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

CARIBSAVE Climate Change Risk Profile for the Dominican Republic

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 THE DOMINICAN REPUBLIC

The Dominican Republic 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.

Detailed climate modelling projections for the Dominican Republic predict:

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

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

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

1. assess the vulnerability of the livelihoods of community residents in **Bayahibe and Saona Island** to climate change; and
2. project sea level rise and storm surge impacts on the **Punta Cana** coastline.

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

Vulnerable Community Livelihoods

- There is a high dependence on tourism and natural resources for various livelihoods within the community.
- In times of extreme events like flooding, drought and storms, residents and workers suffer from income loss and/or property damage.
- Flooding is a particularly serious concern because there is no evacuation route.
- Relatively low household incomes, financial support linkages and security, as well as low levels of insurance coverage inhibit residents from recovering quickly after a disaster.
- Women bear more responsibilities in care-giving and earn relatively lower wages compared to men.

Vulnerable Coastlines

- Tourism is clearly highly dependent on the attractiveness of the natural coastal environment, which has been shown to be vulnerable to SLR.
- At Bavaro Beach, it is estimated that there will be a total land loss of approx. 243km^2, and total beach loss of approx. 230 km^2 as a direct result of SLR.
- 1 m SLR places 46% of the major tourism properties at risk; increasing to 86% under a 2 m SLR scenario.
- The current and projected vulnerabilities of the tourism sector to SLR, will result in economic losses for the Dominican Republic and its people if no action is taken to minimise infrastructure losses.

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

CLIMATE CHANGE PROJECTIONS FOR THE DOMINICAN REPUBLIC

Four primary variables were considered in determining the Dominican Republic's vulnerability to climate change. The projections of *temperature, precipitation, sea surface temperatures;* and *tropical storms and hurricanes* for the Dominican Republic 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.

Box 1: Climate Modelling Projections for the Dominican Republic

Temperature: Regional Climate Model (RCM) projections indicate increases between 3.1 and 3.4˚C in mean annual temperatures by the 2080s, in high emissions scenarios.

Precipitation: General Circulation Model (GCM) projections of rainfall span both overall increases and decreases, ranging from -42 to +7 mm per month by the 2080s across three scenarios. Most projections tend toward decreases. The RCM projections, driven by HadCM3 boundary conditions, indicate large decrease in annual rainfall (-30%) when compared to simulations based on ECHAM4, which indicate no change in annual rainfall.

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

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

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

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

The CARIBSAVE Partnership coordinated a field research team with members from the University of Waterloo (Canada) and the staff from the Ministerio del Medio Ambiente y Recursos Naturales – Departamento de Recursos Costeros y Marinos (Ministry of Environment and Natural Resources – Department of Coastal and Marine Resources) to complete detailed coastal profile surveying on Bavaro Beach in Punta Cana.

Figure 1: High Resolution Coastal Profile Surveying with GPS

Results of these surveys indicate that 1 m SLR places 46% of the major tourism properties at risk; increasing to 86% under a 2 m SLR scenario (See **Error! Reference source not found.**). With a 3 m SLR scenario, all (100%) of Bavaro Beach in Punta Cana will become inundated. Such impacts would transform

coastal tourism in this popular area in the Dominican Republic, with implications for property values, insurance costs, destination competitiveness, marketing and wider issues of local employment and the economic wellbeing of thousands of employees.

Table 1: Beach Area losses at Bavaro Beach, Punta Cana

SLR Scenario	Beach Area Lost to SLR m^2	Beach Area Lost (%)
0.5m	66973	29%
1.0m	38743	46%
2.0m	93529	86%
3.0m	31119	100%

The high resolution imagery provided by this technique is essential to assessing the vulnerability of infrastructure and settlements to future SLR in the Dominican Republic. The imagery also has the ability to identify individual properties, making it a very powerful risk communication tool. Having this information available for community level dialogue on potential adaptation strategies is highly valuable. A detailed map from the study location in the Dominican Republic is provided in Figure 2.

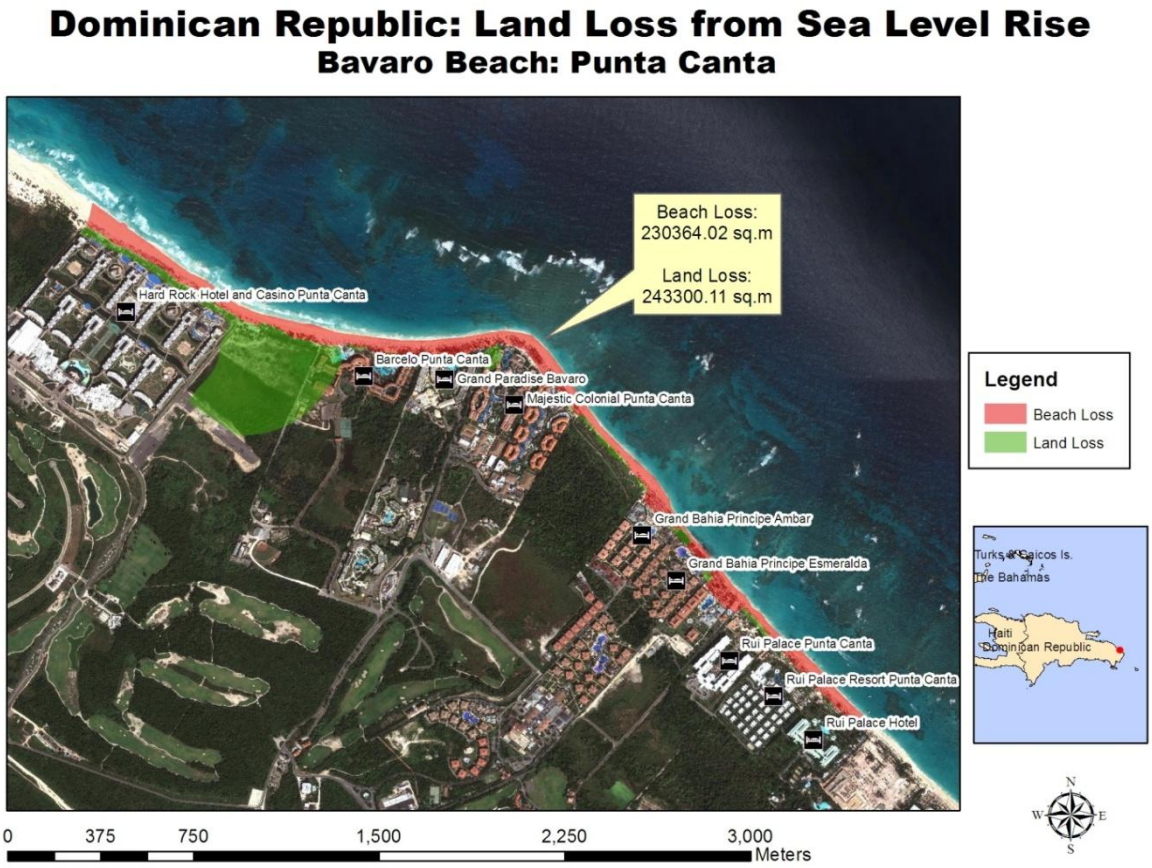

Figure 2: Bavaro Beach, Punta Cana, sea level rise impacts

The current and projected vulnerabilities of the tourism sector to SLR, including coastal inundation and increased beach erosion, will result in economic losses for the Dominican Republic and its people if no action is taken to minimise infrastructure losses. 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 eco-system 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.

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

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

COMMUNITY LIVELIHOODS, GENDER, POVERTY AND DEVELOPMENT

Figure 3: Isla Saona, where many Bayahibe residents work in tourism-related livelihoods

Source: Luis Simo, Ministry of Tourism

More than 50 residents and workers from Bayahibe and Saona[1] 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 provides 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. Even though observations may be specific to some parts within the study area, overall findings (assessments of vulnerability and adaptive capacity) are assumed to be representative for the entire community.

[1] In this document these areas are collectively referred to as "The community".

Community Characteristics and Experiences

Bayahibe is a small, coastal town located to the south-east of the Dominican Republic with a population of approximately 3,000 residents. Originally established as a fishing village, it is now a popular tourist destination and there are a few large resorts on the town's outskirts; it is a part of the overall La Romana tourism zone.

There is a high dependence on tourism and natural resources for various livelihoods within the community. Some of the more common tourism-based livelihoods include tour guiding, boat and dive operations, craft and jewelry making and vending and working in hotels, bars and restaurants as waitresses, ancillary staff, security officers, chefs, cooks and bartenders. Lower echelons of employment within the tourism industry have a far greater proportion of women than men, except within specific fields – e.g. security and bartending. Fishing is another important source of income and tourism-supported activity in the community.

Coastal and marine resources (i.e. beaches, coral reefs and other marine life) are particularly crucial for local tourism. Natural and earth materials such as seeds, shells and stones are necessary for craft-making and vending. Other resources in Bayahibe include freshwater springs and mangroves. Agriculture is not practiced in Bayahibe, but some homes have small kitchen gardens. Given the strong dependence on tourism and natural resources for various livelihoods within the community, short- and long-term climate impacts have several negative implications for the social and financial stability of residents in Bayahibe.

Figure 4: Jewellery made from local seeds

In times of extreme events like flooding, drought and storms, access to natural materials used for craft and other purposes is limited. In fact, drought conditions may result in a reduction in the resource itself. In these instances, those dependent on such resources become very vulnerable. To address this, there is a need to build capacity to strengthen the resilience of livelihoods to climate change. This should be done by using the proven approach of Action Research, whereby selected individuals gain practical knowledge through first-hand experience and personal exchanges from persons within and outside the community. It would also be important to promote relations between livelihood groups and local tourism organisations so the latter could present opportunities for diversification and development of the local tourism product. Additionally, tourism organisations and entities need to further encourage patronage of community businesses, so that the community benefits more from the presence of tourism in their backyard.

Some other *vulnerable groups* to extreme weather impacts in the community include disabled residents, children, sick and home-bound residents, pregnant women, fishers, merchants, boat operators and persons who work in cultural and tourism activities. Hurricanes, tropical storms and flooding result in loss of business and materials for numerous livelihood groups and consequently, a decline in cash flow owing to a reduced income and/or a temporary jump in expenditure for repairs or reconstruction. Some livelihoods are completely compromised and persons are left without a source of income. At the household level, Bayahibe residents have suffered loss of property and loss of life on previous occasions.

Most locations in the community are generally vulnerable to hurricane (wind and rain) impacts and some low-lying areas are flooded during heavy rains, especially in the Punta de Bayahibe area. Flooding is a particularly serious concern for some community residents because there is no evacuation route when

flooding occurs and residents are rendered immobile until floodwaters recede. The only school in the community is located in the flood zone and school is cancelled on almost every occurrence of a flood.

Notably, this school is also used as a shelter for residents during the passage of hurricanes. Residents are aware of the danger, but those who take the chance to seek shelter at the school likely perceive a lower level of risk on the school compound compared to their own homes. It is therefore imperative to establish a dedicated hurricane shelter in or close to Bayahibe (where flooding and storm surge impacts are less threatening) and improve the structural integrity of buildings that are used as provisional shelters to minimise possible damage and discomfort of occupants during a hurricane.

Improper disposal of waste is a concern in the community as this blocks drains and sewers that would normally channel surface water out to sea. Without effective drainage, floodwaters rise faster and take longer to subside, thereby exacerbating inundation of low-lying areas in the community. Basic actions such as regular cleaning of water courses and more prudence in solid waste disposal can help to mitigate some of the problems associated with flooding.

Despite common underscores of gender sensitivity in literature and findings based on experiences in other communities, neither men nor women in Bayahibe specifically indicated many differential impacts by severe weather, except in the case of pregnant women, or sick or disabled men/women who are at a relative disadvantage. Impacts are considered gender-neutral by community residents. Women by nature, however, would bear more responsibilities in care-giving. They also earn relatively lower wages compared to men owing to the local labour market segmentation and these factors would predispose them to a higher level of vulnerability.

Figure 5: Ms. Akilah Stewart (standing) of The CARIBSAVE Partnership guides a small group in the vulnerability mapping exercise

Knowledge of climate change within the community is fair and there is little disparity between the knowledge and perceptions of men and women in the community. The majority of the residents have heard or discussed issues on climate and the environment on previous occasions; but more in relation to general environmental education, solid waste management, disaster management, sustainable tourism initiatives and environmental work by the tourism sector. However, there have been few forums which specifically addressed climate change and only some residents and workers in the area attended on any

given occasion, depending on how many persons were aware of the event. Residents therefore consider their knowledge of climate change to be very basic, because they have only limited information on the more technical aspects of the issue.

The adaptive capacity of community households is challenged by relatively low household incomes, financial support linkages and security, as well as low levels of insurance coverage. This therefore inhibits residents from recovering quickly from a disaster. Learning from the experiences of past weather events, the community is more aware of the preventive measures required to mitigate future impacts. In the event of an emergency, residents in general engage in a number of mitigating activities, which include:

- Noting hurricane shelter locations and seeking shelter if necessary
- Protection of boats used in fisheries and marine recreation in mangrove areas
- Prepare household and store of necessary supplies
- Create response and rescue teams (volunteers/Red Cross) for post-event activities
- Follow all directions of local authorities

Any adaptation interventions for Bayahibe and Saona should also contribute to development objectives (including poverty reduction). In an effort to reduce vulnerability to climate impacts, changes have been made at the government level to avoid the construction of buildings adjacent to the beach. Other adaptive actions include reconstructing and retrofitting buildings and cleaning debris from beaches. For environmental conservation and protection in general, measures have also been taken to reforest areas, reduce water and energy consumption, to maintain and improve the state of natural resources where possible, to reduce pollution and to educate not only the local community, but the entire population.

Given the importance of tourism in Bayahibe, the feasibility of establishing emergency service departments here should be considered. Currently, there is a relative absence of emergency services in the Bayahibe community and while this is not uncommon in some communities, there is major tourism infrastructure in the area and some of the nearest emergency service departments are located at least 30-40 minutes away. In any event, effective response is already hampered by this distance and further compounded should there be a crisis where the community becomes inaccessible (e.g. road blockage) – a strong possibility during a hurricane.

Community level disaster mitigation activities can be implemented by the community in collaboration with national disaster management agencies. The establishment of a disaster group in both Bayahibe and Saona will help build community cohesion, while at the same time increasing the community's resilience to weather-related hazards. Such a group can foster relationships with national emergency management authorities to facilitate training, education and communication activities.

AGRICULTURE AND FOOD SECURITY

Distinct from other Caribbean nations, the Dominican Republic has an agricultural sector that is able to supply 80% of the food demanded for domestic use (by over 10 million Dominicans and approximately 1 million Haitians) and the over 3 million tourist who visit each year, according to FAO estimates. Further, the agriculture sector is estimated to contribute about 6% of GDP, 11% of foreign exchange earnings and generates more than 500,000 jobs. A significant sector in The Dominican Republic, agriculture is highly vulnerable to climate change impacts especially damage caused by storms, drought and floods with heavy implications for those working in the sector, and for national food security.

The recent flooding of Lake Enriquillo (in 2011) exposed the social vulnerability of agricultural communities in the Dominican Republic as large expanses of agricultural land and livestock located in Cordgrass, the Duvergé Township, Bartholomew and, Jimani were left under lake waters. An analysis of disaster risks and vulnerability in the Dominican Republic[i] shows that the provinces with the highest vulnerability for agricultural drought are: Jimaní, Pedernales, San Juan, Santiago Rodriguez Barahona, Santiago de los Caballeros, Mao, Azua, San José de Ocoa, Bani and San Cristobal (see **Error! Reference source not found.**).

Additionally, A UNDP-funded (2005) study on agricultural drought in the Dominican Republic confirms that drought is a cyclical natural phenomenon and it creates problems of water shortages for irrigation of crops, food shortages, livestock deaths and increased disease-causing vectors. The average period of drought is six months and after this period farmers commonly experienced storms and floods which further affects agricultural production in the regions studied.

Figure 6: Agricultural drought threat in Dominican Republic

(Source: Gómez de Travesedo & Saenz Ramírez, 2009)

The main factor contributing to land and soil degradation in the Dominican Republic is improper land use, through activities such as: the elimination of permanent vegetation cover of some soils located on slopes, intensive agriculture development, construction of highways and roads without proper protection and mining operations that move large amounts of land and destabilize large areas. A second is poor farm management practices including misuse of soil slopes, overgrazing, slash and burn agriculture, improper irrigation practices and poor soil tillage.

At the community level, some agricultural communities have begun to use technologies such as greenhouses, selective seeding, drip irrigation, proper fertilization and rational application of pesticides to help to deal with drought, disease, heavy rains and winds. However, many poor rural farmers, especially the ones in the mountainous areas of the country are severely limited in terms of adaptive capacity to climate change. In an effort to encourage small farmers to build their resilience, a “Sloping Agricultural

Land Technology" project featuring the poorest rural communities in the mountains of the Dominican Republic is suggested. The aim of such a project is to teach farmers in the mountainous areas how to use their resources effectively to produce more food by controlling soil erosion and restoring soil structure and fertility.

Figure 7: River transportation in rural areas of the Dominican Republic

At the farm level, low agricultural productivity is directly related to rural poverty and low use of technology. Lack of access to financial resources prevent many rural farmers from adopting the technologies they need to improve their production and their incomes. However, technology is available and is being used by some. Montero[ii] reports that fish farming was recently introduced in the Hondo Valley in addition to greenhouses covered with plastic raffia and anti-insect nets which have so far increased production of tomatoes, cucumbers, peppers, melon, cherries and cantaloupe.

In terms of technological adaptation at the national level, the following measures for the agricultural sector are identified in the First National Communication[iii]:

- an increased use of weather services by agricultural producers, such as early alert systems capable of forecasting droughts, agricultural fires, plagues and diseases and forecasting systems for crop yields and agricultural production
- development of educational programs for farmers on the use of sustainable methods in agriculture aimed at soil and humidity conservation and avoiding soil salinity
- development of new crop varieties, resistant to high temperatures, drought and more tolerant to lack of humidity in soil.

Given the significance of agriculture to the national economy and employment, the Department of Risk Management and Climate Change, under the Deputy Minister for Agricultural Sector Planning, has initiated a programme to reduce, mitigate and adapt to climate change impacts in the agricultural sector. As part of this programme the ministry aims to rationalise a land use plan for the agricultural sector and zoning of crops according to vulnerability of agricultural areas and organise responses to adverse events that affect agricultural production systems. Another prerogative of the department is to develop and implement plans with mitigation measures to reduce disaster risks and prepare agricultural communities to deal with climate change impacts at the farm level.

While efforts to adapt to climate change are evident in the agricultural sector, future success will be dependent on the involvement of youth and the implementation of low cost technologies. Effort to build

interest in agriculture among young people will facilitate the use new technologies because of the fact that youth are more adept with technologies.

ENERGY AND TOURISM

Tourism is an increasingly significant energy consumer and emitter of greenhouse gases (GHGs) both globally (5% of CO_2) and in the Caribbean, with aviation the most important sub-sector. The Dominican Republic is emitting less CO_2 than the global annual average of 4.3 t CO_2 per capita (2.11 t CO_2) and therefore theoretically has room to increase per capita emissions. However, growth in energy consumption would suggest that current emissions are likely to be substantially higher. Current tourism related energy use and associated emissions are estimated to be the equivalent of 21% of estimated national emissions of CO_2, though excluding emissions from cruise ships.

To meet energy demands in the Dominican Republic there are 54 generating stations and over 100 generators in the country with a 2009 installed capacity of approximately 3,000 MW, compared to 2,500 MW ten years prior (see Figure 8)[iv]. The 2009 capacity was distributed near-evenly amongst diesel, hydropower, steam, gas and combined turbines. However, in light of economic, environmental and energy security concerns, the Dominican Republic has recognised the importance of reducing dependence on imported energy sources, and incorporating more renewable energy sources. The country now boasts the largest wind park in the Caribbean with 19 wind turbines which, in its first stage, will generate 33 MW of energy and this park is to be expanded over time.

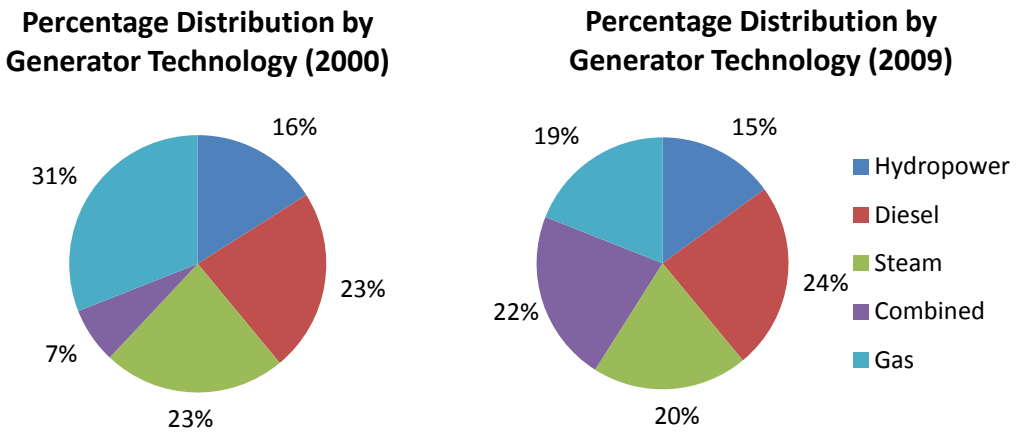

Figure 8: Change in the percentage distribution of installed capacity, 2000-2009

In examining the relationship between climate change, energy and tourism; major concerns arising include rising prices for fossil fuels and emerging climate policy which will make the tourism sector in Dominican Republic increasingly vulnerable. Additionally, climate change impacts also threaten energy infrastructure. High and rising energy costs should 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 National Energy Plan highlights specific proposals for managing energy production, distribution and consumption and ultimately pursuing a low-carbon economy through the development of energy efficiency and renewable energy initiatives. Specific objectives include reducing vulnerability of the sector, promoting energy efficiency, expanding coverage and developing national energy resources. The National Energy Plan

has been further developed into a draft National Climate-Compatible Development Plan. This draft plan includes a tourism strategy that recommends changing the way the tourism sector generates and consumes electricity, for instance, making the vehicle fleet of the sector less fossil fuel-intensive and embarking on modern waste management to achieve a 35% reduction in annual emissions compared to the business as usual (BAU) scenario.

For the tourism, and other important high-consumptive economic sectors (e.g. transport), in order to assess the savings potential, energy audits need to be undertaken first, to understand where energy is used and where emissions are greatest. It can then be determined here improvements can be made, followed with practical actions to curb emissions and wastage. Ultimately, there needs to be an ongoing commitment from all sectors and society in general if these efforts are to be successful. Empowerment of tourism operators and the people of The Dominican Republic through continued capacity building and public education campaigns is an essential part of reducing energy consumption and the emission of GHGs – the major contributor to the climate change phenomenon.

WATER QUALITY AND AVAILABILITY

The Dominican Republic has abundant water resources; approximately 108 watersheds are used for irrigation, drinking water and the generation of hydroelectricity. Due to the country's topography there is a high diversity of microclimates and as such rainfall varies widely across the country. Average annual precipitation is approximately 1,500 mm ranging from less than 500 mm in the northwest and southwest to over 2,500 mm in the northeast part of the country. About 67% of the fresh water supply in the Dominican Republic comes from surface water and 33% from ground water. Most of the ground water resources are in the southern part of the country, such as the Rio Ozama and the Rio Yaque del Sur Basins.

The annual water availability per capita was 2,711 m^3 per person per year in 1999 and has since decreased due to population growth; current per capita consumption of water is 2,186.6 m^3 per person per year. Despite the abundance of natural water resources in the Dominican Republic the supply of water to the population is considered as "low", with recent population growth leading to the country's water availability being categorised as "very low" (less than 2,000 m^3 per person per year)[v], in 2006. Only 65% of the population has easy access to water for domestic use, while 41% of the population has household connection and only 11% of the country's inhabitants have sanitation[vi]. Urban access to improved drinking water has shown a decline since 1990 while rural access has increased (see Table 2).

Table 2: Access to improved drinking water and sanitation in the Dominican Republic from 1990-2008

Year	Percentage (%) of population using improved drinking water sources			Percentage (%) of population using improved sanitation facilities		
	Urban	Rural	Total	Urban	Rural	Total
2008	87	84	86	87	74	83
2005	89	83	87	86	72	81
2000	92	80	87	85	69	79
1995	95	78	88	84	65	76
1990	98	76	88	83	61	73

(Source: WHO/UNICEF, 2010)

Human activities and development is degrading the quality of water resources the Dominican Republic. Surface waters are threatened by pollutants, mining of sand and gravel from rivers, damming and diversions of waterways, dredging of canals and deforestation. High levels of erosion resulting from deforestation cause sedimentation of rivers and this in turn has serious impacts on aquatic biodiversity and

obstructs water flow. Deforestation challenges result from activities in neighbouring Haiti as well; as seen during the flooding and debris flow disaster in the town of Jimaní in 2004. In an attempt to reduce the negative impacts from these activities, the Government of The Dominican Republic has developed policies for multiple uses of water resources including the construction of dams for power generation, irrigation, industrial and civil use but the country lacks a comprehensive water policy. Existing policies that guide the use of water resources are set by various agencies and are highly fragmented. The ministries are aware of the issues and some consensus has been reached about the importance of water management issues. Attempts to pass a new law for water resources based on Integrated Water Resource Management (IWRM) and the separation of roles, however, have not yet been successful[vii].

The main environmental problem affecting groundwater is the over extraction from aquifers, which has caused saltwater intrusion. Infiltration of domestic sewage and irrigation water into groundwater is another concern in the management of national water resources. There is a significant need for developing water supply management plans and accountability for water use or water consumption.

The Secretariat of Environment and Natural Resources (SEMARN) was formed in 2000 after the enactment of an environmental framework law. This law has started to establish basic principles regarding issues such as the penalty for polluting and effluent limits and also mandated that every new hotel should include a wastewater treatment plant[viii]. However, the environmental legislative body has not yet addressed any regulations on water consumption[ix]. Better data on groundwater flow, the impacts of SLR on aquifers and surface contamination would provide strong support for such a policy. As such, it is recommended that models of ground water be urgently developed to effectively mitigate the effects of climate change on freshwater resources. In addition, the development of measures to protect aquifers from contamination is also needed. For example, reforestation of hill slopes will reduce erosion. The principles of IWRM, including public participation and diversification of water sources, can enable the Dominican Republic to better manage their water resources and keep development processes and other economic activities from degrading this essential resource.

COMPREHENSIVE NATURAL DISASTER MANAGEMENT

Figure 9: Beach erosion in Punta Cana, Dominican Republic

The primary hazards affecting this Caribbean nation are tropical storms, hurricanes and flooding. The Dominican Republic is located in one of the most seismically active zones in the world; located at the boundary between the North American and Caribbean tectonic plates[x]. Furthermore, it's many rivers and streams have been known to cause flooding, especially in the Haina, Nizao, Ocoa, San Juan, Yaque del Sur, Yaque del Norte, Yuna, Soco and the riverbanks of the cities of Santo Domingo and Santiago watersheds.

The Dominican Republic has the third highest economic risk exposure to two or more hazards according to the 2008 Disaster Hotspot study. In the period between 1980 and 2008, the Dominican Republic has experienced 40 natural disasters, which affected more than 2.5 million people and caused economic damages in excess of US $2.5 billion[xi].

The recent passage of Hurricane Irene near the popular tourism destination of Punta Cana and the rising lake levels in Lago Enriquillo are evidence of the vulnerability of coastal communities. These risks are manageable to some extent and building public awareness will be key to successful vulnerability reduction across the Dominican Republic.

Another threat to the Dominican Republic comes from the seismic hazard of its location on the Enriquillo-Plantain Garden Fault. While the January 2010 earthquake in Haiti released some of the pressure at this fault, the risk of earthquakes in Hispaniola is still significant. In response to the seismic hazard, the Dominican Republic has a building code which considers shaking resistance, along with wind resistance considerations. This code was reviewed following the 1998 passage of Hurricane George and new structural requirements taking local conditions and building materials into consideration would now part of the legal Building Code. Nevertheless, "unplanned urban growth in areas unsuitable for development and weak enforcement of building codes and zoning regulations" [xi] are of particular concern. Enforcement of the code must be prioritised to continue to reduce vulnerability from the early stages of development.

Analysis of some recent disaster situations will demonstrate both the diversity of hazards and the differing levels of resilience to hazard impacts. A debris flow and flooding disaster that occurred in Jimaní in 2004 exposed a border community, including a significant informal settlement area – La 40, to flooding and debris flow impacts after over 500 mm of rain fell in the area. Heavy rainfall, combined with deforestation in the upper catchment (80% of which is in Haiti) were the primary causes of this extreme event, while the geomorphology of the area (poorly consolidated sediments and gravel consistent with alluvial deposition) and the limited early warning capacity in the communities exacerbated vulnerability[xii].

The May 2004 debris flow carried sediments and boulders into the town of Jimaní, damaging at least 870 homes and killing approximately 400 residents, many of which were from Jimaní's informal settlements. The response to the Jimaní disaster was challenging because of the cross-border nature of the hazards and impacts of this event. However, public participation in the decision making for reconstruction led to successful relocation of residents in homes that included a 'safe zone' where flooding would have minimal or no impact, and redevelopment of the community in an area that was safer. Whilst successful, generally, participatory planning and decision-making in relocation and reconstruction of this nature are not standard procedures, but should be used as a model to address similar scenarios in the future.

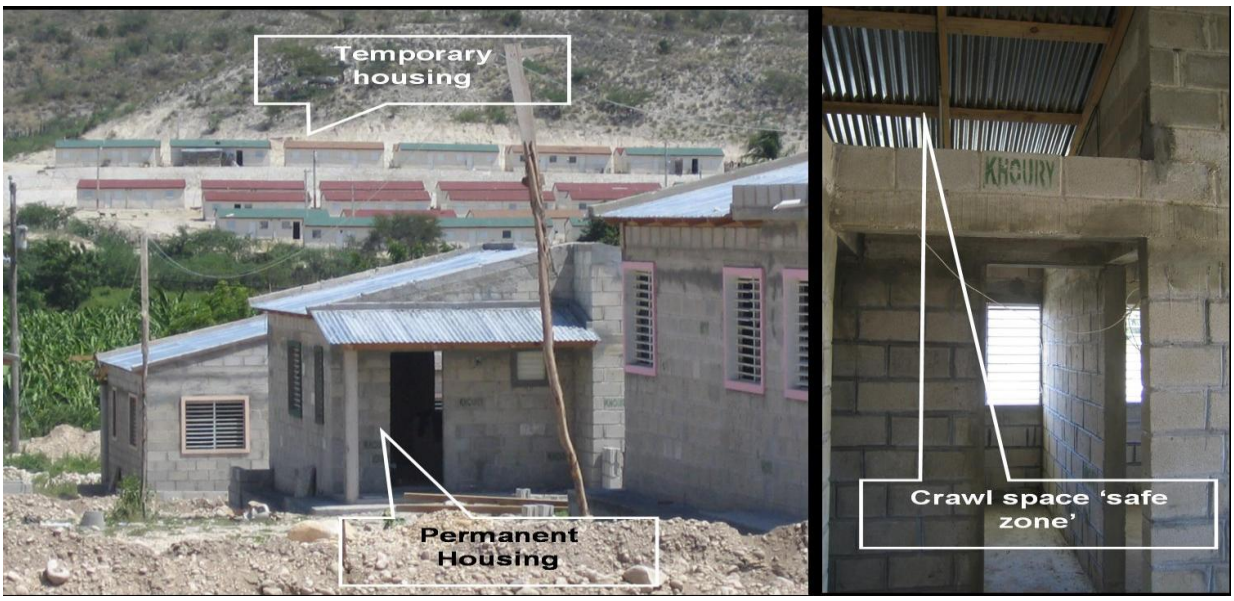

Figure 10: Successful reconstruction of damaged housing in Jimaní - including hazard design
(Source: Doberstein & Stager, in press)

Disaster management in the Dominican Republic is well organised and supported by national legislation and policies relating to all stages of the disaster management cycle: prevention, mitigation, response and recovery. There are multiple agencies involved, from both the public and private sectors, with clearly defined roles and responsibilities including:

- Office of Civil Defence (OCD)
- the National Council on Disaster Prevention, Mitigation and Response (NCDPMR)
- the National Commission for Emergencies (CNE),
    - which is made up of the Technical Committee for Disaster Prevention and Mitigation (TCDPM) and
    - the Emergency Operations Centre (EOC)
- municipal level committees for disaster prevention, mitigation and response

The NCDPMR has the responsibility of encouraging public participation and capacity building. The general public are aware of some of the hazards they face, particularly hurricanes, but more could be done to increase knowledge which would also reduce vulnerability. Additionally, though the disaster management system is fairly well organised, government institutions are lacking of some technical resources and require more financial resources in order to further improve disaster risk reduction and climate change adaptation in all levels of society and in all sectors of the country.

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, the Dominican Republic's 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.

In the Dominican Republic Initial Communication to the UNFCCC, the health sector was one of four sectors assessed in relation to climate scenarios. The main focus of discussion was on malaria. Dengue fever was not addressed in this document but was subsequently included (along with malaria) in the Second National Communication (SNC), suggesting an increase in incidences sufficient to warrant concern. This is consistent with the findings in Table 3. In 2002 which was an epidemic year, the rate of dengue fever occurrence was 37.6 per 1,000 inhabitants in the Dominican Republic – while countries such as Honduras with 490.8 and Trinidad and Tobago 490.4 persons, had the highest incidence of dengue fever in the Americas. The rate of occurrence subsequently doubled in 2003, with 73 per 1,000 inhabitants[xiii].

Table 3: Cases of dengue and dengue haemorrhagic fever between 2003- 2010 in the Dominican Republic

Year	2003	2004	2005	2006	2007	2008	2009	2010
No. dengue cases	6,268	2,473	2,977	6,243	9,639	4,656	8,273	12,119
Rate per 100,000 inhabitants	-	27.2	32.3	66.7	101.5	48.4	84.8	122.6
No. cases dengue haemorrhagic	-	136	92	234	227	199	976	1112
No of deaths	-	23	19	53	43	32	52	49

(Source: PAHO, 2007b; Ministerio de Salud Publica, 2011)

Areas with the highest cases of dengue fever include Santo Domingo, San Cristóbal, Distrito Nacional and Santiago. After natural disasters, dengue fever cases usually rise because conditions become suitable for the growth and spread of the vectors. No other diseases were specifically outlined in the SNC, partly due to the overwhelming burden dengue fever and malaria placed on the country.

Naturally occurring high precipitation events, particularly hurricanes, are an important factor in triggering increases in the transmission of both malaria and dengue fever and The Dominican Republic presents a unique situation with the presence of two dengue fever vectors, *A. aegypti* and *A. albopictus*[xiv]. At present, the World Health Organization has classified the progress of the Dominican Republic in reducing the number of cases of malaria between 2000 and 2009 as *having limited evidence of decrease*[xv]. **Error! Reference source not found.** shows the number of reported cases of malaria between 2000 and 2009, with the highest incidence of cases occurring in 2005 (75% of cases were from rural areas) with a subsequent consistent decline between 2006 and 2009. The cause of this reduction is uncertain. However, it is recommended that the Integrated Vector Management (IVM) Programme developed by WHO be adopted as a holistic approach towards curbing the proliferation of vector populations (during peak seasons especially) and the associated disease threats.

Table 4: Confirmed malaria cases and deaths in the Dominican Republic between 2000 and 2009

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
No. cases	1,233	1,038	1,296	1,529	2,355	3,837	3,525	2,711	1,840	1,643
No. deaths	6	17	11	12	16	16	10	17	11	14

(Source: WHO, 2010a)

Two important findings to note are that at least one study has found that malaria is the most common cause of fever among tourists upon returning from travel in infected areas[xvi] and this disease is the most reported cause of hospitalisations of tourists from malaria prone destinations (Wilder-Smith and Schwartz, 2005). While this is a treatable condition, it can result in grave illness or even death. Given these trends, especially as tourism is a key sector in The Dominican Republic, further research should be conducted to link the epidemiology of diseases in The Dominican Republic with climate data.

The implications of weather for health, sanitation and nutrition are numerous:

- In the Dominican Republic, droughts are either natural or are associated with poor water resource management in vulnerable catchment areas. Winds, dry spells and drought conditions can increase particulate matter in the air, compromising air quality. Currently the particulate matter pollution is becoming an increasing concern and this has resulted in acute respiratory infections becoming an important cause of morbidity trends.
- Increased precipitation may also result in contamination of large areas with raw sewage especially from pit latrines. In the Dominican Republic there are water quality concerns due to pollution from human and animal wastes as well as from fertilizers and other sources. Diseases associated with poor water quality and the contamination of water sources include acute diarrhoea, typhoid fever, hepatitis and paratyphoid fever. Cholera and schistosomiasis which is endemic to the Dominican Republic also present challenges.
- Changing weather patterns could have an impact on agricultural productivity if precipitation decreases because farmers depend largely on rainfall for irrigation, and food availability could have consequences for the health of the population, particularly the poorest sectors of the society.
- In addition, drought and heat stress could also impact the growth of crops in the field, e.g. heat stress of vegetables and other crops.

Mortality and morbidity rates due to injuries sustained during natural disasters such as hurricanes, tropical storms and floods are important considerations when assessing the vulnerability of a country to climate change. In the Dominican Republic, over 75% of the population lives in areas that are at risk to natural hazards, with floods having the greatest impact on the health sector. Physical and capital damage to health facilities may also arise due to natural disasters as has been experienced during hurricane events.

Displacement of persons and loss of shelter are also important because of the associated mental and physical health implications. Increasing temperatures can result in heat stress in a population and heat wave events have been found to be associated with short-term increases in mortality globally as well as morbidity related to heat exhaustion and dehydration. The elderly and young are more susceptible than other groups as well as persons with chronic illnesses, people doing manual labour and persons who engage in outdoor livelihoods e.g. construction workers and fishermen. Increased temperatures can also have a negative impact on persons prone to, or suffering from cardiovascular diseases.

In the National Development Strategy 2010-2030 of the Dominican Republic, climate change and health are mentioned in the line of action detailing the prevention, mitigation and reversing, in coordination with relevant local authorities; the effects of climate change on health in the country. The average of the public expenditure on health, expressed as a percentage of GDP, is 5.76% for 1995 to 2009, however, other sources give significantly lower estimates. For instance, UNDP (2010) estimates that between 2000 and 2007, the average was estimated to be 1.9% of total GDP.

The country's current high disparity in income generation has affected the health sector. It is expected that it will continue to affect the resources available to the poor and by extension deterioration of the social condition of the society. The National Development Strategy 2010-2030 has also devised specific objectives to reduce and alleviate poverty in the country. These includes the stimulation and consolidation of community networks, as well as improvements in the design, implementation, monitoring and evaluation of poverty reduction policies and the promotion of poverty reduction programmes and projects.

The Dominican Republic is on its way to meet the Millennium Development Goal of reducing the incidence of malaria by 2015 over 75% of the 1990 level. In 2004, there were 26 cases per 100,000 inhabitants. This

figure dropped to 16.8 in 2009 and a target rate of 6.6 cases may be achievable by 2015. However, coming out of a health report in 2006, it was noted that mortality and morbidity was under reported to as much as 45-55% and similarly morbidity records were deficient, underscoring a need for more thorough data collection and reporting systems to be established and employed in the health sector.

To protect against pests and other diseases as well as to ensure overall health, the USAID/RED programme has undertaken initiatives in Sanitary and Phytosanitary (SPS) management and compliance. The agency has also targeted pesticide use in the agricultural section with the goal of protecting eco-systems and human health and seeks to encourage the use of Integrated Pest Management.

An important area that can never be over-emphasised for the management of public health (including locals and tourists/visitors) in the face of climate change is that continued health education and promotion campaigns should be developed. This will be crucial in sustainable disease prevention and may save lives. Health sector reform and de-centralisation of the health sector in the last decade along with continued focus on refining management objectives will be crucial to championing forth in the current direction the Ministry of Health is taking. Increased research and validation of data for example with diseases of low but consistent prevalence such as dengue, malaria and leptospirosis should be given greater attention. Such research will pave the way for a sound platform from which to inform policy and planning for the future as the climate changes.

MARINE AND TERRESTRIAL BIODIVERSITY AND FISHERIES

Figure 11: The endemic Rhinoceros Iguana (Cyclura cornuta)

(Source: http://upload.wikimedia.org/wikipedia/commons/6/6b/RhinoIguanaMay07Pedernales.jpg)

The varied landscapes and topography of the Dominican Republic have endowed the country with one of the richest levels of biodiversity and endemism in the Caribbean. However, the removal of the moist forests cover over the years has caused environmental degradation and the unique biodiversity is increasingly threatened by unsustainable agricultural practices, large-scale mining, invasive species, wild fires, hunting, over-fishing and extensive urban and coastal developments. All of these stressors are reducing the natural resilience of eco-systems and their ability to adapt to the present and projected changes in climate. The resources that tourism depends on, such as coastal and marine resources, face several climatic and non-climatic stressors which threaten to depreciate these vital components of the local tourism product.

The Dominican Republic's coral reefs which provide several ecological services are threatened by coastal development and increased pressures from pollution, over-fishing, diving and boating activities and will be further affected by ocean acidification, SLR and increased SST. The World Resource Institute (WRI) Reefs at Risk in the Dominican Republic report estimated the potential increase in beach erosion that could result from further degradation of its coral reefs, climate change notwithstanding. The study concluded that 10 years after the disappearance of live corals, erosion rates could increase by more than 100% on eastern beaches and by more than 65 % on southern beaches.

The country is the premier whale-watching destination in the Caribbean with 33 companies taking about 28,000 passengers on tours in 2008, generating a total of US $8,927,000. The waters off the coasts are breeding grounds for large numbers of humpback whales that migrate to the north coast during the winter months to mate and calve. Samana Bay, Silver Bank and Navidad Bank are the three main areas in which these whales congregate; all three are included in the Marine Mammals Sanctuary[xvii].

Climate change impacts on the chemical and physical characteristics of marine waters will have negative consequences for whale watching tour operators of the Dominican Republic. Information on the biology of many cetaceans is limited and this makes it difficult to predict the effects that climate change may have on them. Nevertheless it is likely that changes in global temperature, sea levels, sea-ice extent, ocean acidification and salinity, rainfall patterns and extreme weather events will decrease the range of many marine mammals[xviii]. This could mean significant financial losses for tourism operators and their employees in Samana Bay, Silver Bank and Navidad Bank.

Climate change impacts will affect forests and marine resources, thus also having negative impacts on the livelihoods of those who depend on these resources. Forests have been historically important to the people of the Dominican Republic as a source of both wood and non-wood products, for the regulation of micro-climate, protection from flood waters and cyclonic winds. Forests are essential habitat for the country's rich biodiversity and numerous threatened and endemic species. Slash and burn agriculture, charcoal production, commercial exploitation of lumber and forest fires has resulted in significant levels of deforestation.

Figures 12 and 13: Lush forest cover in the Dominican Republic and a forested area destroyed by fire

Warmer waters could potentially alter breeding and migration patterns and may drive pelagic species away from the tropics. An expected increase in the intensity of tropical cyclones will mean increase losses to the fisheries sector. Those employed in the sector, generally the poor, can ill-afford such threats to their livelihoods. A strategy should be devised and implemented which will:

- establish a more effective protected area management and enforcement system for coastal communities;
- enhance the capacity of resource managers and users to be more resilient to climate change; and
- establish a sustainable finance mechanism for supporting protected areas and fish sanctuary management.

The strategy should increase the involvement of the tourism sector in supporting community-based MPAs, as well as provide opportunities for alternative livelihoods and technologies for public education. This project should also help to enhance the performance of the large number of protected areas in the Dominican Republic as it aims to build knowledge and awareness of the strong links between livelihoods, natural resource health and climate change.

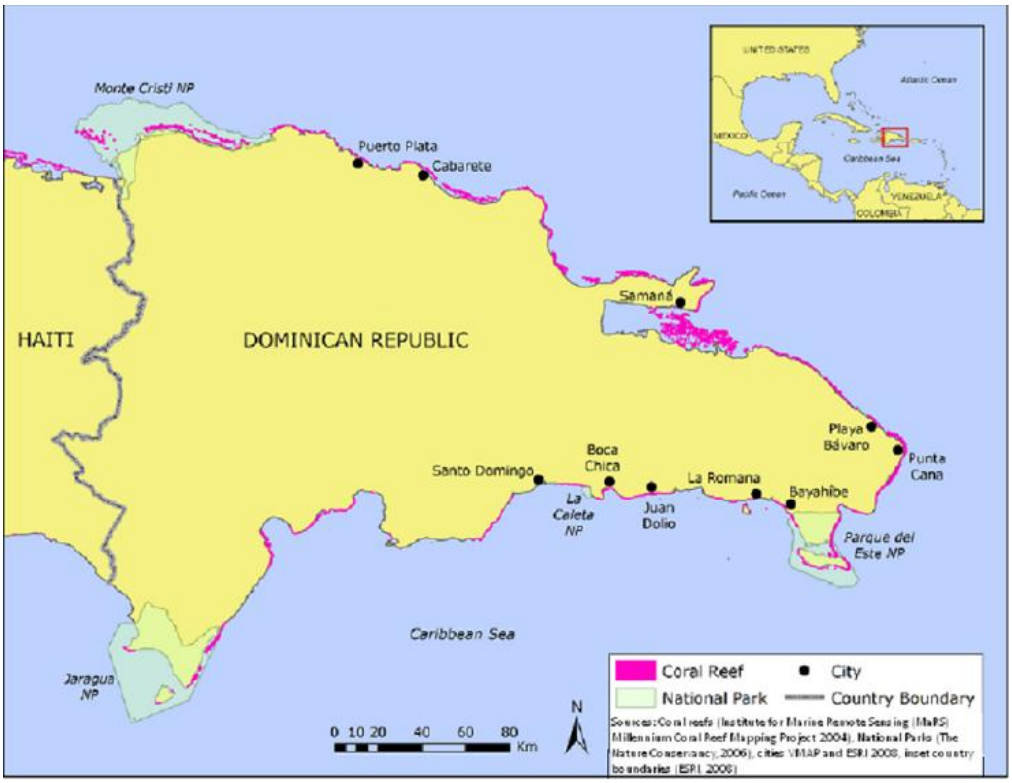

Figure 14: Protected areas and coral reefs in Dominican Republic
(Source: Wielgus, Cooper, Torres, & Burke, 2010)

Despite the heavy reliance of the tourism sector on natural resources, tourism development also presents some of the major threats to coastal and marine resources in particular. In an effort to reduce the impact of each tourist on the already fragile environment, short videos encouraging visitors to be more conscious of their impacts on the fragile eco-systems of the country can be shown during in-bound international flights. The films will focus on positive actions that visitors can take to minimize negative impacts on the environment by decreasing energy and water consumption and wastage, and by taking necessary precautions during marine based recreation (diving, snorkelling, boating).

In light of the challenges facing biodiversity and eco-systems, the Dominican Republic has demonstrated an ethos of conservation evidenced through the creation and continued strengthening of a legal and institutional framework that seeks to involve the relevant sectors such as health, water and tourism. Dominican environmental policies are based on the General Law on the Environment and Natural Resources (Law 64-00) and supported by the Constitution of the Republic which incorporates the environmental component into national policies. The legal framework and policy guidelines have been based on international agreements and the Dominican Republic has aimed to meet the objectives of the Convention on Biological Diversity (CBD). Its policies on the protection of biodiversity take into consideration the human component of eco-system interactions, promote the sustainable use of natural resources, and are integrated into poverty reduction policies and national development.

CONCLUSION

The Dominican Republic has a strong dependence on the tourism industry and the many natural assets that enable tourism to be successful. 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 the Dominican Republic 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. Through the National Council for Climate Change and the Clean Development Mechanism, the Government of the Dominican Republic has made good progress in collecting data and implementing projects relating to climate change adaptation and mitigation. The country is also ahead of many other Caribbean nations in terms of their national assessments of climate change impacts, having already completed two National Communications to the UNFCCC.

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

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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 the Dominican Republic 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 the Dominican Republic.

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