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Protecting and enhancing the livelihoods, environments and economies of the Caribbean Basin

CARIBSAVE Climate Change Risk Profile for Grenada

Summary Document

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THE CARIBSAVE CLIMATE CHANGE RISK ATLAS (CCCRA)

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

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

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

SELECTED POLICY POINTS

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

OVERVIEW OF CLIMATE CHANGE ISSUES IN GRENADA

Grenada is already experiencing some of the effects of climate variability and change through damages from severe weather systems and other extreme events (such as Hurricane Ivan in 2004), as well as more subtle changes in temperatures and rainfall patterns.

Detailed climate modelling projections for Grenada predict:

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

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

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

1. assess the vulnerability of the livelihoods of community residents in the **Marquis/Soubise** area to climate change; and
2. project sea level rise and storm surge impacts on the **Grand Anse, Marquis, Soubise and Carenage** coastlines.

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

Vulnerable community livelihoods

- Average household monthly incomes are very low.
- There is a relative absence of financial support linkages for most households.
- Female-headed households suffer the greatest in times of disaster.
- The levels of household food inadequacy, lack of access to personal transportation, sanitation conveniences are relatively high.
- Most homes are not insured as this money could be spent on more immediate needs.
- Perceptions of vulnerability vary greatly by gender.

Vulnerable coastlines

- Tourism in Grenada is highly dependent on the attractiveness of the natural coastal environment, which has been shown to be vulnerable to climate change and SLR.
- 1 m SLR places 73% of Grenada's major tourism resorts at risk, increasing to 86% at risk with 2 m SLR.
- 1 m SLR places 44% of turtle nesting sites at risk.
- Beaches are critical assets for tourism in Grenada, with a large proportion of beaches being lost to inundation and accelerated erosion even before resort infrastructure is damaged.

Climate change effects are evident in the decline of some coastal tourism resources, but also in the socioeconomic sectors which support tourism, such as agriculture, water resources, health and biodiversity.

CLIMATE MODELLING PROJECTIONS FOR GRENADA

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

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

Box 1: Climate Modelling Projections for Grenada

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

Precipitation: General Circulation Model (GCM) projections of rainfall span both overall increases and decreases, ranging from -40 to +7 mm per month by 2080 across three scenarios. Most projections tend toward decreases. The RCM projections, driven by HadCM3 boundary conditions, indicate decreases in annual rainfall (-29%), while simulations based on ECHAM4 also project significant decreases (-22%).

Sea Surface Temperatures (SST): GCM projections indicate increases in SST throughout the year. Projected increases range from +0.9˚C and +3.1˚C by the 2080s across all three emissions scenarios.

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

SEA LEVEL RISE AND STORM SURGE IMPACTS ON COASTAL INFRASTRUCTURE AND SETTLEMENTS

The majority of infrastructure and settlements in small islands, like Grenada, are located on or near the coast, including government, health, commercial and transportation facilities. These areas already face pressure from natural forces (wind, waves, tides and currents) and human activities, (beach sand removal and inappropriate construction of shoreline structures). The impacts of climate change, in particular SLR, will magnify these pressures and accelerate coastal erosion.

Figure 1: Evidence of Beach Erosion along the Beach at Marquis, Grenada

The CARIBSAVE Partnership coordinated a field research team with members from the University of Waterloo (Canada) and the staff from the Ministry of Environment, Foreign Trade and Export Development to complete detailed coastal profile surveying at Grand Anse, Marquis, Soubise and Carenage.

Results of these surveys indicate that 1 m SLR places 73% of Grenada's major tourism resorts at risk, increasing to 86% at risk with 2 m SLR (see Table 2).

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

		Tourism Attractions		Transportation Infrastructure		
		Major Tourism Resorts	Sea Turtle Nesting Sites	Airport Lands	Major Road Networks	Seaport Lands
SLR	1.0 m	73%	44%	50%	4%	40%
	2.0 m	86%	60%	-	6%	-
Erosion	50 m	95%	100%	-	-	-
	100 m	100%	-	-	-	-

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

Table 2 highlights the beach area losses in four resort areas in Grenada: Grand Anse, Marquis Beach, Soubise Beach and Carenage. Greatest total land and beach loss due to SLR is estimated to occur in Grand Anse including the Allamanda Beach Resort, Coyaba Beach Hotel, Spice Island Resort and Flamboyant Hotel.

Table 2: Beach Area losses at Four Beaches in Grenada

	Grand Anse		Marquis Beach		Soubise Beach		Carenage	
SLR Scenario	Beach Area Lost To SLR (m^2)	Beach Area Lost To SLR (%)	Beach Area Lost To SLR (m^2)	Beach Area Lost To SLR (%)	Beach Area Lost To SLR (m^2)	Beach Area Lost To SLR (%)	Beach Area Lost To SLR (m^2)	Beach Area Lost To SLR (%)
0.5 m	2,148	4%	4,077	100%	3,169	100%	0	0%
1.0 m	10,097	22%	-	-	14	-	0	0%
2.0 m	29,584	77%	-	-	-	-	0	0%
3.0 m	12,680	100%	-	-	-	-	0	0%

The high resolution imagery provided by the survey technique used is essential to assess the vulnerability of infrastructure and settlements to future SLR in Grenada. The imagery also has the ability to identify individual properties, making it a very powerful risk communication tool. Figure 2 and Figure 3 clearly illustrate that the longer term erosion response of the shoreline to SLR would have significant implications for the loss of high value properties.

Figure 2: Sea level rise impacts at Grand Anse beach

Grenada is highly dependent on international tourism and the country will be particularly affected with annual costs as a direct result of SLR. Hard engineering structures such as dikes, levees, revetments and sea walls can be used to protect the land and related infrastructure from the sea to ensure that existing land uses, such as tourism, continue to operate despite changes in the surface level of the sea. Unfortunately, the effectiveness of this approach may not withstand the test of time nor withstand against extreme events. Protection could also be implemented through the use of soft engineering methods, which require naturally formed materials to control and redirect erosion processes. For example, beaches, wetlands and dunes have a natural buffering capacity that can help reduce the adverse impacts of climate change[i]. Although less expensive and less environmentally damaging, soft engineering protection is only temporary and a variety of implications need to be considered.

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

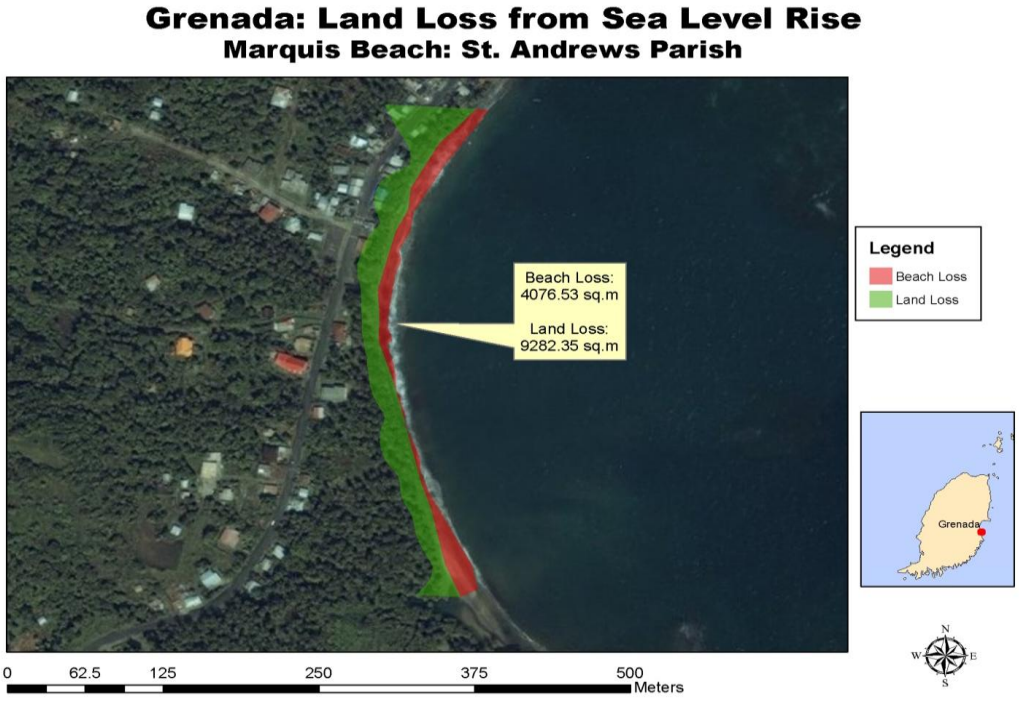

Figure 3: Sea level rise impacts at Marquis Beach

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

COMMUNITY LIVELIHOODS, GENDER, POVERTY AND DEVELOPMENT

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

Figure 4: A lady in Marquis preparing Pandanuas grass (wild pine or straw) for craft making

Some of the popular resource based livelihoods practised by community residents include craft making, fishing, farming and construction. Other sectors include: education, health care, law enforcement, banking and finance, mechanics, cosmetics and retailing. The natural resources needed for the different trades include wild pine trees (for craft making), agricultural land and freshwater (for farming), and sand (for construction); the sea (for pelagic and coastal fisheries); and mangroves which provide matting material and food.

Community Characteristics and Experiences

Climate-related events and climate change are already impacting livelihoods in this community through:

- reductions in fish catch, presumably due to declining stocks;
- reduced cultivation of wild pine since Hurricane Ivan in 2004;
- extended dry periods which make it costly for small farmers to irrigate;
- less water in ripe coconuts; and
- smaller crop-size compared to the past, as well as a greater prevalence of crop pests and diseases which affect productivity (one type of white fungus in particular was highlighted – the epidemiology of it appears to be unknown within the community).

These effects are compounded by other problems such as high water and fuel costs, and lack of fish storage facilities.

In order to strengthen the resilience of the livelihoods of those working in fisheries, it is recommended that cold storage facilities for fisherman be constructed in the Marquis and Soubise area. This will help fishers store fish and allow them to keep prices constant. At present, prices have to be reduced to get rid of the daily catch since no storage facilities exist. In addition, the community would like to establish a system for the sale of produce to the public in conjunction with the Marketing and National Importing Board. This system would contribute to maintaining more stable incomes and a guaranteed market for production by fishers and farmers. A community co-operative will be needed to manage planting and crop rotation to ensure that demand is met.

In 2004, Marquis and Soubise, being located on the eastern coast, were significantly impacted by the passage of Hurricane Ivan. Both areas were impacted by high winds and based on eye-witness accounts, Soubise in particular, experienced storm surge and wave run-up in excess of 3 m above sea level. To cope with the economic effect that damages had on households, 'reducing expenses' was the most frequently used strategy, as savings and insurance are not strong features of families in the community.

Figure 5: A low-lying vulnerable area in Marquis

While, men were more likely to be the main income earner in their household and the male employment rate within the community was higher than that of the female rate (a trend which has been presented in national statistics) still more than a quarter of males were unemployed. Average household monthly incomes are also very low - most of them below US $500. In addition, there is a relative absence of financial support linkages for households, which may become increasingly necessary to address as climate change impacts become more severe.

Low incomes and limited alternate financial support may justify findings of relatively high levels of household food inadequacy, lack of access to personal transportation, sanitation conveniences and a virtual absence of home insurance found amongst the community's residents.

At the community level, there appears to be very little social capital amongst members of the community, evidenced by a lack of community involvement. However, networks of friends within the community *may* exist which can be a strong source of support in difficult times. The minimal community group participation reflects anecdotal reports of the existence of only a few community organisations within Marquis-Soubise and may also suggest that existing groups are not strong or popular. To foster community cohesion and cooperation, opportunities for community level disaster mitigation activities should be explored.

The work in Marquis-Soubise revealed elements of gender inequality, which are reflected mainly in the different impacts and recovery responses from climate variability and change. For example, following the passage of storms; Ivan (2004) and Emily (2005), an assessment done on gender inequality concluded that the country needs to consider the extreme vulnerability of female-headed households to major disasters like hurricanes. This group was most affected since these women and their families are low-income earners. Other groups that were affected were the elderly and the disabled, whose primary carers were women.

The impacts on these groups were emphasised by inadequacies both prior to and following the natural disasters[ii]. Perceptions of the impact of Hurricane Ivan on the community varied significantly by gender, whereas men did not consider the impact to be "too bad", women were less positive and more despondent suggesting that the impact was crippling. This may highlight the different abilities of men and women to mentally deal with the aftermath and also the vulnerable social roles and livelihoods that women are involved in (e.g. craft-making which was severely affected by Ivan and primary caregivers) compared to men. Mainstreaming of gender and poverty is therefore needed in climate change policies and related development policies in order to achieve sustainable development. Further research is needed into the specific reasons for gender gaps and differences in adaptive capacity at the community level so that strategies can be geared towards the specific strengths of individuals in each household and community.

AGRICULTURE AND FOOD SECURITY

The Government of Grenada has identified the agriculture sector as one of the pillars of the national economy. Despite accounting for only 6% of Grenada's GDP, agriculture makes a significant contribution to the livelihoods of many rural people (see Figure 6). The principle exports include nutmeg, cocoa, mace, cinnamon, banana, mango and avocado.

Grenada's agricultural sector is highly vulnerable to the existing climate and is susceptible to extended periods of drought and hurricanes. The northeast region of Grenada and the island of Carriacou in particular, experience drought or prolonged dry spells adversely affecting the yields of crops that are not grown under irrigation. Management of the scarce water resources is therefore important to the success of agriculture given the projected seasonal decreases in precipitation. It is recommended that research and development of new varieties of Grenada's key export crops (nutmeg and cocoa) be conducted to improve the quality and yield of crops under existing pedoclimatic conditions. Further efforts to develop efficient irrigation practices in agriculture are also recommended since higher temperatures and longer dry periods would have implications for productivity and this technology is currently under utilised in Grenada[iii], however large amounts of arable land are located in areas with no available water source, limiting the development of irrigation[iv].

Figure 6: Grenada's Agriculture sector contribution to GDP

(Source: Agricultural Review)

One of the main vulnerability factors for land use and soil degradation in Grenada pertains to competing demands for the limited land area for housing, tourism development, infrastructure, agriculture and forestry. The pressure from these different interests has caused problems such as deforestation and loss of biodiversity, increased soil erosion, shortage of water, decreased agricultural productivity and coastal erosion.

Land degradation due to inappropriate and inefficient agricultural practices, such as the indiscriminate use of artificial fertilisers, herbicides and pesticides, clearing on slopes too steep for agriculture, removal of vegetation and farming too close to riverbanks contributes to the vulnerability of this sector to climate change. Together the factors are causing decreased agricultural productivity at present and the effects will also lead to further problems in the future.

Thus far, some Grenadian farmers have incorporated good agricultural practices for coping with climate risks including the use of strip cropping and mixed intercropping; routine tree management; integrated agro-forestry practices; grass barriers and contour farming. Some farmers have also successfully installed irrigation systems to mitigate the consequences of harsh drought conditions. However, Grenadian farmers have not fully embraced the wide range of new agro-technology available to help improve output. A greater effort to encourage youth involvement in adaptive agriculture by harnessing their knowledge and affinity for new technologies to support sustainable farming is another means by which resilience in the agriculture sector can be built.

ENERGY AND TOURISM

Tourism is an increasingly significant energy consumer and emitter of greenhouse gases (GHG) both globally and in the Caribbean. Current tourism related energy use and associated emissions in Grenada are estimated to be the equivalent of 59% of estimated national emissions of CO_2, though excluding emissions from waste disposal on land (methane, CH_4). Aviation (59%) and accommodation (22%) were identified as the major direct consumers of energy and emissions, although an assessment of the cruise sub-sector was not included. Grenada has been working to increase the number of arrivals and the National Energy Policy identifies specific policies for hotels such as mandatory solar water heaters and incentives for international certification.

A flat tax of $3.00 per gallon on fuel was introduced in 2006 and there is a fuel surcharge applied to fuel retail prices and electricity to account for variations in the cost of oil. An environmental levy is applied to

domestic electricity customers based on pre-determined consumption bands. The Government of Grenada has identified the use of incentives as a possible means of encouraging behavioural change. The National Energy Policy must now be delivered through the development of a detailed action plan that expands the roles of stakeholders and timelines for action. Particular attention is still needed with regard to the major energy consuming tourism sub-sectors currently not considered, i.e. shipping and aviation.

Tourism's share in energy use and emissions is likely to grow in the future, leading to growing vulnerabilities in a business as usual (BAU) climate scenario. At the same time, the sector holds great potential for energy reductions and should thus be one of the focus points of policy considerations to de-carbonise the island's economy; an initiative that would be enhanced if executed across the Caribbean region. A detailed energy assessment of the tourism sector is needed, however, to confirm these emissions and energy use figures because they are, in part, based on estimates with considerable uncertainties in assumptions. Building a green tourism economy would provide new growth in that sector as a result of the marketing advantages that can be gained.

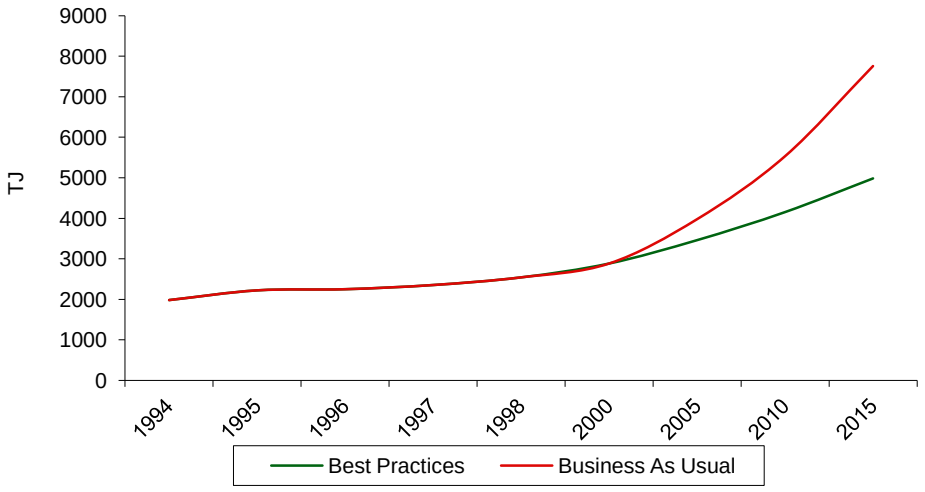

Figure 7: Fuel consumption scenario, 2000-2015

(Source: Government of Grenada, 2002a)

Electricity is currently produced and distributed by Grenada Electricity Services Ltd (GRENLEC), who rely entirely on imported diesel and have a capacity of 49.6 MW. There has been considerable growth in energy consumption in Grenada on a year-on-year basis with an expectation that this trend will accelerate, even in a best practice scenario. Climate change can have both direct and indirect impacts on energy generation, distribution and transmission infrastructure, with implications for existing traditional (fossil fuel based) energy systems, as well as proposed renewable energy initiatives. An increase in the intensity of severe low pressure systems, such as hurricanes, has the potential to affect both traditional and renewable energy production and distribution infrastructure. Some of the more vulnerable components include transmission lines, poles and other relatively light, above ground infrastructure, which can suffer significant damage from high winds. The energy based infrastructure in Grenada is therefore vulnerable and 80% was damaged by Hurricane Ivan in 2004. Power generating stations and other major infrastructure located on the coastline are also highly vulnerable to damage from flooding and inundation resulting from SLR and storm induced surges. Temperature increases have been shown to reduce the efficiency of energy generation at thermal power plants and reduced precipitation may affect water availability for non-contact cooling of power generators. Alternative energy sources, while they are environmentally more sustainable, also face challenges from physical climate change impacts and these must be considered in energy sector planning.

The National Energy Policy outlines a number of areas to address energy efficiency, improve uptake of renewable energy technologies and explore the potential for exploiting offshore hydrocarbon reserves. Some measureable goals have been set in the National Policy, namely a 20% reduction in greenhouse gas emissions by 2020 and at least 20% of domestic energy from renewable sources by 2020. GRENLEC already has plans to achieve 11% renewable sources between 2013 and 2015 (wind and waste to energy) and is investigating the feasibility of a 20 MW geothermal plant that would increase the renewable contribution to 70%. These initiatives are in addition to a public sector energy conservation programme and "Energy for the Poor" programme that have already started. Continued efforts to build knowledge and awareness within the private sector and the general public on the issue of energy consumption is recommended so that future efforts to reduce emissions and invest in alternative energy sources are accepted by Grenadians and, particularly the tourism sector.

WATER QUALITY AND AVAILABILITY

Grenada's water supply is sourced from the upland watersheds from permanent rivers, together with groundwater, rainwater and desalination. The southwest and north-east of Grenada tend to be drier due to their lower elevation which does not support the rich water catchment environment of the interior[v]. Water supplies from the National Water and Sewerage Cooperation have to be provided to both of these areas and these supplies are often affected due by problems in the distribution system, causing water-stress. In a 2005 PAHO welfare survey, 87% of households were estimated to have access to safe drinking water with 70% from public piped supply into dwelling, 8.4% from public supply into yard and 8.5% through standpipes. Potable water is not accessible and affordable to all, and as a result, the Government has undertaken a Water Assistance Programme, which is managed by the Ministry of Social Development. While a water tariff structure was designed to cover the full cost of water under the National Water and Sewage Authority (NAWASA) Act, lack of political will and loss of water to leakage are among the challenges that have prevented full implementation[vi]. Water infrastructure should be developed to reduce vulnerability during drought events and after major storms and hurricanes. In addition, the viability of desalination facilities to supplement rainwater during periods of drought should be assessed.

The water sector also faces various challenges related to rainfall variability and environmental degradation. For example, available surface water in Grenada can decrease as much as 30 to 40% during the dry season[vii]. Carriacou and Petit Martinique are smaller and of lower elevation than Grenada and thus receive less rainfall with intermittent stream formations[viii]. Both of these smaller islands are reliant on rainwater harvesting and cisterns to meet most water demands. There is very little agricultural production on these islands because of the lack of a suitable water supply. Water quality issues are largely associated with population growth and tourism development which have contributed to reductions in stream and river flow volumes, siltation of dams and reduced groundwater recharge rates. It is recommended that a comprehensive investigation of groundwater potential be undertaken, including mapping of the groundwater resource to be able to account for flow and also see where SLR impacts may cause salt water intrusion. Because of abundant surface water, groundwater has not been fully exploited. Development of this resource as a water supply may reduce future vulnerability for Grenadians as well as the vulnerable tourism and agricultural sectors.

Finally, prior to 2007, Grenada had no institutional or legal framework for Integrated Water Resources Management (IWRM). Grenada has sought to address these issues through the Grenada National Water Policy (2007), which is one of the first water policies prepared in the Caribbean region and includes climate change and water availability provisions and aims to bring together multiple different agencies into a

centralised coordinating agency. Grenada is also part of the Pilot Program for Climate Resilience (PPCR), of which water resource management is a key area of interest. Through these initiatives, Grenada has made good progress in the implementation of IWRM, essential for efficient management of water resources under climate change. Nevertheless, continued efforts to protect water resources from contamination are needed, particularly through enforcement of environmental legislation for protection of upper watersheds from sedimentation, sewage and agro-chemicals.

COMPREHENSIVE NATURAL DISASTER MANAGEMENT

Though natural hazards have been affecting populations and interrupting both natural and human processes for millennia, only in the last several decades have concerted efforts to manage and respond to their impacts on human populations and settlements become a priority. Many countries around the world, including Grenada, have adopted the Hyogo Framework for Action (HFA) and its priority actions that are designed to help manage the risks, reduce losses of human life and improve the resilience of settlements. The natural hazards facing Grenada are numerous and unpredictable. The islands are characterised by mountainous terrain, encircled with extensive coral reefs. St. George's, the capital, with its coastal location near a stream is highly vulnerable to impacts as well and thus if this primary port were impacted by a disaster there would be serious supply issues, including food security challenges, for the remainder of the country. The storm surges that accompany hurricanes and tropical storms generate coastal erosion risks in low-lying areas and are of particular concern on the primary road that links coastal and interior communities. Coastal areas are also exposed to erosion from regular wave action, thus storm surges worsen these erosive processes in many parts of Grenada.

Figure 8: Housing damage from Hurricane Ivan, 2004[xiii]

Additional threat from volcanoes also exists and seismic activity is monitored through a network of 17 seismographs located throughout the islands and operated by the UWI Seismic Research Centre; a separate monitoring station exists for early warnings relating to events from Kick-'em-Jenny. Together these technologies are generating information that improves decision making capacities with regard to emergency events and sustainable development.

Disaster and emergency response procedures are the primary means to control impacts, losses and damages from natural hazard events. Warning that Hurricane Ivan was approaching Grenada was noted nearly a day ahead of the impact on September 7, 2004. This early warning provided the National Emergency Relief Organization (NERO, now NaDMA) time to encourage Grenadians to start hurricane preparations. Evacuation notices were issued to those living in low-lying areas and Government preparations for food and water distribution were commenced. Nevertheless, vulnerability of homes and infrastructure led to approximately 89% of the housing stock being impacted, primarily by loss of roof and an additional 30% of all housing was completely destroyed.

Table 3: Estimated affected population in Grenada following Hurricane Ivan[xiii]

Parish	Total population	Population Affected
St. George's	37,057	35,575
St. John's	8,591	7,732
St. Mark's	3,994	799
St. Patrick	10,674	2,135
St. Andrew's	24,647	23,759
St. David's	11,486	10,337
Carriacou	6,081	1,216
Total	**102,632**	**81,553**

The steep mountain slopes expose much of Grenada to landslides and flash flooding is common during heavy rainfall and is particularly threatening to communities located near stream passages. Similarly, high winds from Hurricane Ivan were the cause of the majority of the damages, while rainfall was relatively low so flood damages were not extensive. Significant damages were reported, however, to the housing stock[ix] across all socio-economic brackets. But marginalised homes located on the steep slopes, where high winds were more intense, saw the worst damages[x].

The vulnerability of public utility infrastructure was also noted during Ivan. Electricity poles and lines were knocked down affecting distribution and telecommunications networks were interrupted as well. Water supply services were also disrupted across the island as intake structures and reservoirs became filled with silt and debris. After the devastation of Hurricane Ivan, the Government of Grenada, along with National Disaster Management Agency (NaDMA) and the Grenada Red Cross Society (GRCS), commenced many projects in the reconstruction of the country. Mitigation policies and disaster risk reduction mechanisms were managed by a new government agency, the Agency for Reconstruction and Development (ARD), whose work exemplifies the principles of 'building back better' after disaster, which is a positive sign for vulnerability reduction in Grenada. Efforts have also been started to collaborate with the GRCS in community capacity building and emergency response training. Public education and awareness raising is an important aspect of disaster risk and vulnerability reduction. Use of technology to inform Grenadians of hazards, effective response actions and early warning systems is therefore recommended. Further technical training and capacity building is also needed within NaDMA to improve the components of the warning and alert system (hazard maps, vulnerability assessments etc.).

HUMAN HEALTH

The potential effects of climate change on public health can be direct or indirect and can be conferred onto residents as well as visitors to a given destination[xi]. The acquisition of an infection can have consequences for persons visiting a destination and can have significant impacts on the economies of SIDS. According to the recently completed Grenada Strategic Program for Climate Resilience, human health is one of the sectors most vulnerable to climate change. In Grenada's Initial National Communication to the UNFCCC a number of diseases which can significantly impact the health sector and which also have climate change cues, were identified. These included dengue, malaria, viral conjunctivitis, influenza, gastroenteritis and respiratory-related diseases.

Vector borne diseases, namely dengue and malaria transmitted by mosquitoes and leptospirosis transmitted by rats, are likely to contribute to an increase in the incidence of tropical diseases in Grenada. This increase is associated with increased precipitation and higher temperatures which can create conditions suitable for the breeding of vector borne diseases. Grenada's water supply is usually affected by seasons as available surface water can decrease as much as 30 to 40% during the dry season[xii]. Dry spells and drought conditions the prevailing winds can increase particulate matter in the air, compromising air quality. This may also be heightened by regional dust storms during the hurricane season. This in turn can aggravate persons with respiratory illnesses, particularly asthma in Grenada and result in the worsening of respiratory problems in susceptible persons. Due to the complex inter-relationships between climate, vector habitats and human health, greater research needs to be conducted to link the epidemiology of diseases in Grenada with climate data. In particular, an Integrated Vector Management (IVM) Programme, based on the one developed by the WHO, should also be adopted.

Figure 9: Coastal eco-system

(Source: Truebluebaygrenada.wordpress.com, 2011)

In addition, mortality and morbidity rates due to injuries sustained during natural disasters are important considerations when assessing the vulnerability of a country to climate change. For example, heavy rains and hurricanes have serious implications for health and sanitation when flooding results in areas where pit latrines are used. As such, the implementation of a collective information centre or Clearing House containing detailed information, especially presenting temporal, environmental and climatological data for research purposes in the Caribbean should be developed. The Grenada National Climate Change Committee has acknowledged this in their national review for the Strategic Program for Climate Resilience directed (SPCR) and the Government has stressed its commitment not to reduce the health sector's budget despite the economic challenges it currently faces. In the 2011 budget, the health sector of Grenada received EC $63.6 million or 8.1% of the GDP.

MARINE AND TERRESTRIAL BIODIVERSITY AND FISHERIES

Grenada's natural resources include a variety of marine and terrestrial eco-systems that provide habitat to over 1,068 vascular plants, at least 268 vertebrate species and an unrecorded number of invertebrate species. The forests, coral reefs, beaches and seagrass beds provide many goods and services that support the island's communities and that form the basis of its main economic sector, tourism. However, poor land use practices, improper waste disposal, over-fishing of certain species and improper development of lands are having negative impacts on the islands biodiversity and increasing its vulnerability to climate change impacts.

All six classes of Grenada's forest communities were badly damaged by hurricanes and droughts within the last seven years. Regional climate projections suggest that the island's cloud forests and rainforests may be

drastically reduced or even lost to extreme cyclonic events and reduced rainfall. If this were to happen it would mean the loss of habitat for thousands of species including the critically endangered Grenada Dove.

Figure 10: The Critically Endangered Grenada Dove

Source: www.scscb.org (2012)

Effort to protect and conserve these valuable resources is evident in Grenada; however, some challenges do exist. Environmental monitoring and the enforcement of regulations are weak as is evidenced by the continued degradation of coastal resources. Management of biological diversity is under the jurisdiction of several governmental and quasi-governmental agencies that are guided by policy prescribed by the government. The main agencies are the Forestry Department, Fisheries Division and the Environmental Affairs Department. Efficient management is constrained by duplication of jurisdiction and indistinct roles and responsibilities among the various institutions. Management authorities do however recognise the need for greater involvement of civil society in environmental management and policy development and have begun to take steps to address this.

Coastal eco-systems – beaches, coral reefs, mangroves and seagrass beds – are also under pressure stemming primarily from development that either fragments, damages or removes these habitats entirely. Sand mining, sedimentation and careless recreational activities reduce the aesthetics and integrity of these natural resources. These local threats reduce the quantity and quality of goods and services that these eco-systems provide and decrease their resilience to climate change impacts. Additional pressure on coastal eco-systems comes from coral bleaching events which will occur more frequently as SSTs increase. This in turn increases the risk of coastal erosion and seriously threatens the sustainability of the fisheries sector, which provides jobs and food for local and foreign markets.

The tourism sector is also tightly connected to the health of marine and terrestrial eco-systems and is a major economic driver in Grenada. The tourism sector therefore has a role to play in the management and conservation of the island's biodiversity for it to be sustainable. It is recommended that education and awareness projects be conducted for incoming tourists, but also that all levels of school curriculum be designed to better educate Grenadians about climate change and environmental conservation.

CONCLUSION

Grenada has a growing dependence on the tourism industry, supported by a diversity of natural assets which enable it to be successful and many local livelihoods are also very dependent on these resources. Climate change will continue to exacerbate the already fragile eco-systems and water resources.

Grenada has a recent history of damages and losses from natural disasters that not only interrupt development progress at the national level, but also result in the investment of much time and resources into rebuilding homes and livelihoods after an impact. Since there is high confidence that climate change will result in more intense hurricanes and extreme events, posing even greater threats to eco-systems and the population, preparedness for disasters and climate change adaptation become common goals.

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

It is clear that the Government of Grenada is committed to adapting to climate change, as evidenced by the recent development of the Strategic Programme for Climate Resilience (SPCR), which includes new practices and planned actions for adaptation and mitigation of climate change impacts to the small island nation. However, financial resource shortages along with limited technical capacities hinder successful adaptation efforts across most government ministries and other stakeholder groups. Additionally, resource users with little or incomplete awareness of their risks and alternative courses of action continue to degrade or over-extract from marine and terrestrial eco-systems in an effort to sustain themselves. Continued work in data collection, monitoring and evaluation of climate change adaptation policies, plans and activities will be key to successful development of a sustainable tourism industry in Grenada but also for development in the country as a whole.

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This document provides a synopsis of critical *sectoral* vulnerabilities and capacities and highlights challenges, opportunities and strategies for action. The complete, 250+ page, Climate Change Risk Profile for Grenada is also available from www.caribsave.org and provides detailed climate modelling for various climate parameters, sectoral assessments, and analyses using proven, scientific methodologies to inform pragmatic strategies specific to key sectors in Grenada.

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