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

CARIBSAVE Climate Change Risk Profile for Barbados

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 UKaid from the Department for International Development (DFID/UKaid) and the Australian Agency for International Development (AusAID), was conducted from 2009 – 2011 and successfully used evidence-based, inter-sectoral approaches to examine climate change risks, vulnerabilities and adaptive capacities; and develop pragmatic response strategies to reduce vulnerability and enhance resilience in 15 countries across the Caribbean (*Anguilla, Antigua & Barbuda, The Bahamas, Barbados, Belize, Dominica, The Dominican Republic, Grenada, Jamaica, Nevis, Saint Lucia, St. Kitts, St. Vincent & the Grenadines, Suriname and the Turks & Caicos Islands*).

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

SELECTED POLICY POINTS

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

OVERVIEW OF CLIMATE CHANGE ISSUES IN BARBADOS

Barbados is already experiencing some of the effects of climate variability and change through damages from severe weather systems and other extreme events, as well as more subtle changes in temperatures and rainfall patterns. Detailed climate modelling projections for Barbados 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 residents in **Oistins** to climate change; and
2. project sea level rise and storm surge impacts on the coast of **Sandy Lane and Holetown.**

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

Vulnerable community livelihoods

- Oistins has been rated as the second highest attraction on the island.
- Direct damage to physical resources and infrastructure such as fishing boats and the market structure itself from hurricanes and storm surge is the greatest concern for Oistins.
- Emergency boat hauling and storage is inadequate.
- Many fishermen do not have insurance for the boats and equipment.
- The infrastructure for sheltering patrons (from sun and rain) to food vendors is inadequate and has led to loss of business.

Vulnerable coastlines

- 1 m of SLR places 8% of the major tourism properties at risk, with 32% at risk with 2 m of SLR.
- Critical beach assets would be affected much earlier than the SLR-induced erosion damages to tourism infrastructure; indeed, once erosion is damaging tourism infrastructure, it means that the beach, a vital tourism asset, has essentially disappeared!
- Turtle nesting sites (on beaches) are destroyed by erosion in minor storm surge events.

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

CLIMATE CHANGE PROJECTIONS FOR BARBADOS

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

Temperature: Projections from the Regional Climate Model (RCM) ensemble indicate increases between 2.4˚-3.2˚C in mean annual temperatures by 2080s in higher emissions scenarios.

Precipitation: General Circulation model (GCM) projections span both overall increases and decreases, ranging from -36 to +12 mm per month by 2080 under the high emissions scenario. Most projections tend toward decreases. The RCM projections, driven by HadCM3 boundary conditions, indicate decreases in mean annual rainfall (-32%) when compared to simulations based on the ECHAM4 (-12%).

Sea Surface Temperatures (SST): GCM projections indicate increases in SST throughout the year. Projected increases range +0.8˚C and +3.0˚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

Approximately 25% of Barbados' population lives within 2 km of the coast. The high-density tourism development, particularly on the west coast, is highly vulnerable to SLR and storm surge. The CARIBSAVE Partnership coordinated a field research team with members from the University of Waterloo (Canada) and the staff from the Barbados Coastal Zone Management Unit to complete detailed coastal profile surveying at Holetown and Sandy Lane.

A summary of results for SLR and erosion impacts in Barbados are noted in Table 1. These results highlight that some tourism infrastructure is more vulnerable than others. A 1 m SLR places 8% of the major tourism properties at risk, with an additional 32% at risk with a 2 m SLR. It is important to note that the critical beach assets would be affected much earlier than the SLR induced erosion damages to tourism infrastructure; indeed, once erosion is damaging tourism infrastructure, it means that the beach, a vital tourism asset, has essentially disappeared!

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

		Tourism Attractions		Transportation Infrastructure		
		Major Tourism Resorts	Sea Turtle Nesting Sites	Airport Land	Road Networks	Port Lands
SLR	1.0 m	8%	3%	0%	0%	100%
	2.0 m	32%	8%	0%	0%	100%
Erosion	50 m	56%	63%	-	-	-
	100 m	67%	100%	-	-	-

One hundred percent of the ports in Barbados are projected to be inundated by storm surge associated with a 1 m SLR, but turtle nesting sites (on beaches) are destroyed by erosion in minor storm surge events.

If action is not taken to protect the coastline of Barbados, the current and projected vulnerabilities of the tourism sector to SLR will result in the very significant economic losses for the country and its people.

Hard engineering structures such as dikes, levees, revetments and sea walls can be used to protect the land and related infrastructure from the sea. This is done to ensure that existing land uses, such as tourism, continue to operate despite changes in the surface level of the sea. Even though constructed mainly for social benefit and beach enhancement, the Boardwalk on the south coast of the island serves this purpose (See Figure 3).

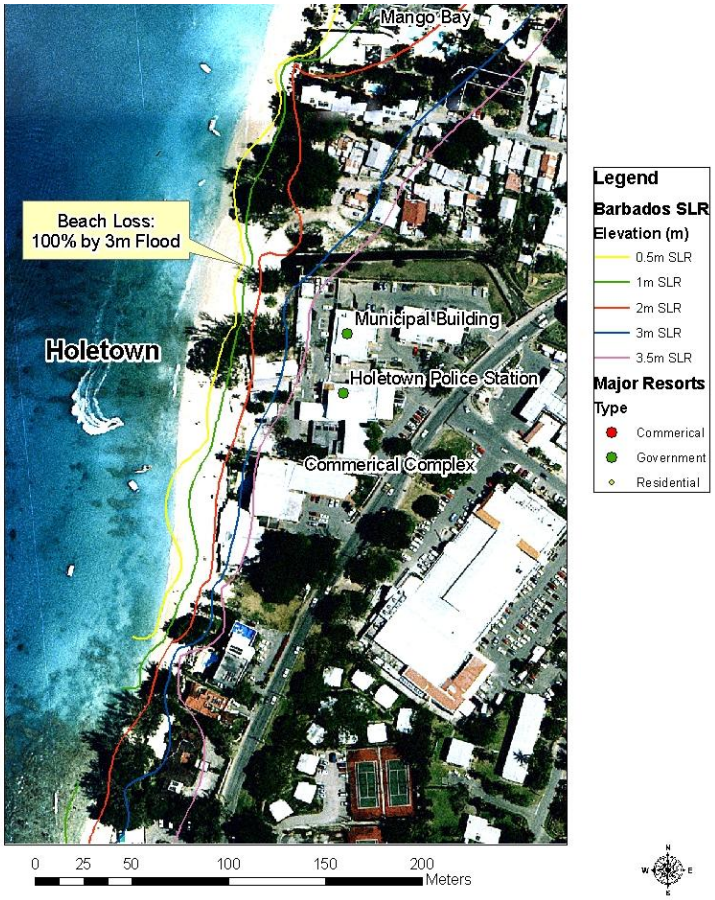

Figure 1: Land Lost from SLR in Holetown, Barbados

It is important to consider that, the capital investment needed for engineered protection is expensive; to protect the city of Bridgetown, US $41.5 million would be required to construct new levees, with an additional US $143.9 million to construct a new 8.43 km sea wall[i]. And unfortunately, the effectiveness of this approach may not withstand the test of time nor against extreme events, so a thorough cost-benefit analysis of coastal protection should be carried out at the local level. Taking a proactive approach (planned adaptation), SLR and storm surge projections should be incorporated into new and renovated coastal investment projects.

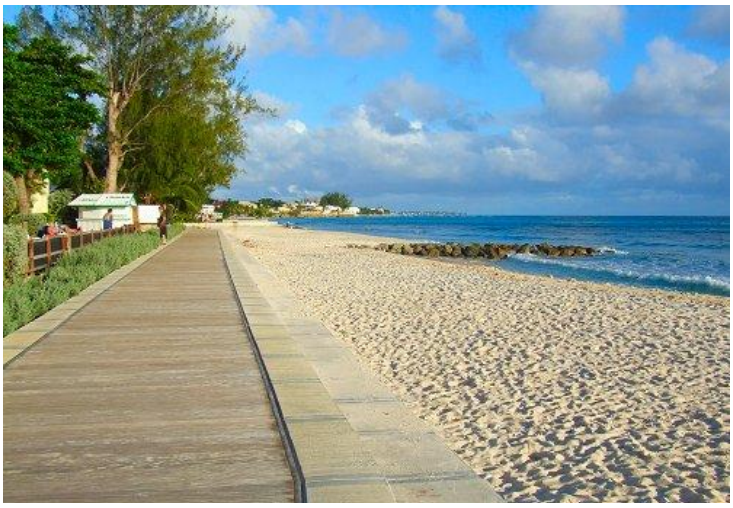

Figure 2: Boardwalk

Source: http://barbados.org/boardwalk/boardwalk.html

When hard structures are not possible or feasible, protection can also be given 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 SLR and storm surge. Through beach nourishment, wetland renewal and beach vegetation programmes, the natural resilience of coastal areas in Barbados can be enhanced. Although less expensive and less environmentally damaging, soft engineering protection is only temporary and can produce a variety of implications (especially for resource users) that need to be considered. Whilst managed retreat is also an adaptation option, it would be very difficult to undertake in Barbados with such a densely developed and populated coastal zone.

COMMUNITY LIVELIHOODS, GENDER, POVERTY AND DEVELOPMENT

More than 50 residents and workers[1] in the fishing community of Oistins participated in CARIBSAVE's vulnerability assessment which included a vulnerability mapping exercise, focus-groups and household surveys based on a sustainable livelihoods framework. This research provided an understanding of: how the main tourism-related activities, including fishing, vending and other micro- and medium-sized commercial activities located along the coast and have been affected by climate-related events; the community's adaptive capacity and the complex factors that influence their livelihood choices; and the differences in the vulnerability of men and women. Oistins is located on the south coast of the island and while it is more developed and more popular as a tourism attraction than other fishing communities in Barbados, it could be regarded as a good representative of the others in that the climate-related issues experienced by the fishers and vendors are very similar.

Figure 3: Oistins community members drawing a vulnerability map of the area

Oistins has been rated as the second highest attraction on the island as it is close to many hotels on the south coast which has several very attractive beaches. Properties and facilities on the water's edge include a few middle- to high-income homes and government offices. There is also a fish market and jetty, kiosks for the vendors, a boat building yard and landing site for

[1] Some of the workers in the Oistins community do not live there. However they have a vested interest through their investment in tools, equipment, infrastructure and other assets to support their income-earning activities in Oistins.

fishing boats although fishing does not take place extensively within the immediate Oistins Bay area. Both tourism and fishing in Oistins depend heavily on coastal and marine resources including beaches, coral reefs and fish which are all sensitive to climate (See Table 2).

Table 2: Use of natural resources in Oistins and surrounding areas

Coral reefs	Marine space	Beaches & nearshore	Fish
•Snorkelling •Diving •Fishing	•Fishing vessel mooring •Commercial vessel mooring	•Recreation •Vending (craft, food, drinks, lounge chairs)	•Commercial fishing •Recreational/sports fishing

Community Characteristics and Experiences

There is a general awareness of climate change in the community, particularly among locals who work at sea, but the perceptions of risk and impacts vary. The main threat to community livelihoods from climate-related events is direct damage to, or destruction of, physical resources and infrastructure such as fishing boats and the market structure itself from hurricanes and storm surge and this is already being experienced. With limited opportunities available for boat storage, the expectation of increasingly severe hurricanes and tropical storms as a result of climate change is understandably a concern in the community, particularly as many fishermen cannot afford or choose not to have insurance for their boats and equipment; and many of the fishers do not have sufficient savings to absorb repair or replacement costs should this be necessary.

Less extreme changes have also been observed; such as an increase in the number of hot days, hotter days and an extended wet or dry season in any given year. These observations strongly correlate to those recognised and predicted as impacts of climate variability and change by the scientific community for Caribbean SIDS.

Clearly, both men and women are vulnerable to physical impacts from weather and climate, but there are differences. And since vulnerability and adapation are largely social issues, it was important to disaggregate data by gender in the community.

- It is noteworthy that the average female household head participating in the reseach was 54 years while the average male household head was over 60 years, which could be indicative of the larger number of female-headed households (younger women may be better able to manage a household -physically and financailly - and this age is within the working-age population).
- Labour within the fishing community is divided such that a greater proportion of men are fishermen and travel out to sea, or tend to their own livestock; whereas a greater proportion of women are engaged in fish vending, processing and food preparation and vending of craft and other items. Apart from the fish itself, the market structure is one of their more important livelihood assets. Damage to the market will therefore affect the livelihoods of these women. Fishermen will also be affected because they would not be able to immediately sell their catches and will have to seek more burdensome alternatives such as selling to customers directly, or using cold storage facilities located elsewhere. This has implications for transport costs and pricing in markets where they may have to compete with others.

In addressing poverty, sustainable development and climate change issues in Oistins (and similarly in other communities) it will be important to assess the impacts of policies and projects by gender, taking the

different roles in these local economies into account, thereby avoiding gender inequalities and the perpetuation of cycles of poverty.

Oistins is therefore in need of protection if it is to remain as a major attraction and source of livelihood for those who depend on it. A Rapid Response Plan is critical for boats to be quickly and safely stored when storms are approaching. This should be part of a wider Community Climate Change and Disaster Risk Reduction Programme to include awareness, capacity building and the improvement of the one landing site which has been damaged over time by beach loss. Food vendors require shelter for their patrons since currently they are not able to attract business when it is raining. With financial and technical support, the well-known community members that are actively involved in the District Emergency Organisation, the Oistins Users Committee and the Oistins Fisherfolk Association, are willing to act as agents of change for the protection of Oistins. They should clearly then be included in any adaptation interventions in the community.

AGRICULTURE AND FOOD SECURITY

Agriculture is no longer a dominant economic sector in Barbados, but is nevertheless critical in ensuring a balance between domestic food production and food imports, as well as for enhancing foreign exchange earnings. Sugar, rum, cotton and a selected range of vegetables, roots and tubers as well as fruits, poultry, swine, mutton and milk have been identified as the major outputs of the agricultural sector in Barbados, but local farmers cannot produce most of the foods that are consumed in the country. The share of sugar agriculture in total GDP declined from 20% in 1965 to 2.6% in 2000, while the contribution of non-sugar agriculture fell from 6.3% to 3.7% over the period.

The main factor responsible for the general decline of the sector is the change in land use and this is the leading cause of land degradation in Barbados. Removing productive land from agriculture (for residential use, commercial buildings, hotels and golf courses) has increased the coverage of hard surfaces, resulting in an increase in surface run-off and flash flooding. This situation is exacerbated by inappropriate agricultural practices that use herbicides that kill ground cover and promote soil runoff; and planting systems that encourage runoff instead of water retention in the topsoil and aquifer. In terms of social vulnerability factors for agricultural communities in Barbados, the continued transformation of rural agricultural lands adversely affects environmental stewardship, rural development and entrepreneurship, especially in younger persons.

The increase in frequency and length of dry spells has severely impacted the penetration of rainfall into Barbados' limestone aquifers which has affected the sugar cane crop and in turn the quantity and quality of sugar. Higher atmospheric temperatures in Barbados are also influencing soil temperatures and affecting the growth and development of local commercial crops. For some vegetables, germination within recent years has been very poor due to increasing soil temperatures. The period of extended drought which began during the 2009 dry season understandably caused major concerns to the country's farmers. This drought was followed by the passing of Tropical Storm Tomas in October 2010 when over 230 farmers were then faced with and suffered huge financial losses on account of the heavy rains which destroyed many crops.

Also, in 2009, carrot growers observed that the extremely dry conditions in Barbados caused an increase in the soil fungus Pythium. This occurrence was one of the principal factors influencing the exceedingly high level of imports for carrots that year as farmers experienced significantly decreased yields. Local farmers also observed a marked increase in the incidence of the bacterial disease Erwinia in onion crops *before*

harvest. Traditionally, Erwinia is a *post harvest* disease which appears on bulbs in storage. However, the disease manifests more aggressively with increased soil temperatures.

Poultry birds have shown the greatest vulnerability to increasing temperatures and local farmers have sustained considerable losses as a result of heat related illnesses. Heat stresses have also reduced both meat and milk production in ruminants and this trend can be expected to continue as average daily temperatures increase. Already, these products are imported in large quantities, especially meat, for supply to the local hotel and restaurant sectors who have strongly defended their case for imported food because of inconsistent and insufficient local production. Furthermore, what is produced locally generally has a higher cost than imports. The projected changes in temperature and rainfall therefore threaten to exert pressure on foreign reserves as agricultural import levels increase to address expected shortfalls.

Farmers in Barbados have started soil testing to address the issue of land degradation caused by traditional agricultural practices and natural climatic stresses in order to strategically and systematically replace the nutrients that are removed with each harvest in an effort to keep production levels high and costs low. Additionally, the Government of Barbados has made provisions for stimulating growth in the agricultural sector since agriculture has had to compete for scarce resources such as land, labour and capital.

According to a report commissioned by the UNDP on *Best Practices for Youth in Agriculture*, Barbados has failed to identify and promote model farmers with best practices for youth in agriculture. However, there are some areas that are attractive prospects to young people, like greenhouse technology, organic farming and farming of certain crops, particularly vegetables because of the quick turnover cycle. In terms of livestock; pig, chicken and rabbit rearing have also captured interest amongst youth because of their profitability and guaranteed local market.

Although strategic plans for agricultural development in Barbados already include some measures that inherently respond to the effects of climate change, there is a need for policy choices and initiatives that explicitly seek to reduce adverse impacts on local farmers and assist them in exploiting opportunities. Such would include crop research, particularly for cultivars suitable for a changing climate; and extension programmes consisting of capacity building geared towards climate change adaptation and mitigation using locally appropriate technologies. The Barbados Ministry of Agriculture already has extensive experience with crop research and has acknowledged the need for investment in laboratory infrastructure to produce useful results for farmers.

ENERGY AND TOURISM

Tourism is an increasingly significant sector in energy use and emissions of greenhouse gases in the Caribbean. Its components such as aviation, accommodation facilities and cruise ships are high energy users (not from indigenous sources) and are vulnerable to changes in climate that could affect tourist preferences. Current tourism-related energy use and associated emissions are estimated to be 41% of Barbados' national emissions and the major direct consumers of energy in this sector are aviation (59%), accommodation (13%) and cruise ships (12%). Rising prices for fossil fuels and emerging international climate policies aimed at mitigating greenhouse gas emissions could make Barbados' tourism sector increasingly vulnerable.

In the absence of specific targets for tourism growth and forecasting models to predict energy demand, no scenarios for future tourist arrivals, energy use and corresponding emissions were considered in this

project. However, it is anticipated that "even with the promotion of energy conservation and efficiency, per capita energy consumption will increase by approximately 4% annually[ii].

The use of natural gas and renewable energy is outlined as a major goal of the government. In particular, the importation of gas from Trinidad & Tobago via a trans-Caribbean undersea pipeline is understood as a viable strategy, along with planned expansion of electricity generation from renewable energy sources to supply 20% of demand by 2026. Overall, the government expects that potential renewable energy generating capacity is 95 – 145 MW, representing 18 – 28% of the required generating capacity in 2026. Specific policy initiatives include the generation of electricity through windfarms, bio-fuels, ethanol and solar; renewable energy legislation; and wider use of biodiesel and ethanol in the transport sector. Solar technology is used extensively in Barbados for water heating such that more than 75% of homes have solar water heaters such as that shown in Figure 4. However, the use of solar (photovoltaic) cells such as those in Figure 6 is limited at this time.

Figure 4: Photovoltaic cells which are expected to be more widely used in Barbados

The transformation of tourism towards becoming climatically sustainable will necessitate concerted efforts in mitigation even to the extent of aiming to achieve carbon neutrality. While this would demand a rather radical change from current business models in tourism, all aspects of a low-carbon tourism system are principally embraced by business organisations. In keeping with this, the Caribbean Hotel Energy Efficiency Action (CHENACT) project was developed to improve the use of energy in Caribbean hotels, thereby making them more competitive. The project focuses on energy audits, information on and implementation of energy efficiency practices and the monitoring of energy use, including water use. Results indicate that the greatest demand for energy in hotels is for air conditioning, operating kitchen equipment and lighting and project outputs include comprehensive reports on energy use in hotels, the possibility of a certification programme for hotels based on CHENACT standards of assessments (which are said to be more detailed and scrutinising than Green Globe certification) and the establishment of Clean Development Mechanism projects in the tourism sector based on promoting energy efficiency and integrating renewable energy production and use.

Since traditional tourism management is primarily concerned with revenue management, to facilitate the shift to a low-carbon industry, emissions and revenue need to be integrated and energy intensities need to be linked to profits. An indicator in this regard can be eco-efficiencies, i.e. the amount of emissions caused by each visitor to generate one unit of revenue. However, this kind of analysis is generally not as yet possible for Caribbean islands due to the lack of data on tourist expenditure by country and tourist type (e.g. families, singles, wealthy-healthy-older-people, visiting friends and relatives, etc.).

While an energy and emissions database would thus be paramount to the understanding, monitoring and strategic reduction of greenhouse gases, it also appears that energy demand in Barbados could be substantially reduced at no cost in the very short term, simply because there are many opportunities in the tourism sector to reduce energy use immediately. Furthermore, technological options to develop renewable energy sources exist and can be backed up financially by involving carbon markets as well as voluntary payments by tourists. In order to move the tourism sector forward to make use of these potentials, it is essential that policy frameworks focusing on regulation, market-based instruments and

incentives be implemented through closer collaboration with the public and private sectors. The choices and preferences of governments thus create the preconditions for tourism development and low-carbon economies. Extending the CHENACT project to all hotels in Barbados would also address many of the issues to make this sector less carbon-intensive.

WATER QUALITY AND AVAILABILITY

Water scarcity and groundwater protection are key water issues in Barbados, with the island being ranked among the 10 most water scarce countries in the world. Groundwater resources from aquifers account for almost all (98.6%) of the country's potable water, with current water use standing at 60-63 gallons a day for residents and 179 gallons a day for hotel guests.

Annually Barbados receives about 400,000 to 500,000 visitors, which translates into higher than average water demand as a result of the consumption patterns of tourists. Barbados' gullies (part of the watershed) are important in the water supply and protecting the gullies is therefore critical for water availability and quality as well as being an attraction for tourists.

Figure 5: Result of drought effects on the natural landscape

SLR is expected to increase saline intrusion of coastal aquifers and decreases in precipitation and changes in rainfall patterns will give rise to more frequent and severe drought conditions. This, in addition to increases in temperature could have a negative effect on recharge rates of ground water resources. Groundwater aquifers are unconfined and hydraulically connected to the sea, leaving them vulnerable to saline intrusion. Some of the most vulnerable areas are those which have the highest water demand and significant contribution to the economy such as the west coast of Barbados, an area which includes luxury tourism. Water levels in aquifers on the west coast are just 0.3 m above sea level and salinity has already been detected in these aquifers, which is indicative of high levels of abstraction combined with reduced recharge rates through reduced rainfall and higher evapotranspiration rates. SLR is likely to increase these impacts on water resource utilities, particularly as the majority of the population lives in the south western coastal limits. Desalination has been used to adapt to this vulnerability by the Barbados Water Authority (BWA) and the private sector. But this is not an easy alternative to expand given the challenges in accessing areas which are most suitable to extract brackish water.

Drought conditions have been severe in the last decade, as six of the last ten years were abnormally dry. While Barbados is a naturally water scarce country, outdated infrastructure compound this problem with water lost due to leakage or through unmetered consumption. Environmental problems related to land management have also contributed to the current water resource situation. In particular, there has been a lack of maintenance in the formerly extensive system of check-dams in gullies, used to direct surface water into the underground aquifers[iii].

Barbados has a long history of policy development relevant to water resources development and the institutional capacity for managing water resources is extensive. One example is the requirement of

residents to utilise rainwater harvesting to wash cars and water gardens necessitating the purchase and installation of catchment tanks in new residencies with over 1,500 square feet of floor space.

While the responsibility for regulation of water abstraction lies with the BWA, in practice many private abstractors do not have water meters installed and the Water Authority is unable to exert control, which creates challenges in regulation during times of drought. Barbados should therefore prioritise the increase in the efficiency of the water metering and distribution system to avoid losses and receive adequate compensation for water use; as well as develop pilot projects to assess artificial recharge of aquifers which will reduce vulnerability in times of drought.

COMPREHENSIVE NATURAL DISASTER MANAGEMENT

Barbados is vulnerable to a diversity of natural hazards including hurricanes, flooding, storm surges, epidemics and even earthquakes and tsunamis. Climate change projections suggest more extreme rainfall events and droughts and more intense tropical storms.

Figure 6: Sunken boat in the port of Bridgetown after Tropical Storm Tomas

The location of Barbados to the east of the Lesser Antilles chain of islands has reduced the number of direct hits from hurricanes and tropical storms, but Barbados is not immune to such impacts. However, the infrequent occurrence of major storms has led to some complacency within the general population and Tropical Storm Tomas in October 2010 was a "wake-up call" and a painful reminder of the importance of disaster preparedness. Public utilities were interrupted in some parts of the island for several days and large areas of vegetation as well as many homes were severely damaged.

The karst topography characteristic of limestone landscapes in Barbados adds another level of vulnerability that is not seen in other islands of the Caribbean, with the existence of sink holes and caves possessing some risk. The tragic cave-in event in 2007 where 5 lives were lost demonstrated that although the risk is relatively small, monitoring of these underground formations is needed.

In Barbados a combination of policy frameworks, management plans and technological instruments make up the disaster management system. However, they are weakened because of limited or no enforcement of environmental and other regulations – some of which are in place for the physical protection of the public. The use of policies that are supported by strong legislation will provide a development future for Barbados that is free from significant risks and the high reconstruction costs resulting from vulnerabilities.

The evaluation of the Hyogo Framework for Action (HFA) for Barbados and the Department of Emergency Management (DEM) in 2009 offered various recommendations relating the review of the National Disaster Management Plan and Act and these recommendations should be implemented as a priority. Further recommendations resulting from research in the CCCRA include the improvement of knowledge and capacities of the general public through an innovative communication strategy that enables individuals to manage their own risk levels and build their resilience to natural hazard events. This is particularly urgent

for vulnerable populations. An integrated warning system for coastal hazards that produces more accurate data should be used to provide better and more usable information for disaster management. Stakeholders in the tourism sector should consider supporting this in part since they would be a primary beneficiary and they also have the means to assist. The industry should also seek to diversify activities away from the already highly vulnerable coastal zone, thus creating a more sustainable tourism product. Well-conceived development and investment in other parts of the island can contribute to enhancing community resilience through improved infrastructure and jobs. As the HFA review indicated, the staff at the DEM lack some of the technical expertise needed to fully and effectively perform their roles. As a result, it is recommended that technical training be offered for DEM employees, possibly through the Caribbean Disaster Emergency Management Agency (CDEMA) who provide training workshops for personnel in disaster management agencies in all CDEMA Participating States. It is therefore evident that cross-sectoral cooperation is required for successful risk reduction and the creation of an adaptive system.

HUMAN HEALTH

Health is an important issue in the tourism industry because tourists are susceptible to acquiring diseases as well as potential carriers of vector-borne diseases. Additionally, Barbados' tropical climate makes it suitable for the transmission of a number of vector-borne diseases.

The effects of climate-related phenomena on public health can be direct or indirect. The former includes weather-related mortality and morbidity arising from natural disasters (e.g. hurricanes) and high temperatures (e.g. 'hot' days/nights). Indirect impacts are more extensive, including vector borne diseases such as dengue fever and malaria. Hurricanes have caused damage to Barbados but not frequently, for example, Hurricane Janet in 1955 was the last hurricane to directly hit Barbados and caused 35 deaths, damage to 8,100 dwellings and the displacement of 20,000 residents.

With the projected changes in climate effects on health could be significant. Also of concern are influxes of Sahara Dust, reducing air quality and resulting in respiratory diseases and infections (e.g. asthma, bronchitis). Malnutrition may also increase as a result of climate change due to decreased agricultural production and reduction in fisheries stocks, locally and globally.

The elderly, who accounted for 16.5% of the population over the age of 60 in Barbados in 2005, are more susceptible than other groups because they suffer from chronic diseases and are often placed in retirement homes and can therefore be socially isolated. Persons who work outdoors for long periods of time (e.g. agricultural workers and fishermen) are also at a greater risk to heat exhaustion and dehydration.

Another key vulnerability factor to note is that even though Barbadians have universal access to water diarrhoeal Illnesses are a concern in Barbados. The seasonal variability of these illnesses may be explained by the fact that a reduction in domestic water supplies due to drought conditions can affect the standards of sanitation at the household and organisation levels. Also, Barbados has been ranked third in the annual incidences of leptospirosis worldwide[iv] and rainfall patterns have been identified as the main factor that affects the distribution of cases on the island. The disease is associated with adults and sanitation and agricultural workers are groups which are at a higher risk. Therefore, emphasis on water and sanitation is critical to public health and may become even more important because of changes in climate and the existing vulnerabilities that will be exacerbated.

A study conducted by the Caribbean Environmental Health Institute over a two year period from 2000 - 2003 to assess the links between climate variability and health in Barbados found that healthcare

professionals had limited knowledge of the links between climate change and health. They also concluded that the time period for the study was too short to make definitive links between diseases and climatic variables and they noted the difficulty in separating other factors such as socio-economic conditions and the status of public health infrastructure as contributors to disease prevalence. Among the diseases included in the study were dengue fever, malaria, leptospirosis, yellow fever, tuberculosis, asthma and other respiratory diseases and infections, schistosomiasis, cryptosporidium, cholera, staphylococcal, salmonellosis and other diarrhoeal diseases.

Given the importance of the tourism industry to Barbados, the links between health, tourism and climate change should be fully evaluated and addressed. This will be to the long term benefit of Barbadian society, both economically and socially. In doing this Barbados would need to establish a research (data collection and sharing) culture in this sector and validation of data from the various components of the Health Sector will provide a sound platform from which to inform policy and planning for the future as the climate continues to change. Barbados should also adopt the Integrated Vector Management (IVM) Programme approach of the World Health Organisation (WHO). This would improve public health overall and certainly increase resilience to climate change. Early Disease Warning Systems that consider temperature signatures for vector borne diseases should be also developed, bearing in mind that these must be validated and be site-specific .

It is important to note that the Health Sector of Barbados has been considered to be ahead in the Caribbean region with respect to quality of healthcare and quality of life indicators – infant mortality; maternal mortality and life expectancy at birth; access to clean drinking water; immunisation coverage; and maintaining the low incidence of communicable diseases. This success within the health sector creates the strong potential to adapt to the impacts of climate change.

MARINE AND TERRESTRIAL BIODIVERSITY AND FISHERIES

Barbados is home to more than 570 vascular plants and more than 240 species of amphibians, birds, mammals and reptiles and compared to other small islands in the region, the terrestrial biodiversity in Barbados is quite limited. Only 2 of the 700 species of flowering plants in Barbados have been identified as endemic. In more recent times extensive land subdivision for residential, commercial, industrial and tourism development and agricultural activity have exerted pressure on remaining natural resources. Total tree cover on the island (including gullies, coastal wetlands, under-cliff woods and other planted woodlands) is reported to be 2% or 800 hectares of the land area. As a result of limited vegetation, terrestrial fauna is also sparse.

Figure 7: Diving in Barbados

Source: Eco-Dive Barbados

Even though comparatively limited, the variety of plant and animal species found in the country and within the coastal waters surrounding Barbados provides numerous goods and services in terms of food, water, industrial and agricultural products, prevention of soil erosion, removal of pollutants, maintenance of soil fertility and resources for recreation. The island's beaches, reefs, gullies and coastal wetlands play a

particularly significant role in the tourism industry as they serve as attractions and also provide services which support the industry.

Figure 8: Disease-plagued coral

For example the location of reefs in shallow waters affords great aesthetic value to the island and they are explored by some 30,000 - 50,000 divers who visit Barbados annually. An evaluation of the island's reefs indicated that if each diver participates in only one dive per visit to Barbados, additional economic value from dive tourism from a 10% increase in coral cover at dive sites could be as high as US $306,000[v]. Reefs also support livelihoods directly and indirectly via the jobs, income and tax revenue generated from fisheries and marine tourism, so much so that the Reefs at Risk Revisited report ranked Barbados as one of the countries which is most dependent on reefs. This report also identified Barbados' reefs as among the most threatened.

Coral reefs are important sources of sand therefore the negative impacts that climate change is expected to have on them will mean a loss of reserves for beach nourishment and a loss of protection from erosive waves. The fatal 'white band disease' and 'white pox' caused by chemical-laden agricultural runoff and sewage discharge are believed to be responsible for much of the coral reef loss in Barbados. This of course, makes them vulnerable to bleaching from increased sea surface temperatures associated with climate change. Another threat to Barbados' reefs and the fisheries sector is the invasive lionfish. The voracious predator can consume over 75% of a reef's fish population in a matter of weeks!

GCM projections indicate increases in SST throughout the year ranging from +0.8˚C and +3.0˚C by the 2080s across all three emissions scenarios. Increased SST's associated with climate change will likely result in thermal thresholds of corals being exceeded more frequently with the consequence that bleaching will recur more often than they can sustain. In August 2005 Barbados experienced its worst bleaching episode with an average of 70.6% of all reef habitats and coral taxa bleaching[vi]. Onset of mortality was rapid, occurring within a few weeks of bleaching although the majority of coral remained alive. Recovery was slow and bleaching continued into mid-2006. Further, there was a delayed onset of mortality observed 10 months after bleaching began, with up to 26% of coral cover having died as a result of the abnormally warm ocean temperatures[vii].

Warmer oceanic waters will also facilitate the uptake of anthropogenic CO_2 which creates additional stress on coral reefs. Increased CO_2 fertilisation will change seawater pH, having a negative impact on coral and other calcifying organisms since more acidic waters will dissolve and thus weaken the skeletal structure of such organisms. Furthermore rising sea levels may reduce the amount of available light necessary for the photosynthetic processes of the corals' symbiotic zooxanthellae.

The ability of coral reef ecosystems to withstand the impacts of climate change will depend on the extent of degradation from other anthropogenic pressures and the frequency of future bleaching events. Coral reefs have been shown to keep pace with rapid postglacial SLR when not subjected to environmental or anthropogenic stresses[viii]. Engaging divers in planting and monitoring of transplanted corals can assist in re-establishing or enhancing populations. This has already been done in Barbados on a small scale. In addition to increasing resilience, transplantation in the most vulnerable or impacted areas will increase public education and awareness and gain public participation in the protection of this critical resource.

Adaptation strategies for biodiversity in Barbados should aim to enhance the quality of terrestrial and marine ecosystems, strengthen the linkages between habitats, resource users and resource managers and increase the size and number of protected areas. The tourism sector should be more engaged in biodiversity conservation and the management of protected areas since these resources are a critical component of the very product they promote.

CONCLUSION

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

Barbados has a strong dependence on the tourism industry and the many natural assets that enable tourism to be successful. It is clear that the Government of Barbados is committed to adapting to climate change, as evidenced by some policy responses, current practices and planned actions; as well as the recognition of the importance of Barbados natural resources (particularly in the coastal zone) to livelihoods and economies. Adaptive capacity in the institutions across Barbados is generally quite good, but efforts are restricted by limited financial and technical resources and limited enforcement of policy and laws. Recommended actions are therefore focused on education and awareness-building and the creation of tools for natural resource management so that communities and other stakeholders are empowered to build their own resilience.

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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 Barbados 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 Barbados.

Notes

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

[ii] Ministry of Energy and Environment. (2006). *Barbados National Energy Policy*. Ministry of Energy and Environment, Bridgetown.

[iii] MEWRD. (2002). *Gully Ecosystem Management Study.* Bridgetown: Ministry of Environment, Water Resources and Drainage. Government of Barbados.

[iv] Pappas G., Papadimitriou P., Siozopoulou V., Christou L. and Akritidis N. (2008). The globalization of leptospirosis: worldwide incidence trends. *International Journal of Infectious Diseases*, *12*, 351-357.

[v] Schuhmann, P., Casey, J., & Oxenford, H. (2008). The Value of Coral Quality to SCUBA Divers in Barbados, 7-11 July 2008. *Proceedings of the 11th International Coral Reef Symposium* (p. 4). Ft Lauderdale, FL: ReefBase.

[vi] Oxenford, H. A., Roach, R., Brathwaite, A., Nurse, L., Goodridge, R., Hinds, F., *et al.* (2008). Quantitative observations of a major coral bleaching event in Barbados, Southeastern Caribbean. *Climate Change, 87,* (3-4), 15.

[vii] Oxenford, H., Brathwaite, A., & Roach, R. (2008). Large Scale Coral Mortality in Barbados: a Delayed Response to the 2005 BLeaching Episode. *11th International Coral Reef Symposium*, (p. 5). Ft. Lauderdale.

[viii] Hallock, P. (2005). Global Climate Change and Modern Coral Reefs New opportunities to understand shallow-water carbonate depositional processes. *Sedimentary Geology , 175* (1-4), 19-33.

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