to increasing resilience of this ecosystem upon which dive tourism depends Keep abreast of international climate change mitigation policies that have the potential to adversely affect visitor arrivals in the long term (e.g. aviation carbon emissions reporting and trading, change in consumer choice to more carbon-friendly destinations, etc.) Revise Visitor Exit Survey or develop other appraisal tools to evaluate visitor perception of beach amenities, local attractions and reef conditions, and implement measures to improve dissatisfaction wherever possible Implement *National Tourism Management Plan* action plans that would help mitigate the anticipated climate change impacts on the tourism product
	Change Activity	Continue to diversify the Grand Cayman product from 'sun-sea-sand' to a wedding, events/conference, health and sports tourism destination Enhance the branding of Cayman Brac and Little Cayman as nature-tourism destinations and seek Green Globe Destination Certification for Little Cayman Offer attractive high season (winter) packages to retain visitor numbers and draw tourists away from destinations in warmer in temperate latitudes Enhance visitor experience by increasing the number and type of attractions not reliant on marine and beach resources, e.g. adventure tourism into interior forests and caves, facilities that recognize the beauty and resilience of ironshore coastline Participation in the Inter-American Development Bank Carbon Neutral Project or development of indigenous scheme for tourists to participate in the offsetting of greenhouse gas emissions associated with their accommodation, dive or watersports activities and transportation whilst in the Cayman Islands
	Spread Loss	Cost-share beach re-nourishment projects with the tourism sector or facilities most at risk from loss of tourist business

ISSUE AREA ***Insurance Sector*** **IMPACT** **Inability to obtain insurance coverage for current risk factors**	Prevent Loss Change Activity Spread Loss	See action items under the Higher Insurance Premiums related to reducing vulnerability of building stock and increasing climate-resiliency of new construction Encourage banks and other lending institutions to institutionalize climate-risk reduction in their lending policies Encourage various sectors to engage in self-insurance or pooled schemes Government to re-evaluate or re-negotiate participation in The Caribbean Catastrophe Risk Insurance Facility to ensure public sector risk and national assets are covered cost effectively.

7.4 Funding Adaptation and Mitigation

Financing adaptation and mitigation action presents a challenge for implementation of the National Climate Change Policy. While adaptation responses that are behavioural, managerial and even some that are policy-based in nature require little or no financial outlay; technological responses, such as remediating flooding and constructing sea defences, do. It is critical then that climate change adaptation is not viewed as an "add-on", rather an integral part of national planning processes and decision making so the resources allocated to programs and projects achieve their main developmental goals while addressing climate change.

The Cayman Islands can ill-afford to plan adaptation in an information void lest limited resources are squandered. Phase 1 of the CCRIF Study has provided a preliminary assessment of the impact of certain climate risks on the Cayman Islands and the cost-benefit of a range of risk mitigation actions. While Phase 2 is expected to consist of a more detailed analysis, the current report should assist government in the interim to select some cost-effective measures. Options that have the greatest sustainable development benefit – that is, 'no-regrets' options, could be readily integrated in ongoing initiatives or take high priority on the national agenda are recommended. Attention can then be turned to costing and financing the mid- and longer-term planning needs.

Despite the impending Phase 2 CCRIF study, the Cayman Islands should still conduct a Stern-type review to assess the actual costs and benefits of specific adaptation strategies being proposed and the timing of their implementation. By articulating the socio-economic impacts of climate change and the cost-effectiveness of proposed action within a Cayman Islands context, this review would motivate policy and decision makers to swiftly endorse the National Climate Change Policy and embark on its implementation. In April 2010 a request by the ECACC consulting team was made to DfID to utilize expertise under the new UK Climate and Development Knowledge Network to carry out Stern Reviews in all the Overseas Territories. To date no response has been received. It is understood that the Turks & Caicos Islands intends to pursue an Overseas Territories Environment Programme (OTEP) grant to undertake this review in their Territory. It would befit the Cayman Islands to similarly pursue alternate means of financing and acquiring the technical expertise to perform this review to support further refinements to the National Climate Change Policy. Perhaps Cayman Finance could assist in this effort.

International funding for local adaptation and abatement action is presently limited. Despite our obvious vulnerability to climate change, and the need for assistance to respond in a timely fashion, our non-sovereign status as an UK OT positions us as a "developed country" under the UNFCCC and means that the Cayman Islands cannot host CDM projects or benefit from the proceeds of this Kyoto Protocol mechanism. In fact, the Cayman Islands is ineligible for any financial assistance for adaptation, technology transfer, mitigation and capacity-building under the current international climate architecture, or new sources of finance negotiated under the Copenhagen Accord to assist developing countries, such as the US$30 billion "fast start" climate financing for 2010-2012 expected to reach US$100 billion a year by 2020. Whilst opportunities for technology

transfer and project financing exist under the JI mechanism, options for the Cayman Islands have been severely restricted by current UK policy to not host JI or domestic projects, as this economic instrument has been deemed cost-ineffective to incentivise abatement in sectors not suitable for coverage by cap-and-trade systems in the UK[224].

Given complications with financial ineligibility under the present UNFCCC/KP architecture, the Cayman Islands must therefore prioritize direct public financing towards cost-effective integrated strategies, and seek funding mechanisms to which it is eligible. The next logical approach is to request direct funding from the UK for implementation of the National Climate Change Policy and establish long-term programmatic financial support for further climate change work. Such an appeal has been made through a jointly-drafted Overseas Territories Declaration on Climate Change to be presented to the UK government shortly. Setting a climate change agenda for the country, which includes costing national adaptation and mitigation programs and projects, signals a clear intent on the part of the Cayman Islands that will serve to attract much needed international financing and bilateral assistance necessary for implementation.

7.5 Opportunities and Constraints

While developmental agendas and national goals can be constrained by climate change, it also provides an opportunity for a fresh look at certain issues. For new initiatives, climate change provides a means of 'getting things right the first time' without costly remediation. The development of a National Energy Policy and other ongoing initiatives must take advantage of opportunities arising from climate change adaptation and mitigation action where they offer cost-effective use of public sector resources by spreading costs across different sectors. Greater self-resiliency across sectors and at all levels means less allocation of government resources to adaptation in those areas.

Constraints

The following constraints were identified during the national consultations and the issues surrounding them have been discussed in this report:

1. Locally there are environmental, economic, informational, social, attitudinal and behavioural barriers to the implementation of adaptation strategies, some more formidable than others. Climate change is still viewed for the most part as some future occurrence to be dealt with in time and separate from over developmental pressures. However, adaptation has its limits and cannot be expected to cope with all the predicted effects of climate change, especially over the long term, as most impacts are expected to increase in magnitude. It is therefore essential that the development pathway chosen for the Cayman Islands does not increase vulnerability beyond the capacity to effectively adapt. However, overcoming some of these barriers to ensure climate change

[224] Department of Energy and Climate Change, 2008. "Review of Whether the UK Should Host the Joint Implementation Mechanism or Alternative Domestic Emission Reduction Projects"

will not exacerbate vulnerabilities will require a shared vision of the type of (sustainable) development desired; such a national vision does not currently exist.

2. The current lack of information on the full extent of adaptation responses required to avoid the worst impacts of climate change and their associated costs is a present constraint. A quantitative assessment of the adaptation strategies and implementation timeframe proposed for the National Climate Change Policy would be an invaluable exercise. Policy makers will have a greater level of confidence in budgetary allocation of limited resources and that publically funded measures will meet their targets.

3. Execution of such a multi-sectoral cross-governmental policy will be challenging to implement; policy implementation being a long-standing institutional weakness for the Cayman Islands. In St. Lucia, where the Climate Change Adaptation Policy is implemented through the National Strategy for Adaptation to Climate Change, the National Climate Change Committee is charged with monitoring the policy's implementation, reporting to Cabinet annually on measures that have been undertaken, and is responsible for conducting five-year public reviews of the policy[225]. The Cayman Islands will have to decide whether such a management framework is suited to the national context given the current lack of statutory power or decision making influence of the Cayman Islands' National Climate Change Committee. It would befit the NCCC and consultation participants to carefully consider and propose a feasible implementation framework for the National Climate Policy so as to avoid the pitfalls of other national planning initiatives. While private sector execution is essential, lack of governance in discharging its own policies can create a problem.

4. Access to financing for local adaptation and mitigation action under the current UNFCCC framework is presently limited, and there is a dire need to seek a range of alternatives, including international private investment. The voluntary carbon markets appear to be a more viable entry point for the Cayman Islands at the moment, valued at US$1 billion per year in 2010, and expected to triple by 2020[226]. However, at present local capacity to fully access what is available is virtually non-existent. The Islands' fear there is steady movement toward a global carbon market and we will not be a player. However, the Cayman Islands recognizes that it cannot rely solely on market mechanisms to fund mitigation measures – that public funds will have to be prioritised for such activities - and understands that there are no existing market mechanisms for adaptation financing.

5. Despite participating in the UNFCCC since 2007, the Cayman Islands still lacks national or sectoral GHG emission reduction targets. Not only does this send a poor signal nationally and to international development partners, it also places the country at a disadvantage for accessing desperately needed funding from very limited international sources.

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[225] Government of St. Lucia, 2003. St. Lucia National Climate Change Adaptation Policy and Strategy. In: Climate Change Adaptation Policy: the Caribbean Experience. Trotz, U.O., G. de Berdt Romily, W. Vergara and J. Clarke.

[226] Coady, L, 2010. "Voluntary Carbon Markets: Opportunities and Risks" Session at GLOBE 2010 11th Biennial Trade Fair & Conference on Business & the Environment, Vancouver, March 26, 2010.

Opportunities

Opportunities for the Cayman Islands presented by climate change are numerous. These are only a fraction of the economic benefits stemming from an integrated approach to climate change, and in particular the pursuit of mitigation activities:

1. Diversification of the economy including within existing sectors is an adaptation not to be missed. This has been a topic of every major national economic planning initiative, including Vision 2008. Niche markets are being carved out in tourism (e.g. weddings) and synergies with agriculture are being created (e.g. agri-tourism). The wider the Cayman Islands spreads its economic base, the better position it will be in to withstand the direct and indirect economic impacts of climate change in the long term. Furthermore, economic diversification is critical for coping with short term external shocks such as recessions, change in international policies or unanticipated trends in key foreign exchange earning sectors. It is crucial however that in diversifying, activities are not pursued or subsidies that will heighten the economic, social or environmental vulnerabilities already inherent in the country.

2. Entrepreneurship opportunities abound in terms of supplying the local market with goods and services necessary for building individual, household or business adaptive capacity. Since hurricane Ivan the new technologies and products now locally available for home or business storm protection is an encouraging sign for adaptive capacity. The rapidly growing number of providers of a range of adaptation and abatement products, including locally-produced hurricane shutters, water purification systems, alternative fuels, renewable energy technology, energy-efficient building materials and IT equipment, signals a private sector eager to participate in a new type of economy. Many of these are up-start companies that are poised to drive a more climate-resilient low-carbon economy, steer sector and national sustainability, and fuel job creation. Climate change has also made residents more aware of food costs and organic produce as substitutes, creating market opportunities for local farmers[227].

3. The Cayman Islands has become a model for business continuity. Hurricane Ivan highlighted the need for Business Continuity Planning, especially in the financial services sector, and catalyzed the expansion of local divisions or entirely new firms solely focused on this market niche. Consultancy in and provision of infrastructural requirements for business continuity planning has focused the public and private sectors' attention on not only applying a risk management approach to business but also on ensuring that resilient structures, procedures and processes (including staff) permeate their organizations. The continued development of these services and associated products is very likely as the inevitability of future disasters to which local companies will be exposed and have to respond effectively is quite evident.

[227] DOE, 2009. Comments from Agriculture Stakeholder Consultation, 22 January 2009.

4. Opportunities exist across the housing, transport and utilities sectors for improvements in energy efficiency and use of renewable energy technology. Tackling energy security by reducing the country's reliance on conventional fuel use in these sectors, utilizing state-of-the-art energy efficiency equipment and capitalizing on indigenous renewable energy sources such as solar or wind, saves on foreign expenditure which can be invested locally in planned development or climate change adaptation projects. Elsewhere upwards of 50% of carbon reduction can be achieved through energy efficiency measures[228]. Renewable energy can support economic activity, bolster competitiveness and create co-benefits for GHG abatement and climate change adaptation when underpinned by an incentivized sustainable energy policy. Likewise, revised building codes would facilitate high-performance building design and technologies that achieve higher energy efficiency or carbon neutrality of new or retrofitted building stock. At the municipal level utilizing landfill gas and waste-to-energy technology to power businesses and communities addresses the energy security issue as an adaptation intervention as well as a mitigation measure.

5. It is a matter of time before a global price on carbon will be set whether under national or regional cap-and-trade systems or directly through the carbon markets. Voluntary carbon markets and carbon offsetting could provide opportunities for much needed forest/biodiversity conservation and renewable energy projects locally. More work would be required on the current GHG emissions inventory to capture emissions from land use change and removals by sinks such as our dry woodlands and mangrove forests However, assistance from the UK could be received in this regard. Carbon credits acquired through emissions reduction from avoided deforestation[229] and agriculture[230] are also being researched in other Caribbean islands. The region is also advancing in electricity from renewable energy sources[231] which could be facilitated from projects financed through participation in these international markets.

6. Discussions are already underway for a regional carbon tax to offset emissions from travel which would fund mitigation and adaptation projects within the tourism sector. Provided the tax is set at a price consumers are willing to pay, this represents a significant means of revenue for small islands that otherwise face the choice of proceeding with their development agendas or diverting scarce resources toward vital adaptation projects.

7. The strength of the Cayman Islands is in its financial services sector which dominates the economy as it is more developed in terms of regulation and

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[228] Schlein, B. (VP Corporate Sustainability, Citigroup, NY), 2010. "Brave New World: Finance and Investment in a Low Carbon Economy" Session at GLOBE 2010 11th Biennial Trade Fair & Conference on Business & the Environment, Vancouver, March 25, 2010.

[229] ECLAC, 2009. Review of the Economics of Climate Change (RECC): Project Document. DFID/ECLAC/ CCCCC, June 2009.

[230] DOE, 2009. Comments from Agriculture Stakeholder Consultation, 22 January 2009.

[231] La Desirade in the Caribbean generates more than 50% of its electricity needs from renewable energy sources. Mimura et al., 2007. Small Islands. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.T. Palutikof, P.J. van der Linden, C.E. Hanson (Eds.), Cambridge University Press, Cambridge, UK, 687-716

risk management requirements, making adaptation to new controls easier. The banking sector can facilitate finance for public programs that foster the introduction of low-carbon technologies or climate-proofing at the individual household level. Local financial services expertise in setting up vehicles, i.e. transferring money can be utilized more effectively. As loan providers, equity investors and project financiers should seek private equity funds to support investment in clean technology locally. A wealth of expertise exists here in carbon funds, with carbon finance projects already established. A growing number of Cayman Islands-registered companies are participating in Clean Development Mechanism projects overseas, however opportunities should be explored to fund GHG-mitigation projects locally with the ability to perhaps list and trade the companies on the Cayman Islands Stock Exchange. Opportunities abound in carbon risk advisory services for clients and the development of carbon risk hedging products (e.g. derivatives). Carbon and environmental technology funds such as the European Carbon Fund established by Allianz Group in partnership with Fortis[232] should be explored for the Caribbean region, with the Cayman Islands financial sector taking the lead.

8. The Cayman Islands' experience with preparedness, response and recovery provide opportunities for regional work by those appropriately skilled. Other islands not typically exposed to the greater intensity hurricanes projected will require expertise in these areas. The Cayman Islands could provide a pool of resources for know-how in learning-based processes and institutional capacity building for adapting to future climate events and reducing disaster impact.

9. Climate change science, adaptation, mitigation and even international negotiation will require continued local and regional research into these areas, thus opportunities exist for young people interested in the natural and social sciences or those who wish to retrain themselves professionally. Climate research has greatly benefited a number of industries in other jurisdictions: Insurance, Tourism, Construction, Energy, Transport, Agriculture, Sports, Health, Retail Food and Retail Clothing, and has the potential to do so in these islands. Evaluation of climate policies opens the pathway for policy analysts whose skills will be relied upon to determine if the Islands' strategy is on course to meet various objectives. Advancing curricula at local education institutions to 'home-grow' enough professionals - lawyers, bankers, architects, planners, traders, carbon fund administrators, energy auditors - required to see us through a national transition to a low carbon climate-resilient future will be advantageous.

[232] Allianz Group and WWF, 2005. Climate Change and the Financial Sector: An Agenda for Action, June 2005.

8. SUMMARY & CONCLUSIONS

Climate change is the single most important issue facing the planet. Lack of action is not an option for the Cayman Islands as a small island nation with existing vulnerabilities to current weather-related hazards and real developmental challenges in its economic and social sectors. Input received during national consultations and the frequency with which climate change now appears in the local media highlight the concern of residents and widespread support for short, medium and long-term adaptation measures. Mainstreaming adaptation policies by integrating the consideration of climate change impacts across the entire development process spectrum has been the approach of CARICOM countries for over a decade. This regional approach serves to focus policy alignment on integrated coastal zone and environmental management regimes, disaster contingency planning and management, building codes and standards, and economic instruments needed for both climate change adaptation and mitigation.

The impacts of climate change have become evident, and we should not wait to mainstream vulnerability and risk reduction approaches into the national agenda. Particular attention must be paid to some issues outside of our immediate control such, as those in the tourism sector: international climate policy, mitigation responses of other countries, and shifts in customer choice towards other destinations. In moving this sector towards climate resiliency while remaining competitive the Cayman Islands cannot afford to set itself on a development path that heightens climate risks, increases vulnerability or erodes the ability to meet future climate challenges. Paramount to this is avoiding a future of uninsurability of coastal infrastructure and property, including Government assets. Neither can the country afford the 'no adaptation' option as the potential costs of doing so are too high. Food security is always a challenge for small islands like the Cayman Islands with a small production base and heavy reliance on importation to meet the needs of residents and visitors. Demand drivers, such as rapid population growth and increased tourist arrivals, when combined with climate change could elevate insecurity, if only temporarily. Other societal challenges posed by climate change include improving the plight of the most vulnerable groups, particularly chronic health sufferers which have implications for the future cost of public services. Setting clear sustainable development and climate agendas to better position these groups to increase their adaptive capacity and resilience is essential.

It is imperative to remove the notion that climate change is a matter for the Ministries of Environment only, and bring it forth as an issue to be addressed by ministries responsible for planning, finance, economic development, health, public works, etc[233]. Changing the general attitude that responding to climate change is solely the responsibility of government is also needed through public outreach targeted at individual, household, community, business and key sectors so that responses by these groups are timely and appropriate to ensure the Cayman Islands are truly prepared for future climate challenges.

[233] MacCormack, D., J. Hoffmaister, and W. Jones, 2007. Views on the integration of socio-economic information into vulnerability assessment, SustainUS, September 2007.

A key principle which should form the core of a national climate change policy is that common-sense, win-win or no-regret policies and measures which achieve multiple benefits should be implemented as a first step. This will no doubt address issues already on the socio-economic and sustainable development agendas, and include measures to reduce existing vulnerabilities to prevent or avoid the continuation of what happens now, correct mal-adaptive behaviours and practices by removing stressors within our control, and enhance resilience capabilities. A portfolio of adaptation and mitigation measures can reduce risk and achieve multiple benefits through cost-effective means. Energy security is one area where clear co-benefits can be achieved if properly incentivized.

Critically reviewing development policies in light of climate change, and integrating adaptation into all future economic and social plans under an overarching national sustainable development framework is the way forward. An assessment of some current policies and ongoing processes has identified entry points where climate change adaptation can be integrated, such as the Development Plan review cycle, building codes and standards revision, continued development of the disaster risk reduction programme, advancement of a national energy policy, etc. Subsequent iterations of the National Tourism Management Plan and National Assessment of Living Conditions must bring climate change more clearly into focus with specific responses for appropriately climate-proofing economic and social sectors. Present strategizing to revive the economy should be seen as an opportunity for fresh approaches to be taken, while ensuring that new initiatives are consistent with existing consensus-derived plans and goals set for adapting to climate change.

New legislation or legislative reform and other instruments will be needed to enact some policies and plans, correct existing counterproductive practices and facilitate effective adaptation. This is the case with adaptation responses that seek to protect, enhance and improve management of existing natural buffers, which rely on the passage of the National Conservation Bill and various Development and Planning Law amendments. The present Government has committed "to taking the necessary steps to ensure that we have the legislative means and policy framework that will enable our environment and natural resources to be adequately protected and sustainably managed"[234]. Tools such as environmental assessments also support better environmental management through the evaluation of climate change and other impacts of new developments and minimization of unsustainable practices to increase climate-resiliency. If national level projects and other major development proposals were to be evaluated in light of the overall sustainable development agenda for the country this would reduce the potential for mal-adaptations that are counter to these objectives and costly to rectify.

While enough is known about the likely effects of climate change to act now, more specific information may be needed to refine detailed planning and allocation of limited government resources. In addition to the tourism Vulnerability and Capacity Assessment, similar assessments of other economic

[234] UKOTCF, 2009. Remarks from The Hon. W. McKeeva Bush, Leader of Government Business and Minister of Financial Services, Tourism and Development, for the Opening Reception of the UK Overseas Territories Conservation Forum conference "*Making the Right Connections: A conference on conservation in the UK OTs, Crown Dependences and other small island communities.*" Grand Cayman, 30th May to 5th June 2009

sectors would provide valuable information for adaptation planning. Other decision support tools for considering climate change implications, such as risk assessments and economic feasibility studies, are also recommended. While a regional study is underway to assess the economic impact of climate change for the Caribbean from which useful information can be drawn, local decision-makers would be wise to seek technical expertise and resources to perform a Stern–type economic assessment of the impacts of climate change for the Cayman Islands specifically. This would facilitate timely, cost-effective and scale-appropriate delivery of adaptation options by government, and likewise guide other sectors in initiating adjustments that may be necessary to safeguard businesses and communities and the overall sustainability of economic sectors and livelihoods.

While responding to climate change could be costly, integrating adaptation across national planning initiatives and at all levels spreads the costs and responsibility, resulting in greater cost-effectiveness and a higher level of resiliency. Responding to climate change will necessitate the uprooting of problems that have plagued policy integration and implementation in the past and persist in present national strategic planning efforts undertaken in the Cayman Islands. Recognition of the climate change-national planning interconnections notwithstanding, a change in government priorities away from climate-proofing the economy, society and the environment can come about from the need to respond to other unexpected external shocks or from a change in administration. Hence it is important to embed climate change adaptation and mitigation into existing national plans and policies in order to see these Islands through difficult times and enable us to stay the chosen course of climate-resiliency. This is the goal sought for the National Climate Change Policy and the premise around which the response options to inform future action plans have been formulated.

However, a National Climate Change Policy in the absence of a strong implementation framework is “good intention without commitment”. The political will required to proactively engage and convince constituencies and private sector partners will be dependent on how well the issues of projected climate change impacts and feasible adaptation responses for the Cayman Islands have been communicated. It is hoped that this Green Paper has been effective in meeting this objective, and that through the supporting Public Education and Outreach strategy, the National Climate Change Policy will be in place readying the Cayman Islands for the global climate change challenges ahead.

APPENDICES

Appendix 1: Hurricanes and Tropical Storms with Direct Impacts on The Cayman Islands, 1852-2008

Date	Storm	Storm category at CPA	CPA Grand Cayman	CPA Little Cayman	CPA Cayman Brac	Max winds at CPA
7/10/1852	Storm 5	II	74			104
27/9/1857	Storm 4	II	67			96
09/10/1865	Storm 4	II		14	7	104
10/06/1870	Storm 6	I		51	41	77
30/9/1873	Storm 5	TS	51	29	27	46
17/10/1876	Storm 5	II	32			96
13/08/1878	Storm 2	TS				58
19/10/1878	Storm 11	I	8			69
04/10/1879	Storm 6	TS	40	35	48	58
13/10/1879	Storm 5	TS	46			46
07/08/1880	Storm 2	I	69			104
06/27/1886	Storm 3	TS		11	20	58
08/07/1887	Storm 5	TS		65	53	40
10/12/1887	Storm 13	I		46	39	86
5/10/1891	Storm 7	TS	28			52
26/8/1895	Storm 2	I	30			98
20/10/1895	Storm 5	I	41			104
26/9/1896	Storm 4	I	25			102
16/10/1897	Storm 5	TS	44			62
8/10/1898	Storm 9	TS	21			58
10/28/1899	Storm 8	TS		21	4	73
7/6/1901	Storm 2	TS		5	12	69
9/14/1901	Storm 7	I		16	9	75
12/8/1903	Storm 2	III	12	42	53	121
10/14/1904	Storm 3	TS		19	2	58
17/7/1909	Storm 4	TS	43			62
7/8/1909	Storm 5	TS	15			37
16/9/1909	Storm 8	I	33	24	33	65
9/10/1909	Storm 6	II		60	52	100
9/9/1910	Storm 3	I	34	26	34	81
11/21/1912	Storm 6	TS	28			41
8/14/1915	Storm 2	III	55	9	16	117
9/2/1915	Storm 4	I	8			86
8/16/1916	Storm 4	I	22	36	45	111
9/27/1917	Storm 3	III		31	22	115
8/4/1918	Storm 1	TS	55			63
10/18/1927	Storm 7	TS	40			41
10/31/1927	Storm 6	TS	12	24	21	46

9/3/1928	Storm 3	TS	48			47
9/13/1931	Storm 8	TS	64			46
11/8/1932	Storm 10	IV	59	4	20	132
7/2/1933	Storm 18	I	55	36	53	83
7/17/1933	Storm 15	TS	71			83
8/17/1933	Storm 6	TS	10			46
9/21/1933	Storm 3	I	33	28	35	52
10/3/1933	Storm 2	I	38			85
9/27/1935	Storm 4	III		22	14	121
8/12/1938	Storm 2	I	55			92
10/31/1939	Storm 5	I	8	34	36	90
8/21/1944	Storm 11	I	7	44	58	92
10/15/1944	Storm 4	I	32			86
10/12/1945	Storm 11	I	75	7	22	76
9/20/1947	Storm 6	TS		3	15	40
9/19/1948	Storm 7	I	7			89
10/16/1950	King	I			68	92
8/18/1951	CHARLIE	II	58			104
10/14/1951	ITEM	I	20			81
10/3/1953	Storm 10	TS			66	40
8/23/1955	Storm 5	TS	4			40
9/5/1955	HILDA	II	16	5	7	92
5/23/1970	ALMA	TS	16	7	21	40
9/20/1973	GILDA	TS	56	15	3	48
9/20/1975	ELOISE	TS	36	15	13	40
8/6/1980	ALLEN	IV		23	11	142
5/7/1981	ARLENE	TS	38	20	11	46
11/5/1981	KATRINA	TS	21	36	46	83
9/13/1988	GILBERT	IV	24			150
9/19/2002	ISIDORE	I	52	18	9	69
9/30/2002	LILI	TS		9	4	73
8/12/2004	CHARLEY	I	32	44	58	92
9/12/2004	IVAN	IV	22			155
8/17/2008	FAY	TS			73	52
8/30/2008	GUSTAV	I	52	22	33	94
11/7/2008	PALOMA	IV	33	13	9	135

Cat IV **Distances in statute miles**
Cat III **Max winds at CPA in miles per hour**
CPA (Closest Point of Approach) has to be below 75 statute miles to be a direct hit

Source: Cayman Islands National Weather Service, 2010

Appendix 2: Institutions Relevant to Climate Change Adaptation and Mitigation – Their Roles and Capacities

Environmental and Coastal Management Agencies

Department of Environment (DOE)

The DOE, established in 1996, currently falls under the Ministry of Health, Environment, Youth, Sports & Culture. Its mission is to facilitate responsible management and sustainable use of the natural environment and resources of the Cayman Islands through a variety of environmental protection and conservation strategies and programmes. The DOE's Technical Review Committee advises Cabinet on applications proposed in the coastal zone seaward of the Mean High Water Mark (MHWM) and inputs into the CPA approval of development landward of the MHWM. Apart from administering and enforcing the Marine Conservation Law and sections of the Animals Law, the Department provides advice on an array of environmental policy matters, including climate change adaptation and mitigation. Notably, the DOE has input into a number of reports and plans generated by multi-agency and/or stakeholder groups which contain recommendations for integrating environmental considerations into national development planning so as to achieve a higher level of sustainable development. These recommendations have particular relevance for climate change resiliency and have been summarized in Appendix 4. The Department has long advocated for Development Plans for Sister Islands which are particularly vulnerable to the climate change impacts. Although the DOE chairs the National Climate Change Committee, integrating climate change and sustainable development considerations into national planning will continue to be a challenge, as the Department has no legal mandate in this or any other regard. Neither is there currently statutory requirement for environmental impact assessments which could assist in integrating climate change considerations into development applications. The draft National Conservation Law - languishing for the last 9 years - would establish this and provide for the effective implementation of MEA obligations.

Planning Department and the Central Planning Authority (CPA)

The Planning Department currently sits with the Ministry of Finance, Tourism and Development. It facilitates land use planning and regulation by ensuring that development proposals are in accordance with the Development Plan 1997, Development and Planning Law and associated regulations and policies. The Planning Department is also responsible for code enforcement. It functions as the technical and administrative arm of the statutory bodies ultimately responsible for approval of physical development: Central Planning Authority (CPA) in Grand Cayman and the Development Control Board (DCB) for the Sister Islands. The CPA is also charged with developing and reviewing Development Plans for these islands every five years in consultation with other bodies. The Department's Building Control Unit undertakes inspections of and issues permits for approved projects in accordance with the Building Code, which has seismic and wind provisions in addition to typical structural, electrical, gas, plumbing and mechanical requirements. The review and further advancements in the Building

Code falls to this Unit working in tandem with the construction industry and others in the private sector.

Water Authority-Cayman (WAC)

Established in 1981, the mission of this statutory body is to ensure that the entire population of the Cayman Islands has access to a pure, wholesome and affordable supply of potable water; and to regulate other entities licensed by the Government to provide public water supplies. Sitting within the Ministry of District Administration, Works, Lands & Agriculture, the WAC currently provides water and sewerage services to over 12,000 customers in the Grand Cayman districts of George Town, Bodden Town, East End, North Side and the Sister Island of Cayman Brac. Its mandate extends to development control relating to water production and supply, wastewater treatment and discharge and the protection of groundwater resources. It also controls discharge of trade effluent to the sea. The WAC and DOE have managed a joint-agency water quality monitoring programme in George Town Harbour since 1991 and North Sound since 2002. The Authority's reverse osmosis plants are insured against hurricane threats however its underground pipeline is not insured, like other utilities self-insurance is built into its business model. The cost recovery for damaged water mains has not typically been passed on to WAC customers. Water conservation and other no-regrets options are supported as these reduce demands placed on the WAC to supply these services. The Authority has embarked on a more active conservation campaign in 2009[235]. A concern for the WAC is whether they have sufficient land for planned 15-20-year expansion.

Lands & Survey Department (L&S)

The Lands and Survey Department falls under the Ministry of District Administration, Works, Lands & Agriculture. The Department's Survey Section plays a vital role in preserving the interests of the Crown along the coast and wherever Crown lands exist (e.g. ponds, some Animal Sanctuaries), and regulating land surveys in accordance with the Land Surveyors Law and Regulations for the purposes of the Registered Land Law. Development control in the coastal zone in part relies on determining the seaward extent of parcel boundaries or ownership (regulated under the Land Survey Regulations), from which coastal construction setbacks are measured (regulated under the Development and Planning Regulations). The L&S Department, often in concert with the Legal Department, is called upon to provide expertise in the interpretation and application of the High Water Mark definition along various coastline types in cases where jurisdiction is unclear (i.e. CPA planning permission versus Cabinet coastal works licence). Tide gauges have been installed on all three islands to more accurately determine the MHWM in the face of rising sea levels. The Survey Section is currently undertaking highly specialized projects such as the formulation of a new Cayman Islands Geoid and Projection, extensive bathymetric data acquisition from shore to "drop-off" and the installation of Seismic Monitors for Hazard Management Cayman Islands (HMCI).

[235] DOE, 2009. Comments By Gelia Frederick van Genderen. In: Minutes of Tourism and Commerce Stakeholder Consultation, 22 January 2009.

National Trust for the Cayman Islands (NT)

The National Trust for the Cayman Islands is a non-profit, Non-Governmental Organisation (NGO) established by law in 1987 with a mission: "To preserve natural environments and places of historic significance in the Cayman Islands for present and future generations." The NGO owns nearly 2,000 acres of land representing diverse habitats that support critical species and biodiversity and held in perpetuity for the people of the Cayman Islands under the National Trust Law. These holdings, along with Crown lands comprising environmentally sensitive areas, are the foundations of a terrestrial protected area system for which the Department of Environment and the National Trust have long advocated through support of enabling legislation and amendments for inclusion of appropriate zones in the Development Plan. The environmental programmes undertaken by the NT support the Department of Environment's agenda through conservation of key species and habitats, as well as play a vital role in meeting obligations under various MEAs. Inherently, this NGO suffers from lack of financial resources to further its programmes, many of which have relational climate change adaptation benefits.

Department of Agriculture (DoA)

The Department of Agriculture falls under the Ministry of District Administration, Works, Lands & Agriculture. The department has the primary responsibility of implementing government policy aimed at protecting, developing and expanding the local agriculture sector; increasing domestic production of wholesome, quality, nutritious food; increasing farmers incomes and livelihoods and preserving the agricultural traditions and heritage of these islands. The DoA is also responsible for protecting the local flora and fauna, both natural and domesticated, through the prevention of the introduction and control of pest and diseases, through the Animals Law (2003) and the Plants Law for which the DoA has primary regulatory responsibility. The DoA is also responsible for animal welfare and the regulation of veterinary practitioners through the Veterinary Practitioners Law. In addition the DoA through the control of importation of animals and animal products contributes to the protection of human health through the prevention of the introduction of various zoonotic diseases. For a number of years the DoA has been recommending the passage of comprehensive pesticide regulation legislation which it sees as essential for the protection of human health and the environment. Draft legislation was prepared but like the draft revised Plants Importation law, this has not yet been tabled in the LA.

Key Disaster Risk Reduction and Management Agencies

Hazard Management Cayman Islands (HMCI)

HMCI was established in 2007 following Hurricane Ivan which highlighted inadequacies of existing recovery plans. The agency builds on the expertise of the National Hurricane Committee and has overall responsibility for the national hazard management programme, including preparedness, response, mitigation and initial recovery. The agency fulfils a number of Vision 2008 Contingency Planning Strategy recommendations through its mandate to deal with a broad range of potential hazards (man-made and natural). The Strategic Framework for Disaster Risk Management guides HMCI's risk management programme and recognizes climate change as a clear threat to be factored in to the country's

hazard assessment. The interface with climate change is through HMCI's Mitigation Programme and policies which look at long term issues such as planning, coastal zone management and resilience of the built environment, especially to wind resistance. The agency's goal is to plan for the worst-case scenario and have appropriate national response capabilities within the HMCI structure and at the community level. HMCI is permanently staffed and ready to go operational at all times, and is responsible for the National Emergency Operations Centre (NEOC) which is located at the Fire Station in George Town. The NEOC is activated to direct and coordinate the response to national threats. HMCI also has responsibility for maintaining the National Hazard Management plans for threats such as hurricanes and earthquakes. It works with local entities such as the National Weather Services and Lands & Survey Department during the threat of impending storms and hurricanes, and with preparedness and response partners such as district level Emergency Response Teams, community level Disaster Response Teams and the Cayman Islands Red Cross. These combined efforts have continued to reduce or avoid loss of life from the threat of tropical storms and hurricanes. The agency works with regional organizations such as the Caribbean Disaster Response Emergency Agency (CDERA), the UN and other international partners. HMCI awaits passage of the Disaster Preparedness Bill which among other issues will provide for delineation of Specially Vulnerable Areas based on risk analysis and mapping.

Cayman Islands Red Cross (CIRC)

The Red Cross is heavily involved in disaster preparedness through education programmes and response by providing shelter and health services for vulnerable groups. Through the Container Project in which each district across the islands has a shipping container of essential supplies, the CIRC is able to offer immediate assistance post-disaster. Between 2006 and 2007 the Red Cross significantly contributed to raising the awareness of climate change impacts and adaptation through extensive public outreach. Funded by the European Commission for Humanitarian Aid Office (ECHO), Dr. Pablo Suarez assisted the CIRC in producing a video of local perceptions of climate change, conducting vulnerability and capacity assessments within communities, and enhancing the skills of Community Disaster Response Teams (CDRT) in Grand Cayman in first aid/CPR, hazard and resources mapping, family and community disaster response planning, and radio and communication handling. This work at the grassroots has increased the adaptive capacity of individuals, households and communities where it is needed most. However the Red Cross has limited resources to sustain such extensive capacity building efforts long term. The perception of the Cayman Islands as being 'wealthy' hinders many funding possibilities for the CIRC and access to DfID funds is precluded. Collaboration between local disaster agencies could benefit from opening up the consultative process and information sharing among the HMCI subcommittees. In the CIRC experience, District Emergency Response Teams led by civil servants or government appointed individuals do not always achieve the desired results; community leaders must be recognized and accepted by their communities, which is critical for delivering the climate change adaptation message.

National Weather Services (NWS)

The National Weather Service was established in the early 1980s and plays a key role in the Cayman Islands' early warning system for tropical storm and hurricane threat. Within the Ministry of District Administration, Works, Lands &

Agriculture, it has the responsibility for the monitoring of meteorological events and providing meteorological information. The staff currently operates a service for 17 hours daily with a 24-hour service envisaged for the future. The Service's operation includes an Upper-Air Station, Surface Weather Observations, Climatology, Forecasting and Aviation weather briefing. The NWS is also a vital partner in raising awareness of global climate change and the need to respond to local threats presented by projected regional impacts. The Service, aided by a team from the CCCCC and Cuban Institute of Meteorology, was instrumental in providing a *Climate and Weather Assessment for the Cayman Islands* as part of the *Tourism Sector Vulnerability and Capacity Assessment* under the ECACC Project. This assessment detailed the historical trends in several weather variables which were compared to outputs for future climate of the Cayman Islands produced using the Hadley PRECIS Regional Climate Model.

Lands & Survey Department (L&S)

Through the development and use of its TAOS (The Arbiter of Storms) integrated storm modeling system and a real-time assessment tool (Emergency Management Mapping & Analysis, EMMA), L&S and HMCI can predict the extent of possible physical damage from storm surge, waves and wind at the onset of, during and after an event. A comprehensive buildings inventory, including construction characteristics and replacement costs, facilitate structural damage and associated financial loss assessments to be generated. Impact to roads and other infrastructural assets at specific locations can be forecasted allowing structural failures to be determined and evacuations to be ordered. Maps and damage reports are useful tools for assessment post-storm and making adjustments in other aspects of the disaster risk management cycle. Further, the Department has produced a Storm Atlas containing a selection of impact scenarios modeled under varying meteorological conditions which is a valuable planning tool for siting critical infrastructure and other developments away from highly vulnerable areas. The Lands and Survey Department also acts as facility manager for numerous Government-owned buildings and therefore coordinates with PWD to secure these assets when a hurricane warning is announced.

Key Agencies relevant to Climate Change Adaptation and Mitigation

National Climate Change Committee (NCCC)

The NCCC was first assembled in December 2007 as the National Climate Change Adaptation Working Group (NCCAWG) to manage and coordinate activities under the ECACC Project and work collectively and with key stakeholders toward the creation of a *National Climate Change Adaptation Strategy* for Cabinet approval. Since the December 2009 consultation on the Issues Paper when consensus was formed around including mitigation options as part of an adaptation strategy for the Cayman Islands, the group changed its name (to NCCC) and focus to a *National Climate Change Policy* to better capture the broader mandate of its work. The NCCC is also charged with formulating and executing a national Public Education and Outreach (PEO) strategy on climate change to support the development and implementation of the *National Climate Change Policy*.

The National Climate Change Committee currently consists of representatives from a wide cross-section of public sector agencies, including:

Department of Environment (Chair)
Department of Agriculture
Department of Environmental Health
Department of Tourism
Government Information Services
Hazard Management Cayman Islands
Lands & Survey Department
Ministry of Health, Environment, Youth, Sports & Culture
Ministry of Finance, Tourism & Development and Office of The Premier
Mosquito Research & Control Unit
National Weather Service
Office of the Governor
Planning Department
Water Authority-Cayman

The NCCC has found it challenging to engage some agencies such as the National Roads Authority and since the change in Government in May 2009 has not been able to re-gain representation from the Risk Management Unit.

The Committee also has representatives from key economic sectors and non-profit think-tank groups conducting climate change research in the Cayman Islands:

Finance
Tourism
Building and Construction
The Cayman Institute

The NCCC has consulted with climate change and insurance expert Dr. Robert Muir-Wood who advised on climate risk factors faced by the Cayman Islands, including the potential for uninsurability and how to build resilience in physical infrastructure and government policy; and tourism and climate change expert Dr. Murray Simpson who discussed climate change impacts affecting regional tourism, an adaptation framework for tourism and other sectors and possible vulnerability assessment work in the Cayman Islands through a separate UK funded grant. Appendix 4 contains a list of local stakeholders consulted during the development and review of the Issues Paper. Additionally, some of the key stakeholders engaged during the Tourism Sector Vulnerability and Capacity Assessment, Knowledge Attitude and Perception Survey, or the development of the PEO strategy were the Cayman Islands Tourism Association, Sister Islands Tourism Association, Central Caribbean Marine Institute, and CITN.

Ministry of Health, Environment, Youth, Sports & Culture (HEYS&C)

Ensuring adequate protection and enhancement of the natural environment and the health and well-being of the community are among this Ministry's responsibilities. Implementation of MEAs that speak to policies that foster a robust natural environment vital for climate-resiliency and allow ecosystems to function act as sinks to sequester carbon from the atmosphere are within the remit of this Ministry. The National Sustainable Development Framework (NSDF) and National Conservation Bill - key strategic goals of this Ministry - are policy and legislative tools that will aid in building more climate-proofed environment,

social and economic sectors. It will be crucial for the National Climate Change Policy to effectively address health impacts and ensure that these measures are consistent with or supplement existing plans and policies for this sector, and the Ministry will likely spearhead the coordination of such policy integration. Under an agreement with the UK DECC, the Ministry HEYS&C, with assistance from the DOE, also plays an important role in regulating the participation of Cayman Islands-based companies in CDM projects undertaken in countries abroad.

Department of Environment (DOE)

In 2002 the DOE started collaborative research on climate change adaptation in the Cayman Islands with researchers from the Tyndall Centre for Climate Change Research. Since then ongoing work on adaptation with regional OTs has culminated in the production of *Surviving Climate Change in Small Islands: A Guide* and collaborations with UK researchers at the University of Oxford's Environmental Change Institute and University of Leeds Sustainability Research Institute. Since 2005 the DOE has been collating data for the annual national emissions inventory as part of the Cayman Islands' UNFCCC obligations. This information is submitted to AEA Technology plc, the inventory compilers contracted by the UK Department of Energy and Climate Change to produce the UK Greenhouse Gas Inventory Annual Report for submission under the UNFCCC (see http://www.naei.org.uk/report_link.php?report_id=593). The Department has produced a number of public and sector-specific materials aimed at reducing energy use and associated GHGs, and it continues to host and participate in annual fairs and events geared at raising the level of awareness on issues related to both climate change mitigation and adaptation. The DOE is a member of the newly formed National Energy Policy Committee and frequently advices both government and non-government entities on measures to better manage energy associated with their organisations' activities.

Ministry of District Administration, Works, Lands & Agriculture (DAWL&A)

The Ministry DAWL&A provides critical infrastructure support for the maintenance of a strong, viable economy, while managing the human-environment interface in all three islands. As some portion of the current road network and other critical infrastructure is expected to be affected by the unavoidable effects of climate change and sea-level rise, this Ministry, supported by its various departments, will play a vital role in responding to those challenges ahead of time and ensuring that future infrastructural needs are climate-resilient. Certain initiatives of the DAWL&A have gone some way toward addressing key mitigation issues, such as the Traffic Law revision to allow Low Speed Electric and Neighbourhood Electric vehicles. The Law Review team also considered regulations for vehicle emission standards but to date no amendments have been made. The Ministry has also taken a leading role on energy security and fossil fuel usage in the country by setting up a long-awaited public-private sector Committee to formulate and implement a National Energy policy for the Cayman Islands. As food security could be periodically threatened by future weather-related natural disasters and climate change, this Ministry along with its Department of Agriculture, will play a vital role in ensuring safeguards are built into various policies that support continuous supplies of locally produced and externally sourced goods.

Electricity Regulatory Authority (ERA)

The ERA is a statutory body under the Ministry DAWL&A charged with regulation of electricity in the Cayman Islands, including the issuance of generation and T&D licences. The Authority is committed to the development of electricity from renewable energy (RE) sources to reduce the sector's dependence on diesel fuel. In concert with CUC, the ERA was instrumental in developing the Consumer-Owned Renewable Energy (CORE) program, which allows for the grid-integration of residential and small-scale commercial RE systems. In December 2008 full import duty exemption on RE equipment for homeowners was brought to fruition by the Ministry DAWL&A to support the CORE program. The Authority currently oversees the recently established public-private sector National Energy Policy (NEP) Committee. The goals of this policy include the reduction of the country's carbon footprint in line with agreed national targets, development of RE sources and promotion of energy conservation and efficiency in all sectors. Implementation of the NEP is expected by 2012.

Ministry of Finance, Tourism & Development (FT&D)

At present this is a key Ministry in which much policy coordination could occur as FT&D holds responsibility for the two economic pillars – finance and tourism – and through its decisions can significantly influence the construction and real estate sectors which are also important drivers of the economy. It is essential that entry points for adaptation and mitigation measures are identified in national policies and plans developed for these sectors else timely opportunities to safeguard the economy against the adverse effects of climate change are missed with extremely costly consequences in the not too distant future. Additionally, the allocation of public funding for adaptation and mitigation implementation projects identified in Action Plan under the National Climate Change Policy falls within this Ministry's mandate, especially for public projects.

Central Planning Authority / Development Control Board / Planning Department

The CPA and DCB are Government statutory boards that approve development applications under the guidance of the Planning Department in Grand Cayman and Planning Office in Cayman Brac, and in accordance with the Development Plan and relevant laws and regulations. These boards and agencies need to start integrating climate change considerations into physical development planning and application approvals. A review of the Grand Cayman Development Plan 1997 and the formulation of development plans for each of the Sister Islands are strategic entry points for adaptation. The Planning Department and Building Control Unit are developing a revised code that addresses energy efficiency in (new) buildings, a significant step toward mitigating future climate change. Codes that also increase the passive survivability of the building stock create cost-effective synergies. These agencies fall within the Ministry of Finance, Tourism & Development, which can create the policy framework and work with the appropriate private sector organizations to provide incentives geared at increasing the climate-resiliency and energy efficiency in older buildings as well.

Cabinet Office

The Cabinet Office responds to decisions concerning governmental policy as set by Cabinet. Since many of the policy areas have application across Government, the Cabinet Office includes a number of sections and departments whose work

has cross-governmental scope. The Policy Coordination Unit currently monitors international policy developments and provides technical support and advice to the Cabinet in these matters while the Public Relations and Community Services Unit develops strategies to promote and monitor public engagement with policy. Both of these units are viewed as essential in the coordination of various Ministry programs for successful buy-in and implementation of the climate change policy.

Government Information Services (GIS)

Falling under the Cabinet Office, GIS is at the forefront of information delivery using a variety of media. This Department has been instrumental throughout the ECACC Project in keeping the general public informed about the activities associated with the development of the national climate change policy, whether upcoming national consultations or outcomes of workshops. GIS has produced a series of *Spotlight* shows covering these issues. As a member of the NCCC, the services and expertise of this Department has been vital to the formulation of the PEO strategy and action plans. GIS will retain an essential role in promoting widespread awareness of the policy thus ensuring its successful implementation.

Agencies that provide assistance to The Cayman Islands

Caribbean Community Climate Change Centre (CCCCC)

The CCCCC, a CARCIOM institution established in Belize in 2004, works throughout the Caribbean to enhance regional capacity-building for the coordination of national responses to the adverse effects of climate change. It supplies guidance and technical assistance to the NCCC in executing the ECACC Project and shares the knowledge and experiences gained from similar regional adaptation projects undertaken in CARICOM countries dating back to 1997. The Centre collaborates with regional institutes undertaking various climate change research specific to the Caribbean, including the generation of regional climate model outputs and impact scenarios. CCCCC serves as a clearinghouse of regionally relevant climate change information, is the primary institute developing a regional strategy and negotiates along with other SIDS groups the Caribbean's position at international climate meetings.

Joint Nature Conservation Council (JNCC)

JNCC is a statutory advisor to HMG on UK and international nature conservation and provides to the governments of the Overseas Territories and Crown Dependencies and others, timely and sound advice to support the achievement of the 2010 biodiversity target, the progressing of Environment Charters, and the implementation of multilateral environmental agreements. Through the Caribbean Natural Resources Institute (CANARI) the JNCC has produced a series of public outreach materials on climate change issues relevant to the OTs (http://www.jncc.gov.uk/page-4362) launched locally on Earth Day 2009 and which have become essential awareness-raising tools as part of the PEO strategy under the ECACC Project.

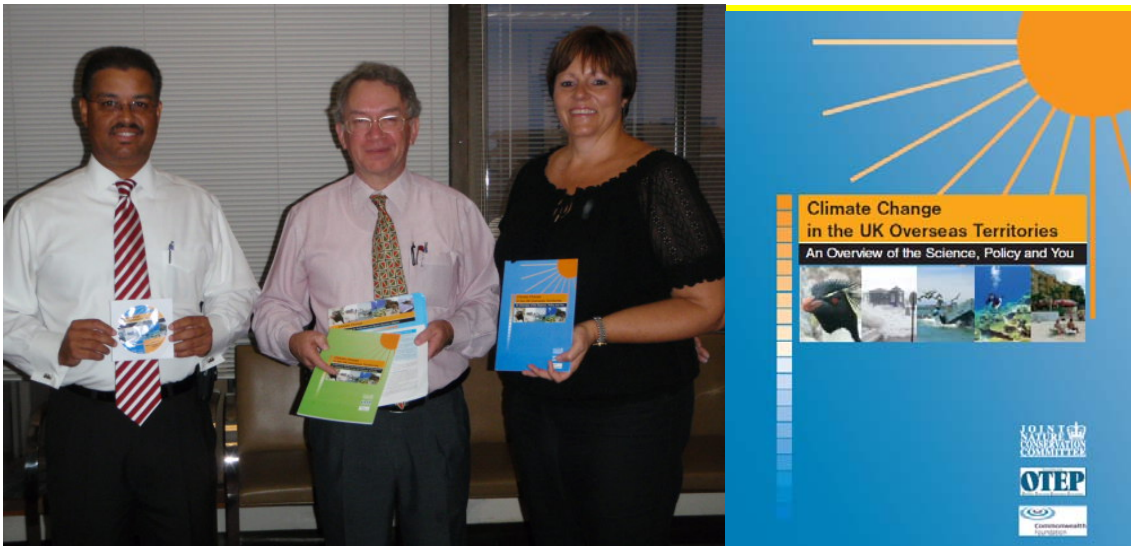

Photo 13 Launch of JNCC PEO materials by former Governor Stuart Jack, former Minister for Environment, Charles Clifford, and Direct of Environment, Gina Ebanks-Petrie, Earth Day 2009, *Photo courtesy: GIS*. Front Cover of one of six JNCC publications.

Appendix 3: Legislation and Policies Relevant to Climate Change Adaptation and Mitigation in the Cayman Islands

Existing Legislation and Policies Governing Environmental & Coastal Management relevant to Climate Change Adaptation		
Statue	**Objectives**	**Responsible Agency**
The Development and Planning Law (2008 Revision) and The Development and Planning Regulations (2006 Revision); Building Code Regulations (2006 Revision)	General physical planning including coastal construction setbacks, mangrove buffer zoning and Building Codes	Planning Department, Central Planning Authority (Grand Cayman), Development Control Board (Sister Islands) under Ministry of Finance, Tourism & Development
Marine Conservation Law (2007 Revision), Marine Conservation Law (Marine Parks) Regulations (2007 Revision), Marine Conservation Regulations (2004 Revision), and Marine Conservation Law (Turtle Protection) Regulations (2008 Revision)	Fisheries and resource management, including requirement for Cabinet approval to disturb seabed vegetation and formations and prohibition on raw sewage and harmful effluent discharge into Cayman waters	Department of Environment under Ministry of Health, Environment, Youth, Sports & Culture
Animals Law (2003 Revision)	Regulation of the importation of live animals and animal products. Control of animal disease, protection and regulation of animal health and welfare. Protection of non-domestic birds, iguanas; Animal Sanctuaries provisions	Department of Agriculture under Ministry of District Administration, Works, Lands & Agriculture and Department of Environment under Ministry of Health, Environment, Youth Sports & Culture
Plants Import Law (1997)	Regulation of the importation of plants and plant products to prevent the introduction of invasive species of pest and plants that would affect the local cultivated and wild flora	Department of Agriculture under Ministry of District Administration, Works, Lands & Agriculture
National Trust Law (1997 Revision)	Legal mandate for entity to protect historic, cultural and natural assets	National Trust for the Cayman Islands
Water Authority Law (1996 Revision) and Water Authority Regulations (2007 Revision)	Management of ground water resources including development over water lenses and discharge of trade effluent in Cayman waters; regulation of wastewater treatment and disposal.	Water Authority-Cayman, Water Authority Board under Ministry of District Administration, Works, Lands & Agriculture
Port Authority Law (1999 Revision) and Port Authority Regulations (2008 Revision)	No dumping from vessels in territorial waters	Port Authority under Ministry of Finance, Tourism, & Development
Public Health Law (2002 Revision)	Prohibits domestic sewage discharge into Cayman waters	Public Health Department, under Ministry of Health, Environment, Youth, Sports & Culture, Department of Environmental Health under Ministry of District Administration, Works, Lands & Agriculture

Land Surveyors Law (1996 Revision) and Land Surveyors Regulations (1996 Revision)	Governs extent of land ownership and poorly defines High Water Mark on various types of coastline;	Lands and Survey Department under Ministry of District Administration, Work, Lands & Agriculture
Registered Land Law (2004 Revision)	Governs boundary surveys	Lands and Survey Department under Ministry of District Administration, Works, Lands & Agriculture
Dangerous Substances Handling & Storage Law, 2003	Provides for the safe handling and storage by various users and customers of substances considered dangerous	Petroleum Inspectorate under Ministry of District Administration, Works, Lands & Agriculture
Mosquito Research & Control Law	Land reclamation of wetland areas required to particular level above highest MSL (generally 4 ft); adequate provision for water runoff	Mosquito Research & Control Unit under Ministry of District Administration, Works, Lands & Agriculture
Roads Law (2005 Revision)	Governs development of arterials including the gazetting of corridors	National Roads Authority under Ministry of District Administration, Works, Lands & Agriculture
Policy	**Objectives**	**Agency Responsible**
Development Plan 1997	Effectively directing development to safeguard the economic, cultural, social and general welfare of the people, and subject thereto the environment	Central Planning Authority, Development Control Board, Planning Department, Ministry of Finance, Tourism & Development
Coastal Works Policy (draft Feb 2007)	Sets jurisdictional procedures for permitting works in coastal zone, guides decisions on inter-agency coordination where other (statutory) approvals may also be required	Cabinet via Ministry of Health, Environment, Youth, Sports & Culture, input to and enforcement of by Department of Environment
National Tourism Management Plan 2009-2013	Sector development and management based on sustainable approach and integrated planning	Department of Tourism under Ministry of Finance, Tourism & Development
Proposed Legislation and Policies relevant to Climate Change Adaptation		
Statue	**Objectives**	**Agency Responsible**
National Conservation Law	Legal mandate for DOE, establishment of protected areas, EIA provisions and other MEA obligations, including aspects of UNFCCC	Department of Environment under Ministry of Health, Environment, Youth, Sports & Culture
National Sustainable Development Framework	Integrated policy and planning framework based on shored vision that ensures social, economic and environmental considerations are given equal weight in decision-making	Department of Environment under Ministry of Health, Environment, Youth, Sports & Culture
Disaster Preparedness	Establishment of Specially Vulnerable Areas and No Build Zones	Hazard Management Cayman Islands under the Portfolio of Internal and External Affairs
Pesticide Regulation Legislation	Regulate the importation, storage, sale, use and disposal of pesticides to protect local flora and fauna, the environment and human health and safety	Department of Agriculture under Ministry of District Administration, Works, Lands & Agriculture

Existing Legislation and Policies relevant to Climate Change Mitigation		
Statue	**Objectives**	**Responsible Agency**
The Development and Planning Law (2008 Revision) and The Development and Planning Regulations (2006 Revision); Building Code Regulations (2006 Revision)	General physical planning including coastal construction setbacks, mangrove buffer zoning and Building Codes	Planning Department, Central Planning Authority (Grand Cayman), Development Control Board (Sister Islands) under Ministry of Finance, Tourism & Development
Traffic Law (2003 Revision)	To permit Low Speed Electric and Neighbourhood Electric Vehicles to operate on public roads	Ministry of DA, Works, Lands & Agriculture, Department of Vehicles & Licensing under Ministry DAWL&A
Policy	**Objectives**	**Agency Responsible**
Import Duty Waiver on renewable energy equipment for residential installations	To incentivize homeowners to take advantage of the CORE program	Financial Secretary's Office, Ministry of DA, Works, Lands & Agriculture
Customer-Owned Renewable Energy (CORE) Program	To facilitate the grid-connection of renewable energy systems installed are residences in Grand Cayman	Electricity Regulatory Authority, CUC
Proposed Legislation and Policies relevant to Climate Change Mitigation		
National Energy Policy	Providing for an efficient, diversified energy sector, supported by an informed public, which provides secure, reliable and affordable energy in an environmentally sustainable manner	National Energy Policy Committee, under Ministry of DA, Works, Lands & Agriculture

Appendix 4: Past Reports - Key Recommendations Relevant to Environmental & Coastal Management for Climate Change Resiliency

ENVIRONMENT & COASTAL ZONE MANAGEMENT SIC REPORT, APRIL 2002
Create a system of terrestrial protected areas to complement marine protected areas in existence since 1986
Create a new Special Planning Area overlay for areas of environmental significance separate from the system of protected areas
Enact provisions for environmental impact assessments for certain types and locations of projects
Establish an Environmental Assessment Board to manage the EIA process
Creation of an Integrated Coastal Zone Management programme that: • recognizes the interconnection between land and sea in all decision making on coastal development; • amends the coastal development approval process to address the current split jurisdiction; • increases protection for remnant mangrove on Grand Cayman's coastline not currently designated Mangrove Buffer; • measures coastal construction setbacks from the permanent vegetation line and use site-specific setbacks; • requires planning permission for all redevelopment and or repair of damaged coastal structures; • appropriately locates marinas and marine commercial zoning
Require mitigation of environmental impacts of proposed developments
Remove from the planning legislation compensation statue for refusal of applications not in the best interest of the public

INFRASTRUCTURE SIC REPORT, MAY 2002
Siting infrastructure corridors should avoid, minimize and mitigate impact on natural ecosystems
Use of natural features/wetlands, alternative construction and filling and techniques, and retention of mature natural vegetation in project stormwater management plans
Determine short and long term cost-effective approaches to alleviating existing and future stormwater problems in Grand Cayman
Develop a National Energy Policy
More stringent requirements for development over water lenses in East End, North Side and Lower Valley
Conduct EIAs for any major infrastructure related project
Use of Special Planning Area zones/overlays to ensure environmentally sound and sustainable development practices in or adjacent to wetlands and primary dry forest areas
Protection of Class I and II agricultural lands bordering environmentally significant areas and reserved for agricultural purposes and shown as overlays on the Development Plan
Rezone Class II and IV agricultural lands to Residential zones or environmentally sensitive areas
Underground supply of utilities for all future multi-occupancy developments
Introduce Specific Planned Areas to promote Smart Growth

BEACH REVIEW AND ASSESSMENT COMMITTEE REPORT, MAY 2003
The following summary outlines the major recommendations of the Beach Review and Assessment Committee by April 2003. The recommendations are presented in the order in which they appear in the document and the order does not reflect their priority for action or implementation. The more detailed recommendations can be found in the body of the report with rationale and examples provided were appropriate. Timelines and priorities are discussed in the Executive Summary of this document.
Establishment of a 'Strategic Beach Management Plan'.
Removal of specifically identified and inappropriately sited rock and rubble obstructions along Seven Mile Beach.
Establishment of the Historic Vegetation Line using suitable archived aerial photography as the benchmark for determining setbacks on all beaches.
A Coastal Setback Category Map, that will detail site-specific setback distances, should be generated for all coastlines on Grand Cayman (beginning with Seven Mile Beach) as well as the Sister Islands.
Conduct an immediate trial for Government initiated Spot Nourishment of heavily eroded sections of Seven Mile Beach utilising sand sources stockpiled on the island from previous construction projects.
Conduct an 'Engineering Feasibility Study' in preparation for a beach nourishment program during the next major erosion event and as a central component of the Strategic Beach Management Plan.
Immediately implement a policy of Opportunistic Nourishment (return of stock-piled beach sand from previously approved development and any sand removed from the beach ridge during the construction of new foundations, seawalls and pools).
Amendment of Planning Regulations to include a requirement that Heavy Vehicle Access is maintained to the Seven Mile Beach between future buildings considered for Planning approval to allow heavy equipment access to the beach in the event of a major beach restoration effort.
Establishment of a permanent Beach Management Fund with an initial deposit by Government in the 2003/4 financial year and in subsequent years from private and Government funding mechanisms to be determined at a later stage.
Developers and residents shall be encouraged to use native beach vegetation to assist beach stabilisation both before and after storm events.
Amendment of Section 31 of the Development and Planning Law (1999 Revision) to prevent the practice of sand removal from all beaches.
Amendment of Development and Planning Regulations and/or CPA policies such that all repair of coastal structures damaged by storms and hurricanes shall require planning permission in accordance with established policies and recommendations.
The Committee strongly recommends that the current Department of Environment and Lands and Survey Beach Monitoring Programme is continued and information and data collected in this programme is incorporated into specific Beach Management Plans as part of the Strategic Beach Management Plan.

Appendix 5: National Consultations and Workshops

Photo 14 HE The Governor Stuart Jack with Overseas Territories participants at a reception to launch the ECACC Project, Grand Cayman, November 2007. ***Courtesy of GIS***

Name of Participants	Designation	Organization	Country
Kenrick Leslie	Executive Director	Caribbean Community Climate Change Centre (CCCCC)	Belize
Ethlyn Valladares	Executive Assistant to Director	Caribbean Community Climate Change Centre (CCCCC)	Belize
Ulric Trotz	Science Advisor	Caribbean Community Climate Change Centre (CCCCC)	Belize
Dick Beales	Senior Natural Resources & Environment Adviser	Overseas Territories Department, DFID	United Kingdom
Karen Dickinson	Climate Change Officer	Joint Nature Conservation Committee	United Kingdom
Kenneth Hodge	Principal Assistant Secretary	Government of Anguilla	Anguilla
Karim Hodge	Director of Environment	Ministry of Environment	Anguilla
Anthea Ipinson	Senior Projects Officer	Ministry of Finance, Economic Development, Investment, Commerce and Tourism	Anguilla
Josephine Callwood	Permanent Secretary	Ministry of Natural Resource and Labour	British Virgin Islands
Patlian Johnson	Deputy Director	Government of British Virgin Islands	British Virgin Islands
Lynda Varlack	Environmental Education Officer	Conservation and Fisheries Department	British Virgin Islands
Bertrand Lettsome	Chief Conservation & Fisheries Officer	Conservation and Fisheries Department	British Virgin Islands
Gloria McField-Nixon	Permanent Secretary	Ministry of Tourism, Environment, Investment and Commerce	Cayman Islands
Samuel Rose	Deputy Permanent Secretary	Ministry of Tourism, Environment, Investment and Commerce	Cayman Islands
Andrea Fa'amoe	Corporate Communications Officer	Ministry of Tourism, Environment, Investment and Commerce	Cayman Islands
Gina Ebanks-Petrie	Director of Environment	Department of Environment	Cayman Islands
Timothy Austin	Assistant Director -	Department of Environment	Cayman Islands

	Research & Assessment		
Lisa-Ann Hurlston	Sustainable Development Coordinator	Department of Environment	Cayman Islands
Jennifer Ahearn	Acting Deputy Chief Officer	Ministry of District Administration, Planning, Agriculture and Housing	Cayman Islands
Kenneth Ebanks	Director of Planning	Department of Planning	Cayman Islands
Barbara Carby	Director	Cayman Islands Hazard Management	Cayman Islands
Fred Sambula	Director of Meteorological Services	Cayman Islands Airport Authority	Cayman Islands
Produce Barnes	Information Officer	Government Information Services	Cayman Islands
Eugene Skerritt	Permanent Secretary	Ministry of Agriculture, Land, Housing and the Environment	Montserrat
Cecil Browne	Project Officer	Developing Unit	Montserrat
Judith Garland-Campbell	Permanent Secretary	Ministry of Natural Resources, Fisheries and Environment	Turks and Caicos Islands
Lichele Hue	Developing Planner	Planning Department	Turks and Caicos Islands
Michelle Fulford-Gardiner	Deputy Director	Department of Environment & Coastal Resources	Turks and Caicos Islands

First Mission, January 2009		
Sector Stakeholder Meetings		
Construction / Real Estate	Cayman Islands Association of Architects, Surveyors & Engineers (CASE)	Mr. Sam Small, President
	Cayman Islands Real Estate Brokers Association (CIREBA)	Mr. Kel Thompson, President
Insurance / Banking	Insurance Managers Association of Cayman Ltd (IMAC)	Mr. Willie Forsythe, General Manager
	The Cayman Institute	Mr. Nick Robson, Chairman
Tourism, Water & Commerce	Cayman Islands Chamber of Commerce (CICC)	Dr. Gelia Frederick van Genderen, Board Member
	Water Authority-Cayman	Mr. Hendrik van Genderen, Water Resources Engineer
Critical Infrastructure	Water Authority-Cayman	Ms. Catherine Crabb, Senior Development Control Technologist
		Dr. Brenda McGrath, Laboratory Manager
	Caribbean Utilities Company	Mr. David Watler, Vice President, Production
		Ms. Naomi Johnatty, Training, Safety & Environmental Specialist
	Planning Department	Mr. Kenneth Ebanks, Director
		Mr. Robert Lewis, Deputy Director Strategic Planning
	Mosquito Research & Control Unit	Mr. Fraser Allen, Research Manager
	Lands and Survey	Ms. Anna Verrill, Assistant GIS Officer
	Central Planning Authority	Mr. Dalkeith Bothwell, Chairman
Disaster Management	Cayman Islands Red Cross (CIRC)	Mr. Hemant Balgobin, Disaster Manager

Tourism & Environment	Ministry of Tourism, Environment, Investment & Commerce (TEI&C)	Mrs. Gloria McField-Nixon, Chief Officer
		Mr. Samuel Rose, Deputy Chief Officer
	Department of Tourism	Mrs. Sharon Banfield-Bovell, Deputy Director Tourism Product Development
	Department of Environment	Mrs. Gina Ebanks-Petrie, Director
		Mrs. Lisa-Ann Hurlston-McKenzie, Manager, Sustainable Development Unit
Physical Planning, Agriculture & Sister Islands	Ministry of District Administration, Planning, Agriculture & Housing (DAPA&H)	Ms. Jennifer Ahearn, Deputy Chief Officer
		Ms. Leyda Nicholson-Coe, Deputy Chief Officer
	District Commissioner	Mr. Ernie Scott
Health	Ministry of Health & Human Services	Mr. Leonard Dilbert, Chief Officer
		Ms. Janet Flynn, Senior Policy Advisor
Education & Human Resources	Education, Training, Employment, Youth, Sports, Culture & International Financial Services Policy	Ms. Angela Martins, Chief Officer
Finance	Financial Secretary's Office	Mr. Rick Quittell, Risk Management Unit
		Ms. Cassandra Connolly, Economics & Statistics Office
		Mr. Ronnie Dunn, Budget & Management Unit
Disaster Management	Hazard Management Cayman Islands (HMCI)	Dr. Barbara Carby, Director
		Mr. Omar Afflick, Deputy Director, Preparedness
Agriculture	Department of Agriculture	Mr. Brian Crichlow, Assistant Director (Acting)
		Mr. Raymond Coleman
Communications & Outreach	Government Information Services (GIS) – Communication Officers	Ms. Prudence Barnes
		Ms. Susan Watler
		Mr. Lennon Christian
		Ms. Kenisha Morgan
		Mr. Aare Toomist
		Ms. Bina Mani
	Hazard Management Cayman Islands	Mr. Simon Boxall, Public Relations & Communications Officer
		Mr. Omar Afflick
	Department of Agriculture	Mr. Brian Crichlow
		Mrs. Marjane Ebanks Fellows
	Department of Environmental Health	Ms. Tania Johnson, Public Relations & Education Officer
	Department of Environment	Mrs. Joni Kirkconnell, Senior Sustainable Development Officer
		Ms. Sophie Halford, Sustainable Development Officer
National Climate Change Adaptation Working Group	Planning Department	Mr. Kenneth Ebanks, Director
		Mr. Robert Lewis, Deputy Director Strategic Planning

(constitution at time of consultation)	Governor's Office	Mr. Andy Holbrook, Governor's Staff Officer
	The Cayman Institute	Mr. Nick Robson, Chairman
	Water Authority-Cayman	Ms. Catherine Crabb, Senior Technologist
	Lands & Survey Department	Ms. Anna Verrill, Assistant GIS Officer
	Hazard Management Cayman Islands (HMCI)	Mr. Simon Boxall, Public Relations/Communications Officer
		Mr. Omar Afflick, Deputy Director, Preparedness
	Ministry of Health & Human Services (H&HS)	Mr. Leonard Dilbert, Chief Officer
	Ministry of District Administration, Planning, Agriculture & Housing (DAPA&H)	Ms. Jennifer Ahearn, Deputy Chief Officer
	Ministry of Tourism, Environment, Investment & Commerce (TEI&C)	Mr. Samuel Rose, Deputy Chief Officer
	Department of Environment (Project Co-ordinating Committee)	Mrs. Gina Ebanks-Petrie, Director
		Mr. Tim Austin, Deputy Director, Research & Assessment
		Mrs. Lisa-Ann Hurlston-McKenzie, Manager, Sustainable Development Unit
		Mrs. Joni Kirkconnell, Senior Sustainable Development Officer
		Ms. Sophie Halford, Sustainable Development Officer
		Mr. John Bothwell, Senior Research Officer
Technical Team	Caribbean Community Climate Change Centre	Dr. Neville Trotz, Scientific Advisor & Program Manager
	CCCCC Consultant	Mr. George De Romilly, Policy & Institutional Expert
	CCCCC Consultant	Ms. Judi Clarke, Outreach & Awareness Specialist

Photo 15 Minister of Environment, Hon. Mark Scotland with participants and CCCCC Technical Team at the Issues Paper National Consultation, Grand Cayman, December 2009. ***Courtesy of GIS***

Second Mission, December 2009		
National Consultative Workshop		
Construction & Real Estate	Cayman Islands Association of Architects, Surveyors & Engineers (CASE)	Mr. Sam Small, President
Insurance & Banking	Liberty Consulting	Mrs. Lisa Bowyer, Principal Consultant
Tourism & Commerce	Cayman Islands Tourism Association (CITA)	Mr. Steve Broadbelt, President
	Cayman Islands Chamber of Commerce	Mr. Wil Pineau, Chief Executive Officer
	Department of Tourism	Ms. Oneisha Richards, Deputy Director
		Ms. Racquel Brown, Manager – Tourism Development Services
Critical Infrastructure	Water Authority-Cayman	Ms. Catherine Crabb, Senior Development Control Technologist
		Dr. Brenda McGrath, Laboratory Manager
	Caribbean Utilities Company	Mr. David Watler, Vice President, Production
		Mr. Chris Lansley, Training Safety Environmental Specialist
	Cayman Brac Power & Light	Mr. Jonathan Tibbetts
Disaster Management	Cayman Islands Red Cross (CIRC)	Mr. Hemant Balgobin, Disaster Manager
	Cayman Islands National Recovery Fund	Mr. Finley Josephs, Executive Director
Physical Planning	Planning Department	Mr. Robert Lewis, Deputy Director Strategic Planning
Health	Ministry of Health, Environment, Youth, Sports & Culture	Ms. Jennifer Ahearn, Chief Officer
		Ms. Sheila Watler, Policy Officer - Environment
Youth		Mr. Joel Francis, Senior Policy Advisor
Agriculture	Department of Agriculture	Mr. Brian Crichlow, Assistant Director (Acting)
Communications & Outreach	Government Information Services	Ms. Cornelia Olivier, Information Officer
Education	Ministry of Education, Training & Employment	Ms. Marilyn Eden
UK Government	Governor's Office	Mr. Steve Moore
Weather/Climate	National Weather Services	Mr. Fred Sambula, Director
		Mr. John Tibbetts, Chief Meteorologist
		Mr. Kerry Powery, Forecaster
Environment	Department of Environment (Project Co-ordinating Committee)	Mrs. Gina Ebanks-Petrie, Director
		Mr. Tim Austin, Deputy Director, Research & Assessment
		Mrs. Lisa-Ann Hurlston-McKenzie, Manager, Sustainable Development Unit
		Mrs. Joni Kirkconnell, Senior Sustainable Development Officer
		Ms. Sophie Halford, Sustainable Development Officer
		Mr. John Bothwell, Senior Research Officer

Technical Team	Caribbean Community Climate Change Centre	Dr. Neville Trotz, Scientific Advisor & Program Manager
	CCCCC Consultant	Mr. George De Romilly, Policy & Institutional Expert
	CCCCC Consultant	Ms. Judi Clarke, Outreach & Awareness Specialist
	CCCCC Consultant	Mr. Ottis Joslyn, VCA Consultant/SPACC Project Manager

Photo 16 Governor Stuart Jack with Dr. Neville Trotz (left) and Ottis Joslyn (right) of the CCCCC, Chief Officer for Ministry of Environment, Gloria McField-Nixon, Department of Tourism's Racquel Brown, ECACC Project Focal Point, Lisa-Ann Hurlston-McKenzie, and Director of DOE, Gina Ebanks-Petrie at the Vulnerability and Capacity Assessment (VCA) Training Workshop, Grand Cayman, October 2008. ***Courtesy: Prudence Barnes*****.**

VCA Training Workshop, October 2008		
Name of Participants	**Organization**	**Organization Designation**
Dr. Ulric Trotz	Caribbean Community Climate Change Centre (CCCCC)	Science Advisor
Mr. Ottis Joslyn	Caribbean Community Climate Change Centre (CCCCC)	VCA Consultant
Fred Sambula	Airports Authority	Chief Executive Officer
Dax Basdeo	Cayman Islands Investment Bureau	Executive Director
Trina Christian	Cayman Islands Tourism Association	Executive Director
Danielle Borden	Cayman Islands Youth Chamber	

Kadane Hall	Cayman Islands Youth Chamber	
Amber Martinez	Cayman Islands Youth Chamber	
Wil Pineau	Chamber of Commerce	Chief Executive Officer
Taron Jackman	Deloitte	Consulting Group Partner
Maria Phillip	Deloitte	Senior Consultant, Strategy & Operations
Brian Crichlow	Department of Agriculture	Marketing Coordinator
Raymond Coleman	Department of Agriculture	
Gina Ebanks-Petrie	Department of Environment	Director of Environment
Timothy Austin	Department of Environment	Assistant Director - Research & Assessment
Lisa-Ann Hurlston-McKenzie	Department of Environment	Sustainable Development Coordinator
Joni Kirkconnell	Department of Environment	Research Officer
Sophie Halford	Department of Environment	Research Officer
John Bothwell	Department of Environment	Research Officer
Racquel Brown	Department of Tourism	Tourism Development Services Manager
Karie Bounds	Department of Tourism	Product Development Officer (Research & Policy)
Erik Rankine	Go East, East End District	Go East District Committee Member (East End)
Prudence Barnes	Government Information Services	Information Officer
Andy Holbrook	Governor's Officer	Governor's Staff Officer
Dr. Barbara Carby	Hazard Management Cayman Islands	Director
McCleary Frederick	Hazard Management Cayman Islands	Deputy Director, Mitigation
Simon Boxall	Hazard Management Cayman Islands	Public Education & Awareness Officer
Anna Verrill	Lands & Survey Department	Assistant GIS Officer
Sophy Brophy	Ministry of Health & Human Services	Administrative Officer II
Samuel Rose	Ministry of Tourism, Environment, Investment & Commerce	Deputy Chief Officer (Environment & Commerce)
Stuart Mailer	National Trust for the Cayman Islands	Field Officer
John Tibbetts	National Weather Service	Chief Meteorological Officer
Alan Ebanks	National Weather Service	
Kenneth Ebanks	Planning Department	Director of Planning
Robert Lewis	Planning Department	Assistant Director (Strategic Planning Unit)
Nick Robson	The Cayman Institute	Chairman
Stuart Petch	Water Authority-Cayman	Water Resources Technologist
Shavonnie Hislop	Water Authority-Cayman	Development Control Technologist

Photo 17 Caribbean Overseas Territories participants at the PRECIS Model training workshop organized by the CCCCC, UWI and INSMET, Grand Cayman, February 2010. *Courtesy of GIS.*

PRECIS Model Training Workshop, February 2010		
Name of Participants	**Countries/ Organization**	**Organization Designation**
Dr Kenric Leslie	CCCCC/Belize	Executive Director, CCCCC
Dr. Ulric Trotz	CCCCC/Belize	Science Adviser/Project Manager ECACC
Ms. Terry Audinett	CCCCC/Belize	Procurement Clerk
Mr. Ottis Joslyn	CCCCC consultant/ St. Vincent	VCA Consultant
Mr. Arnoldo Bezanilla	INSMET/Cuba	Institute of Meteorology
Mr. Abel Centella	INSMET/Cuba	Institute of Meteorology
Dr. Michael Taylor	UWI/Jamaica	Lecturer- Dept. of Physics
Dr. Leonard Nurse	UWI/Barbados	Senior Lecturer - CERMES
Dr. John Charlery	UWI /Barbados	Lecturer- Dept. Computer Science, Mathematics, and Physics
Julian Hughes	Anguilla	Senior GIS Officer, Physical Planning Dept.
Rhon Connor	Anguilla	Deputy Director, Department of Environment
Jeffrey Jennings	Anguilla	Meteorological Officer in the Air Traffic Services
Michelle Fulford Gardiner	Turks & Caicos	Undersecretary, Ministry of Environment and District Administration
Dainer Lightbourne	Turks & Caicos	Assistant Director, Planning Director
Kendre Wilson	Turks & Caicos	Local Meteorological Office
Angela Burnett-Penn	BVI	Administrative Cadet – Climate Change Coordinator, Conservation and Fisheries Dept.
Rozina Norris-Gumbs	BVI	GIS Officer – Conservation and Fisheries Dept.
Cynthia Rolli	BVI	Senior Technical Planning Manager – Dept. of Disaster Management
Ms. Ernestine Corbet	Montserrat	Environment Officer, Dept. of Environment
Ms. Tika Aymer	Montserrat	GIS Expert, Physical Planning Unit
Mr. William Tonge	Montserrat	Meteorology/Hydrology, Montserrat Utilities Ltd.
Fred Sambula	Cayman Islands	Director of National Weather Services
John Tibbetts	Cayman Islands	Chief Meteorologist
Allan Ebanks	Cayman Islands	Met Observer, National Weather Services

Kerry Powery	Cayman Islands	Forecaster, National Weather Services
Gina Ebanks-Petrie	Cayman Islands	Director of Environment
Timothy Austin	Cayman Islands	Deputy Director - Research & Assessment, Dept of Environment
Lisa-Ann Hurlston-McKenzie	Cayman Islands	Manager - SDU, Dept of Environment (National Focal Point)
Joni Kirkconnell	Cayman Islands	Senior SD Officer, Dept of Environment
Sophie Halford	Cayman Islands	Sustainable Development Officer, Dept of Environment
John Bothwell	Cayman Islands	Research Officer, Dept of Environment
Jeremy Olynik	Cayman Islands	GIS Specialist, Department of Environment
Anna Verrill	Cayman Islands	Assistant GIS Officer, Lands & Survey Dept
Amber Biberdorf	Cayman Islands	GIS Technician II, Lands & Survey Dept
Charles Brown	Cayman Islands	Planning Assistant, Planning Department
Jon Japal	Cayman Islands	Planning Assistant I, Planning Department
Catherine Crabb	Cayman Islands	Senior Development Control Technologist, Water Authority-Cayman
Marty Tammemagi	Cayman Islands	Civil Engineer, Water Authority-Cayman