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

CARIBSAVE Climate Change Risk Profile for Dominica

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 DOMINICA

Dominica has been able to take advantage of its rugged terrain, unexploited rainforest and rare species of fauna as tourism attractions given that it does not have white sandy beaches, a typical Caribbean tourism offering. The country 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 Dominica 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 in Portsmouth were extensively analysed to:

1. assess the vulnerability of the livelihoods of community residents in **Portsmouth** to climate change; and
2. project sea level rise and storm surge impacts on coastal resources and infrastructure on **Bell Hall, Coconut and Purple Turtle Beaches**.

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

Vulnerable community livelihoods

- Portsmouth is growing as an important commercial and tourism centre.
- Hurricanes are of the greatest concern and the most destructive events with widespread impacts throughout Portsmouth and surrounding areas.
- Hurricane Omar in 2008 caused damage to buildings from high winds and flooding; landslides; and sea swells.
- Men tend to underestimate the dangers in post-disaster search and rescue efforts and place themselves at greater risk to injury as a result.

Vulnerable coastlines

- 2 m SLR places 6% of the major tourism properties at risk. Road networks are particularly vulnerable with 15% of roads inundated with a 2 m SLR and 50% of airport lands inundated with a 2 m SLR.
- Sea turtle nesting sites, a tourist attraction, are also at risk to SLR and erosion, with 19% affected by a 100 m erosion scenario.
- A 3.5 m flood scenario for Purple Turtle Beach resulted in a total loss of more than 2874 m^2 of beach area and an additional loss of 27,786 m^2 of land area.

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 DOMINICA

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

Temperature: Projections from the General Circulation Model (GCM) ensemble indicate an increase spanning 0.8 - 3.0°C in mean annual temperatures by the 2080s. Regional Climate Model (RCM) projections driven by ECHAM4 and HadCM3 indicate greater increases in temperature over Dominica than the median change projected by the GCM ensemble under a higher emissions scenario.

Precipitation: GCM projections of rainfall span both overall increases and decreases, ranging from of -35 to +14 mm per month by 2080 under a higher emissions scenario. Most projections tend toward decreases. The RCM projections, driven by HadCM3 boundary conditions, indicate large decrease in annual rainfall (-26%) when compared to simulations based on ECHAM4 (-6%).

Sea Surface Temperatures (SST): GCM projections indicate increases in SST throughout the year. Projected increases range from +0.7˚C and +2.9˚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

As a result of its mountainous topography, the majority of infrastructure and settlements in Dominica, including government, health, commercial and transportation facilities, are located on or near the coast and these areas already face pressure from natural forces (wind, waves, tides and currents) and human activities, (including inappropriate construction of shoreline structures). The impacts of climate change, in particular SLR, will magnify these pressures and accelerate coastal erosion.

Figure 1: Coastal Erosion at Bell Hall Beach, Dominica

The beaches of Dominica have been monitored since the mid-1980's by the Forestry, Wildlife and Parks Division, indicating there is change from season to season and from year to year, but the underlying trend in the majority of locations has been a loss of beaches due to accelerated erosion, with accretion in a few beaches (e.g. Soufriere and Batalie).

Figure 2: High Resolution Coastal Profile Surveying with GPS, Coconut Beach, Dominica.

The CARIBSAVE Partnership coordinated a field research team with members from the University of Waterloo (Canada) and the staff from the Ministry of Environment, Natural Resources, Physical Planning and Fisheries to complete detailed coastal profile surveying on three beach areas: Coconut Beach, Purple Turtle Beach and Bell Hall Beach.

1 m and 2 m SLR scenarios and beach erosion scenarios of 50 m and 100 m were calculated. Table 1 identifies what tourism infrastructure would be at risk of inundation from a 1 and 2 m SLR scenario and to erosion of 50 and 100 m. These results highlight that some tourism infrastructure is more vulnerable than others. A 2 m SLR places 6% of the major tourism properties at risk. Road networks are particularly vulnerable with 15% of roads inundated with a 2 m SLR and 50% of airport lands inundated with a 2 m SLR. It is important to note that the critical beach assets would be affected much earlier than the SLR induced erosion damages to tourism infrastructure.

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

		Tourism Attractions		Transportation Infrastructure		
		Major Tourism Resorts	Sea Turtle Nesting Sites	Airport Lands	Road Networks	Seaport Lands
SLR	1.0 m	0%	7%	0%	14%	67%
	2.0 m	6%	10%	50%	15%	-
Erosion	50 m	29%	17%	-	-	-
	100 m	35%	19%	-	-	-

Sea turtle nesting sites, a tourist attraction, are also at risk to SLR and erosion, with 19% affected by a 100 m erosion scenario. Transportation infrastructure, also of key importance to tourism, is at risk. Ports are threatened, with 67% of port lands projected to be inundated with a 1 m SLR, followed by one of only two airports to be inundated with a 2 m SLR. Roads will also be impacted, with 15% of Dominica's road network projected to be inundated with a 2 m SLR.

As Table 2 indicates, even under a 1 m SLR, more than 35% of the highly valued beach resources at all three of the studied beaches would be inundated. With a 2 m SLR, 100% of Purple Turtle beach will be inundated, as will Bell Hall Beach and Coconut Beach with a 3 m SLR. Results for the popular Bell Hall Beach area found that a 3.5 m flood scenario resulted in a total loss of more than 4,213 m^2 of beach area and an additional loss of 14,281 m^2 of land area. Similar results were found for Coconut Beach in Portsmouth and a 3.5 m flood scenario resulted in a total loss of more than 11,352 m^2 of beach area and an additional loss of 46,318

m^2 of land area. Results for Purple Turtle Beach during a 3.5 m flood scenario resulted in a total loss of more than 2874 m^2 of beach area and an additional loss of 27,786 m^2 of land area.

Table 2: Beach Area losses at three Dominican Beaches

	Purple Turtle		Bell Hall Beach		Coconut Beach	
SLR Scenario	Beach Area Lost To SLR (m^2)	Beach Area Lost To SLR (%)	Beach Area Lost To SLR (m^2)	Beach Area Lost To SLR (%)	Beach Area Lost To SLR (m^2)	Beach Area Lost To SLR (%)
0.5m	39	1%	777	18%	1707	15%
1.0m	1197	42%	2432	58%	4426	39%
2.0m	2874	100%	3844	91%	11285	99%
3.0m	-	-	4214	100%	11352	100%
3.5m	-	-	-	-	-	-

Figure 3 and Figure 4 clearly illustrate that the longer term erosion response of the shoreline to a 1 m SLR would have significant implications for the shoreline and the loss of a total of high value commercial tourism properties. Indeed, if erosion is damaging tourism infrastructure, it means the beach will have essentially disappeared. With projected 100 m erosion, 35% all the resorts in Dominica would be at risk. Such changes in the coastal profile would transform coastal tourism in Dominica, with implications for property values, insurance costs and wider issues of local employment and economic well-being of thousands of employees. The response of tourists to such a diminished beach area remains an important question for future research given that this resource is not a primary part of the island's tourism product.

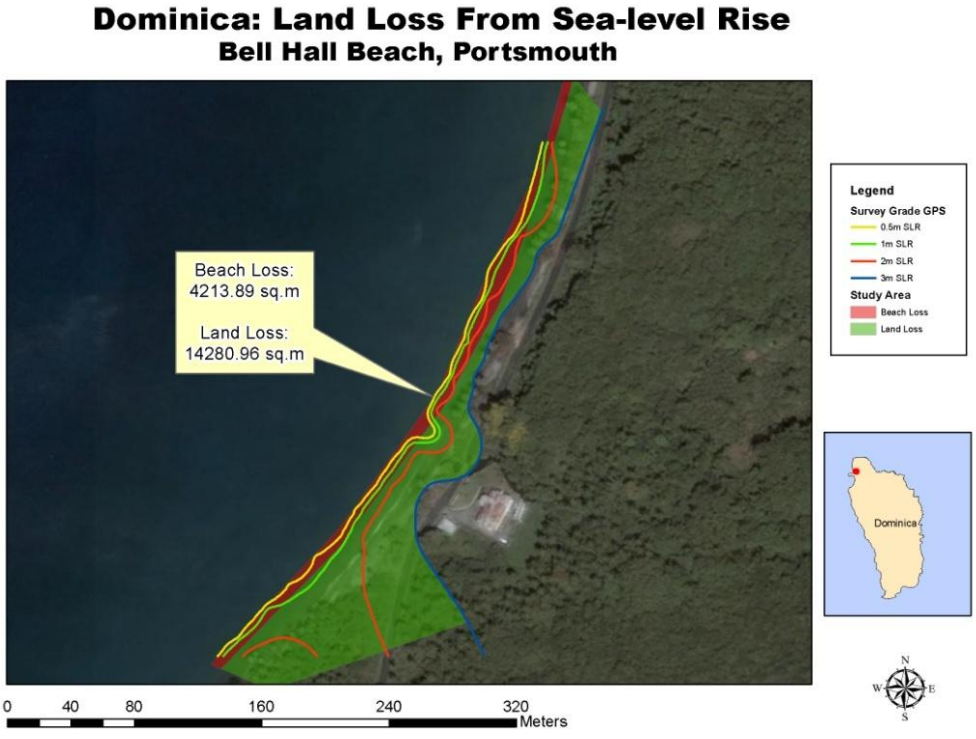

Figure 3: Total Land Loss, Bell Hall Beach, Portsmouth, Dominica

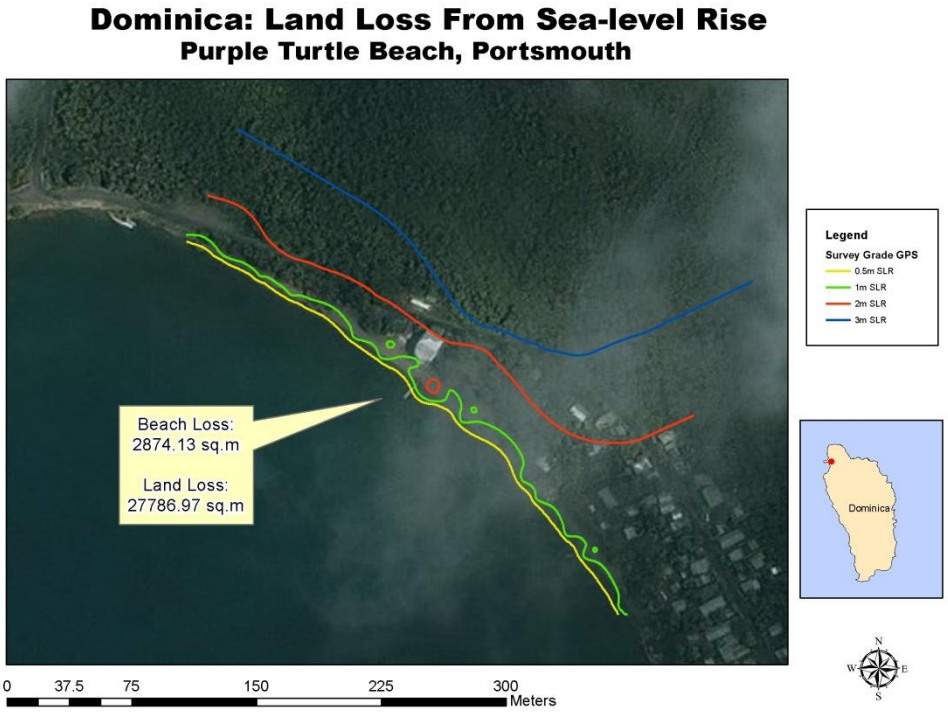

Figure 4: Sea Level Rise Vulnerability at Purple Turtle Beach, Portsmouth

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

Dominica could be considerably affected with annual costs as a direct result of SLR, possibly incurring annual losses between US $16 million in 2050 to over US $55 million in 2080 (based on a mid range scenario). Capital costs are also high with infrastructure critical to the tourism sector will also be impacted by SLR. This will result in capital costs to rebuild ports are estimated to be between US $24 million in 2050, to US $66 million by 2080. Airports will not be impacted by a 3 m SLR scenario and roads will be impacted by SLR resulting in capital costs to rebuild roads are estimated to be between US $4 million in 2050, to US $10 million by 2080[i].

Adaptation interventions will require revisions to development plans and investment decisions and these considerations must be based on the best available information regarding the specific coastal infrastructure and ecosystem resources along the coast, in addition to the resulting economic and non-market impacts.

Given the historical damage caused by event driven coastal erosion, as well as slow-onset SLR, the need to design and implement better strategies for mitigating their impacts is becoming apparent. There are a number of solutions that can be used to tackle beach erosion.

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

involved in decision making in the coastal zone. Interventions should also benefit coastlines in light of both climate and non-climate stresses.

COMMUNITY LIVELIHOODS, GENDER, POVERTY AND DEVELOPMENT

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

Figure 5: A small bay in Portsmouth

Source: www.sunsail.com

Portsmouth is the second largest town in Dominica and agriculture and fisheries are significant components of the local economy. The area has been targeted for tourism development and consequently, several accommodation facilities, tours and attractions have been established in the area. Existing tourism infrastructure includes a few tourism accommodation sites on the outskirts of Portsmouth and some natural and heritage attractions.

Community Characteristics and Experiences

There is some degree of awareness of climate change within the community and it is acknowledged generally that human beings are the cause of the changes in the climate system being observed. Changes in climate and extreme weather events have had significant impacts on the livelihoods of many persons in Portsmouth – farmers, fishermen, hotel and tourism workers, informal sector workers and also those who do not directly depend on climate or nature, but have been affected in various ways by hurricanes.

Hurricanes are of the greatest concern and the most destructive events with widespread impacts throughout Portsmouth and surrounding areas. The last major system to affect Portsmouth was Hurricane Omar in October 2008 which caused damage from high winds, flooding, landslides, coastal flooding and sea swells. No lives were lost, but buildings and the natural environs suffered and there was some temporary disruption to livelihood activities.

The most serious impact on Portsmouth and the country as a whole; was from Hurricane David in 1979, a category four system at the time of passing. Numerous lives were lost, residents were made homeless, the agriculture sector was devastated and eco-systems were destroyed. Although the loss and suffering caused by Hurricane David has not been experienced since, community residents are well aware of the possibility that a similar outcome can occur in the future.

Other weather related impacts of concern are:

- heavy rainfall (apart from hurricanes);
- landslides and flooding which all have significant impacts on tourism, agriculture and transport within Portsmouth.
- Coastal flooding as some residential areas (such as Lagon) are adjacent to the coastline and are therefore exposed to high sea swells, with a high risk of coastal inundation.

Some coping strategies are evident in Portsmouth, but some lead to additional problems:

- As a result of the risk posed to existing coastal residences and communities from storm surge and sea swell impacts, new developments are being constructed further inland, converting low lands suitable for agriculture to residential areas. This has resulted in farmers planting further uphill in the mountains, placing their crops and their livelihoods at risk of landslide events.
- Although farming faces several pressures (climatic and man-made), some fishermen have changed their livelihoods completely to engage solely in farming because it is perceived to be more lucrative the catches in fishing have reduced significantly in size over time, translating to less revenue and economic depression for some fisher folk.

In times of reduced rainfall the mouths of the Lagon and North rivers become stagnant and create ideal breeding grounds for mosquitoes. Then, with the first heavy rainfall, all of the sediment and debris is flushed out to sea, polluting the immediate nearshore environment making it unattractive to beach goers.

In terms of gender, women, especially women who are single parent heads of households with children and elderly members, are considered more vulnerable generally to harsher weather impacts, because of the heavier burdens of family care and security and dependence on neighbours for emergency assistance (in cases where the number of dependent household members are high). Men however, tend to underestimate the dangers involved in immediate post-disaster search and rescue efforts and place themselves at greater risk to injury as a result. In the aftermath of a storm or major event, men tend to be better positioned than women because of the types of jobs available immediately after a disaster by means of repairs and reconstruction, which was the case after the more recent hurricane events.

Household income in the community is generally low and male headed households are more likely to have higher earnings compared to women. There is also a relative absence of:

- financial support linkages that could supplement household income;
- financial security in the event of a shock; and
- insurance protection.

Households that are unable to sustain themselves after one month and subsequently unable to source any external help, are very vulnerable to falling into poverty, or more so if poverty is already an issue.

In terms of natural resource use and importance, given the proximity of rivers and the sea to the community and the high involvement in agriculture, it follows that community residents have greater uses for these natural resources compared to others. When further disaggregated on the basis of sex, there was little disparity in the use of natural assets, albeit men are slightly more dependent on natural resources for their livelihoods.

Men and women assume various roles in disaster management, insofar as community experiences with storms and hurricanes are concerned. Women deal with lighter tasks whereas men attend to more

physically demanding tasks in preparation for and during the recovery and response after an event (especially hurricanes). Before a hurricane, although these roles are not strictly defined, women tend to perform more domestic actions (e.g. ensuring supplies are available and secured), whereas men may affix shutters and secure roofing. After a hurricane, men are involved in clearing roads, power lines, unblocking drains, repairs and reconstruction. Women assert that their roles in disaster management however, are extremely crucial and they can be flexible in performing any required task.

There are a number of non-government and community based organisations in Portsmouth which play active roles in community development and empowerment in Portsmouth. However, little indication was made of any adaptation or mitigation strategies to protect respondents, their households and their livelihoods against impacts of extreme weather. This is of great concern, as it has implications for household and overall community vulnerability to future weather and climate change impacts.

The Portsmouth Community Watch Foundation has developed a 'Green City' programme for Portsmouth for which it is seeking funding. It illustrates the environmental consciousness of Portsmouth's citizens and their willingness to promote the conservation and protection of the local natural environment. This would be achieved by reducing detrimental habits and encouraging sustainable resource use, building design, infrastructure and transport development, energy conservation and efficiency and the creation of open spaces and green areas. While not developed to specifically address climate change, implementing this programme will set Portsmouth on its way to adapting to climate change.

AGRICULTURE AND FOOD SECURITY

Dominica relies heavily on the agricultural sector for economic survival, which provides about 60% of the food needs of the Dominican population. The agricultural sector is characterised by a tradition of banana production along with traditional non-banana crops such as citrus, root crops, coconuts, plantains and other foods. Banana was the most important cash crop up until 1991 but has significantly declined from 60-70,000 metric tonnes to under 30,000 tonnes by 2000 due both to the loss of preferential European markets and destructive hurricanes in 1989 and 1995. There was a further decline in banana production in 2009 as changes in market prices and market requirements forced some farmers to abandon their farms while others diversified out of the sector. As a result, the number of farmers involved in banana production reduced by approximately half compared to the previous year. These production trends are shown in the Table 3 below.

Table 3: Banana Growers Statistics, 2005-2009

Year	No. of Growers	Acreage
2005	880	2403.61
2006	809	2418.61
2007	728	2544.59
2008	412	1744
2009	300	1200

Figure 6: An organic farm in Dominica

Source: Dominica Organic Agriculture Movement http://www.doamdominica.org/

According to The National Coalition of Dominican Women (2009) women have traditionally played a critical role in the banana industry. At the collapse of the banana sector many of these women were not equipped with the necessary skills to pursue other methods of income generation, thereby making them economically vulnerable as well as vulnerable to climate change impacts. In response to this concern, the Caribbean Network of Rural Women Producers which was established in 1999 has a national chapter in Dominica, involved in a range of business activities from agricultural production to small-scale processing, craft and services. Women farmers also have several small holdings scattered throughout the island.

Dominica has experienced several major climate-related events in the last two decades that have severely affected the agricultural sector:

- Hurricane Dean destroyed over 90% of the area under banana production in 2007.
- Flash flooding which occurred in August 2011 when heavy rains from a strong tropical wave caused the Layou River to overflow its banks and break a dam. The Chinese funded Hillsborough Horticultural Centre, a main producer of seedling materials for distribution to local farmers was completely destroyed. Thirteen greenhouses under production, with yam, citrus and other plant tissue, as well as agricultural equipment were washed away. Recovery period is estimated at six months due to the sand deposit 6 ft deep which was left when the waters subsided.

The main factor contributing to vulnerability of this sector (and which is exacerbated by climate change) is land degradation through the indiscriminate clearing of forests in environmentally fragile areas and subsequent replacement by intensive agricultural cultivation; an increase in alien species on abandoned agricultural land and an increase in pressure for land by non-agricultural uses such as tourism, manufacturing, housing and other urban uses. The most critical social vulnerability factors for agriculture in Dominica pertain to the high incidence of poverty in rural agricultural communities; the change in the social fibre of agricultural districts which affects preservation of traditional farming practices; and the threat of fading agriculture industry as Dominican migration patterns uphold and migrant workers move on to more profitable income earning ventures.

The Government of the Commonwealth of Dominica (2011) has embarked on a pilot project for climate resistance which encompasses a critical review of the national climate change adaptation and policy and action plan. The national implementing agencies, The Ministry of Finance and the Ministry of Environment, Natural Resources, Physical Planning and Fisheries, have allocated agriculture and food security as one the major areas for intervention concerning climate change adaptation and mitigation.

Agricultural policy in Dominica is centred on export promotion, food security and agricultural diversification. The policy goals for agriculture in Dominica are pursued through a mix of national strategies to address some of the constraints that affect agricultural production and trade. Key aspects of these policies include measures that consider the realities of climate change. For instance, the investments made

in the pack houses at Fond Cole, Marigot and Portsmouth provide means for proper storage and processing of agricultural products.

Farmers in Dominica, through the government led the Support for Horticulture Programme, have overcome seasonality and experienced increased yields in yam production and other crops such as dasheen, tannia, passion fruit, hot pepper, pineapple, ginger and plantain in their efforts to grow climate resilient foods. Organic farming has also been adopted as a means of promoting healthy foods and preserving the environment.

Given the financial and human resource limitations and the cultural and historical nature of agriculture in Dominica, a community-based approach towards climate change adaptation is recommended. The Dominica Organic Agriculture Movement should receive capacity building to enable them to further empower farmers to deal with the most severe impacts of climate change on food. Components of such a project should include addressing the issue of increasing food production through organic cultivation of climate resilient varieties of crops. A second component would be to strengthen farmers' capacity to deal with drought through improved water management and improved access to seeds of drought adapted crops. The promotion of soil conservation through reforestation, planting vegetative barriers and innovative composting methods as well as the production of certified organic cocoa would be of great benefit to farmers and the national economy.

So far, the Government of the Commonwealth of Dominica has taken some measures that can aid farmers in climate change adaptation and some plans are in the works to incorporate agriculture into the national climate change discourse and policy framework.

ENERGY AND TOURISM

Tourism is an increasingly significant energy consumer and emitter of greenhouse gases both globally (5% of CO_2) and in the Caribbean, with aviation the most important sub-sector. Dominica's per capita emissions are currently considerably less than the global average (1.56 t CO_2 compared to 4.3 t CO_2), an exceptional situation that the island could make use of to remain a leading low-carbon destination in the world. This is a major marketing advantage, further fostering the island's image as a 'green' destination. Estimates of current tourism related energy use and associated emissions, however, put emissions at almost 97% of national emissions since tourism is a mainstay of the economy. While this comparison is misleading, as it includes fuels bunkered by cruise ships and aircraft elsewhere (there are no direct flights to Dominica from long-haul markets), it nevertheless indicates that the Dominican economy is far more energy dependent than official fuel use statistics indicate.

Figure 7: DOMLEC signage showing the water-conveyance system

Oil consumption in Dominica increased from 428 barrels per day in 1990 to 825 barrels per day in 2009, representing almost a doubling of fuel consumption; and electricity sales increased from 42 GWh in 1996 to 71 GWh in 2007.

Dominica's energy production is currently divided between diesel powered plants (69% of capacity) and hydro plants (28% of capacity) (Table 4). The potential physical climate change impacts specific to traditional energy production systems is of critical concern; and consideration of potential impacts on infrastructure for renewable energy must be considered in the planning process.

Table 4: Electricity plant capacity, 2011

	Capacity (MW)	% of total
Diesel Generating Plants		
Fond Cole Plant, Roseau	10.25	
Sugar Loaf Plant, Portsmouth	5.78	
Total	16.03	69.43
Hydro Plants (operating)		
Laudat	1.3	
New Trafalgar	3.52	
Padu	1.6	
Total	6.42	27.8
Total Operational Capacity	22.45	
Hydro Plants (not operating)		
Old Trafalgar	0.64	2.77
Total Capacity	23.09	
Other	Privately owned 225 kVA wind turbine	

(Source: M. Fadelle, Ministry of Public Works, Energy and Ports, personal communication, March 28, 2011)

Only a minor share of total electricity consumption is used by hotels, which accounted for 2.33 GWh in 2009, or 2.9% of national electricity consumption. Estimates show that cruise tourism (53%) and aviation (29%) are the biggest contributors to CO_2 emissions.

Rising prices for fossil fuels and emerging climate policy will make the tourism sector in Dominica increasingly vulnerable and climate change impacts also threaten energy infrastructure. High and rising energy costs should self-evidently lead to interest in more efficient operations, but this does not appear to be the case in tourism generally. Rising oil prices will affect tourism in particular since aviation has limited options for using alternative fuels and increases in fuel costs will inevitably be passed on to the passengers. The International Energy Agency (IEA) anticipates that even under its New Policies Scenario, which favours energy efficiency and renewable energies, energy demand will be 36% higher in 2035 than in 2008, with fossil fuels continuing to dominate demand. At the same time there is reason to believe that 'peak oil', i.e. the maximum capacity to produce oil, may be passed in the near future.

An increase in the intensity (and possibly frequency) of severe low pressure systems, such as hurricanes, has the potential to affect both traditional and renewable energy production and distribution infrastructure, including generating plants, transmission lines and pipelines, as experienced during Hurricane Dean in 2007. 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 and for driving hydro plants efficiently. Alternative energy sources, while they are environmentally more sustainable, also face challenges from physical climate change impacts and these must be considered in energy sector planning.

Tourism's share in energy use and emissions is considerable and likely to grow in the future, leading to growing vulnerabilities in a business-as-usual scenario. At the same time, the sector holds great potential for energy reductions and should thus be one of the focus points of policy considerations to de-carbonise island economies. Hotels in Dominica appear to have very low electricity demands compared to other islands and the National Energy Policy gives further consideration to the policies needed to target energy efficiency in hotels, including reducing tax on energy saving devices. This strategic advantage should be maintained and also be exploited to further market Dominica as a 'green' destination. It seems that few islands in the world are better suited than Dominica to become low carbon or even carbon-neutral destinations.

The Government of the Commonwealth of Dominica is undertaking an expansive energy development programme that is reviewing legislation, exploring potential for renewable energy and developing national policies and plans. Hydropower, geothermal, wind and solar energy are all being investigated with the aim of achieving 100% renewable capacity by 2015. In particular work is underway to develop a geothermal capacity that will be used to sell power to Martinique and Guadeloupe. The Draft National Energy Policy also highlights a number of institutional and energy efficiency initiatives that need to be undertaken including energy audits and use of efficient technologies in power generation. There are few recommendations for the transportation sector and none that address the cruise and aviation sub-sectors. It is assumed that the proposed National Sustainable Energy Office will ensure that any future direction taken with regard to renewable energy will be sustainable under the climate change circumstances.

It is advisable for all destinations in the Caribbean to initiate discussions of new tourism management models to reduce energy use and emissions, with a focus on market structure and average length of stay. This is because some markets are economically more beneficial, while consuming considerable less energy and causing lower emissions. The analysis of markets based on a combined assessment of their economics and energy intensity should thus be a key priority. For example, since cruise tourists in Dominica are day visitors, the high fuel dependency of this sector should be seen in comparison to its economic value to the island. If the economic value is low, which the short stay of the day-visitors would indicate, vulnerabilities linked to rising fuel prices or emerging global climate policy are likely to be less relevant. However, if the economic value of cruise tourism to Dominica is high because of the large number of arrivals, it would seem advisable to see the fuel dependency of this sector as a key vulnerability.

Furthermore, average length of stay is declining throughout the region, but has remained relatively stable in Dominica (varying between 8.7 and 9.5 days in the period 2004 - 2007)[ii]. The Caribbean Tourism Organisation reports that average length of stay in 2009 was 14.4 nights[iii]. Nevertheless, it would seem advisable to work pro-actively with this key performance indicator to maintain a stable number of bednights. Otherwise, tourist volumes would have to continuously grow in the future making the island more vulnerable to energy prices and climate policy. Marketing efforts to increase average length of stay should thus be considered. Evidence from a case study in Barbados suggests that this is indeed feasible and at the same time there is scope to increase spending.

With regard to management of the existing infrastructure, following Hurricane Dean in 2007, Dominica Electricity Services (DOMLEC) are pursuing alternative options for insurance to ensure that resources are available to restore power following a major catastrophe.

Fossil fuel consumption can be substituted through technological innovation that reduces energy needs as well as renewable energies. In Dominica, geothermal energy exploitation is expected to lead to radically lower costs of electricity. However, the planned reduction in electricity tariffs would be counterproductive to ambitions to become a low-energy, low-emission island, as declining energy prices will encourage consumption. Rather, it may be advisable to maintain current cost levels for electricity and to use options to reduce electricity prices (because of the development of low-cost geothermal energy sources) to foster innovation that supports the objective of a low-carbon destination, for instance regarding the introduction of electric cars. The introduction of many technologies is economically feasible in tourism, while new financing mechanisms, such as the Clean Development Mechanism and voluntary carbon offsetting schemes, can make contributions to implementing new and innovative, but not economical technical solutions.

Policy frameworks are needed to engage stakeholders in tourism planning with regard to energy use and emissions. Without clear policy goals regarding energy use and emissions, as well as the communication and monitoring of these goals, it is unlikely that stakeholders will engage in major changes in their operations. Consequently, measures ranging from regulations to market based instruments to incentives will have to be implemented to involve stakeholders, as outlined in the Draft National Energy Policy. Better understanding of energy use and associated emissions through carbon audits at national, sectoral and business levels would help to further reduce emissions and the island could, based on its geothermal energy strategy, seek to become a carbon neutral tourism destination.

WATER QUALITY AND AVAILABILITY

The water-rich island of Dominica is considered to be the wettest island in the Caribbean, due to it receiving approximately 2,500 mm of rainfall per year (estimated average of 20,000 m^3 of renewable water per capita per year). The northwest coast is relatively drier; experiencing average precipitation of 1,245 mm, while the central mountain region can have precipitation as high has 7,620 mm. The island's interior is still heavily forested (and much of it legally protected) which aids in the generation of these high precipitation volumes.

The majority of water consumed in Dominica is sourced from rivers and streams. Ground water resources have not been exploited extensively as in other islands. The island also possesses volcanic and sedimentary aquifers, though hydrological studies conducted in 1986 have found that the aquifers that do exist have low yield potentials. Nonetheless, there is potential for groundwater resource abstraction on the eastern side of the island. Overall, water resources are considered to be more than sufficient to provide for the water needs in Dominica.

The major uses of water includes for domestic, hydropower and irrigation purposes as well as for export to foreign water markets. The largest water system supplies over 4.3 million gallons per day to Roseau and its environs while two other main systems supply approximately 1.4 Mg/d. The Dominica Water and Sewerage Company (DOWASCO) supplies water to 90% of the island and a small percentage of the population is also supplied with water from local NGOs such as the Small Projects Assistance Team (SPAT). Additionally, all catchments areas have private land owners and are therefore managed independently from public supply and have an impact on water quality. The tourism industry also represents an important water user to the island of Dominica. For instance, the Dominica Port Authority has been providing 33 million gallons of water per year to cruise ships since 1979. There has been an increase in demand in recent years so this figure is perhaps an under estimation. However, water quality concerns due to high turbidity levels have presented a challenge to operation of this service.

Figure 8: The mouth of the Layou river in dry times
Source: http://dominicanewsonline.com/

Water flow in many rivers has decreased significantly and their replenishment has been increasingly dependent on periods of rainfall and high rainfall in mountainous areas means that landslides and flooding are recurrent problems. Sedimentation of river beds and reservoirs is also a problem during the rainy season.

Ninety-seven percent of Dominican households have access to safe drinking water, but only 84% have access to sanitary toilet facilities[iv]. However, in the Carib Territory, approximately 39% of the population does not have access to safe water and flush toilets are not widely utilised. Indeed, on a whole 25.3% of the population of Dominica uses pit latrines and ventilated pit latrines and another 6% do not use either flush toilets or pit latrines. According to the Country Poverty Assessment 2008/2009, 19.1% of households accessed water from standpipes in 2009 and the proportion of households accessing water from standpipes increased from 80% in 2003 to 88.7% in 2009. Further, only 45.3% of the population is estimated to have water seven days per week.

Water tariffs were increased by 15% over 1998 rates in May 2011 by DOWASCO. These are divided into domestic metered, commercial and industrial metered as well as unmetered fixture rates. Water for commercial use is abstracted from specific springs located in the interior of the island where water is considered to be of the highest quality. There are water supply problems on the drier west coast of the island where the capital Roseau is located and where around one quarter of the population live. Incremental development on hillsides has resulted in the need to create intakes to cater for these customers as most water distributed is gravity flow dependent. There are around 500 standpipes in Dominica. While they are meant to buffer the effects of poverty in poor communities, they have been abused in a number of ways, such as being used for washing vehicles or to fill private water tanks. This is a substantial cost to government.

Turbidity problems present one of the main challenges to the supply of potable water, not only for domestic consumption but also for commercial use. This is due to the island's high vulnerability to landslides owing to its mountainous topography, its geology (the island has a history of earthquakes) and soil. The threat of landslides is greatest in the wet season, which is also the hurricane season, which runs from June to October. Intense weather events during this period are combined with the high flow rates in

the island's many rivers and streams to further compound the problem of vulnerable hillsides and lead to land degradation. Other factors include:

- Poor land use practices such as farmers' use of pesticides and fertilisers in water catchment areas.
- Deforestation by farmers and rural communities on steep slopes without interventions leads to soil erosion and siltation of water courses.
- A transition from larger-scale agriculture to small farms.
- Mining and quarrying operations.
- Illegal housing developments, particularly in upland hillside locations. These housing developments also do not possess proper solid and liquid waste disposal systems, which results in biological contamination of water courses and downstream areas of the water catchment.
- Indiscriminate solid waste disposal and industrial practices (rum distilleries, auto repair garages and furniture manufacturers) in rural communities is also a major pollutant.

Natural disasters such as hurricanes and tropical storms present a challenge for water distribution systems on the island, such as occurred after Hurricane Dean in 2007 which caused damages to some of the water intakes on the island. Similarly, a storm surge generated from Hurricane Lenny in 1999 caused extensive damage that cost the DOWASCO US $125,852 in line repair, maintenance and relocation works. In the Commonwealth of Dominica Initial National Communication to the UNFCCC, it was estimated that "statistically Dominica averages a direct strike or close range hit (within 60 miles) by a cyclonic storm system every 3.82 years"[v]. In addition to experiencing a high frequency of hurricanes and tropical storms, the island also has a history of experiencing multiple events in one year such as Hurricanes Dean and Felix in 2007.

Dominica presently depends virtually exclusively on rain-fed surface water for its freshwater supply thereby making it vulnerable to variations in rainfall; and the island does experience dry spells and periods of drought. Stream flow can be as low as 30% of the average rainy season flows. One of the worst droughts that Dominica experienced occurred in 2001. As with the rest of the Caribbean region, one of Dominica's most recent drought events occurred between October 2009 and January 2010. Dry spells and drought periods can have implications for the entire country; for example, droughts affected the economic performance of the country in the 1990's. In the agriculture sector, which is primarily rain-fed, declining flows have become a concern with declines of between 12 and 26% in production due to drought. Increased risk of forest and brush fires during drought, which intensifies land degradation, may also affect water catchments. Increased temperatures in rainforests can reduce the water flow generated by their associated catchments. On the other hand, Dominica also has the capacity to export water to neighbouring countries in periods of extreme drought.

According to the Commonwealth of Dominica Initial National Communication under the UNFCCC, only 1%, or 21,156 ha of farmland is irrigated, primarily for vegetable produce. The report expects that, as rainfall patterns are reduced under a changing climate, the need for irrigation will increase and the demand for water from the agricultural sector will also increase. It is also important to note that DOWASCO is not obligated to provide water for the agriculture sector. There have been a few small scale irrigation projects particularly in banana production, however no formal assessments have been found for the status of irrigation schemes in Dominica.

Flooding and landslides are a recurrent annual problem in Dominica as the majority of development is located along the coast. Sediment loads become higher in streams during the wet season which increases the turbidity of water and the areas of watersheds become more prone to flash floods as material mobilised from landslides and soil erosion decreases the hydraulic capacities of river channels. During and

after hurricanes, Dominica's water resources can be significantly affected. Hurricane Dean in 2007 caused flooding in Dominica particularly in Roseau, where there was a 1 in 4 year, 24 hour rainfall event.

The Central Water Authority Regulations No 1 of 1973 states it seeks "to see to the orderly and coordinated development and use of Dominica's water resources, to conserve and protect such resources for the benefit of present and future generations of Dominicans and to provide the Dominican public with a safe, adequate and reliable supply of water and with dependable sewerage services"[vi]. The policy is considered weak in the context of land management provisions. Other relevant legislation are summarised in Table 5.

Table 5: Major Policies for Protection of Water Sources

Policy	Year
The Forests, Soil and Water Conservation Ordinance	1947
Crown Lands (Forest Produce) Rules	1949
Forestry Act	1958
Pesticide Control Act	1974
National Parks and Protected Areas Act	1975
Stewart Hall Catchment Rules	1975
Forestry and Wildlife Act	1976
Forest Rules	1977
Mines and Minerals Act	1996
Water and Sewerage Act	1997

(Source: Drigo, 2001)

Dominica does not currently have a National Water Policy and neither does it have an entity specifically responsible for Watershed Management. Further, there is no land use policy. However under the Integrated Watershed and Coastal Areas Management in Caribbean Small Island Developing States Project, the preparation of the National Integrated Water Resources Management Policy is underway. This policy is expected to present the basis for an Integrated Water Resources Management Plan. Some of the areas that are to be addressed in the development of both the policy and plan include merging the various legislative instruments that currently exist so as to create a comprehensive water resource management instrument, harmonisation of overlapping strategies that have some role in water management, development and training of human resources within the sector and revitalisation of enforcement channels and legislation.

Hydrological monitoring is carried out in Dominica, where DOWASCO measures the stream flow in a number of its major rivers which include the Picard, Douce and Springfield Rivers and the Snug Corner. A number of other gauging stations exist in the country, however, there are insufficient data for effective planning and management of freshwater resources. The current water distribution infrastructure is 30 years old and requires upgrading in several areas.

The main problems Dominica faces with water are:

- water distribution and development on the drier west coast;
- turbidity caused by sedimentation, exacerbated by deforestation and landslides;
- pollution through land use practices, waste disposal and industry;
- reduced and or insufficient water supply during periods of drought; and
- insufficient sanitation facilities.

The following recommendations would enable this sector to increase its resilience to climate change as well as address other social and environmental issues to the benefit of the people of Dominica:

1. Water infrastructure should be developed to increase access to sanitation facilities and safe water and to reduce vulnerability during drought events and after major storms and hurricanes.
2. Implement a national rain water harvesting plan and assess the possibility of broad scale implementation of localised waste water recycling schemes and legislation, including for agricultural irrigation.
3. Restrict incremental housing developments on hills lopes, particularly around Roseau and develop water intakes for existing developments to alleviate water supply problems.
4. Within the National Integrated Water Resources Management Policy being developed, agricultural and domestic water needs should be integrated and management practices which impact on water resources should be controlled. Watersheds, riverbanks and wetlands should be protected, restored and rehabilitated.

COMPREHENSIVE NATURAL DISASTER MANAGEMENT

Dominica faces an array of natural hazards that have a great potential to cause significant loss of life and seriously affect livelihoods and climate change threatens to increase the probability of some of these hazards. The vulnerability of communities in Dominica is, however, manageable if actions are taken to prepare and mitigate the impacts.

Figure 9: Landslide in the Layou River Valley, 1997
Source: http://www.oas.org

Examination of recent disasters has exposed some of those vulnerabilities and so by revisiting the responses and outcomes of these disasters, much can be learnt about the resilience of Dominica and its communities. For example, Hurricane Lenny, travelling west to east, reminded people that hurricanes can take surprising paths and highlighted the vulnerability of coastal infrastructure in Roseau to storm surges. With rising sea levels, storm surge heights will also increase and the impacts will include greater erosion and damages to coastal infrastructure. The Layou Landslides caused significant damage in 2011 and less but still notable damages in 1997. Damages to agricultural land, transportation routes (including a major bridge) caused economic losses, though there was no loss of life in either case. The size of the landslides that dammed a major Layou River is evidence that large amounts of material can be displaced from heavy rainfall in Dominica. Additionally, the need to monitor river water heights and prevent development along rivers became apparent following these flooding events. The topography of Dominica is conducive to landslides in many areas and settlements near steep slopes are at great risk of damage and destruction across the island, not just in this area.

Other hazards are also present in Dominica and could create disaster situations. The threat of volcanic eruptions is real since Dominica has 9 active volcanoes. Eruption is very unpredictable, however. The case studies herein demonstrate the great need for a natural hazard impacts assessment as part of the normal land use planning process, as well as providing evidence of the vulnerability of public utilities and infrastructure around the entire island.

The Office of Disaster Management (ODM) and the National Emergency Planning Organisation (NEPO) are charged with the responsibility of dealing with impacts from natural hazards and controlling vulnerability in urban and rural areas of Dominica. The ODM works closely with the NEPO whose responsibility is for planning and organisation of counter-disaster measures at the central level. NEPO is operating under the Ministry of Communication, Works and Housing (MCWH) with the Permanent Secretary of the MCWH acting also as the Director of disaster management because there is no Director under ODM. The ODM has 3 competent technical specialists but the office could benefit from specialists in GIS and hazard mapping as well as personnel for public engagement and education. As the ODM shifts away from a response paradigm and aims to focus on mitigation and preparedness, these shortcomings are to be addressed.

To guide the disaster management actions, there are two policy documents: the National Disaster Plan and the Emergency Powers Act. The National Disaster Plan was recently amended and is awaiting review from the Caribbean Disaster Emergency Management Agency (CDEMA) before it is officially adopted. Though these documents outline the roles and responsibilities of various agencies including NEPO and the ODM, the absence of a Disaster Management Act to enforce these actions is a significant shortfall. The creation of a Disaster Management Act would provide ODM with the proper legislation to ensure vulnerability is managed and risks are prevented, as much as possible.

In addition, it is a common practice to include some kind of environmental impact assessment (EIA) or natural hazard impact assessment in the land use planning process. In Dominica, the EIA process is regulated under the Physical Planning Act (PPA) by the Physical Planning and Development Authority. There is a consultation process through which ODM can provide hazard information; however this is not an official requirement, although it should be. Further to the EIA process, the use of a building code for all structures is a valuable tool through which to control some vulnerability. The regional building code is still being processed and individual countries are to create their own Caribbean Application Document (CAD) to ensure the employment of the Caribbean Uniform Building Code (CUBiC) is catered to local conditions.

Communication is also an important part of disaster management and the demographics in Dominica pose a unique challenge. Public education and good communication are imperative to successful reduction of risks in a population with a large percentage of elderly persons. Encouraging cooperation and fostering support networks will be very important to successful evacuation during emergencies. The already strong network of community disaster committees and government communication systems has proven effective for many emergencies thus far. Other technologies for early warning also exist in Dominica. The recent installation of a tidal gauge is a notable addition to the early warning systems (EWS) put in place under the Caribbean Disaster Mitigation Project (CDMP) implemented by CDEMA. These EWS cover seismic and hydro-meteorological hazards and are linked to regional organisations. A formal evacuation plan exists for the southern parts of the island and one for the northern region is being devised. Promotion and education on these warning systems and evacuation protocols must now be promoted regularly to ensure persons in the public and private sectors, as well as community members, are aware of how to respond in the case of emergency.

Overall, the Dominican disaster management system has a satisfactory capacity to adapt to climate change and good capacity to respond to disaster. There are areas where changes could improve the achievement of vulnerability reduction goals, however. As a result, following the assessment of Dominica's disaster management system and investigation of the vulnerabilities of Dominican's, several recommendations are made that will enhance the resilience and improve disaster management in this highly vulnerable island. Those recommendations are as follows:

1. Formulate an interactive and innovative community education and capacity building initiative designed to reach all levels of Dominican society thus enabling individuals to manage their own risk levels and also building resilience to natural hazard events.
2. Complete multi-hazard early warning systems across the entire island and conduct participatory community workshops to identify appropriate evacuation routes and procedures.
3. Work with relevant tourism stakeholders to develop and implement sustainable tourism efforts, including a Sustainable Tourism Policy and Plan.
4. Conduct capacity building and technical training programs for ODM employees so that the current technical deficiencies can be remedied and skills gained.
5. Update building regulations and hire building inspectors, in permanent positions, with the responsibility of reviewing all construction on the island.
6. Improve data collection, especially for bathymetry, meteorology data, also ameliorate monitoring of beach erosion and install more tidal gauges to monitor SLR.

HUMAN HEALTH

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

The health sector is addressed briefly in the Commonwealth of Dominica Initial National Communication under the United Nations Framework Convention on Climate Change (UNFCCCC) and human health is also identified as an area that is considered to be of priority in the preparation of the Second National Communication.

Mortality and morbidity rates due to injuries sustained during natural disasters such as hurricanes, tropical storms, landslides, mudslides and floods are important considerations when assessing the vulnerability of a country to climate change. Hurricanes and tropical storms can also affect health infrastructure due to SLR and storm surges, with coastal rural areas being particularly vulnerable. Displacement of persons and loss of shelter are also important in social terms and because of the associated health risks which include "contamination of water supplies, loss of food production and storage and increased risk of infectious diseases" as well as psychological effects.

Increasing temperatures results in heat stress and subsequent increase in morbidity and related to heat exhaustion and dehydration. The elderly (11% over 60) and young (36% under 20 years) of the population of Dominica in 2005[vii], are more vulnerable than other groups as well as persons with chronic illnesses**,** manual labourers and persons who gain their livelihood outdoors e.g. farmers and fishermen. In terms of tourism this will be an important consideration for elderly travel enthusiasts when choosing destinations. Exposure to higher temperatures can also contribute to increase in skin diseases.

Dominica's rainy tropical climate combined with a heavily forested area provides suitable conditions for mosquito proliferation which in turn presents the risk of mosquito borne diseases such as malaria and dengue. The possible re-emergence of malaria is considered to be a real threat to the region and by extension to specific countries such as Dominica, particularly because there has been an increase in migrants from countries where malaria is endemic[vii].

Poor air quality also can have implications for the local population; it can easily cause increase respiratory problems among the vulnerable. In a similar way, travellers who suffer from respiratory diseases and those with pulmonary and cardiac diseases would be at greater risk.

Emphasis on water quantity and quality, proper water treatment and sanitation is critical to public health in Dominica and may become even more important because of changes in climate and the associated vulnerabilities that will be exacerbated. Diseases linked to water supply, improper sewage disposal and poor sanitary conditions have been found to be prevalent in children. A number of food-borne illnesses are associated with water and poor sanitation and include typhoid, cholera, shigellosis, salmonella, gastroenteritis, hepatitis A and hepatitis E.

Flooding can also affect water supplies and contribute to the spread of diseases such as those mentioned above. Changing rainfall patterns and the increased incidence of dry spells may necessitate development of irrigation schemes to ensure maximum crop production and food availability. The IPCC Fourth Assessment Report states that under-nutrition, protein energy malnutrition and or micronutrient deficiencies are cause for concern in terms of climate changes and its possible impacts. The Annual Ciguatera Fish Poisoning (CFP) incidence in Dominica was 1.2 per 10,000 in 1981; however, there were no reported cases from 1998 – 2006. An increase in the incidence of Ciguatera may arise as seas become warmer due to climate change, subsequently harmful algal blooms increase (HAB's) and can result in the problem of toxin bio-accumulation in fish species**Error! Bookmark not defined.**[,viii].

Diseases such as dengue, typhoid and gastroenteritis, leptospirosis, malaria and schistosomiasis could become more prevalent during the rainy and hurricane seasons. Leptospirosis has been identified as a vector-borne disease of importance in the PAHO, Commonwealth of Dominica Health in the Americas report[vii]. In Dominica, there have been a number of deaths caused by the transmission of the disease by rodents with an increased incidence of the disease occurring after natural disasters[ix]. As for schistosomiasis, there have been no reports of autochthonous schistosomiasis on Dominica, but visitors and immigrants harbouring the worm have been documented. If there is an increase in irrigation channels (to support agricultural production) it is quite likely that these irrigation projects, undertaken in the last decade and planned in the future, may trigger an increase in the incidence of schistosomiasis among farmers, as suitable habitats for the snails that harbour the parasites increase.

Legislation that governs the health sector in Dominica includes the Hospital, Health Care Facility Act 2002 and the Draft Medical Act and Food and Safety Act. The National Climate Change Adaptation Policy 2002 seeks "to foster the development of processes, plans and strategies to avoid, minimise, adapt to or mitigate the negative impacts of climate change on human health" and has policy directives to achieve them. The government has recently launched its National Strategic Plan for Health (NSPH) 2010 - 2019 which aims to strengthen the health care system of the country and makes specific reference to climate change. Other documents that consider climate change and its potential to impact health in the country include the National Integration Water Resources Management Policy (Draft) 2010 and the 2007 National Policy for the Agriculture – Environment (Agri – Eco) System 2007 – 2025.

A number of different agencies have a role in the Health Sector of the Commonwealth of Dominica which include Ministry of Health (MoH) and its subdivisions, the Ministry of Land, Housing, Settlements and Water Resource Management, the Ministry of Social Services, Community and Gender Affairs and the Ministry of Environment, Natural Resources, Physical Planning and Fisheries. Government expenditure on health was 12% of the total recurrent budget expenditure for the period 2009/2010. There were a number of initiatives coming out of the Commonwealth of Dominica Economic Social Review for the Fiscal Year 2009/2010 regarding health care as it relates to climate change including improvements in the

management of communicable diseases, purchase and donation of equipment and technology, professional training and refurbishment of facilities, infrastructural developments as well as a number of poverty reduction initiatives.

Further research is needed to link the epidemiology of diseases in Dominica with climate data and the development of early disease warning systems, better water storage and sanitation infrastructure should be prioritised. On the issue of vector-borne diseases, based on the endemicity of dengue in Dominica it is recommended that the Integrated Vector Management (IVM) Programme developed by the World Health Organisation (WHO) be adopted.

Morbidity and mortality as a result of physical injuries during natural disasters can be reduced by strengthening existing disaster prevention measures. Another important area that cannot be over-emphasised is that both locals and tourists/visitors should be provided with continued health education and promotion campaigns which will be crucial in sustainable disease prevention and may save lives during and after natural disasters.

MARINE AND TERRESTRIAL BIODIVERSITY AND FISHERIES

The rich diversity of eco-systems and wildlife has earned the Commonwealth of Dominica the title "Nature Island of the Caribbean". Sixty-five percent of the island is covered by a range of natural vegetative types including the largest percentage of rainforest in the Lesser Antilles (See Figure 11). There are approximately 1,226 species of plants, 18 species of wild terrestrial mammals, 19 species of reptiles and the most diverse avifauna of the Lesser Antillean islands with 175 species of birds including 2 rare and endemic parrots[x].

Figure 10: The Sisserou, Dominica's National bird

The population is also heavily reliant on the island's natural resources for basic needs such as food, water and fuel. Forest vegetation protects and regulates the quality of Dominica's freshwater, controls micro-climate, provides windbreakers during extreme cyclonic events, absorbs flood waters during periods of heavy rainfall and provides many tourism opportunities. Plant seeds, pods and other plant products are commonly used in locally handcrafted jewellery and artistic carvings. Native Carib Indians use the larouman reed to weave baskets, hats and other products that represent a significant and unique part of their cultural heritage. Arts and crafts are an important part of the tourism product and provide a source of income for crafts-people. Wood products are extracted for fuel and construction of buildings and furniture. Dominica's forests are key to the country's tourism product with sites such as the Morne Diablotin and Morne Trois Piton National Parks and Syndicate Nature Trail providing opportunities for hiking, mountain climbing and even aerial tours through the forest canopy: adventurous, historical and highly educational experiences for tourists and locals. Wild animals such as the agouti, manicou (opossum) and wild pig are hunted for food.

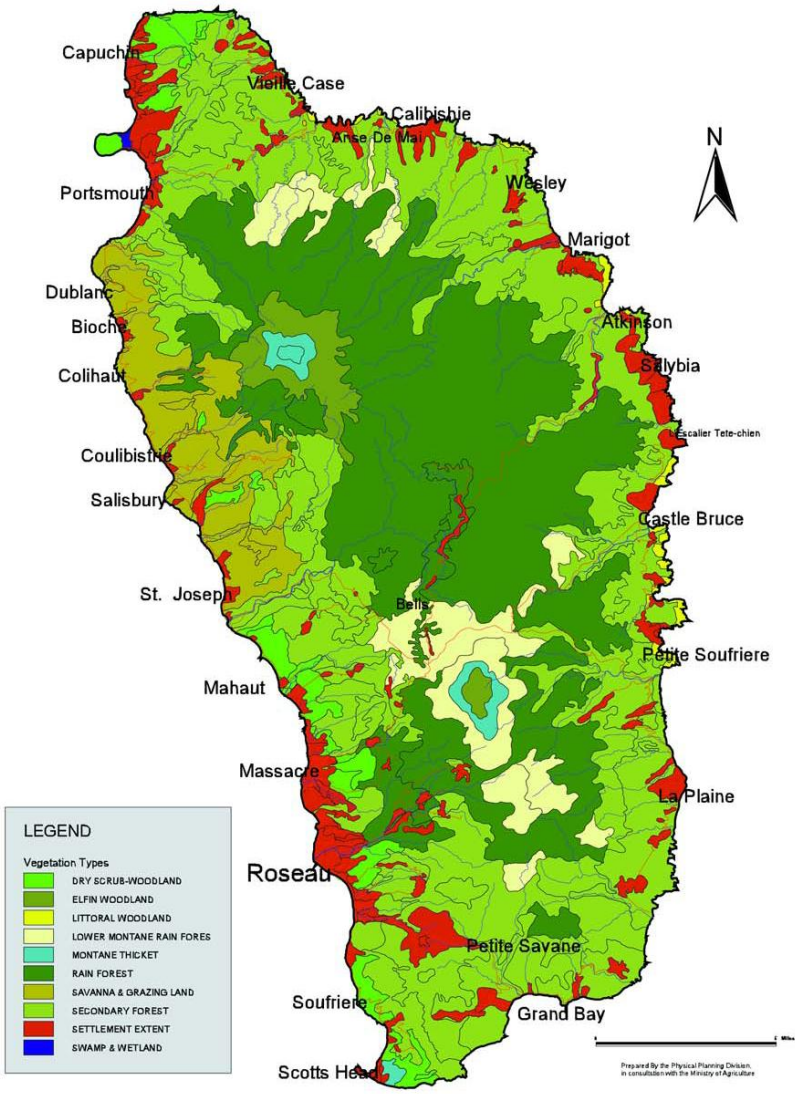

Figure 11: Generalised vegetation map of Dominica

(Source: MOAE, 2001)

Two rare and endemic species to the island are the Sisserou (*Amazona imperialis*) and Jaco (Red-Necked) (*A. arausiaca*) parrots both of which inhabit rainforests and have been the conservation flagships for Dominica's rainforests ecosystem. Hurricane David in 1979 did significant damage to the island's forests, and deforestation for agriculture also contributed to habitat loss. The birds were reduced to critically low numbers, so much so that conservationists feared the extinction of the Sisserou, the largest if the Amazona parrots. Public awareness campaigns, new protected areas legislation protecting the species and other conservation efforts have all helped to restore population numbers.

Although its natural environment is seemingly unspoilt, Dominica's biodiversity is under pressure from:

- improper land use, pollution and over extraction of resources;
- forest clearing for lumber, agricultural and other uses; and
- pollution of wetlands, rivers and coastal waters by agro-chemicals, industrial wastes and sedimentation from land erosion and quarry activities and over-fishing threatens reef health.

Furthermore, these eco-systems are at times severely impacted by natural disasters and can take years to recover, if they do completely recover at all.

Yet another concern is the threat that climate change is presenting to species and habitats.

- Increased atmospheric and sea surface temperatures, changes in precipitation patterns and SLR are already having negative effects on eco-systems around the region; for example the mass coral bleaching event of 2005, also affected reefs around Dominica.
- The rate of climate change is expected to accelerate in the coming decades and as these impacts increase, so too will the importance of preserving the services that Dominica's eco-systems provide.
- Changes in the average annual temperature and precipitation patterns may affect the growth of trees and other plant species and could result in a loss of rainforest zones and an associated increase in the tropical dry forest zones. The implications are a loss of habitat for endemic species and a loss of revenue for the eco-tourism sector, especially since forests have been repeatedly damaged by hurricanes.

Although Dominica is not known as a beach destination, the island's beaches serve recreational purposes for locals and tourists and are popular locations for hotel and other tourism related development. Fisher folk value beaches for launching boats and landing their catch, most of which is sold directly at the landing site. Dominica's beaches provide habitat for shorebirds and some have been identified as turtle nesting sites. Although most of the island's beaches are narrow they still serve to buffer and dissipate wave energy, reducing their impact on coastal structures. Climate change, in particular SLR and extreme events, is likely to increase rates of beach erosion. As sea levels rise gradually, a reduction in the width of the beach buffer zone will leave coastal infrastructure more vulnerable to erosive wave action and possibly result in the loss of critical fish landing sites and threaten the survival of species such as marine turtles, iguanas and shore birds.

Due to Dominica's narrow island shelf there are not many large expanses of coral reefs. However, there are approximately 41 dive sites in Dominica and dive tourism continues to grow in popularity. So much so that Dominica's marine environment has earned it a ranking of one the top dive destinations in the world. But these areas are also at risk according to The Reefs at Risk analysis which rates all of the coral reef around Dominica as threatened by human activities, namely land based sources of pollution, sedimentation, over-fishing and coastal development.

Dominica's marine habitats have supported a diverse fishery for centuries. The fisheries are primarily artisanal and supply local demand (including for the tourism sector) and are thus important to national food security. Game fishing, although offered by only a few boat charter operators, is another tourist attraction that is offered in Dominica and is reliant on a diversity of marine species. A healthy fishery is therefore vital to supporting any plans for sustainable tourism in Dominica and the country would do well to invest efforts in rebuilding nearshore reef fisheries.

The Government of the Commonwealth of Dominica is to be commended for the efforts made in policy and strategy development with regards to managing its environment. Despite not having an over-arching environmental policy, the Government, in collaboration with other agencies, has developed various policies that address environmental issues and has begun to implement strategies towards monitoring and building the resilience of its biodiversity to climate change impacts. It is essential that polices are put into action quickly as SLR, higher sea surface temperatures (SSTs) and increased storm intensity are projected to accelerate and will have long-term effects. The country's track record in creating and managing its National Park systems since the 1970's and its commitment to increasing protected areas and preserving endangered species such as the Sisserou parrot, all demonstrate the potential that Dominica has to manage

and protect its natural resources. The country's capacity to adapt to climate change however, is hampered by a weak economy, limited human and technical resources and inadequate capacity for law enforcement.

Adaptation strategies should strengthen current activities and build capacity through education and empowerment of all natural resource users. A holistic approach to adaption, which examines the linkages between all eco-systems, marine and terrestrial as well as the linkages between stakeholders and natural resources, is required in order to ensure that development is not in conflict with conservation. Conservation and restoration activities will be increasingly important for the long-term sustainability of this small island developing state and will require the participation of all key stakeholders, particularly the private sector. To this end the strategies recommended in this document, such as the revision of pricing structure for eco-based tours will help to recognise the true value of eco-systems and build more resilient eco-systems.

CONCLUSION

Tourism contributes only a small percentage of total GDP, but is a crucial foreign exchange earner. If considered in the broader perspective as is used by the World Tourism Organisation (UNWTO) in assessing the total contribution of travel and tourism to the national economy the reported contribution of tourism to the national economy is as high as over 20%. The success of this sector has been through the marketing of the island's nature-based tourism resources, but these resources are vulnerable to climate change.

Terrestrial and marine eco-systems and water resources are already facing serious pressures from increasing development and poor land use practices and climate change is exacerbating these impacts. It is evident that the Government of Dominica is committed to adapting to climate change. Many policies and plans for action are in place, but serious financial resource shortages along with limited technical capacities hinder the successful adaptation efforts across most government ministries and other stakeholder groups.

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

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

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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 Dominica 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 Dominica.

NOTES

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