The Virgin Islands

Vulnerability and Capacity Assessment of the Tourism Sector to Climate Change

Prepared by the Conservation and Fisheries Department,
Ministry of Natural Resources and Labour

April 2011

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Acknowledgements

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Introduction

Purpose of the Vulnerability and Capacity Assessment (VCA)

The purpose of the VCA is to better understand and quantify climate change impacts to the tourism sector. This type of climate change research is important to understand vulnerability, risks, available and needed capacity, and attitudes towards adaptation in a local context.

Based on the work of hundreds of independent scientists around the world, the Intergovernmental Panel on Climate Change (IPCC), local governments and non-governmental groups, the world has a much clearer scientific understanding of what climate change is, how aspects of climate are changing, and how these changes will impact our lives. Work by the Caribbean Community Climate Change Centre (CCCCC), the University of the West Indies and the Cuban Institute of Meteorology has helped to downscale this climate change knowledge to a regional Caribbean level and now even to a country level.

It is generally understood that climate change will have serious economic consequences of a scale that small islands like The Virgin Islands are not able to absorb, it is also understood that early actions to adapt to climate change can significantly minimise impacts and associated costs. Tourism has been identified globally as one of the economic sectors most vulnerable to climate change and is the mainstay of The Virgin Islands economy. This study was conducted to better understand and quantify how climate change will impact the tourism sector and, therefore, a major part of the economy of The Virgin Islands.

Because climate change is not occurring evenly, even at a regional scale, and because each country has unique characteristics that will influence its vulnerability to climate change, country specific studies are important. The best adaptation strategies are those that are based on sound knowledge of what local climate change impacts are likely to be – the more precisely or quantitatively we understand the impacts, the better we can plan a response.

Components and limitations of the VCA

The VCA consists of four main components:

Knowledge Attitudes and Practices (KAP) Surveys

This component seeks to understand how much tourists, tourism sector managers and the general public know about climate change, how they feel about the issue, and their attitudes towards climate change adaptation, including what actions they are willing to take. Understanding knowledge, attitudes and practices is an important part of understanding overall vulnerability and adaptive capacity.

Hazard Vulnerability and Risk Assessment

This component seeks to understand physical climate change risks and vulnerability to risks based on the following studies:

a. Climate Assessment - discusses how key components of The Virgin Islands climate are projected to change based on the PRECIS (Providing REgional Climates for Impact Studies) regional climate model and how these changes may impact the tourism sector;
b. Static Risk Maps of Cane Garden Bay – discusses the present physical and organizational components of risk in Cane Garden Bay by mapping important natural resources and features, land use patterns, tourism properties, critical infrastructure and natural hazards that may be amplified by climate change, including earthquake, wind, storm surge, landslide and flood;
c. Beach Vulnerability Assessment – discusses the area of important tourist beaches on Tortola that would be lost as a result of various sea level rise scenarios;
d. Sea Level Rise Vulnerability Assessment – discusses the land area, critical infrastructure and tourism properties (accommodations and marinas) that would be impacted by sea level rise on Tortola and Beef Island, Virgin Gorda, Anegada and Jost Van Dyke;
e. Coral Reef Vulnerability Assessment – discusses the potential economic impact of future mass coral bleaching events to the scuba diving and snorkeling tourism sector based on impacts from the 2005 mass bleaching event;
f. Risk Assessment – priorities climate change risks based on stakeholder consultation;

Capacity Assessment

This component seeks to understand the ability of the Territory to cope with and respond to climate change impacts by discussing the institutional, management and legal framework in which adaptation will have to take place.

Risk Reduction Options

This component provides a range of strategies for responding to all of the current and potential climate change impacts identified to tourism and supporting sectors.

Together these components provide a clear idea of the climate hazards predicted to face the tourism sector, how key elements of the tourism product will be impacted by climate change, how the tourism sector (operators and tourists) perceive and will respond to these hazards, the capacity of the sector to respond and specific options available for responding.

The VCA should be taken as a first attempt to better understand climate change impacts to the tourism sector. Further studies are needed to better quantify impacts and determine costs associated with the impacts identified.

CLIMATE CHANGE – WHAT IS IT?

In basic terms, climate change is exactly what it sounds like - a change in the Earth's climate, the long term average weather conditions for various regions.

Climate change is an issue of much global debate, and has been described by many as "the defining challenge of our time". To provide the world with a clear scientific view on the current state of climate change and its potential environmental and socio-economic consequences, the Intergovernmental Panel on Climate Change (IPCC) was established by the United Nations. The IPCC defines climate change as

> "a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity" (Pachauri, R.K., Reisinger, A. & Core Writing Team, 2007).

Over its extensive history, the Earth's climate has gone through many transformations. However, for the first time since modern civilization (which developed in a fairly stable climate) the Earth's climate is changing in a profound way – the average global temperature is warming at an unprecedented rate triggering changes in other fundamental aspects of our climate.

Over the 100 year period (1906-2005), average global temperatures increased by 0.74°C (1.33°F). As show in Figure 0-1, by the end of this century, the year 2100, average global temperatures are expected to rise another 1.5°C – 5.8°C (2.7°F - 10.4°F) (Pachauri, R.K., Reisinger, A. & Core Writing Team, 2007; Taylor et al., 2007).

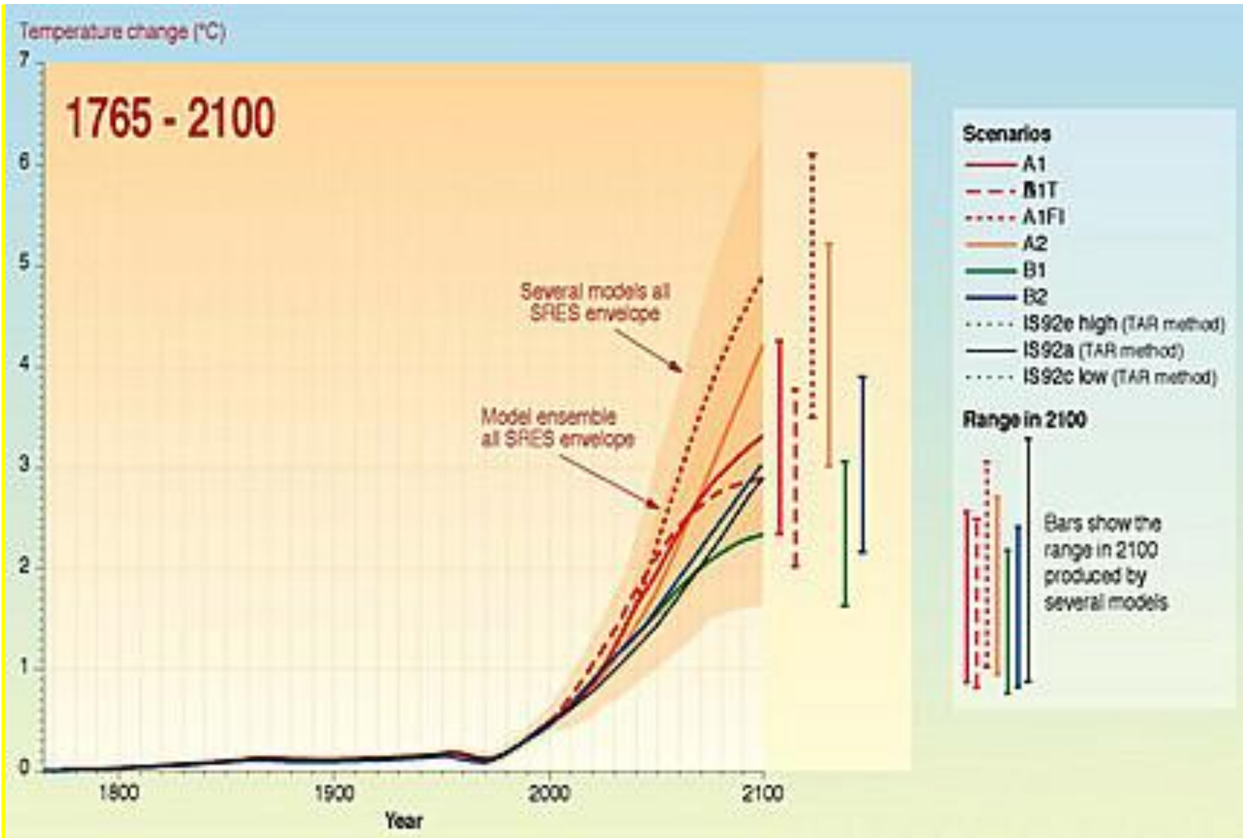


Figure 0-1. Past and predicted changes in average global temperatures under different greenhouse gas emission scenarios. *(Source: IPCC Third Assessment Report).*

While these figures may appear to be small, they are actually quite significant in the context of the global climate system where just a few degrees make a big difference in experiences on the ground. This warming characterises the current period of global climate change, thus the phenomenon is commonly referred to as global warming (CANARI, 2008 a).

The other novelty about present day *global climate change* is that humans are primarily responsible for the problem (UNFCCC, 2010).

Since the dawn of the Industrial Revolution (18th Century or 1700s), human activities related to fossil fuel derived energy use in homes, industry and transportation, as well as agriculture and deforestation have been causing a rapid and excess buildup of carbon dioxide and other "greenhouse gases" such as methane in our atmosphere. These gases act as a huge invisible blanket that is trapping more and more of the sun's heat within the Earth's atmosphere, thus causing our average air and ocean temperatures to rise. This is called the enhanced greenhouse effect (UNFCCC, 2010) and is depicted in Figure 0-2.

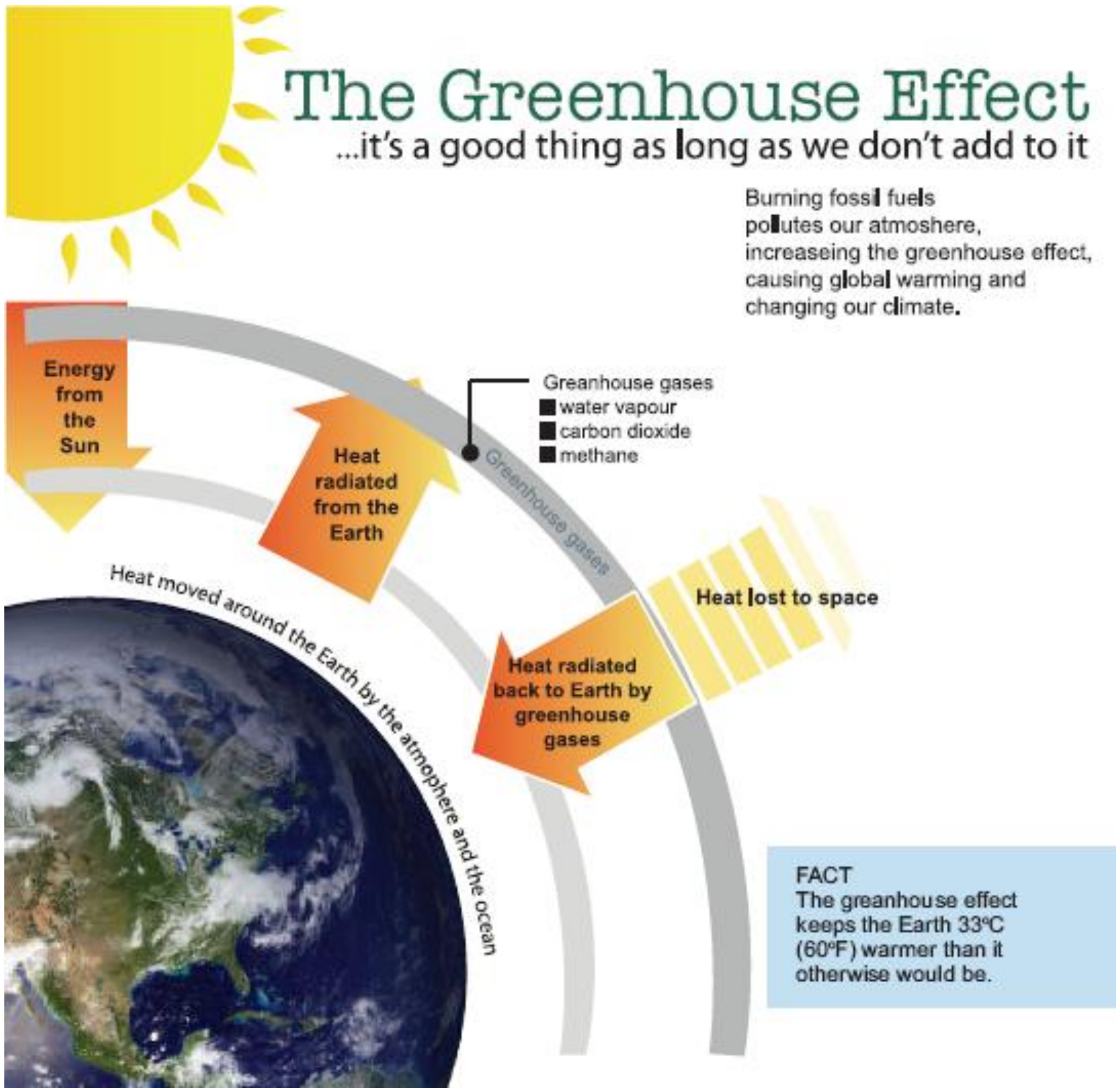


Figure 0-2. The Greenhouse Effect. Excess greenhouse gases (heat trapping gases such as carbon dioxide) in the atmosphere are causing the average temperature of the Earth to rise.

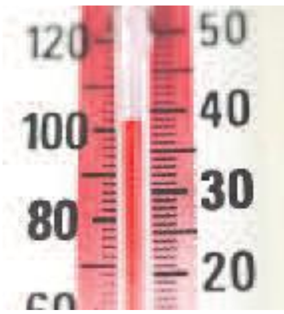
The science on climate change is clear. In their 2007 Synthesis Report, the IPCC states, "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level" (Pachauri, R.K., Reisinger, A. & Core Writing Team, 2007).

Contrary to a popular misconception, the ozone hole is not responsible for climate change. There is a limited connection, however, in that in an attempt to fix the ozone hole, the approved replacement chemicals for chlorofluorocarbons (CFCs) (the cause of the ozone hole) produce greenhouse gases that contribute a small percentage to climate change.

Since temperature is a basic control of the Earth's climate, climate change is not just limited to increasing temperatures, but changes in other fundamental aspects of climate (UNFCCC, 2010).

Projected Changes in Climate

In the Caribbean region the projected changes of most concern include:



Rising temperatures

1°C - 5°C (1.8°F – 9°F) warmer by the 2080s under the Medium-High Carbon Emissions Scenario (Taylor et al., 2007);

Changing rainfall patterns

Up to 25% drier by the 2080s under the Medium-High Carbon Emissions scenario, accompanied by a *change in rainfall patterns such that more, heavier rain events and thus floods are likely* (Taylor et al., 2007);

Stronger, more persistent and devastating hurricanes A greater likelihood of category 4 and 5 hurricanes as is already being observed (Mimura et.al, 2007).

Rising sea level 0.18 – 0.59 metres (0.6 – 1.9 feet) higher sea level by 2100 (according to the IPCC 2007 report; Mimura et. al, 2007). More recent studies suggest a 1m to 2m rise by 2100 is possible (Simpson et al., 2010).

Climate Change and Tourism

Because The Virgin Islands tourism sector is so dependent on a relatively stable climate it is highly vulnerable to changes in climate – that is, the present phenomenon known as *global climate change*.

The Virgin Islands, like all small island developing states, is among the countries that will be the first and worst affected by climate change, as identified by the United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC). The vulnerability of the tourism sector to climate change impacts contributes significantly to this fact.

Whether we are consciously aware of it, the tourism sector revolves around and is closely linked to climate – temperature, rainfall patterns, humidity, the trade winds, and severe events including drought, floods and hurricanes.

A fundamental element of the product is our relatively stable subtropical climate, constantly moderated by the Northeast Trade Winds. Our tourism attractions, primarily nature-based, are directly impacted by even slight changes in weather and cycles of extreme events – coral reefs can bleach with just a 1-2 °C (1.8-3.6 °F) rise in ocean temperature above the normal maximum and beaches are highly prone to erosion due to hurricane events and long-term sea level rise. Tourism infrastructure and properties are concentrated in the low-lying coastal zone and have traditionally not taken into account appropriate building standards, drainage, elevation, and set-back considerations to deal with regular floods, strong hurricanes and storm surges and sea level rise, making them very vulnerable to climate change impacts.

The Virgin Islands is aware of this inherent sensitivity when we experience short term abrupt changes such as droughts and floods, hurricanes, and unusually hot days and nights. While changes over the long-term occur more slowly, they are more permanent, and unless we take adequate measures to prepare, we remain equally or perhaps more vulnerable to long-term changes in climate such as sea level rise possibly up to 1m or 2m by the end of the Century. Importantly, predictions about long-term changes in climate include a tendency towards more frequent and or higher impact extreme climatic events, particularly floods and hurricanes.

The following direct climate change impacts have been identified for the tourism sector through public consultation:

- **Natural tourist attractions degraded - beaches, pristine waters, coral reefs, and biodiversity**

- **Tourism facilities at risk from sea level rise, stronger hurricanes, stronger storm surges and flooding**
- **Sport fisheries and fresh produce at risk from warmer waters, stronger hurricanes and rainfall changes**
- **Rising energy, water and food costs for the industry**
- **Changes to our alluring subtropical climate - hotter, less predictable, floods**
- **Decreased demand for winter getaways as winters in tourism source markets become warmer**
- **Less demand for long-haul flights as international pressures to reduce carbon emissions increase**

The economic costs of these impacts are huge. While not calculated for The Virgin Islands, the following bits of information from a local study of the economic impact of coral bleaching events and various regional studies give an idea of the scale of costs:

- The 2005 mass coral bleaching event resulted in an estimated total loss of $1,270,000 to The Virgin Islands scuba diving and snorkeling sectors (equivalent to 24.9% of 2005 revenues) based on estimated decreased willingness to pay (WTP) and estimated decrease in purchases of excursions;
- A survey conducted in Barbados and Bonaire in 2005 found that 80% of tourists would be unwilling to revisit the destination at the same price should there be reduced beach area as a result of sea level rise (Uyarra, 2005);
- A regional report commissioned by The World Bank titled "Assessment of the Economic Impact of Climate Change in CARICOM Countries," found that reduced tourism demand could account for 15% - 20% of rough estimates of total losses across all sectors by 2050 – 2080 (1999 US$1.4 - $9.0 billion) under low impact and high impact climate change scenarios respectively (Margaree Consultants, 2002);
- The most recent and comprehensive study on the impacts of sea level rise (SLR) in CARICOM countries found that tourism will be the sector most affected. In some of the smaller CARICOM countries, such as Antigua and Barbuda, Barbados, St. Kitts and Nevis and The Bahamas, annual losses to tourism as a result of SLR would range up to 5% of GDP (Simpson et al., 2010).

In addition to these direct impacts, several sectors that interact with tourism will be impacted by climate change as shown in Figure 0-3 below:

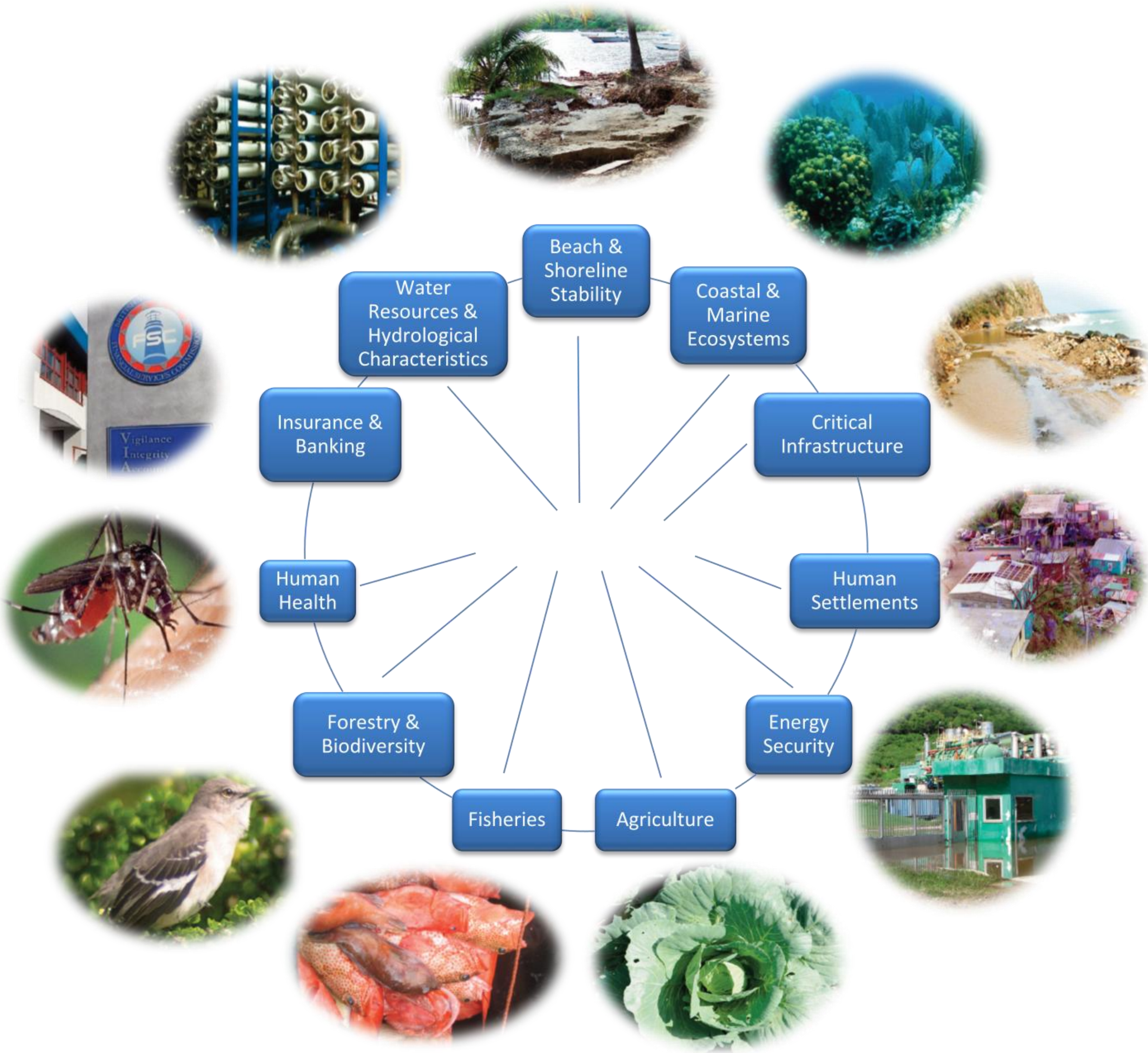


Figure 0-3. Important sectors that interact with tourism also likely to be impacted by climate change.

EXECUTIVE SUMMARY

The VCA seeks to better quantify climate change impacts to the tourism sector to improve our understanding of risks, vulnerability, available and needed capacity, and attitudes towards actions to minimise climate change impacts (*adaptation*) in a local context.

In basic terms, climate change is exactly what it sounds like - a change in the Earth's climate, the long term average weather conditions for various regions. Climate change has been described by many as "the defining challenge of our time". Based on the work of hundreds of independent scientists around the world and the Intergovernmental Panel on Climate Change (IPCC), the world has a much clearer scientific understanding of climate change.

For the first time since modern civilization (which developed in a fairly stable climate) the Earth's climate is changing in a profound way - the average global temperature is warming at an unprecedented rate due to our excess emissions of carbon dioxide and other "greenhouse gases". As a result, other fundamental aspects of climate are changing. In the Caribbean the projected changes of most concern include: rising temperatures (1-5°C/1.8-9°F warmer by the 2080s), more extreme rainfall patterns (drought/floods), stronger hurricanes and sea level rise.

Climate change will have serious economic consequences that are beyond the capacity of small islands to absorb. Early actions to adapt can significantly minimise impacts and costs.

Tourism has been identified globally as one of the economic sectors most vulnerable to climate change and is the mainstay of The Virgin Islands economy. This study was conducted to better understand and quantify how climate change will affect the local tourism sector through impacts to demand and supply of tourism services, both of which by their nature are climate sensitive. Impacts, for example, include degradation of the tourism product base (stable climate, beaches, coral reefs, coastal water quality, biodiversity, etc.), changes in visitor perceptions and willingness to travel/pay, and increased tourism property damages and operating costs. The VCA consists of four main components: Knowledge Attitudes and Practices (KAP) Surveys, the Hazard Vulnerability and Risk Assessment, the Capacity Assessment and Risk Reduction Options that explore these potential impacts and adaptation measures.

THE VIRGIN ISLANDS CONTEXT AND VULNERABILITY

The Virgin Islands is comprised of about 60 islands, cays and rocks with a land area of 154 km^2 (59 m^2). There are 16 inhabited islands with a population estimated at 28,882 in 2009. With the exception of the limestone island of Anegada, the islands are dominated by hilly ridges. The climate is subtropical with a distinguishable wet and dry season. Tropical cyclones are a significant climatic threat; flooding and landslides are now a major concern also. There are at least four distinctive vegetative communities that support a diverse group of animals, including island endemics. Coastal and marine habitats are particularly important and are home to an extremely diverse marine wildlife community.

The Virgin Islands enjoys a relatively stable and prospering service-based economy, dominated by tourism and the financial services sectors.

The majority of the Territory's critical infrastructure (including for tourism) and settlements are located in the low-lying coastal zone. This, together with the Territory's small size, limited capacity, narrow economic base, and strong dependence on nature-based tourism, built primarily around fragile coastal and marine resources, makes the islands highly vulnerable to the impacts of climate change.

While climate change impacts are diverse and costly they are also manageable to a degree through implementation of best management practices, utilization of new technologies and strengthening legislation, policies, institutions and programmes in impacted sectors. Through climate change adaptation, the Territory can improve its environmental management and the development planning process, reduce our inherent vulnerabilities to natural disasters and external shocks, diversify our tourism and energy portfolios, and ultimately ensure our security and long-term viability.

KNOWLEDGE ATTITUDES AND PRACTICES SURVEYS

Climate Change Tourist Perception Survey

The purpose of this Survey was to understand tourists' values and their knowledge and attitudes about climate change and how it would impact their travel decisions. The Survey generated 191 responses from tourists visiting The Virgin Islands in 2009-2010.

The Survey clearly shows that tourists visit The Virgin Islands to enjoy its ideal climate, natural beauty and nature-based recreational activities such as swimming, sailing and snorkeling. Climate change threatens basically all of these attractions and, therefore, puts The Virgin Islands' tourism industry and economy at high risk.

Presently, a high percentage of visitors no longer view the Islands' natural resources as "pristine". Climate change will lead to further degradation. 30% to 60% of tourists report that the specific climate change impacts described in the Survey would have a "significant influence" on their decision to revisit The Virgin Islands. This is particularly important as The Virgin Islands depends heavily on repeat visitors. Based on results from other regional surveys, those who do continue to visit might prefer to pay less for activities and services. The combination of reduced visitor arrivals and expenditure could significantly impact tourism revenues.

In addition, the Survey found that tourists do care about the carbon footprint and environmental practices of The Virgin Islands tourism industry and are willing to offset their carbon emissions through paying a voluntary carbon levy that would be dedicated to climate change adaptation. Tourists are also willing to support proposed climate change adaptation measures, especially those that are not intrusive to the natural environment.

Climate Change Tourism Sector Knowledge, Attitudes and Practices (KAP) Survey

This Survey explored the local tourism sector's (tourism sector business owners/managers) general knowledge about climate change and its potential impacts, perception of and vulnerability to these impacts, and willingness to take various actions to minimise impacts.

The results show that owners/managers are aware of and concerned about climate change and its present and future impacts to the Territory. Results shows that the sector is physically highly vulnerable to climate change impacts as tourism businesses are concentrated in natural hazard prone areas and are not built in the most climate resilient fashion possible; all survey respondents reported previous damage from climatic events or long-term beach erosion, many reporting "major damages."

Although some businesses have a reasonable capacity to prepare for or recover from the impacts of natural disasters, there still needs to be improvement in this area. The sector acknowledges the need for climate change adaptation and is willing to engage in actions and assist government in climate change policy development for the tourism sector.

Funding is an important limiting factor hindering businesses taking the necessary adaptation actions in response to climate change. This problem can be addressed by introducing a small carbon/environmental levy on tourists dedicated to climate change adaptation.

Climate Change General Public Knowledge, Attitudes and Practices (KAP) Survey

This Survey examined community knowledge, perception and concerns about climate change, vulnerability to climate change impacts and attitudes towards adaptation.

The Survey found that although the community has basic knowledge about climate change, it is not knowledgeable enough about the range of impacts and necessary adaptation measures to effectively deal with the threat. The majority, however, is willing to learn more.

Overall, the housing stock, particularly roofs, can be considered relatively resilient to hurricanes. Most homes have concrete slab or hip roofs which are most resilient to high winds. While the majority of homes have regular glass windows which are vulnerable to wind damage, the community's practice of protecting windows with ply board has reduced historical damages; 14% of respondents reported major wind damage from hurricanes. The survey results indicate that a significant portion of the community is vulnerable to flood events, with 28% experiencing "major damage" from previous events. There is room to continue to build the resilience of the housing stock, particularly through utilizing windows appropriate for hurricane impact and improving drainage.

Knowledge of climate change has led to a high level of concern among roughly half of the community and the attitude among almost 90% that early adaptation is necessary, even if costly. The public agrees that dealing with climate change and its impacts is the responsibility of everybody – government, businesses, community and individuals. Persons taking actions important to reducing climate change impacts remain in the minority. This is particularly true for actions that reduce vulnerability to natural hazards and protect the environment. The community is most constrained in taking more action by inadequate finances and lack of specific information.

HAZARD VULNERABILITY AND RISK ASSESSMENT

Climate Assessment

The climate assessment quantifies and describes in detail how key variables of The Virgin Islands climate (rainfall, temperature, relative humidity, wind speed and comfort index) are projected to change at different time intervals up to the end of the Century (2090-2099) based on the PRECIS (Providing REgional Climates for Impact Studies) climate model. From this, potential local climate change impacts to tourism attractions, infrastructure and supporting sectors can be better assessed as described below.

Coastal waters, coral reefs and sport fishing – Due to changes in seasonality, average monthly rainfall is projected to increase over the entire *tourist season*, increasing the chance of sedimentation and, therefore, degradation of coastal waters. By the 2011-2020 period average maximum temperatures increase enough, 1-2°C, to trigger frequent mass coral bleaching events that have already, for example in 2005, seriously affected the scuba and snorkeling sector, resulting in an estimated decrease in value of $1,270,000 (25% of the sector's 2005 revenue). These increases will also likely cause important sport fish species to migrate north.

Beaches - In the near-term, climate change will impact beaches through more intense hurricanes and associated storm surges which can cause significant erosion as Hugo did (averaging 3metres/9 feet on Jost Van Dyke). Over the long-term beaches on Tortola could possibly lose 24%-94% of their area under various sea level rise scenarios.

Food supply for the tourism sector - Climate change threatens to negatively impact agricultural production through changing rainfall patterns, soil degradation, increased pests and diseases and direct damage to crops. Important commercial fish species depend heavily on coral reefs and mangroves, ecosystems significantly threatened by climate change. Climate change is also projected to cause long-term changes in plankton, an important base of the marine food web, and large scale fish migrations. Such changes could also have a significant impact on commercial fish stocks important to tourism.

Comfort Level, Outdoor Activities and Special Events/Festivals - As most tourist activities, events and festivals occur in an outdoor setting they are highly susceptible to weather conditions and, therefore, climate change. The combined effect of locally projected temperature increases by up to 3.1°C, increased relative humidity, decreased wind speed during the *tourism season* and an increased number of days classified as "uncomfortable" by the comfort index may act as a deterrent to tourists.

Tourism Infrastructure and Energy - As the result of climate change, the number of strong (category 4 and 5 hurricanes) is projected to increase. Assuming similar building standards to public buildings and shelters, tourism properties could experience significant structural damage ranging from 11% to 70% and 31% to 77% in category 4 and 5 hurricanes, respectively. The storm surge threat, enhanced by sea level rise, is especially important as the majority of tourism facilities are located along the narrow coastal strip. The entire tourism sector is extremely vulnerable to heavy rain events. The combined effect is a reduced lifespan of tourism infrastructure, more costly damages and higher insurance costs.

As The Virgin Islands is projected to experience an increasing number of "uncomfortable days" increased demand and associated costs for cooling and water in the tourism sector is expected. The electricity supply system itself is vulnerable to the climate change impacts described.

Static Risk Maps – Cane Garden Bay

Static risk maps were created for Cane Garden Bay, an important tourism centre, using Geographic Information Systems (GIS) to map environmental features, critical infrastructure and natural hazards (including earthquake, wind, landslide, flooding and storm surge) to better understand the present physical and organizational components of risk in relation to tourism.

There are approximately 20 hotels/villas/guesthouses in Cane Garden Bay; this equates to a capacity of 166 rooms and 215 beds. There are 7 restaurants in the Bay and one water sports operation, all of which are located on the beachfront.

Four hazard zones of varying degrees were identified, labeled A through D. Overall the four hazard zones account for 11 tourism accommodation properties (equivalent to 79 rooms and 107 beds, or 48% and 50% of Cane Garden Bay's total room and bed capacity, respectively), 7 restaurants, 1 water sports operation and all critical public infrastructure, except for the Police Station and Community Centre. From a hazard perspective, it is clear that tourism properties and critical public infrastructure are concentrated in the worst possible areas. All of the hazards discussed are likely to increase as a result of climate change.

Beach Vulnerability Assessment

This assessment was conducted to determine the areas of popular/potential tourist beaches on Tortola (Beef Island Beach/Long Bay, Lambert Bay, Josiah's Bay, Brewer's Bay and Cane Garden Bay) under threat from various sea level rise scenarios (0.18m, 0.39m, 0.59m, 1m and 2m). The assessment was conducted using GIS and detailed beach profiles of each beach.

The results show significant average beach area loss for all sea level rise scenarios, ranging from roughly a quarter to all of the beach area – 24% for the 0.18m scenario, 34% for the 0.39m scenario, 46% for the 0.59m scenario, 68% for the 1m scenario and 94% for the 2m scenario.

Some of the beaches studied, such as Cane Garden Bay beach, are very popular tourist beaches that are already experiencing overcapacity/overcrowding. As such, any loss of beach area, especially of the significant percentages predicted, would represent a major degradation in the quality, attractiveness and usability of the beach and could result in major losses to the tourism sector as indicated by local and regional tourist surveys. Furthermore, erosion of beaches as a result of sea level rise will greatly increase the storm surge hazard to developments along the beach and could lead to the eventual undermining of these structures.

Sea Level Rise (SLR) Vulnerability Assessment

The potential impact of sea level rise (SLR) on The Virgin Islands is discussed based on a review of the latest Caribbean literature (a 2010 study) and simple GIS-based SLR maps created for The Virgin Islands that show coastal areas at risk from a sea level rise of 0.59m, 1m and 2m and the tourism properties and critical infrastructure located is these areas.

Tourism will be the sector most affected by SLR. The study assessed impacts to tourism in terms of resort damages as well as loss of income due to beach loss. In some smaller CARICOM countries annual losses to tourism as a result of SLR could range up to 5% of GDP. In addition to these losses, tourism would be impacted by SLR from flood risk to the majority of CARCICOM country airports and flood damage to a high percentage of the islands' coastal road network.

Like the CARICOM countries studied, the tourism sector of The Virgin Islands is set to be heavily impacted by SLR. A more detailed study would be needed to determine the specific economic costs of impacts locally. As with the CARICOM countries considered in the regional report, however, it can generally be observed and is visible from the GIS maps, that most of The Virgin Islands' tourist centres, accommodations and critical support infrastructure (ports of entry, main roads etc.) are located in the low-lying coastal zone where they are extremely vulnerable to the combined effect of SLR and stronger storm surge.

Coral Reef Vulnerability Assessment

This study seeks to understand the scale of impact that future mass coral bleaching events could have on The Virgin Islands dive and snorkel tourism sector by using the impact of the 2005 Caribbean mass bleaching event, as experienced locally, as a proxy. The information presented is taken directly from the PhD thesis of Stephanie Patricia Hime of the University of East Anglia, UK.

Choice experiments were administered to scuba divers and snorkelers visiting the Territory in 2006 to estimate their willingness to pay (WTP) for marginal changes in coral cover. The frequency of diving and snorkeling excursions was also determined based on records.

Results of the study clearly show that the 2005 bleaching event had a significant impact on coral cover. Taken together, the decrease in willingness to pay (WTP) and the estimated decrease in purchases of excursions resulted in an estimated decrease in value of $1,270,000 ($1,050,000 from scuba divers and $220,000 from snorkelers), equivalent to 24.9% of the sector's 2005 revenues.

The results confirm that scuba divers and snorkelers place a high value on reef quality and that future mass bleaching events will have a significant impact on coral cover and consequently a major economic impact on scuba diving and snorkeling, an important tourism subsector.

Risk Assessment

For the practical purposes of allocating resources and action timeframes to climate change adaptation, a stakeholder-based risk assessment was conducted to prioritize climate change impacts to The Virgin Islands across all affected sectors. Priority climate change impacts were determined by rating the *national significance*, *certainty*, *severity*, and *urgency* of each impact.

The resulting priority climate change impacts fell under the following sectors: Beach & Shoreline Stability, Coastal & Marine Resources, Fisheries, Forestry & Biodiversity, Tourism and Water Resources & Hydrological Characteristics and include:

1st tier priority impacts:
- Coral reefs experiencing increased bleaching, structural damage, disease and death
- Biodiversity threatened by habitat loss, invasive species and hurricanes
- Diminished natural tourist attractions, such as coral reefs, beaches and wildlife
- Changes in water quality and quantity

2nd tier priority impacts:
- Loss of or more costly damage to tourism infrastructure and properties from floods, stronger hurricanes and storm surges, and sea level rise
- Degradation of critical fish habitat, such as coral reefs, mangroves, and seagrass beds

3rd tier priority impacts:
- Rising overheads in energy, water and insurance
- Migration of some fish species to cooler waters
- Increased beach and shoreline erosion from sea level rise, and stronger hurricanes and storm surges
- Decreased rainwater (as the region becomes up to 25% drier and rainfall patterns change) leading to greater dependency on the desalinated public water supply and an increased threat of water shortages in emergencies.

Impacts to natural resources, and by extension tourism, feature strongly among the priorities.

Capacity Assessment

Institutional Framework

Climate change adaptation will require an ongoing collaborative effort between a wide range of Government departments and agencies, the private sector and communities. Under the ECACC Project, Cabinet approved the formation of a National Climate Change Committee which will draw upon relevant government agencies and be central to guiding the Territory's long-term adaptation to climate change.

Legal Framework

The Law Reform Commission has identified environmental law as one of the priority areas for reform and agreed that what is direly needed is a comprehensive environmental management law. Towards this end, the Commission drafted the Environmental Management and Conservation of Biodiversity Bill, 2008 still up for review by Cabinet.

The 2004 Physical Planning Act represented a significant improvement in the laws governing the physical development process, especially as it relates to the environmental impact assessment (EIA) process. The Development Control Guidelines of 1972, however, are still in use and need to be updated (into planning regulations) to reflect the new legislation; this is currently underway. The Buildings Ordinance, 1955 and Building Regulations, 1999 are also outdated and in need of an overhaul. In this regard, work is being done towards the Territory adopting the International Building Code and producing a local supplement.

Weak penalties and/or limited enforcement capacity in many instances inhibit the effectiveness of the legislation discussed.

Management Framework

Under the physical development control process, before any development (whether private or commercial) can begin, the developer must seek approval. Applications requiring an EIA go through a more detailed approval process. The physical development control process needs improvement through a more holistic approach to decision making guided by a national integrated development plan and comprehensive physical development plan which have never been formally approved for the Territory though drafted.

The environment is in need of improved management. While a number of initiatives are underway to address environmental concerns, they are generally underfunded and uncoordinated, and are being implemented without adequate institutional capacity and human resource capability. Important management gaps include a comprehensive coastal zone management plan, specific management plans for beaches, a sustainable management programme for fish stocks and management plans for Fisheries Protected Areas.

The National Environmental Action Plan, 2004, again never formally approved by Government, sets out the framework within which The Virgin Islands' environment can be managed in a responsible and sustainable manner. Further, the Protected Areas System Plan (approved by Cabinet January 2008) sets out all of the areas which are to be managed for sustainability and provides the policy framework for such. The newly approved protected areas still need to be officially declared, however.

The Territory has a relatively strong disaster management programme. The National Disaster Management Plan, updated and approved in 2009, and the Mitigation and Development Planning Framework, developed in 2002, are key to this programme.

Risk Reduction Options

Adaptation refers to any action aimed at minimising the local impacts of climate change. ***Mitigation*** refers to efforts that attempt to reduce carbon emissions, the primary cause of climate change, and is important locally to decrease the percentage of GDP expended on energy and capture external revenue (through a carbon levy) in order to redirect those monies into climate change adaptation and achieving development goals.

Through wide stakeholder consultation a series of climate change adaptation strategies (risk reduction options) have been identified for the tourism sector and supporting sectors as presented in the body of this document. The general principles guiding these adaptation strategies are listed below for each sector.

Impact Areas	General Guiding Adaptation Principles
BEACH & SHORELINE STABILITY	✓ Avoid undermining natural beaches/shorelines or creating vulnerable man-made ones. ✓ Protect beaches and vulnerable shorelines with natural defences where practical. ✓ Allow for natural adjustments in beaches/shorelines as sea level rises, to the greatest extent practicable. ✓ Avoid constructing in destructive and or vulnerable locations too close to beaches and the shoreline.
COASTAL & MARINE ECOSYSTEMS	✓ Enhance the resilience and natural adaptive capacity of coastal and marine ecosystems by increasing legal protections, enhancing management and monitoring and educating the public to reduce local impacts.
CRITICAL INFRASTRUCTURE AND HUMAN SETTLEMENTS	✓ Enhance physical and spatial planning, lands management, building standards, drainage design, disaster management and relevant human capacity to increase the resilience of existing and future critical infrastructure and human settlements to climatic events, disasters and sea level rise.
ENERGY SECURITY	✓ Implement policies to reduce energy use by promoting energy efficiency and conservation through education and incentives. ✓ Implement policies to encourage greater energy independence through the integration of renewable energy technologies. ✓ Enhance electricity sector performance and generating power efficiencies. ✓ Enhance the resilience of the electricity generation and distribution system to climate change impacts.

FOOD SECURITY: AGRICULTURE	✓ Expand and increase resilience of local agricultural production (through best management practices for water efficiency, erosion control, pest management, hurricane resilience and environmental sensitivity) ✓ Implement policies that encourage agricultural growth and diversification, use of new technologies and local capacity building.
FOOD SECURITY: FISHERIES	✓ Place greater emphasis on protection of fisheries habitat and sustainable fisheries management and practices. ✓ Explore new fisheries methods and species.
FORESTRY & BIODIVERSITY	✓ Enhance protection of wildlife and associated habitats. Engage in habitat restoration. ✓ Add value to wildlife preservation through tourism.
HUMAN HEALTH	✓ Emphasize a preventative versus treatment approach to managing health. ✓ Increase the resilience of the population to natural disasters and associated health impacts. ✓ Enhance the health care sector legal and policy framework to address climate change impacts. ✓ Enhance the health care sector capacity to monitor and respond to climate change impacts.
INSURANCE & BANKING	✓ Build resilience to minimise vulnerability of insured and mortgaged properties to climate change impacts. ✓ Depend less on global insurance companies and look towards more regional and local solutions to risk pooling and disaster recovery.
TOURISM	✓ Take strong "no regrets" measures to protect the quality of natural and historical attractions from existing local impacts and additional climate change impacts. ✓ Enhance the resilience of tourism infrastructure and facilities to climate change impacts. ✓ Create a more environmentally responsible tourism industry.
WATER RESOURCES & HYDROLOGICAL CHARACTERISTICS	✓ Increase resilience of infrastructure, homes and sectors to rainfall extremes - heavy rain events and drought. ✓ Enhance the management of freshwater resources. ✓ Use water more conservatively and efficiently.

1.0 | The Virgin Islands Context

The Virgin Islands is comprised of about 60 islands, cays and rocks that rise from the Puerto Rican Shelf with a total land area of 154 square kilometres (59 square miles) (see Figure 1.0-1).

With the exception of the limestone island of Anegada, the islands are dominated by hilly ridges; flat land is scarce and is concentrated in the valley bellies and the narrow coastal zone. There are 16 inhabited islands in The Virgin Islands with a total population estimated at 28,882 in 2009. Between 1984 and 1994 the population doubled, largely due to immigration; today population growth and immigration continue to be rapid (DPU, 1999; DPU, 2009b).

The climate is subtropical, moderated by the Northeast Trade Winds and has a distinguishable wet and dry season. Located directly in the hurricane belt, tropical cyclones are a significant climatic threat while, until recent years, flooding and landslides were traditionally not a concern outside of hurricane events.

The Virgin Islands has at least four (4) distinctive vegetative communities - moist forests, dry forests, woodlands, and shrublands that support a diverse group of animals, including island endemics. Coastal and marine habitats are particularly important and primarily include salt ponds, mangroves, beaches, seagrass meadows, and coral reefs and are home to an extremely diverse marine wildlife community.

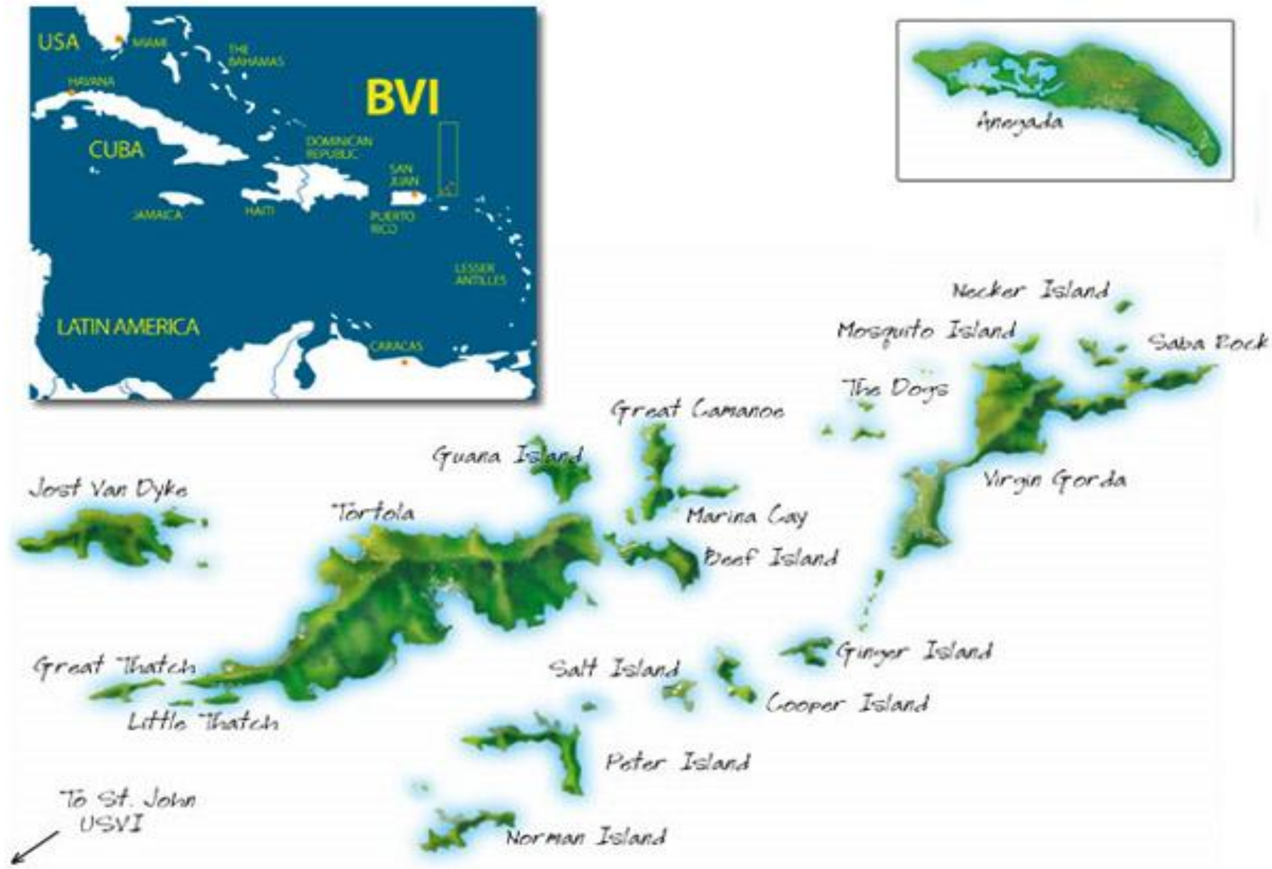


Figure 1.0-1. Map showing the larger islands and cays and the location of The Virgin Islands within the Caribbean basin. (Source: BVI Tourist Board- http://www.bvitourism.com)

1.1 | Economy

Until the 1960s The Virgin Islands was a subsistence economy depending heavily upon fisheries and agricultural production. Today The Virgin Islands enjoys a relatively stable and prospering service-based economy, dominated by tourism and the financial services sectors.

The small size and narrow production base renders The Virgin Islands a very open economy in which international trade is a dominant factor (DPU, 1999). Most goods (with the exception of minimal agricultural and fisheries produce) are imported from the United States.

In 2008, tourist expenditure was estimated at some $552.43 million; the industry accounts for at least half of gross domestic product (GDP) and at least 30% of employment (DPU, 2009c; DPU, 2009a). These numbers speak clearly to the heavy dependence of The Virgin Islands on tourism. The tourism industry can be directly credited for the relatively high standard of living enjoyed by the average Virgin Islander today, and perhaps for creating the backdrop against which the lucrative financial sector has now developed. The gravitation towards tourism is not by chance; given the small size, geography, and absence of mineral resources, alternative avenues for high economic growth are severely limited. Thus, it is predictable that the Territory will continue to look towards tourism as one of its primary economic pillars.

The main tourist market of The Virgin Islands is the Northeast United States. While the cruise ship sector (followed distantly by the charter boat and then hotel and rented accommodations sector) leads the industry in terms of arrivals, the cruise sector lags significantly behind in visitor expenditure which is led by the charter boat sector and trailed closely by the hotel and rented accommodations sector (DPU, 2009c). Figure 1.1-1 shows the growth in tourist arrivals and Figure 1.1-2 shows the growth in tourist expenditure from 1999 to 2008.

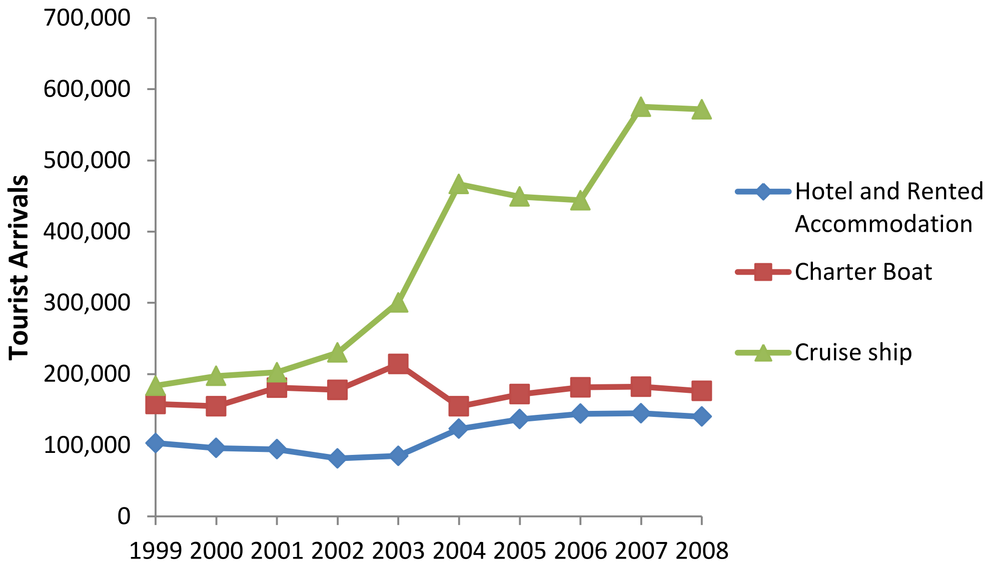


Figure 1.1-1. Growth in The Virgin Islands tourist arrivals, 1999-2008. Numbers for 2004 forward are estimates. *(Data source: Development Planning Unit, 2009c)*

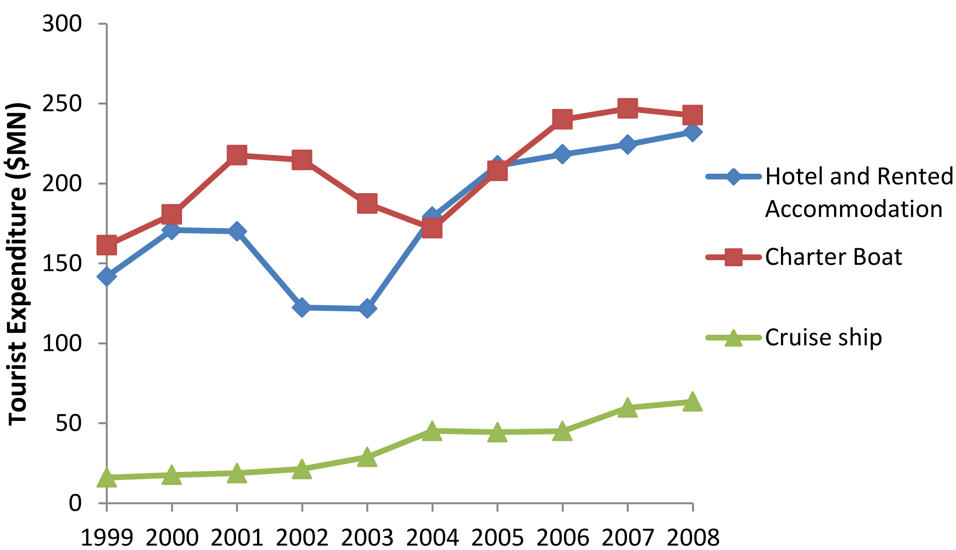


Figure 1.1-2. Growth in The Virgin Islands tourist expenditure, 1999-2008. Numbers for 2004 forward are estimates. *(Data source: Development Planning Unit, 2009c)*

Tourism in The Virgin Islands squarely fits the definition of 'nature tourism,' with the tourism product primarily revolving around the fragile natural resources of the Islands, especially their coastal resources (DPU, 2005). This truth is epitomized in the Islands' popular marketing slogan: "Nature's Little Secretes." The Virgin Islands are endowed with a dramatic geography, refreshing natural landscapes, colorful coral reefs, white sand beaches, and mainly pristine waters (see Figure 1.1-3). The yachting industry thrives in offering the adventure of plying the waters of The Virgin Islands, always a stone throw away from a choice of over 60 islands. The hotel and cruise industries take advantage of the fun and relaxation found in the beaches, seascapes and views. The diving industry finds its treasure in the shipwrecks and coral reefs that surround the Islands.

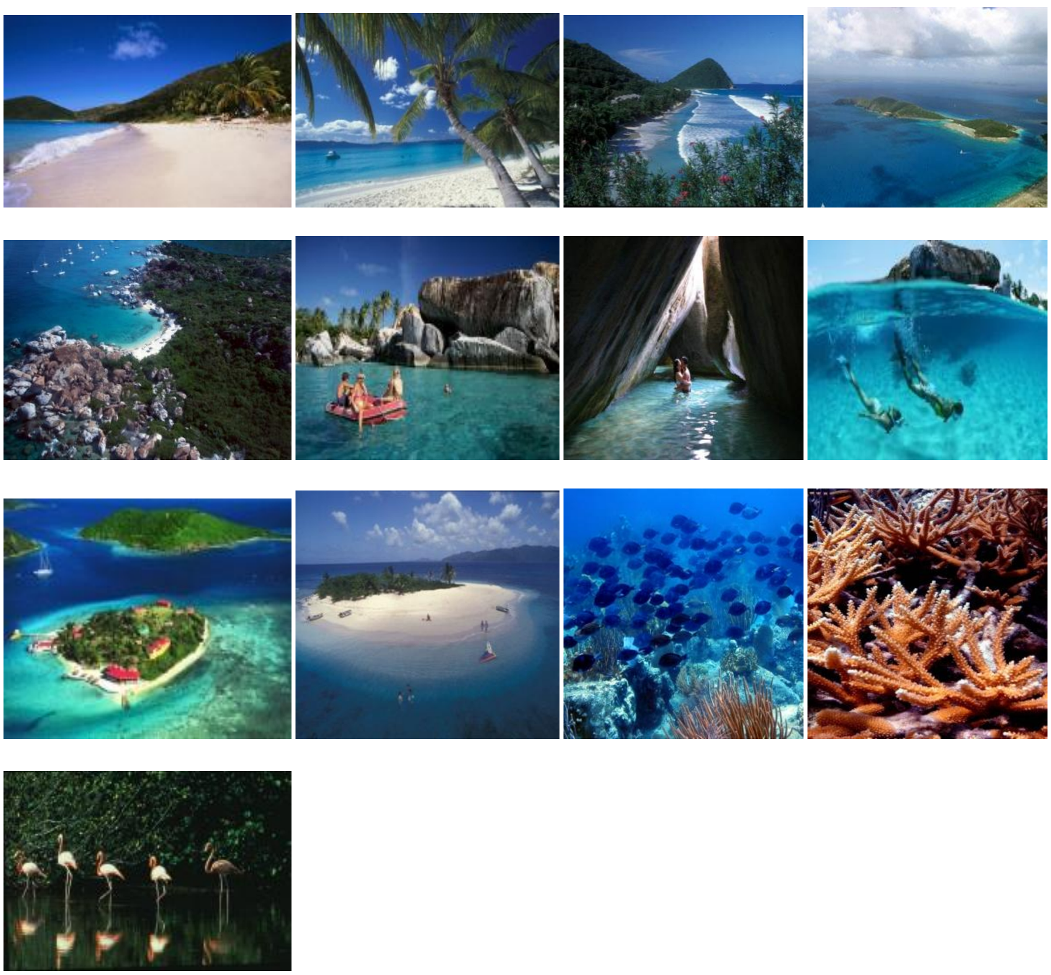


Figure 1.1-3. Snapshots of the scenic beauty of The Virgin Islands. (Source: BVI Tourist Board- http://www.bvitourism.com; Department of Environment and Fisheries- http://www.bvidef.org/main/component/option,com_zoom/Itemid,69/catid,4/

With increasing tourist arrivals, modest to luxurious accommodations ranging from small cottages to large hotels and marinas have emerged.

Foreign private sector interests dominate the leading sectors while the local private sector tends to engage in smaller-scale operations, provides support services, and is especially active in construction. Government performs the important role of facilitator, regulator, provider of physical and social infrastructure and developer of human resources (DPU, 1999). Table 1.1-1 below shows the breakdown of main economic activity in the Territory as estimated for 2008.

ECONOMIC SECTOR	CONTRIBUTION TO TOTAL EMPLOYMENT (%)	MILLIONS GENERATED	CONTRIBUTION TO GDP (%)
Real Estate, Renting and Business Activity	11.1	$320,301	29.3
Hotel and Restaurants	20.3	$173,904	15.9
Wholesale and Retail Trade	12.8	$154,708	14.1
Transport and Communications	3.7	$135,441	12.4
Construction	10.1	$70,840	6.5
Government Services	30.6	$70,433	6.4
Financial Intermediation	2.3	$49,643	4.5
Education	1.9	$28,081	2.6
Manufacturing	2.6	$27,248	2.5
Other Community, Social and Personal Services	3.2	$21,852	2.0
Health and Social Work	0.7	$19,447	1.8
Electricity, Gas and Water	0.0	$18,817	1.7
Fishing	0.1	$5,397	0.5
Agriculture, Hunting and Forestry	0.4	$4,102	0.4
Mining and Quarrying	0.1	$360	0.0

Table 1.1-1. Estimated financial activity for The Virgin Islands, 2008. The financial services and tourism sectors are not fully represented. ***(Data Source: Development Planning Unit, 2009a)*.**

1.2 | The Virgin Islands Vulnerability and Adaptation Potential

While climate change impacts are diverse and costly they are also manageable, in most cases through implementation of a variety of well-established environment and development best management practices, and strengthening existing legislation, policies, institutions and programmes.

The topography of The Virgin Islands, characterised by steep hills and limited flat lands in the interior, has resulted in the majority of the Territory's critical infrastructure and settlements being located in the low-lying coastal zone. This, together with the Territory's small size, limited capacity, narrow economic base, and strong dependence on tourism, which is built around fragile coastal and marine resources, makes the islands highly vulnerable to the impacts of climate change.

Studies, including the Stern Review on the Economics of Climate Change have proven that "the benefits of strong and early action [on climate change] far outweigh the economic costs of not acting" (Stern, 2007). Some of the major constraints that will have to be faced in the adaptation process include, limited financial and human resources, and creating legislative and systemic reforms that institutionalise and integrate climate change adaptation into the Territory's development policies and planning.

If The Virgin Islands continues to take sustained and early action on addressing climate change, while impacts will be incurred, they can be significantly minimised. In the process the Territory can take advantage of the opportunities presented to improve environmental management and the development planning process, reduce our inherent vulnerabilities to natural disasters and external shocks, diversify our tourism and energy portfolios, and ultimately ensure our security and long-term viability.

2.0 | Knowledge Attitudes and Practices Surveys

2.1 | Climate Change Tourist Perception Survey

PURPOSE

The Virgin Islands (VI) tourism sector is the most important industry within the Territory. This industry not only brings in about forty-five percent (45%) of overall gross domestic project (GDP) (Business BVI, 2008), but it also provides more jobs for its people than any other industry. The purpose of the Tourist Perception Survey (TPS) is to understand what tourists value and their knowledge and attitudes about climate change and how it would impact their travel decisions in order to better understand the potential impacts of climate change on tourism and determine the availability of options for the sector to reduce these impacts. This report discusses the results of the Survey and policy recommendations based on the findings.

METHOD

The TPS surveyed tourists visiting the Territory to explore the potential impacts of climate change on The Virgin Islands tourism industry and the actions needed by government and by the industry to reduce these impacts. The questionnaire consisted of these main sections. The first section, "About You," captured basic information about tourists such as their age, gender, region of origin, purpose of visit and frequency of travel to the Territory. The second section, "Impressions of the BVI," captured tourists' impressions of The Virgin Islands environment and visitor attractions, detection of change in the quality of these by repeat visitors and whether degradation of the islands natural environment would impact their choice to return. The third section, "Your Motivations and Concerns" was the longest and drew attention to the potential impacts of climate change and hence captured the influence these impacts would have on respondents' decision to make future visits. It also addressed what measures tourists would support to help minimise climate change impacts.

The surveys were distributed via the aid of the BVI Tourist Board to different ports of entries and businesses/individuals who were in direct contact with tourists. There were two rounds of survey distribution; unfortunately in both cases distribution times were not able to match the peak of the tourist season. The first started in May 2009 and ran for a period of 2 months. The second round started in April 2010 and was also in rotation for 2 months. In the second round, questionnaires were revised to include an additional 11 questions to get further clarity/detail on the questions in the original survey.

Copies of first and second versions of the Tourist Perception Survey are provided in Appendix 1A and Appendix 1B respectively.

RESULTS AND DISCUSSION

About the Respondents

The Tourist Perception Survey generated 191 responses - 146 from the first round of surveys and 45 from the second. A wide cross-section of tourists participated in the survey, including personal/family vacationers, yacht charterers, business travelers, wedding/honeymooners, cruise ship trippers, individuals visiting family and friends and persons visiting for special events. The breakdown of respondents is shown in Figure 2.1-1.

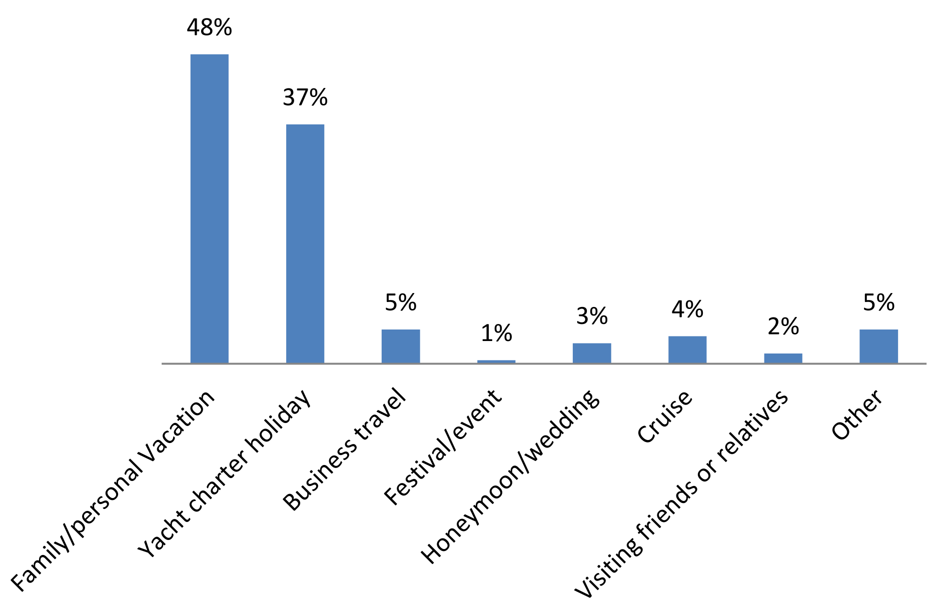


Figure 2.1-1 Cross-section of the 191 respondents of the Tourist Perception Survey. Unfortunately, questionnaires were distributed at the end (April/May) of the Territory's peak tourism season (typically from October to April). The cross section of respondents, therefore, does not reflect the typical percentage make-up of the tourist population during the peak of the season. Historically cruise ship passengers are present in the highest numbers, followed by charter yachters and family/personal vacationers (Development Planning Unit, 2009). None the

less, the majority of respondents represented the two sub-sectors of the tourism industry that generate the most revenue per visitor.

The majority of tourists (70%) who responded to the Survey were repeat visitors. Respondents traveled to the Territory from a wide range of places, including but not limited to North America, South America, Europe and other Caribbean islands (see Table 2.1-1). The results show that the clear majority (83%) of visitors are from North America which can be classified as highly industrialized and temperature in climate. It is, therefore, easy to understand the appeal of The Virgin Islands' natural beauty on land and sea and its moderate subtropical climate. Data from the second round of questionnaires suggests that the majority (87%) of Survey respondents were roughly middle-aged (31-65 years) (see Table 2.1-2).

Region of Origin	% of Respondents
North America	83%
Europe	7%
Caribbean	6%
South America	2%
Other	3%

Table 2.1-1. Origin of TPS respondents. Data based on sample size of 191 tourists. Most of the VI's tourists originate from North America.

Age Group (yrs)	# of Individuals
20 – 30	3
31 – 40	10
41 – 65	29
Over 65	3

Table 2.1-2 Age range of the 45 respondents from the second round of surveys. The majority of survey participants were in the 41 – 65 age group followed by that of the 31 – 40 age range.

Tourists' Impressions of The Virgin Islands

Tourists were asked to rate overall environmental quality, coastal and marine waters, beaches, coral reefs and national parks as either pristine, fair or degraded.

Although most tourists view the Islands as pristine, particularly our beaches (81%) and coastal and marine waters (72%), the results are very concerning in that a notable percentage of tourists rated overall environmental quality and specific environmental features as only “fair” or “degraded” (see Figure 2.1-2).

Overall environmental quality and the quality of coral reefs received the poorest ratings. Half or nearly half of responses received rated overall environmental quality (50%) and coral reefs (46%) as either only “fair” or “degraded.” National parks in theory should be of the highest quality; 36% of respondents, however, rated these areas as only “fair”. Beaches and coastal and marine waters appeared to be in the best condition as ratings of “fair” or “degraded” were the least for these attributes, being 20% for beaches and 27% for coastal and marine waters.

For a Territory that markets itself as being pristine (“Nature’s Little Secrets”) these numbers speak to a tourism product that has gotten to a critical stage and must be restored if tourism is to continue to thrive. Basically, the tourism product is at the crossroads.

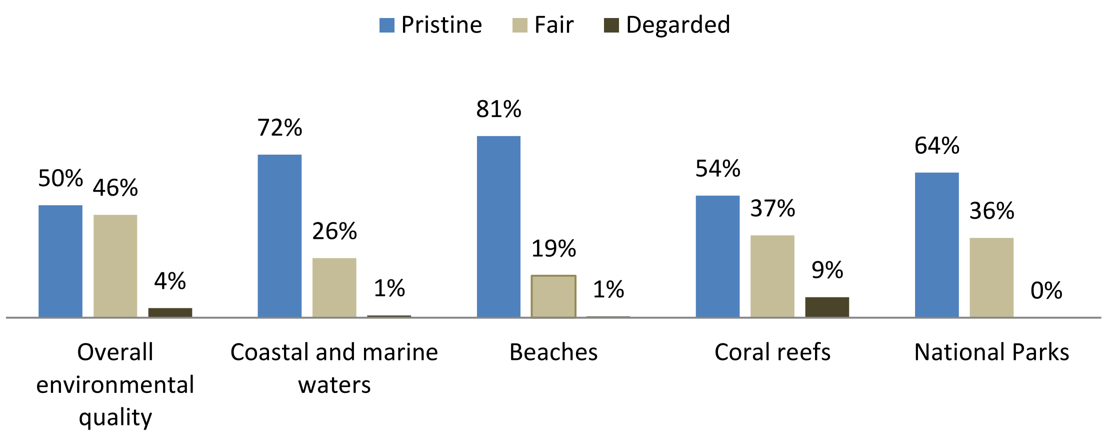


Figure 2.1-2. Respondents’ impressions of The Virgin Islands environment. The sample size for each attribute varied. Overall environmental quality is based on 188 responses, coastal and marine water quality on 189 responses, beaches on 187 responses, coral reefs on 175 responses and national parks on 169 responses.

Tourists were also allowed to comment openly on environmental quality. Where degradation was detected, disposal of solid and land-based sewage waste were by far the most commented on (75% of the 45 comments received from participants). This shows that tourists are well aware of and dissatisfied with the major waste issue The Virgin Islands is currently facing. Other tourists were concerned about holding tanks for yachts (7% of the 45 comments), the loss of fish populations (5%) and fewer coral reefs (13%).

The Virgin Islands' tourism industry is extremely sensitive to these latter issues as the yachting sector accounts for a large percentage of the industry and bases its livelihood on the coastal waters and marine life, including fish and coral reefs. A negative change in these features will depress tourism activity as tourists' point of visitation would be lost. In the Survey 58% of respondents indicated that degradation of the Territory's environmental quality would impact their decision to revisit The Virgin Islands.

The results of the Survey further confirm that tourists are conscious of changes in environmental quality over time. A notable percentage of repeat visitors (20%) perceived degradation in environmental quality between their last and present trips; 62% noticed no change and 18% observed improvement. This shows that changes to environmental quality are evident to a substantial percentage (38%) of respondents; however, the observed degradation is slightly higher than the observed improvement. It should be taken into account that the survey did not specify the last time these individuals visited the Territory. Thus, the "no change" result might be skewed depending on the length of time between the current and last visit to the Territory.

Perception of the atmosphere/ambience of popular tourist attraction areas is a key element in the rating of tourists' impressions of the islands. Most tourists (more than 80% of participants), gave positive feedback on measures of atmosphere/ambience of popular attraction areas, noting that they are relaxing or comfortable, clean, tidy or attractive, and exciting or fun with appropriate signage. A small percentage of individuals (less than 10%) gave negative feedback on these measures of atmosphere/ambience (see Figure 2.1-3). These results speak well of The Virgin Islands, but are liable to change during the peak of the tourist season (between November and February) when visitor numbers are significantly higher. In future surveys, the specific date and attractions visited can be considered, as these replies would help to determine the appropriate carrying capacity of specific attractions. This additional information can further aid in implementing strategies to reduce impacts to these areas.

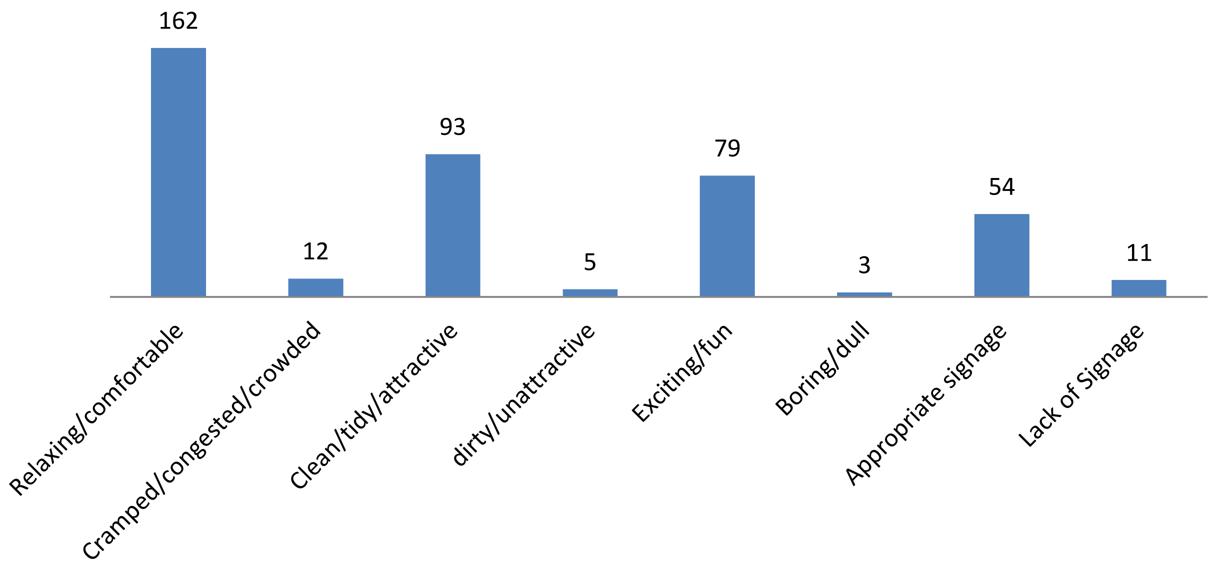


Figure 2.1-3. Tourists' impressions of the atmosphere/ambiance at popular visitor attractions in The Virgin Islands. Data based on sample size of 191 tourists. Most individuals gave positive remarks about the visitor attraction areas. Of the 191 respondents, 162 persons stated that these areas were relaxing or comfortable, 93 indicated that they were clean or attractive, 79 noted that they were fun or exciting and 54 pointed out that they had appropriate signage. The negative feedback was a small portion of the sample size. Thirteen (12) persons reported that the areas were congested, 5 stated that they were dirty or unattractive, 3 persons noted that they were boring and 11 stated that they lacked signage.

Tourists' Motivations and Concerns

Climate Change Impacts

Tourists travel to these beautiful islands to enjoy the sun, marine environment, landscape and overall atmosphere. The Survey showed that there is a broad spectrum of features that have a "significant influence" in attracting visitors to the Territory; these include recreational opportunities such as water sports (86% of respondents indicated this feature as having a "significant influence" in attracting them to the islands), pristine coastal waters (85%), the islands' general serenity/tranquility (81%), geography and scenery (81%), healthy coral reefs (73%), good predictable weather/climate (65%), white sand beaches (64%), overall environmental quality (63%), environmentally conscious tourist facilities (42%), price and quality of accommodations (41%) and entertainment/special events (24%) (see Figure 2.1-4).

The data shows that at the end of the day, tourists are more interested in and driven by the islands natural attractions than the cost and quality of accommodations or entertainment and special events. Degradation to the environment will thus significantly affect the Territory's tourism industry. As noted above, tourists already perceive degradation in environmental quality. Healthy coral reefs, for example, are among the top five features that have a "significant influence" on tourists' decision to visit the islands, yet nearly half (46%) of responses received from tourists rated coral reefs as either only "fair" or "degraded."

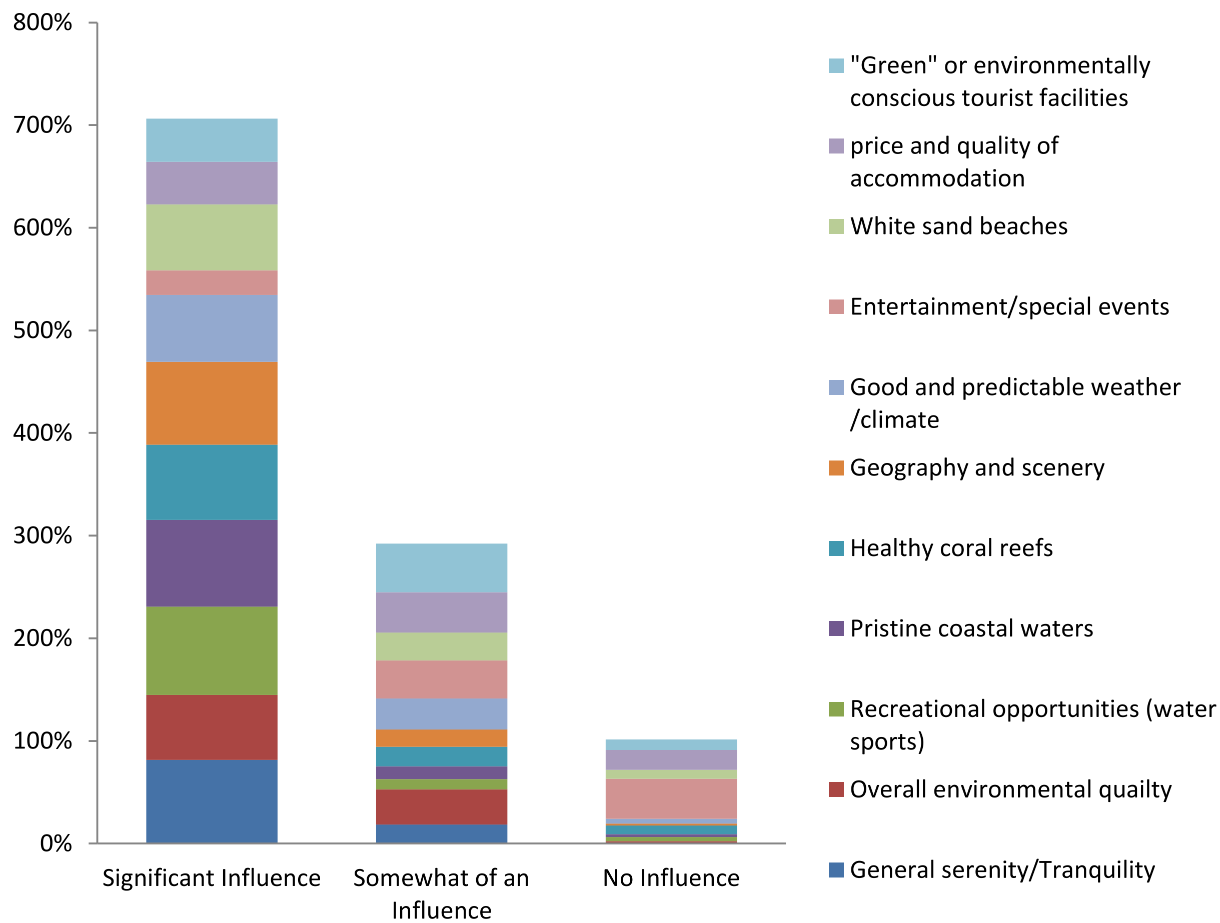


Figure 2.1-4. Influence different attributes of The Virgin Islands have in attracting tourists to the Territory. Data based on varies sample sizes - "general serenity / tranquility" 178 tourists, "overall environmental quality" 175 tourists, "recreational opportunities (water sports) 169 tourists, "pristine coastal waters 176 tourists, "healthy coral reefs" 171 tourists, "geography and scenery" 153 tourists, "good and predictable weather/climate" 152 tourists, "entertainment/special events" 138 tourists, "white sand beaches" 151 tourists, "price and quality of accommodations" 140 tourists and "green/environmentally conscious tourist facilities" 38 tourists. All these attributes have some effect on magnetizing visitors; however, of all the features, general serenity/ tranquility, geography and scenery, the marine environment and related activities are the most influential.

Warmer average temperatures, including warmer winters, are one of the global results of climate change. Only 16% of respondents (169 responses) would be less likely to vacation in The Virgin Islands if winters were milder in their country of residence (see Figure 2.1-5). On the other hand, if average temperatures in The Virgin Islands increased slowly to more than 4^{o}C by the end of the Century, 21% of survey respondents would be less likely to vacation in the Islands (see Figure 2.1-6). Severe hurricanes are more likely as a result of climate change and are an important deterrent to tourists; 45% of surveyed tourists indicated that they would be less likely to vacation in the Territory if more incidents of severe hurricanes are experienced (see Figure 2.1-7). One of the most important adaptation measures, therefore, is to have a stronger disaster management system in the Territory, including the tourism sector, to maintain confidence in tourists in the face of more extreme natural disasters. Measures also need to be taken to help minimize heat stress to visitors; these may include the construction of cooling stations and shade areas.

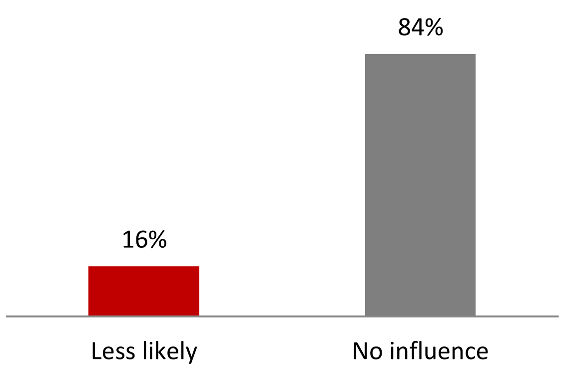


Figure 2.1-5. Tourists' likelihood to vacation in the tropics if winters become milder in their country of residence. Data based on sample size of 169 tourists. Results show that The Virgin Islands tourism industry would not be greatly affected in the event that tourists' home country becomes warmer during the winter period.

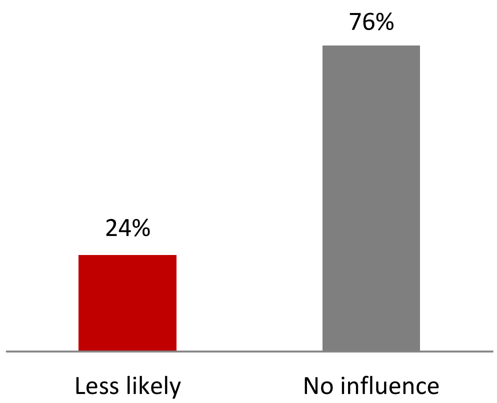


Figure 2.1-6. Tourists' likelihood to vacation in The Virgin Islands if local average temperatures rose more than 4°C by the end of the Century. Data based on sample size of 165 tourists. Results show that rising average temperatures in The Virgin Islands would have an effect on almost a quarter (24%) of visitors. While most individuals (76%) are not deterred by this change, a big enough percentage is to cause serious consideration of this issue and lead to measures to help minimize heat stress to visitors, such as cooling stations and shade areas.

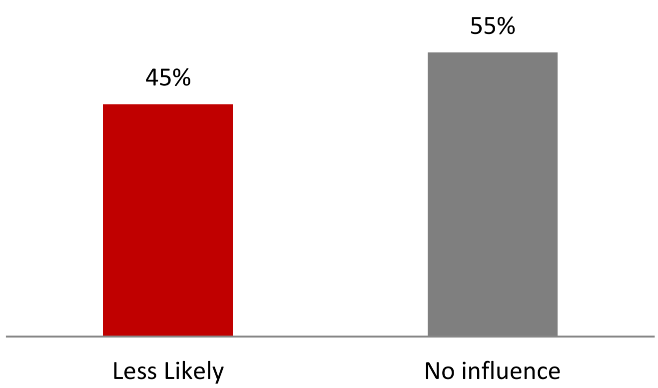


Figure 2.1-7. Tourists' likelihood to vacation in The Virgin Islands if the Territory experiences more severe hurricanes. Data based on sample size of 38 tourists. Results show that an increase in severe hurricanes does have a notable impact on tourists' decision to visit The Virgin Islands. 45 % of individuals declared that they would be less likely to vacation in the Territory if this occurs, while 55% will continue to visit.

Climate change not only impacts weather patterns, but also impacts a wide range of resources that are critical to the tourism industry. As shown in Figure 2.1-8, impacts that can arise from this phenomenon all have a "significant influence" on between 30% to 60% of tourists and their decision to make future visits to the Islands, including degradation of coral reefs (significant influence on 59% of respondents), increased dengue fever outbreaks (57%), erosion of beaches (56%), water shortages (51%), increased climate variability (48%), more severe hurricane events (43%), increased flood events (36%) and decline of fisheries (30%).

Of the impacts investigated, degradation of coral reefs, erosion of beaches and dengue fever outbreaks would have the greatest impact on tourists' decision to revisit The Virgin Islands. These results support the findings above of the significant influence that coral reefs and beaches have on attracting tourists to the Territory. They also support the results of a similar survey conducted in Barbados and Bonaire in 2005 which found that 80% of tourists would be unwilling to revisit the destination at the same price should there be coral bleaching as a result of increased sea surface temperatures or reduced beach area as a result of sea level rise. That survey also found that low health risk is among the top three most important environmental features considered by tourists in selecting a vacation destination (Uyarra, 2005).

It has been well documented that repeat visitors account for a high percentage of annual tourist arrivals (71% of tourists in this survey were repeat visitors). The "significant influence" of climate change impacts on 30%-60% of tourists' decision to revisit The Virgin Islands is, therefore, serious for the sustainability of the industry and indicates that climate change impacts must be carefully managed and minimized.

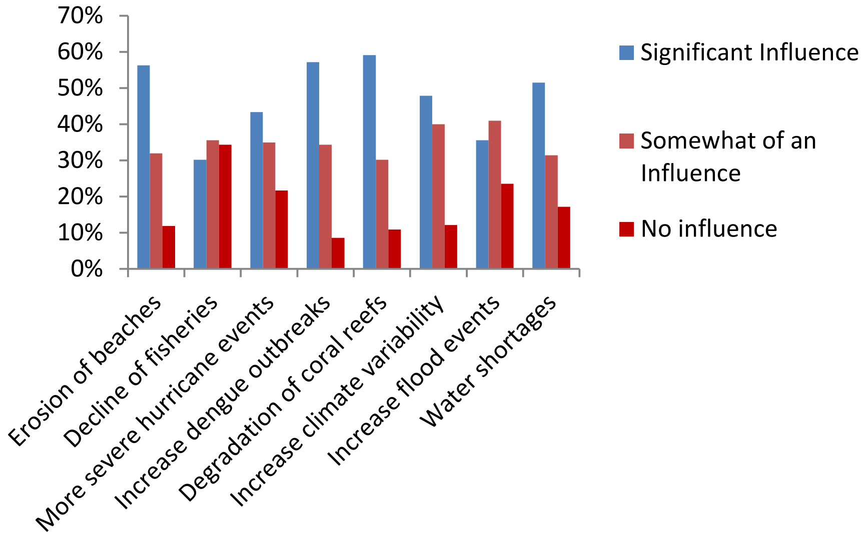


Figure 2.1-8 Effect of climate change impacts on tourists' decision to revisit The Virgin Islands. Data sample size varied between some impacts – "erosion of beaches" was based on 169 tourists, "decline of fisheries" 166 tourists, "more severe hurricane events" 166 tourists, "increased dengue outbreaks" 35 tourists, "degradation of coral reefs" 166 tourists, "increase climate variability" 165 tourists", "increase flood events" 166 tourists and "water shortages" 35 tourists. All impacts have a "significant influence" on between 30% to 60% of tourists and their decision to make future visits to the Islands. The impacts with the highest percentage of tourists reporting "no influence" on their desire to revisit include decline of fisheries, increased flood events and more severe hurricane events. Tourists may not see a direct relationship between the fisheries sector and their experience. Hurricanes and floods, while high impact events, are temporary in nature (versus a more permanent change such as degradation of coral reefs) and, therefore, the chance of impact to any one respondent is less.

Environmental Practices

Tourists are concerned about the ongoing phenomenon of climate change. In particular, having been informed that carbon emissions are the primary cause of climate change, most visitors reported being concerned about The Virgin Islands tourism industry's carbon footprint (64% of respondents are concerned, 24% are somewhat concerned while 12% are not concerned). This indicates that the industry could improve visitor satisfaction by implementing initiatives to reduce energy use and incorporate renewable sources of energy.

While it is evident that most tourists care about carbon emissions, the TPS also revealed that the majority (83%) of these individuals are not inclined to travel less as a result; however, 32% of these persons are not inclined to travel less because they offset their carbon emissions. On the other hand, 17% of tourists are likely to travel less because of concerns over carbon emissions.

Some important conclusions can be drawn from this data. Firstly, despite concerns over carbon emissions, the majority of tourists will continue to travel just as often. Instead of traveling less, many tourists (32%) are already acting on their concern by offsetting their travel emissions in some fashion (see Figure 2.1-9). The combination of high concern over carbon emissions and a relatively high willingness among tourists to offset their carbon emissions creates an opportunity for The Virgin Islands tourism sector to offer "home-grown" carbon offsetting programmes, reap the financial benefits locally and reapply them to climate change adaptation.

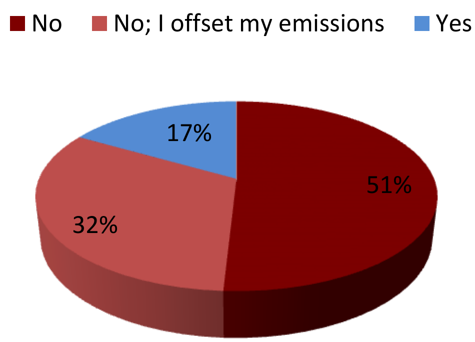


Figure 2.1-9. Individuals inclined to travel less due to concerns over climate change and the linkage to flight carbon emissions. Data based on sample size of 173 tourists. Fifty one percent (51%) of tourists are not inclined to travel less due to concerns over carbon emissions, another 32% are not inclined to travel less, but offset their carbon emissions. The smallest group, 17%, are inclined to travel less.

The environmental practices of the Territory's tourism industry are not ignored by its visitors. Only a mere 4% of tourists surveyed reported that they are not concerned about these practices (the majority, 72%, noted that they are concerned, while 24% stated that they are somewhat concerned). In keeping with this concern, a substantial percentage (45%) of respondents reported that "a guarantee of good environmental practices from an international recognized body such as Green Globe and Blue Flag" would provide an added incentive to choose a particular destination or accommodation (see Figure 2.1-10). This indicates that poor environmental practices may be a deterrent to tourists or at least have an impact on visitor satisfaction for the majority of tourists and that the tourism industry would benefit greatly from efforts to "green" the industry.

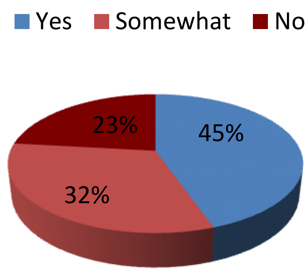


Figure 2.1-10. Individuals viewing a guarantee of good environmental practices from an internationally recognized body as an added incentive in their decision to choose a particular vacation destination or accommodation. Data based on sample size of 168 tourists. Of all the participants, 45% see this feature as a "plus", 32% view it as somewhat of an incentive while 23% would not be influenced by this added feature.

A growing trend in The Virgin Islands is building tourist accommodation properties as close to the beach/coast as possible. Results of the TPS, however, revealed that the majority of tourists (82%) strongly value beach fronts and other coastal environments remaining natural / undeveloped. The survey also found that overall tourists are not very strongly driven by a desire to stay at beachfront accommodations. There was an almost even split between the percentage of tourists that indicated it was "extremely important" to stay at a beachfront hotel (35%), "somewhat important" (28%) and "not important" (37%) (see Figure 2.1-11). These results clearly indicate that the development focus of the tourism industry should be protecting and improving this important element of the tourism product as opposed to developing beachfront accommodations that threaten beaches in the long-term and detract from their natural appeal.

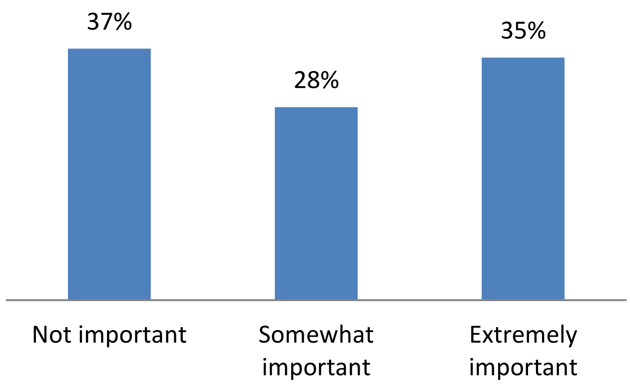


Figure 2.1-11. Tourists' opinion about the importance of staying at beachfront hotels in The Virgin Islands. Data based on sample size of 153 tourists. More beachfront hotels are not necessary to keep The Virgin Islands tourism Industry afloat. Results show a roughly even split between individuals who consider beachfront accommodations extremely important, somewhat important and not important.

Adaptation Measures

Adaptation refers to any action aimed at reducing the local impacts of climate change and has become an important focus for small islands, including The Virgin Islands. The TPS captured tourists' support for a number of proposed policies to reduce impacts from anticipated changes in climate; tourists reported being "extremely in favour," "somewhat in favour" or "not in favour" of policy measures.

While tourists were willing to support all measures proposed, some received far more support than others. The percentage of tourists "extremely in favour" of each measure is listed below in Table 2.1-3 and full results are shown in Figure 2.1-12. Measures focused on protecting threatened resources through preventative strategies and soft engineering approaches received the highest support. There is also high support for conserving energy and reducing carbon emissions in the tourism sector. Least favored where more hard engineering approaches that would take away from the natural beauty of the environment (sea walls and artificial reefs).

Proposed Adaptation Measure	% of Tourists "Extremely in Favour" of Measures
Greening and managing the tourism sector to decrease existing impacts on coral reefs, beaches etc.	70%
Building further away from beaches and the coastline	60%
Mangrove replanting (for coastal defense)	57%
Beach nourishment (i.e. replacing beach sand that has eroded)	55%
Conserving energy and decreasing the carbon emissions of the tourism sector	53%
Encouraging a more historical and cultural visitor experience to supplement the impacted "sand and sea" experience	47%
Conserving water and reducing water use in tourism facilities	48%
Artificial reefs	31%
Sea walls (for coastal defense)	26%

Table 2.1-3 Percentage of tourists extremely in favour of proposed adaptation measures. Data sample size varied – "greening and managing the tourism sector to decrease existing impacts on coral reefs, beach etc." based on 155 tourist responses, "building further away from beaches and the coastline" 149 tourists, "mangrove replanting" 157 tourists, "beach nourishment" 157 tourists, "conserving energy and decreasing carbon emissions" 157 tourists, "encouraging a more historical and cultural visitor experience" 155 tourist, "conserving water" 31 tourists, "artificial reefs" 157 tourists and "sea walls" 156 tourists.

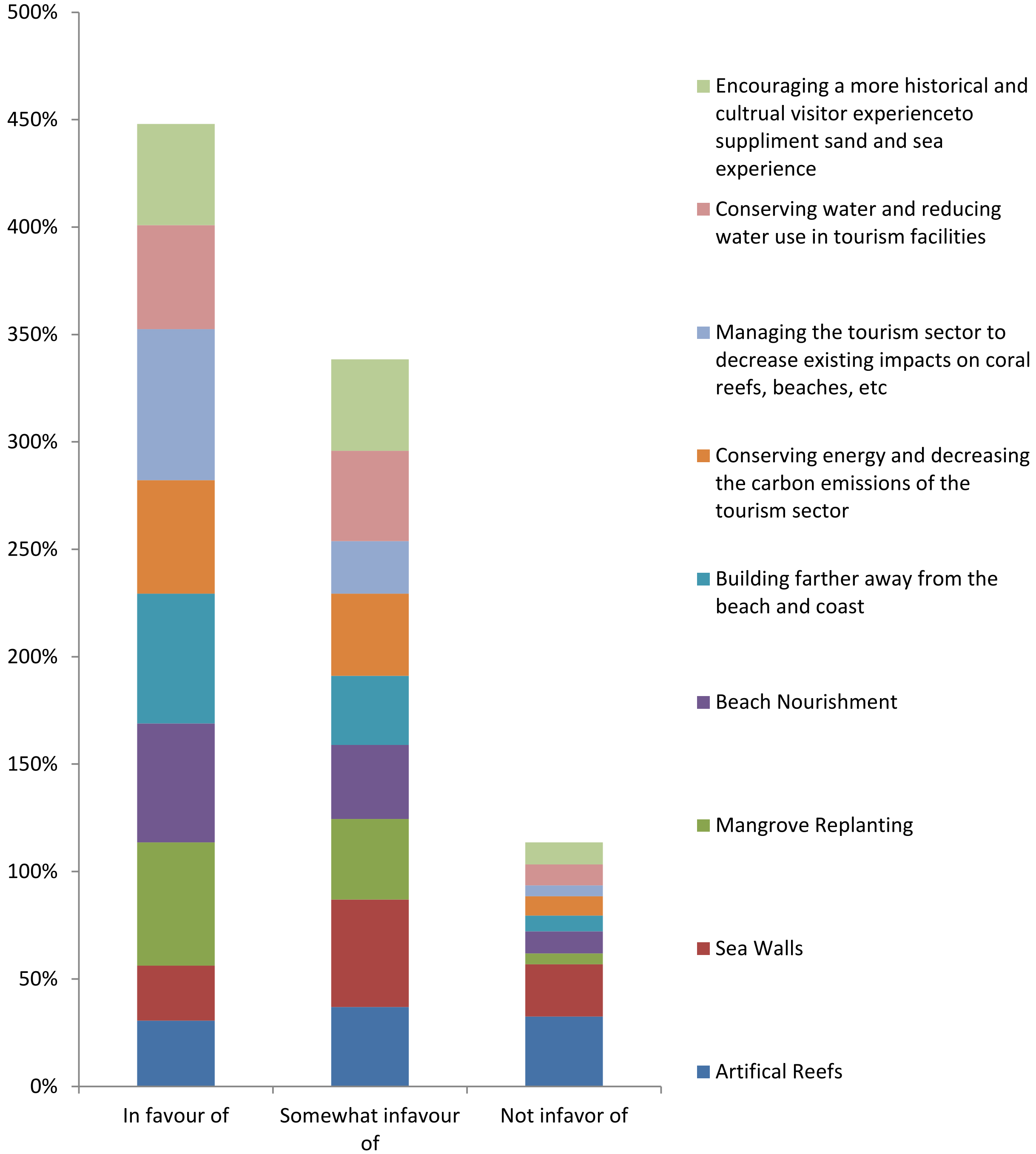


Figure 2.1-12 Tourists' support for various proposed policies to reduce climate change impacts in The Virgin Islands. Data sample size varied – "greening and managing the tourism sector to decrease existing impacts on coral reefs, beaches etc" based on 155 tourist responses, "building further away from beaches and the coastline" 149 tourists, "mangrove replanting" 157 tourists, "beach nourishment" 157 tourists, "conserving energy and decreasing carbon emissions" 157 tourists, "encouraging a more historical and cultural visitor experience" 155 tourists, "conserving water" 31 tourists, "artificial reefs" 157 tourists and "sea walls" 156 tourists. All policies would be supported by tourists to some degree; most favoured are measured to better

protect threatened natural resources by reducing existing local impacts. Least favoured are sea walls and artificial reefs as these structures take away from the beauty of the natural environment.

Implementation of the proposed adaptation measures would be extremely costly. The TPS explored tourists' willingness to pay a voluntary "environmental/carbon levy" collected upon arrival or departure that would generate funds dedicated to minimizing climate change impacts and ensuring environmental sustainability.

The results revealed that most tourists do not mind contributing to this fund once it is being used for the intended purpose. Overall (both survey rounds averaged), 60% of respondents indicated that they would be willing to support a carbon levy. The second survey round asked the question in a more detailed fashion, allowing tourists to support a carbon levy geared for more specific purposes; support received for each is reported in Table 2.1-4. The table shows that tourists are most likely to support a carbon levy if it is dedicated specifically to protecting The Virgin Islands environment. Of those who declined to support a levy for any purpose, 28% would change their decision if the levy was managed by a trusted financial institution.

All together, the data shows that even on a voluntary basis a carbon levy can generate a substantial amount of money. The TPS revealed that tourists are willing to pay at least $1, but no more than $50.00 towards a carbon levy. The majority of respondents would volunteer to pay in the $5.00 to $20.00 range (see Figure 2.1-13).

Specific Purpose of Voluntary Carbon Levy	% of Tourists Willing to Support Levy
Reducing the carbon footprint of The Virgin Islands' tourism industry	68%
Implementing measures to reduce The Virgin Islands' vulnerability to climate change impacts	75%
Implementing measures to protect The Virgin Islands' natural environment	81%

Table 2.1-4 Tourists' support for a voluntary carbon levy. Data based on sample size of 36 tourists for all purposes except "reducing the carbon footprint of The Virgin Islands' tourism industry" which was based on 38 tourist responses.

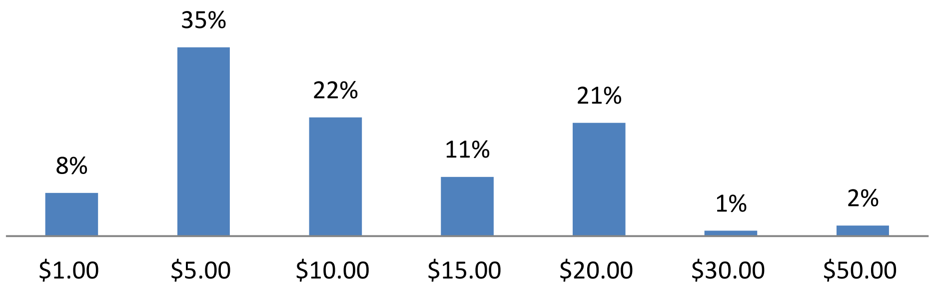


Figure 2.1-13. Maximum amount that supporters of a voluntary carbon levy would be willing to pay per visit. The majority of tourists are willing to contribute monies within the $5.00 to $20.00 range.

CONCLUSION

Tourists travel to The Virgin Islands to enjoy its ideal climate, natural beauty and nature-based recreational activities such as swimming, sailing and snorkeling. Climate change threatens all of these attributes and, therefore, puts The Virgin Islands' tourism industry and economy at high risk.

The Territory's natural resources and environmental quality are extremely important to tourists and it is this characteristic that primarily motivates them to visit. Presently, a high percentage of visitors no longer view the Islands' natural resources as "pristine". Climate change will lead to further degradation of natural resources and environmental quality. The specific impacts described would have a significant influence on 30% to 60% (almost a third to two thirds) of tourists' decision to revisit The Virgin Islands. This is particularly important as The Virgin Islands depends heavily on repeat visitors. Although not tested in this survey, based on results from other regional surveys it should be noted that those who do continue to visit might prefer to pay less for activities and services.

The combination of reduced visitor arrivals and expenditure could put a significant strain on revenues from The Virgin Islands tourism sector. As an indicator of the importance of this effect, a regional report commissioned by The World Bank titled "Assessment of the Economic Impact of Climate Change in CARICOM Countries," found that reduced tourism demand could account for 15% - 20% of rough estimates of total losses across all economic sectors by 2050 – 2080 (1999 US$1.4 - $9.0 billion) under low impact and high impact climate change scenarios respectively (Margaree Consultants, 2002).

Tourists do care about the carbon footprint and environmental practices of The Virgin Islands tourism industry. About half of tourists are willing to offset their carbon emissions through paying a voluntary carbon levy that could raise a significant amount of money that could be dedicated to environmental protection and climate change adaptation. Tourists are also willing to support proposed climate change adaptation measures, especially those that are not intrusive to the natural environment.

RECOMMENDATIONS

The results of the TPS give an evident picture that the tourism product has gotten to a critical point. Immediate measures are needed to reduce degradation of the Territory's natural resources and environmental quality, in particular, from climate change and other impacts to keep the tourism industry afloat.

To support these measures, one of the first actions should be the generation of funds via a mandatory "carbon" or "environmental" levy in which tourists have to pay no less than $5.00 upon entry to or departure from the Territory. At $5 per person, this levy, based on the 2008 projections of 934,268 tourist arrivals, can generate about $4,671,340 annually. $5.00 was the amount most tourists were willing to contribute to the levy on a voluntary basis. Potential revenue from implementing a mandatory levy of different amounts (and tourists' willingness to pay each amount) is provided in Table 2.1-5.

Carbon/Environmental Levy Amount	Potential Revenue	% of Tourists Willing to Pay Amount on a Voluntary Basis
$1.00	$934,268.00	8%
$5.00	$4,671,340.00	35%
$10.00	$9,342,680.00	22%
$20.00	$18,685,360.00	21%
$30.00	$28,028,040.00	1%
$50.00	$46,713,400.00	2%

Table 2.1-5. Amount of money that can be generated by collecting a mandatory carbon/environmental levy from tourists visiting The Virgin Islands. These figures were generated based on the 2008 projected tourist arrivals from the Development Planning Unit of the Government of The Virgin Islands.

There are many polices that need to be implemented immediately to reverse the degradation of The Virgin Islands tourism product and reduce climate change impacts to the tourism sector. Based on the survey results, these policies should focus most importantly on preventative measures to protect the Islands' natural beauty, resources and coastlines. Measures should take a natural and soft engineering approach unless in extreme cases where artificial reinforcement is needed. In particular, tourists' decision to revisit The Virgin Islands would be most impacted by degradation of coral reefs and beaches; every effort should be made, therefore, to protect these resources. Specific adaptation measures/policies to do so are provided in the "Risk Reduction Options" section of the VCA.

Improved disaster management and strengthening of tourism infrastructure to enhance resilience to stronger hurricanes together with improved management of dengue fever outbreaks and heat stress in the future are critical to maintain traveler confidence and avoid deterring tourists. The industry would also benefit (from immediate cost savings and enhanced visitor satisfaction) from implementing measures to conserve energy and reduce its carbon footprint. Again, specific measures to achieve these goals are provided in the "Risk Reduction Options" section of the VCA.

On a separate note, the TPS should be repeated to capture tourists at the peak of the season to produce a larger and more representative sample size and monitor changes in tourists' perception over time. The questionnaire should also be modified to include questions that ask the last time tourists visited and specific areas visited. This will help the industry and officials to get a better picture of specific issues at popular attractions and be in a better position to improve the tourism product.

2.2 | Climate Change Tourism Sector Knowledge, Attitudes and Practices (KAP) Survey

INTRODUCTION

The Virgin Islands is highly sensitive to climate change as most of its economic activities (particularly tourism) have evolved around traditionally dependable climate patterns or are impacted by climatic events – droughts, floods and hurricanes. It is an accepted fact that the global tourism sector, and in particular that of small islands, is at high risk to the phenomenon of climate change. Climate change has many direct and indirect consequences for tourism demand and supply of tourism services and, therefore, the health and viability of the industry. These consequences result from degradation of the base of the tourism product (stable climate, beaches, coral reefs, water quality, marine and terrestrial biodiversity, etc.), changes in visitor perceptions, property damages and increases in operating costs.

The Tourist Perception Survey focused on tourists visiting The Virgin Islands and the ways in which climate change impacts, including to the environment, would influence their decision to travel to tropical destinations like The Virgin Islands in the future. This section, however, focuses on tourism sector businesses in The Virgin Islands and discusses their vulnerability and adaptive potential to climate change impacts based on the findings of the Climate Change Tourism Sector Owners/Managers Knowledge, Attitude and Practices (KAP) Survey.

METHOD

The Climate Change Tourism Sector Owner's/Managers KAP Survey explored the tourism sector's general knowledge about climate change and its potential impacts to The Virgin Islands, the sector's perception of and vulnerability to climate change and these impacts, and their willing to take various actions to reduce these impacts. The questionnaire consisted of three main sections. The first collected basic information about each business, such as its type, size/capacity, location, structural integrity, experience with previous natural disasters, insurance coverage and disasters plans. The second section gathered information on general knowledge and views about climate change and its impacts. The final section focused on attitudes towards adaptation and willingness to take specific actions to reduce climate change impacts.

The Survey was conducted online via the aid of Survey Monkey (an online surveying tool). The link to complete the questionnaire was distributed by the BVI Tourist Board to managers/senior officers of tourism sector businesses such as marinas and independent charter yachts, tourist accommodation properties, tourism-focused restaurants and tour/taxi operators. The online survey was conducted over a month and a half period, starting in November and ending in December 2010.

A copy of the Climate Change Tourism Sector Owners/Managers KAP Survey is provided in Appendix 2.

RESULTS AND DISCUSSION

Business background

There was a poor response rate to the Climate Change Tourism Sector Owners/Managers KAP Survey. A total of 14 businesses participated, the majority of which were of a small to medium sized operational scale (Table 2.2-1 outlines the size/capacity of the businesses that responded to the Survey). The survey captured feedback from all sectors within the tourism industry, with some businesses representing more than one sector. Tourist accommodation properties were represented by 43% of respondents, water sports operations by 43% of respondents, the yachting sector by 36% of respondents, souvenir/gift shops by 29% of respondents, restaurants by 7% of respondents, and tour/taxi operators by 7% of respondents (see Figure 2.2-1). Because of the small sample size, the results of the survey should be interpreted and applied carefully as the sample size may not necessarily be representative of the wider industry.

Size/capacity of tourism sector establishments that participated in the Survey	
Yachting sector	
1 to 50 boats/slips	More than 50 boats/slips
5	0
Accommodations	
1 to 20 rooms	More than 20 rooms
6	0
Restaurants	
1 to 75 person capacity	More than 75 person capacity
0	1
Water sports	
Small to Medium *(using local market for comparison)*	Large *(using local market for comparison)*
5	1
Souvenir / gift shops	
Small to Medium *(using local market for comparison)*	Large *(using local market for comparison)*
3	1

Table 2.2-1. Size/capacity of tourism sector businesses represented in Survey sample. Data based on a sample size of 14 businesses. All businesses in the yachting sector and tourism

accommodation properties sector were small to medium sized establishments. Eighty three percent (83%) of water sports operators and 75% of souvenir/gift shops were also at a small to medium sized scale with the remaining 17 % and 25%, respectively being on a large scale.

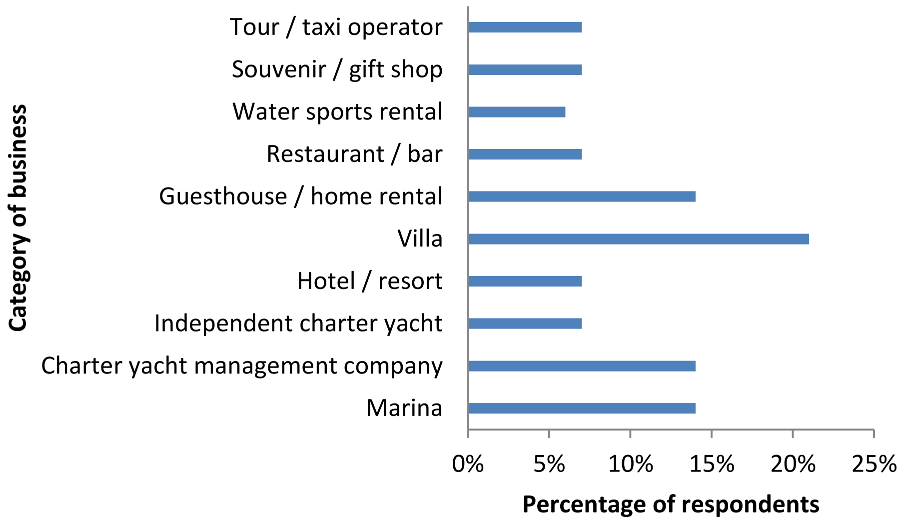


Figure 2.2-1. Percentage of respondents representing the tourism sector business categories surveyed. Data based on a sample size of 14 businesses. Some respondents represented more than one business category (i.e. some businesses are a combination of a tourism accommodation property and a souvenir/gift shop). Twenty one percent (21%) of the survey participants represented villas, 14% guesthouses/home rentals, 7% hotels/resorts, 43% water sports operations, 14% charter yacht management companies, 14% marinas, 7% independent charter yachts, 29% souvenir/gift shops, 7% restaurants and 7% tour/taxi businesses.

Vulnerability of Tourism Sector Businesses

The vulnerability of The Virgin Island's tourism sector businesses can be viewed from two perspectives; (1) a physical perspective - the integrity of the buildings that accommodate these businesses and (2) an information perspective - the businesses' knowledge, attitudes and concern about climate change and its impacts.

Location and Structural Integrity of Businesses

From a physical perspective, vulnerability of tourism sector businesses is controlled by the location and structural integrity of the buildings that house them.

Most businesses that responded to the survey are located in areas at high risk to climate change impacts. Based on their location along the coastline, eighty six (86%) percent of businesses may potentially be threatened by sea level rise, shoreline retreat and stronger storm surge. Flood risk potential to businesses was also obvious as some are located in flood prone areas (21% of respondents) or next to a natural drainage (43% of survey respondents). In fact, 75% of businesses indicated that they are currently having problems with flooding around their property (25% noted that they experience major flooding, while 50% stated that there is minor flooding around their property).

Stronger hurricanes and storm surges are predicted as a result of climate change. The structural integrity of buildings is a good proxy to determine how much impact these events would have on tourism businesses. Overall, the majority of business owners/managers perceive the structural integrity of their building as “strong” to “very strong.” On a scale from 1 to 5, where 1 represented “very weak” and 5 represented “very strong,” 93% of respondents gave their building a rating of 3 or above.

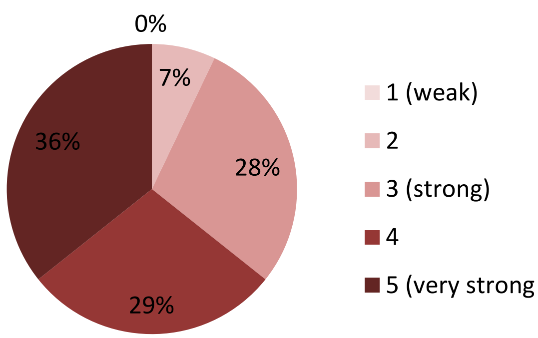


Figure 2.2-2: Building’s structural integrity for tourism businesses in The Virgin Islands. Data based on a sample size of 14 businesses. Thirty six percent (36%) of respondents rated their building as “very strong” (rating of 5), 27% gave a rating of 4, 27% gave a rating of 3 (“strong”) and 7% gave a rating of 2.

A building’s construction style (choice of roofing and windows in particular) plays a vital role in its structural integrity. In order for a building to be protected from high winds the “integrity of the building envelope, including roofs and windows” must be maintained and the structure designed to withstand strong lateral and uplift forces (Whole Building Design Guide Secure/Safe Committee, 2010).

Roof shape is, therefore, an important determining factor in vulnerability to hurricanes and flooding by extension. Wind tunnel testing has shown that “low-sloped roofs have significantly higher wind uplift forces than steeper sloped ones” (Prevatt, et al., 2010). Wind tunnel testing has also shown that “a roof with multiple slopes, such as a hip roof (4 slopes), performs better under wind forces compared to the gable roof with two slopes [or monoslopes]" (Gandemer and Hélary-Moreau, 1999). The literature also states that "gabled roofs present a flat surface to high winds; thus are more likely to suffer hurricane damage than other roof types, and can collapse if not properly braced" (Godschalk, D., n.d.). The literature concludes that a hip-roof of a cubical form is one of the best configurations to use in high wind or hurricane prone areas (Taher, 2009).

On the other hand, to avoid leakage and weakening of the structure, roofs need to be constructed to allow water to drain off as opposed to settling and penetrating the structure over time. Overall, therefore, hip roofs can be considered most resilient to the combined threat of hurricanes and floods, while the other designs can be considered more vulnerable.

Figure 2.2-3 portrays different types of roof structures including gable, gambrel, mansard, hip, flat and shed. The survey revealed that while all respondents have some form of sloping roof and are, therefore, less vulnerable to flood damage via the roof, less than half (42%) of businesses have a hip roof, the most resilient to hurricane wind damage. An equal 42% of businesses have gable roofs which the literature has identified as among the most vulnerable to hurricane wind damage. The remaining businesses have roof types (primarily shed or mansard) that are also considered more vulnerable to hurricanes (see Figure 2.2-4).

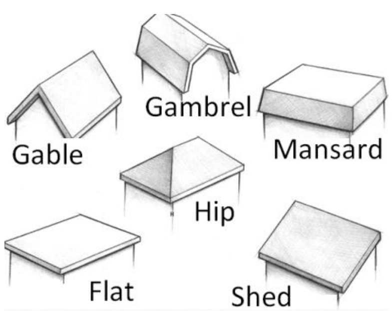


Figure 2.2-3. Types of possible roofing structures in The Virgin Islands.

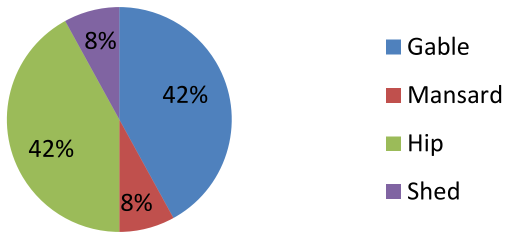


Figure 2.2-4: Roof types used in The Virgin Islands tourism sector businesses surveyed. Data based on a sample size of 12 businesses. An equal percentage (42%) of businesses have the most resilient roof form to hurricanes (hip roofs) and one of the least resilient (gable roofs). Eight percent (8%) of establishments have shed roofs and mansard roofs, both of which are also more vulnerable to hurricanes. Gambrel and flat roofs were not represented in the sample.

The type of windows each establishment has also plays a role in vulnerability. Windows that can be easily damaged puts the entire building in a vulnerable position to high winds. Although a large percentage (67%) of respondents reported having regular glass windows that can easily be damaged, these businesses also all had hurricane shutters to protect these windows. Other establishments had impact resistant glass windows (17%), wooden shutters (25%) or aluminum windows (17%). Based on these results it can be concluded that the businesses surveyed all have windows that are resilient to hurricanes.

The vulnerability of buildings is also determined by the presence and quality of supporting infrastructure. For example, drainage accommodations are essential to protect businesses in heavy rain events by diverting water from the property to reduce the risk of flooding. Just over half (54%) of respondents indicated that they have drainage mechanisms in place. To help prevent against landslides, 23% of respondents have retaining walls in place. All of these walls consist of drainage holes that allow excess water to flow out of saturated soils and thus reduce build up of water pressure and the possibility of damage to retaining walls. All businesses have paved roads preventing erosion or washing away of the access to the business.

Overall it can be said the tourism sector is vulnerable to climate change impacts, including stronger hurricanes, increased chance of flood events and landslides, stronger storm surge and sea level rise. Location is the key component of the industry's vulnerability with 86% of properties located in areas that may potentially be vulnerable to sea level rise and stronger storm surge and 64% located in areas that are already flood prone or that may flood in extreme rain events. In addition to vulnerable location, with the exception of windows, businesses have not been built with the maximum resilience to hurricane and flood events. Most business (64%)

lack the most resilient roof type (hip roof) and almost half of business lack drainage accommodations.

This vulnerability is evident in the high prevalence of previous damage to tourism businesses from natural hazards. The survey revealed that at some point all of the respondents were impacted by one or more natural hazards, including hurricane, storm surge, flood, landslide and long-term beach erosion. Hurricanes caused the most widespread physical damage (major and minor) and other impacts, followed by storm surge and floods. Figure 2.2-5 summarizes the impact previous natural disasters had on businesses within the tourism sector.

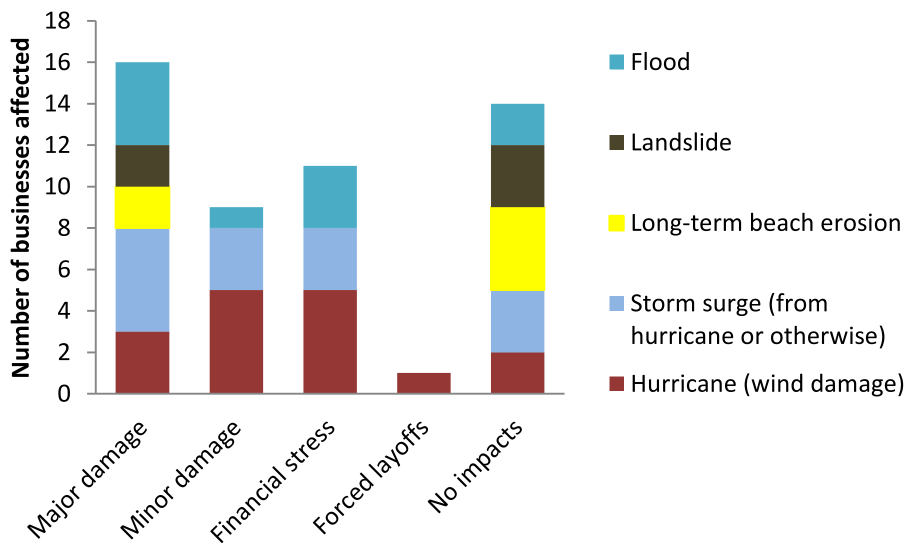


Figure 2.2-5. Impact from previous natural disasters on tourism sector businesses. Data based on a sample size of 13 businesses. At some point all of the respondents were impacted by one or more natural hazards. Hurricanes resulted in 23% of respondents reporting major damage, 38% minor, 38% financial stress and 8% forced layoffs. Storm surges resulted in major damage to 38%, minor damage to 23% and financial stress to 23%. Floods resulted in major damage to 31%, minor damage to 8% and financial stress to 23%. Both long-term beach erosion and landslides caused damage to 15% of businesses, with "major" damage being reported in all cases. In terms of "major" damage, storm surge followed by flood and then hurricane were reported to have the highest impact.

Another way to determine businesses' resilience to natural hazards as a result of climate change is their ability to access clean/drinkable water in the event that the public water supply is unavailable. Traditionally cisterns are constructed to allow each building a potable water supply that can sustain a building and its occupants during such times at minimum. Despite this, the survey revealed that only 71% of tourism businesses surveyed have access to cistern water, 7% of which have limited access (such as only in the kitchen or only on certain days).

Knowledge, Attitudes and Concern about Climate Change

Management's knowledge, attitudes and concern about climate change is one of the many factors that can determine a business's vulnerability. If businesses are aware and concerned about climate change then their resulting actions are more likely to work towards preventing or reducing impacts to their livelihood, thus making them less vulnerable.

All respondents of the questionnaire had previous knowledge about climate change (25% of survey participants indicated that they were "highly informed," while 75% reported being "somewhat informed" on the issue). All establishments knew the definition of climate change and the majority (85% of respondents) correctly identified the primary cause as energy use/production of greenhouse gases. Their knowledge was obtained in many cases via a combination of sources including, television (responsible for 85% of respondents' climate change knowledge), newspapers (85%), websites (69%), radio (46%), exhibitions (31%), email communications (31%), presentations (15%) and information packages (8%) (see Figure 2.2-6).

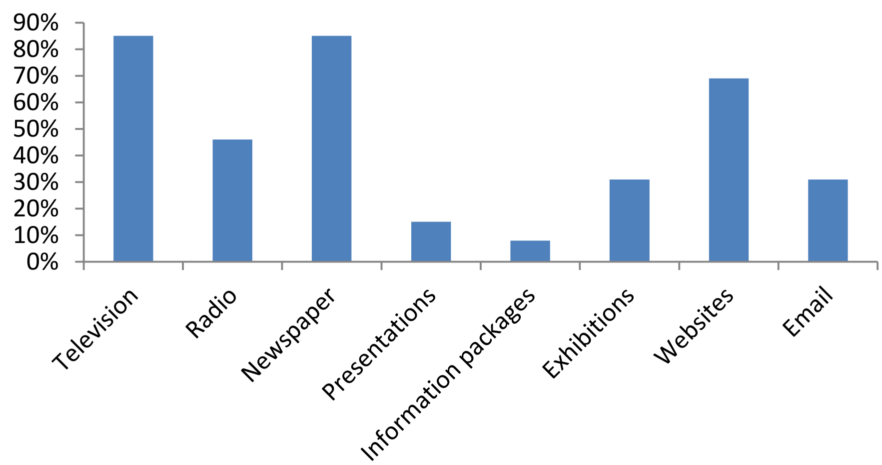


Figure 2.2-6. Respondents' sources of existing climate change knowledge. Data based on a sample size of 13 businesses. Most respondents (69% or more) had learned about climate change from television, newspapers and websites. Radio, emails and exhibitions had the second widest reach of between ~31% and 46% of respondents. Presentations and information packages reached the smallest audience, less than 15% of respondents.

The dominant view of the tourism sector is that climate change is real and already affecting the Territory. In the survey 46% of respondents thought that climate change is "real and important for us," while 92% of respondents went further to indicate that climate change is "affecting us already" (respondents were able to select multiple answers to this question). In addition to this, the level of concern respondents have about climate change is overwhelming; 85% indicated that they are "extremely concerned" while the remaining 15% were "somewhat concerned".

The majority of tourism businesses were able to identify the actual potential climate change impacts to The Virgin Islands. Of all the actual potential climate change impacts, only "increased dengue fever outbreaks" (15%) and "water shortages" (8%) were incorrectly identified by respondents as not being a local impact of climate change. In all cases between almost half (46%) and all of respondents were "extremely concerned" about climate change impacts identified. The impacts of most concern are "decreased tourism demand for the Territory" (100%), "coral bleaching" (92%) and "stronger hurricanes" (92%). Respondents were least concerned about a "greater demand for green tourism destinations" and "water shortages" (see Figure 2.2-2).

Potential Impacts	Extremely Concerned	Somewhat concerned	Not Concerned	Not Local Impact of Climate Change
*Decreased tourist demand for BVI	100%			
*Coral bleaching	92%	8%		
*Stronger hurricanes	92%	8%		
*Beach erosion	77%	23%		
*Increase energy cost	77%	23%		
*Migration of important fishes	77%	23%		
*Rising temperatures	77%	15%	8%	
*Increase damage to tourist infrasturcture/properties	69%	23%	8%	
*More frequent floods	69%	23%	8%	
*Sea level rise	69%	15%	15%	
*Loss of biodiversity	69%	23%		
*Increase dengue fever	62%	15%	8%	15%
*Increase insurance cost	54%	31%		
*Greater demand for "green" tourism destinations	46%	54%		
More tsunamis	46%	31%	15%	8%
Stronger earthquakes	46%	31%	15%	8%
*Water shortages	46%	23%	23%	8%
Increase in tourist spending	38%	23%	8%	23%
More volcanic eruptions	23%	38%	23%	15%
Cooler winter months	15%	62%	15%	8%
Black sand beaches	15%		46%	38%

Table 2.2-2 Tourism sector's knowledge and concern about local climate change impacts. Based on a sample size of 13 businesses. The majority of respondents were able to identify the actual potential impacts of climate change to The Virgin Islands (indicated by an asterisk *) and are greatly concerned about most of them.

All respondents were also able to make a connection between expected changes in climate and impacts to their businesses, with 75% recognizing a direct linkage and 25% seeing an indirect link. They independently identified health impacts, decline in tourism (and hence their businesses), increase in utility bills and effects of natural disasters as ways in which climate change will affect their businesses.

There is also a high willingness among tourism sector managers to learn more about climate change and the impacts it will have on tourism and consequently their businesses (85% of participants indicated that they would like to know more). Knowledge about climate change can be shared within this sector by many means, however, when asked to indicate their preference for learning more, the most popular methods were by presentations, exhibitions, websites and e-mails, (23% of respondents indicated that they prefer each of these means). Television and newspaper media from which existing knowledge was most commonly gained was less popular with only 15% of respondents preferring either means. A small percentage of respondents also opted for "new" media including newsletters, workshops and video distribution (see Table 2.2-3 and Figure 2.2-7 below).

Preferred method of learning more about climate change	% of Respondents
Presentations	23%
Exhibitions	23%
Website	23%
Email	23%
Television	15%
Newspaper	15%
Information packages	15%
Workshops	15%
Newsletter	15%
Video distribution	8%
Radio	8%

Table 2.2-3. Respondents' preferences for learning more about climate change. Data based on a sample size of 13 businesses. The most popular media for learning more about climate change were electronic media (websites and email, both selected by 23% of respondents) and more interactive/hands on media, including exhibitions and presentations (also each selected by 23% of respondents. Traditional print media - information packages (15%), newsletters (15%),

newspaper (15%), television (15%), workshops (15%), radio (8%) and video distributions (8%) were less popular.

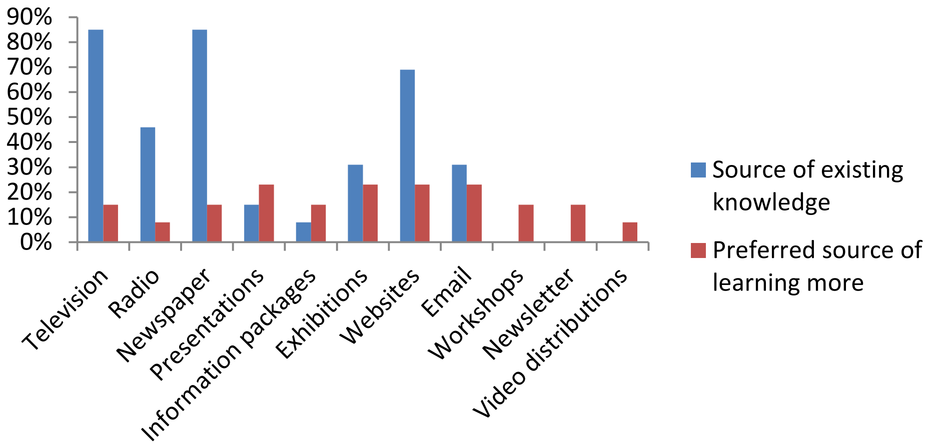


Figure 2.2-7. Comparison between sources of existing knowledge on climate change and sources from which respondents would like to learn more. Data based on a sample size of 13 businesses. The most common sources of existing knowledge were television, newspaper, and websites. Websites remained among the most popular choices for learning more accompanied by email communications, exhibitions and presentations. The ideal education strategy would incorporate the media that have been most successful in the past with the media most preferred by the tourism sector for continued learning.

The solid knowledge base, positive attitudes, high level of concern and willingness to learn more about climate change among the tourism sector should decrease its vulnerability to climate change impacts, provided the sector is willing to take actions in line with their knowledge, attitudes and concerns. This aspect is discussed below.

Given the method of Survey distribution (email) and the low response rate, there is a possibility that the results to this section of the survey in particular could be skewed to some degree, with persons more aware and concerned about climate change opting to respond to the survey from the pool of persons receiving the email.

Climate Change Adaptation

Natural Disaster Preparation and Recovery Plans

Previous experience with natural disasters among businesses in the tourism sector has in the majority of cases resulted in major damages (experienced by 62% of businesses) and financial stress (experienced by 38% of businesses). The cost of recovering from major damage is extremely high; analysis from the Caribbean has shown that reconstruction costs can be as much as 40% of the original investment (CANARI, 2008 a).

Natural disasters are predicted to have higher and more costly impacts as a result of climate change. Disaster plans and access to finances (from insurance or savings) to prepare for and recover from natural hazards is a key adaptation action for businesses to minimize major damage and financial stress. The survey revealed that the clear majority (79%) of respondents has a plan to prepare for natural hazards and 64% have a plan for recovery. Establishments which do not currently have a preparation/recovery plan in place (21% of respondents) indicated their interest in obtaining one.

The availability of funds to adequately prepare for and quickly recover from natural disasters is another key adaption measure for businesses. Although there are a significant number of businesses that have insurance for at least hurricanes (86%) and extra funding (64%) to prepare for and recover from a disaster, there is still need for improvement. Figure 2.2-9 shows the percentage of businesses that have insurance coverage for hurricanes, landslides, floods and storm surges. The figure shows that while the rate of insurance against hurricanes is high (86% of respondents), it is relatively low for other hazards (between 21% and 36%) which have historically had high impact and resulted in financial stress.

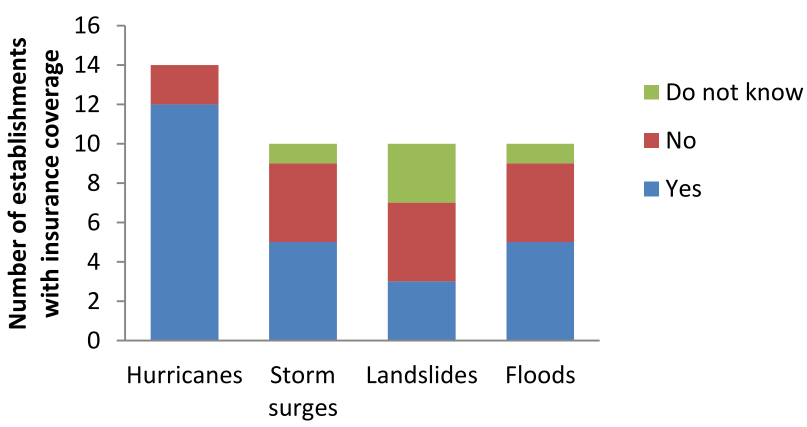


Figure 2.2-8 Insurance against natural hazards in The Virgin Islands among tourism sector businesses. Data based on a sample size of 14 businesses. The majority of businesses are insured against hurricanes (86% - 12 out of 14 respondents). 36% (5 out of 14 businesses) are insured against storm surges and floods while 21% (3 out of 14 businesses) are insured against landslides.

There are many actions that business owners can take to adapt to climate change and reduce its impacts. Fifty percent (50%) or more of businesses reported to be already taking the following adaptation measures: maintaining good sanitation to reduce risk of mosquitoes breeding (92%), disposing of solid waste and sewage properly (85%), conserving water/increasing efficiency (77%), avoiding operating in hazard prone areas (69%), purchasing adequate insurance against natural disasters (69%), having a plan to prepare for and recover from hurricanes and floods (69%), avoiding anchoring on or touching coral reefs (69%), minimising business' overall impact on the environment (54%), conserving energy/increasing efficiency (54%) and paving the access to business properties (54%) (see Table 2.2-3 below).

For the most part, where actions are not currently being taken, there is a relatively high willingness to take them in the future. More than half of respondents were willing to build industry and political support for key actions (57%) and participate in relevant "green" certification programmes (62%). Just under half (46% each) were willing to conserve energy/increase efficiency and use renewable energy sources. Relatively few (less than 25%) of businesses indicated needing support to take any one particular action identified. Most support is needed for building hurricane and flood proof structures and improving drainage around properties to reduce flood risk (see Table 2.2-4).

Actions	% of respondents already taking action	% of respondents willing to take action	% of respondents not willing to take action	% of respondents need support in taking action
Avoid operating in hazard prone areas	69%	-	-	-
Build hurricane and flood proof structures	46%	8%	-	23%
Improve drainage around property to reduce flood risk	38%	23%	-	23%
Purchase adequate insurance against natural disasters	69%	15%	8%	15%
Have a plan to prepare for and recover from hurricanes / floods	69%	31%	-	-
Minimise business' overall impact on the environment	54%	38%	-	8%
Pave the access to the business property	54%	8%	-	-
Maintain good sanitation to reduce risk of mosquito breeding	92%	8%	-	-
Avoid anchoring on or touching coral reefs	69%	15%	-	-
Dispose of solid waste and sewage properly	85%	8%	-	8%
Build industry & political support for key actions	15%	62%	-	15%
Conserve energy / increase efficiency	54%	46%	-	15%
Use renewable energy sources e.g. solar/wind	38%	46%	-	15%
Conserve water / increase efficiency	77%	8%	8%	8%
Participate in relevant "green" certification programmes E.g. Green Globe and Blue Flag	31%	62%	-	15%

Table 2.2-4 Tourism sector businesses' current participation in and willingness to take climate change adaptation actions. Data based on a sample size of 13 businesses. A significant percentage of establishments are already taking one or more actions that will reduce their vulnerability to climate change. For those that are not, many are willing to do so.

The survey explored energy and water conservation/efficiency practices within the tourism sector in more detail. Table 2.2-5 shows the percentage of businesses that are currently using various energy and water conservation/efficiency practices and appliances. The results show that while water and energy conservation/efficiency is being practiced by some businesses within the sector, they are still in the minority and there remains room for much improvement in this area. Of the 11 water and energy conservation/efficiency measures listed, only 4 were being utilized by 50% or more of businesses.

In terms of energy efficiency this included use of energy saving light bulbs (64%). In terms of water conservation/efficiency these include use of "green landscaping" (75%), use of front loader washing machines (67%) and use of low flush toilets (50%). Surprisingly, low flush toilets that are now standard in many countries are still only utilized by 50% of businesses surveyed. Other inexpensive and easily accessible means of reducing water and energy use, including aerated faucets, low flow showerheads and energy star appliances are also underutilized (used by 25%-36% of respondents) (see Table 2.2-5).

The high percentage of businesses that either claim to already be taking or willing to take measures to reduce water and energy use suggests that lack of awareness of the range of measures available to reduce energy and water use may be playing an important role in inaction.

Water/energy conservation/efficiency measures	Yes	No	Don't know	Less than 50% (of fixtures/energy supply)	More than 50% (of fixtures/energy supply)
Smart design faucets (e.g. timed/metered or motion sensitive)	18%	55%	27%	-	9%
Aerated faucets (use 0.5 - 2.75 gals/min vs. standard faucets at 3.5 -7 gals/min)	36%	36%	27%	-	-
Low flow showerheads (use 1.5 – 2.5 gals/min vs. standard showerheads at 4.5 - 8 gals/min)	36%	64%	-	9%	-
Low flush toilets (use 1.6 gals/flush vs. standard toilets at 5 gals/flush)	50%	50%	-	-	-
Waterless urinals, dual flush toilets, composting toilets	18%	72%	9%	-	-
Front loader washing machines (use 25-30 gals/load vs. a standard top loader at 35-55 gals/load)	67%	25%	8%	-	7%
Energy saving light bulbs (compact fluorescent light bulbs)	64%	36%	-	-	-
Energy star appliances	27%	55%	18.2%	9%	-
Alternative energy (e.g. solar, wind)	27%	73%	-	-	-
Green landscaping (e.g. smart sprinkler system, mulching, drought tolerant plants)	75%	25%	-	8%	-
Green design (to maximise natural cooling and lighting)	36%	64%	-	-	-

Table 2.2-5 Percentage of tourism sector businesses currently using various forms of water and energy conservation/efficiency. Data based on different sample sizes - "low flush toilets" were based on a sample size of 10 businesses; "smart design faucets", "aerated faucets", "low flow showerheads", "waterless urinals," "dual flush toilets", "energy saving light bulbs", "energy star appliances", "alternate energy" and "green design" were all based on a sample of 11 businesses; and "front loader washing machines" and "green landscaping" were based on a sample size of 12 businesses. There is still substantial room for improvement in energy/water conservation and efficiency within the tourism sector.

When asked what factors that would hamper businesses taking the indentified adaptation actions, the most commonly selected factor was lack of finances (62% of respondents) followed by lack of human resources (54%) and lack of specific information (37%). Other priorities (8%) played a minor role in inaction while other undefined circumstances affected 23% of respondents.

Despite recognizing their hindrances to taking adaptation actions, all respondents maintained a very proactive view on adaptation, indicating that early actions need to be taken to reduce impacts, even if they are most costly. They also all agreed that everyone (government, businesses, community organizations/NGOs and individuals) has their part to play in reducing climate change impacts to the Territory. Eight two percent (82%) of respondents further noted that they would participate in stakeholder consultations to develop strategies in response to climate change impacts on the tourism sector; this is important as the most successful adaptation measures are those developed with the input of stakeholders.

The generation of funds to help The Virgin Islands implement climate change adaptation strategies and protect the environment is vital. A carbon/environmental levy on tourists has been suggested as one means of raising adaptation funds. About half (54%) of respondents are in support of this approach. Of the supporters, 67% preferred a collection amount of $1.00 per person, 17% suggested $10.00 per person and 17% stated $20.00 per person. The clear majority of supporters would prefer the levy to be collected at ports of entry (71% of supporters prefer this). Collection at ports upon departure and at tourist accommodation properties were equally favoured by 14% of respondents.

CONCLUSION

Businesses in The Virgin Islands tourism sector are aware of and concerned about climate change and its present and future impacts on the Territory. The sector is physically highly vulnerable to climate change impacts due to the hazard prone areas in which businesses are situated. Results shows that the sector is physically highly vulnerable to climate change impacts as tourism businesses are concentrated in natural hazard prone areas and are not built in the most climate resilient fashion possible; all survey respondents reported previous damage from climatic events and beach erosion, many reporting “major damages.”

Although some businesses have a reasonable capacity to prepare for or recover from the impacts of natural disasters, there still needs to be improvement in this area to increase resilience. The sector acknowledges the need for improvements and is already participating in or willing to participate in a number of adaptation actions. The sector is also willing to work with government to help design adaptation polices and strategies for tourism.

Funding is an important limiting factor hindering businesses from taking the necessary actions in response to climate change. This problem can be addressed by introducing a carbon/environmental levy on tourists. Even with a contribution of a dollar per person, The Virgin Islands can raise a substantial amount of money annually to help fund adaptation.

2.3 | CLIMATE CHANGE GENERAL PUBLIC KNOWLEDGE, ATTITUDES AND PRACTICES (KAP) SURVEY

INTRODUCTION

Information on physical vulnerability to natural hazards and the publics' knowledge, attitudes and practices in regards to climate change is important for better understanding the potential magnitude (physical and financial) of climate change impacts to the Territory.

Understanding the vulnerability of the wider community to climate change impacts is important as tourism depends on the resilience of the entire Territory and not just those operating in the tourism sector.

The Climate Change General Public Knowledge, Attitudes and Practices (KAP) Survey examined what the community knows about climate change, their vulnerability to climate change impacts, their perception of and concerns about the issue and their attitudes about adaptation, including what actions individuals themselves would be willing to take to reduce expected climate change impacts.

METHOD

The Climate Change General Public KAP Survey was divided into four sections. The first section captured background information on respondents such as their age, gender and education level as well as their historic resilience to natural hazards. The second section of the questionnaire captured respondents' knowledge of climate change and its impacts while the third section focused on respondents' views and concerns about the issue. The last section focused on attitudes towards climate change adaptation, including what actions respondents would be willing to take to reduce climate change impacts to the Territory.

The Survey was targeted at adults (18 years of age and older) and was distributed to a wide cross-section of the public via the aid of many businesses such as medical offices, travel agencies, trust companies, insurance agencies and hair salons/barber shops. Schools also assisted in the distribution of the survey by having parents of students fill out the questionnaire. Questionnaires were in rotation from August 2010 to October 2010.

A copy of the Climate Change General Public KAP survey is provided in Appendix 3.

RESULTS AND DISCUSSION

Background Information

The General Public KAP survey generated a total of 253 responses with an even ratio of males and females. Most of the respondents fell into the age range of 31-40 years. The majority of respondents (68%) had achieved either an Associate's or Bachelor's Degree. Figures 2.3-1 and 2.3-2 show the breakdown of the respondents' age group and education level.

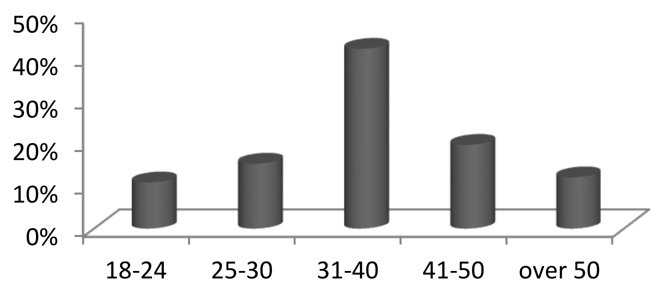


Figure 2.3-1 Age range of survey respondents. Data based on a sample size of 249 persons. Most respondents (62%) were middle aged (31 -50 years). 11% were 18–24 years, 15% were 25–30 years and 12% over 50 years.

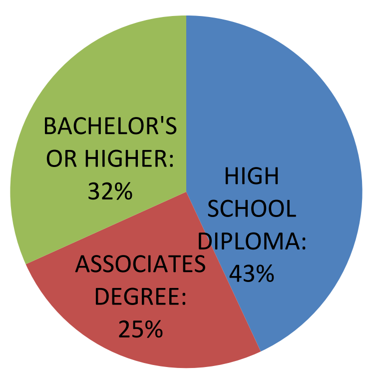


Figure 2.3-2 Educational background of survey respondents. Data based on 230 persons. 43% of respondents' highest level of education was a High School Diploma, 25% an Associate's Degree and 32% a Bachelor's Degree or higher.

Resilience to Natural Hazards

Currently, at least 23% of respondents live in locations that can generally be considered at risk to natural hazards that are predicted to become more severe as a result of climate change. Nine percent (9%) of respondents live immediately along the coastline which makes them susceptible to stronger storm surges and in the future to sea level rise. Four percent (4%) of respondents live in flood prone areas while 9% live next to a natural drainage (ghut). In heavy rain events ghuts can overflow (due to excessive debris) and hence cause flooding to adjacent lands. Lands adjacent to ghuts also tend to be prone to landslides. A mere one percent (1%) of respondents resides on a boat (see Figure 2.3-3). Of the 49% of respondents that live on a hill, a percentage of these may also be vulnerable to landslides, however this cannot be deduced from the data.

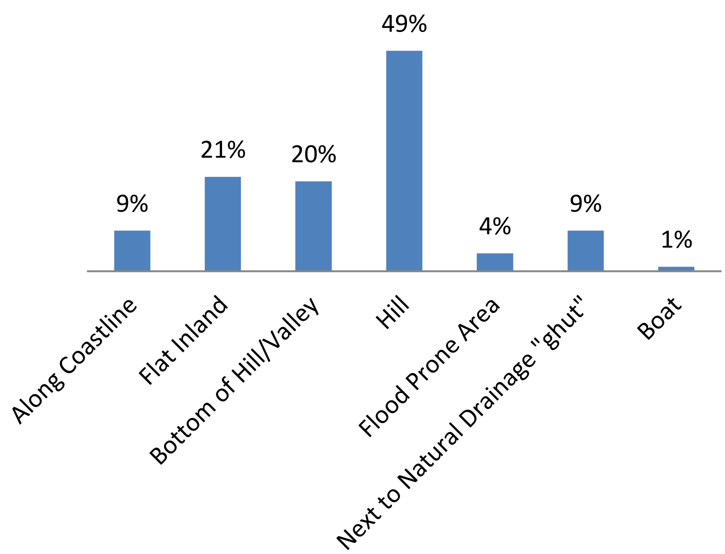


Figure 2.3-3 Geography of area where survey respondents live. Data based on 252 respondents: 49% reside on a hill, 21% on a flat surface inland, 20% at the bottom of a hill/valley, 9% immediately along the coastline, 13% in flood risk areas (4% flood prone, and 9% next to a ghut) and 1% on a boat.

The construction style of homes plays a vital role in determining a community's resilience to natural hazards such as hurricanes (and associated floods) which are predicted to become stronger as a result of climate change. The roof and windows of a building, in particular, are key to protecting homes. In the event of damage to these parts of the building, household members are at higher risk of injury, damage to the interior of their homes and financial strain to replace damaged property.

The survey revealed that 45% of respondents have homes with flat concrete slab roofs while 34% have hip roofs. Together, therefore, 79% of respondents have the two types of house roofs known to be most resilient to wind damage in hurricanes (see Figure 2.3-4). While highly effective against wind damage, flat concrete slap roofs can cause gradual weakening of the structure as water settles, seeps through and causes corrosion over time.

Whereas the majority of respondents have roofs that can be classified as resilient to wind damage, a high percentage of respondents have windows that are vulnerable to high wind impact. Sixty seven percent (67%) of respondents' homes have regular glass windows, 26% have impact resistant glass windows, 9% have aluminum windows and 3% have wooden shutters. Of all respondents only 26% stated that they have hurricane shutters. While impact resistant glass windows reduce the risk of damage during hurricanes, they are still vulnerable to damage from airborne objects and the like in a hurricane. On the other hand, aluminum windows, wooden shutters and hurricane shutters can be considered resilient and are only possessed by roughly a third (38%) of respondents (see Figure 2.3-5)

At the time of this survey, 52% of respondents had experienced wind damage from hurricanes, with 14% reporting major damages. Most storm surge events experienced in The Virgin Islands have been associated with hurricanes. Thirty five percent (35%) of respondents reported damage from storm surge with 3% suffering major damage (see Figure 2.3-7).

Overall, the housing stock can be considered relatively resilient to wind damage from hurricanes, especially roofs. While the majority of windows (~67%) can be considered vulnerable to wind damage, historically actual damage has been reduced by the community's general good practices to prepare for hurricanes, including protecting glass windows with sheets of ply board.

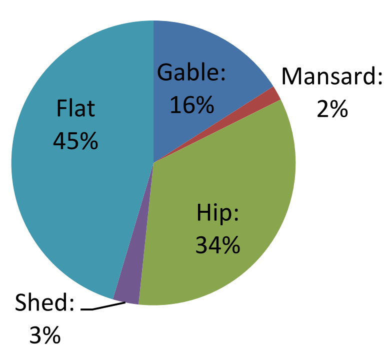


Figure 2.3-4 Roof types on homes of survey respondents. Data based on a sample size of 236 persons. 45% of homes have flat roofs, 34 % hip, 16% gable, 3% shed and 2% mansard.

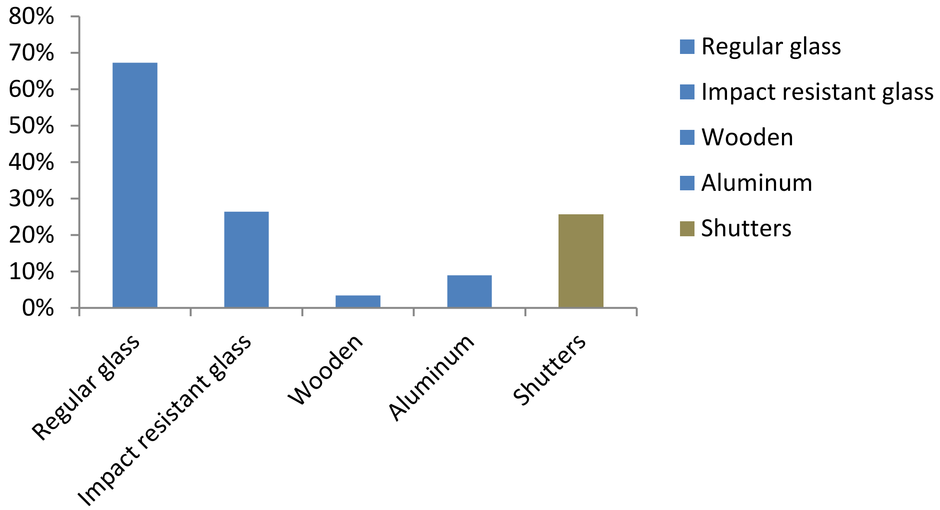


Figure 2.3-5 Windows types in the homes of respondents. Data sample size based on 235 persons for window types and 203 persons for shutters. 67% have regular glass windows, 26% impact resistant glass windows, 9% aluminum windows and 3% wooden shutters. 26% of respondents have hurricanes shutters.

Over the past 7 years (since 2003) flood events have been a regularly occurring natural hazard in The Virgin Islands. While the local climate assessment does not provide any strong evidence that the frequency of flood events will increase with climate change, more severe flood events may be experienced from the stronger hurricanes predicted to threaten the region. The survey data shows that more than a third of homes (38%) currently have poor drainage in their yards manifested by pooling of water in rain events (6% reported major pooling while 32% reported minor pooling; see Figure 2.3-6). At the time of this survey 41% of respondents had experienced damage from floods, with just over a quarter (28%) reporting major damages. The prevalence and severity of damage from floods was greater than for any other natural hazard reported (see Figure 2.3-7).

Previous flood events have resulted in significant damage and so should not be taken lightly. For example, the November 2003 flood in which an average of 20 inches of rain fell in 5 days resulted in total losses (response/relief costs, rehabilitation costs, and reconstruction costs) estimated at US$19,147,898 (DDM, 2003). In addition to direct physical damage to homes and infrastructure, floods can result in seepage of sewage from septic systems (the primary means of sewage treatment in residential areas) and from the sewage collection system in Road Town. This results in a major health hazard and pollution of coastal waters (in addition to sedimentation), thereby negatively impacting coastal protective barriers (coral reefs) and fish populations.

The combination of survey results (38% of homes with poor drainage and 41% already having experienced flood damage) indicates that a significant portion of the community is vulnerable to flood events. This has been evidenced by the high degree of damages recorded by the Department of Disaster Management from previous flood events.

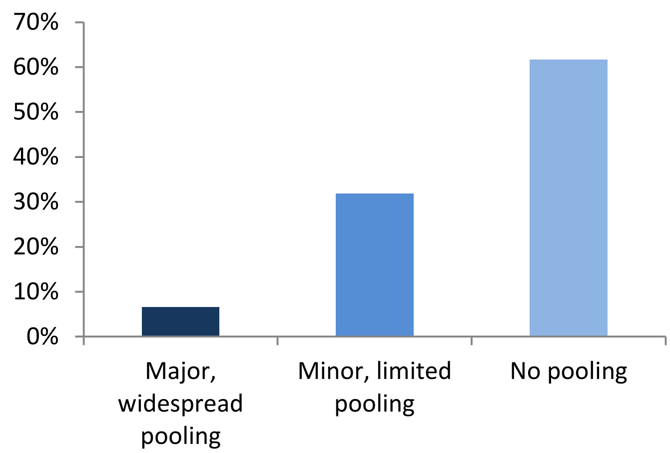


Figure 2.3-6 Percentage of respondents who are currently experiencing pooling of water in their yard during rain events. Data based on a sample size of 245 persons. 6% experience major pooling, 32% minor pooling, while 62% experience no pooling at all.

Flood events are commonly accompanied by landslide events as the shallow layer of the Islands' soil quickly becomes saturated. A large percentage of homes (49%) are potentially exposed to landslide risk as they are located on hillsides.

A common measure to protect homes against landslide events is retaining walls. The presence of drainage holes within retaining walls is important as they allow excessive water from saturated soils to runoff, thereby reducing the likelihood of the wall collapsing due to increased water pressure. The survey revealed that a high percentage (43% - almost equal to the percentage of homes located in hills) have retaining walls, with 87% having drainage holes. While the majority of homes have some measure of protection against landslides, these measures may fail in very heavy rain events. At the time of this survey, 32% of respondents had experienced damage from landslides, with 7% reporting major damages.

Figure 2.3-7 below provides a comparison of previous damage incurred from hurricanes (wind damage), storm surge, flooding and landslides.

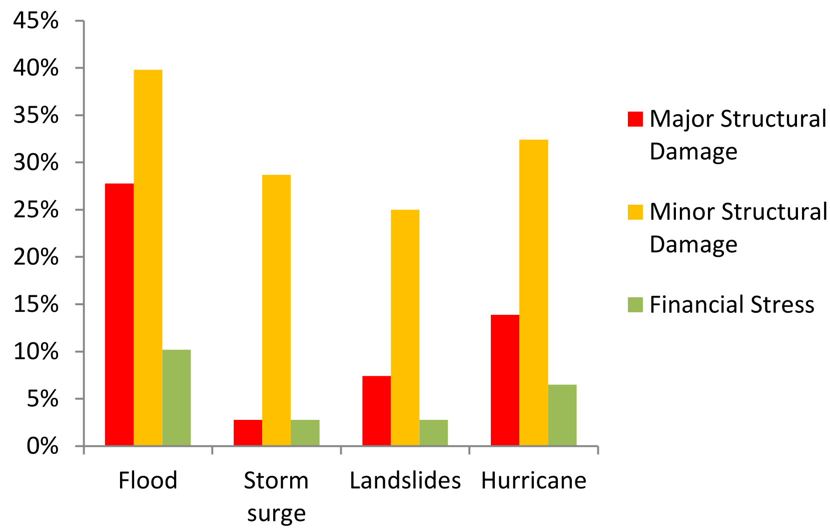


Figure 2.3-7 Previous damages incurred by respondents from natural hazards. Data based on a sample size of 108 persons. Flooding has affected more respondents and caused more major damage than any of the other hazard identified. 41% of respondents reported some sort of flood damage; 28% reported having major structural damage to their homes, 21% minor damage and 10% financial stress. Hurricanes caused damage to 28% of respondents, with 14% reporting major damage, 16% minor damage and 6% financial stress. Storm surges resulted in 3% reporting major damages, 11% minor damages and 3% financial stress. Landslides was approximately along the same line as storm surges with 7% indicating major damages, 6% minor damages and 3% financial stress.

Climate Change Knowledge, Views and Concerns

Apart from the physical aspect, the community's knowledge, attitude and concerns about climate change play a major role in determining vulnerability. Knowledge of projected changes in climate and expected impacts is an important factor in forming views and attitudes among the community that will hopefully result in actions to minimize impacts.

The survey results show that the public has relatively good knowledge of climate change basis (definition and key changes), but are less aware of the details. The majority lack a deep understanding of the issue, such as the impacts of changes across various sectors. The majority of participants (82%) reported being "somewhat informed" on the issue while only 10% reported being "highly informed".

The clear majority of respondents (94%) were able to identify the correct definition of climate change. However, only 39% were able to correctly identify the primary cause of climate change as energy use/production of greenhouse gases (see Figure 2.3-8). Most other respondents primarily attributed climate change to natural cycles (a theory put forward by some) and the ozone hole (a common misconception). This in turn begs the question: if the public becomes conscious of the main contributor to climate change, would they reduce their energy usage or better yet turn to renewable energy sources (e.g. solar)?

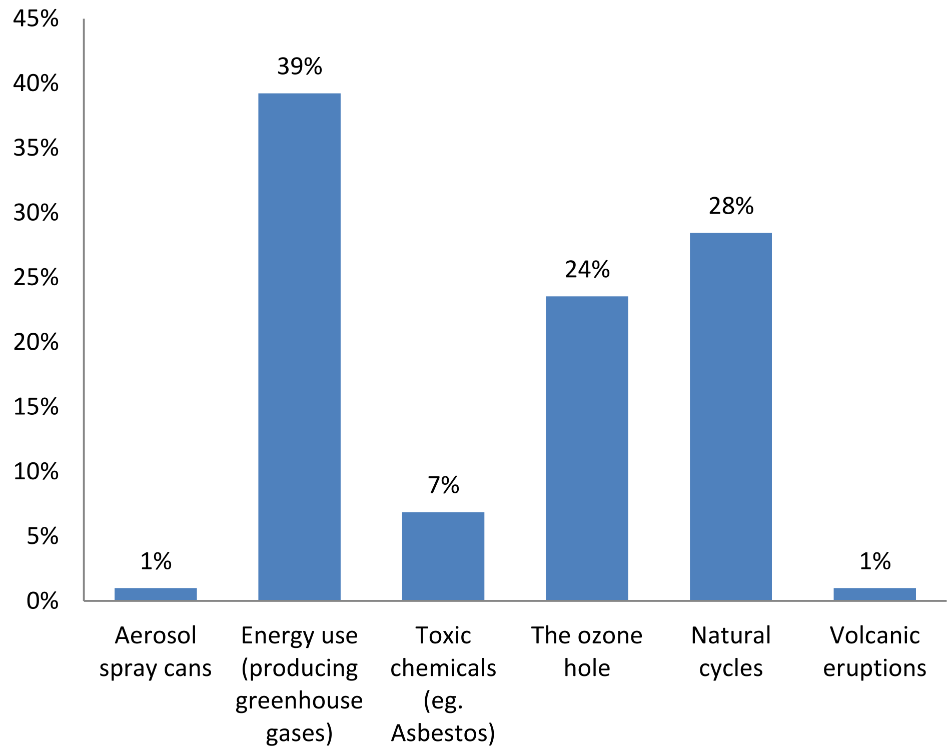


Figure 2.3-8 Respondents' opinion on the primary contributor to climate change. Data based on a sample size of 204 persons. Only 39% were able to correctly identify the main cause of climate change (energy use). 61% indicated some other factors such as natural cycles (28%), the ozone hole (24%), toxic chemicals such as asbestos (7%), aerosol spray cans (1%) and volcanic eruptions (1%).

There are many impacts that can arise as a result of climate change. The public can only safeguard themselves against these impacts if they are aware of them. Table 2.3-1 shows the response from the Survey in which participants were asked to identify the local impacts of climate change. Although the majority (between 50% and 78%) of respondents were able to distinguish the major physical changes/impacts such as stronger hurricanes, rising temperatures, flood events, sea level rise and beach erosion; outside of infrastructural and utility based impacts (identified by between 53% - 60% of individuals), a concerning majority (33% to 76%) still lack the linkage between these changes and other impacts, especially irreversible and already occurring impacts to the environment and health. Incorrect climate change impacts were in most cases selected by the lowest percentage of respondents (19% to 40%). The percentages, however, are higher than desired and indicate that more work needs to be done to educate the public about the primary and secondary impacts of climate change.

Impacts	% of respondents selecting impact
*More frequent floods	77%
*Stronger hurricanes	78%
*Rising temperatures	76%
*Beach erosion	62%
*Sea level rise	61%
*Water shortages	60%
*Increased energy costs	58%
*Increased damage to tourism infrastructure/properties	53%
*Increased insurance costs	50%
*Increased dengue fever	45%
*Less tourists seeking winter getaways	46%
*Coral bleaching	44%
*Migration of important fish	43%
Stronger earthquakes	40%
*Less overall rainfall	38%
More tsunamis	36%
*Loss of biodiversity	33%
More volcanic eruptions	30%
Increase in tourist spending	21%
Black sand beaches	19%

Table 2.3-1 Respondents' knowledge of climate change impacts to The Virgin Islands. Data based on sample size of 212 persons. The asterisk (*) represents the correct climate change impacts to The Virgin Islands.

In addition, the majority of respondents remain only "somewhat informed" (79%) or "not informed" (20%) about the Territory's involvement in the Enhancing Capacity for Adaptation to Climate Change in the UK Overseas Territories (ECACC) Project in collaboration with the Caribbean Community Climate Change Centre. Only 1% of survey respondents reported being "highly informed" (based on a 102 respondents).

There are a considerable number of persons (92% of respondents) who are willing to learn more about climate change, with the most popularly desired mode for continued learning being by television (66% of respondents). The least popular modes identified for learning more were video distribution and email. A number of other modes for sharing information followed closely behind television (selected by 39%-50% of respondents), including radio, newspapers, lectures/presentations, brochures/information packages, exhibitions, workshops and websites (see Figure 2.3-9).

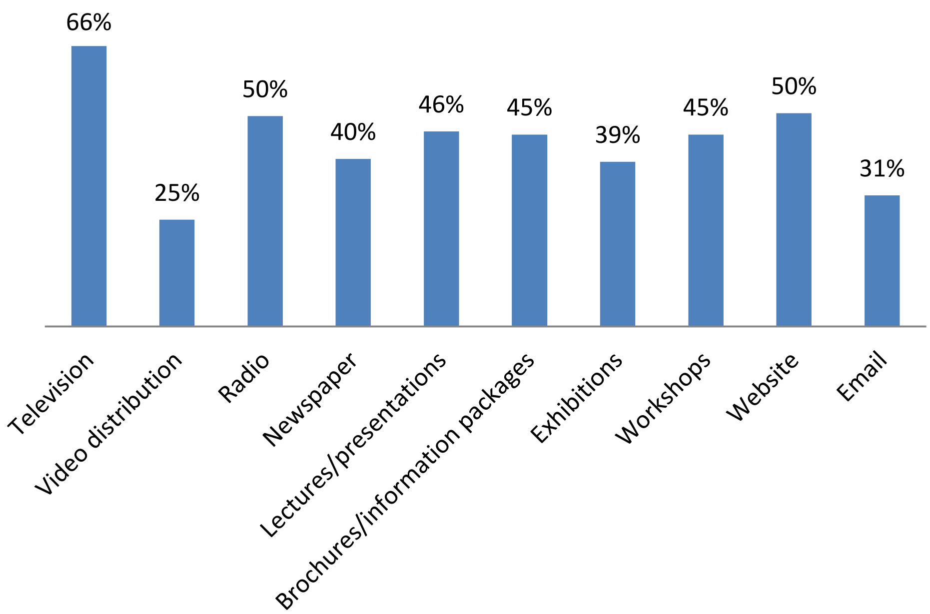


Figure 2.3-9 Respondents' preferences for learning more about climate change in The Virgin Islands. Data based on a sample size of 139 persons.

While not fully aware of all of the impacts of climate change, the public is able to make a personal connection to the issue. The majority (81%) stated that they would be directly affected by climate change, while 31% stated that they would be indirectly impacted. Only 7% indicated that climate change will have no effect on them. Persons were able to independently link climate change to impacts to property and infrastructure, food supplies, the economy (via tourism), increase in their utility and insurance bills, increase in flooding and hurricanes events, power outages, displacement of family members, health and weather patterns in general.

There are a substantial number of persons (75% of respondents) who are conscious of changes in The Virgin Islands weather pattern over the last 5 – 10 years, most pointing out the increase in rainfall and flood events locally and hurricane threats regionally.

Respondents' knowledge of climate change has resulted in healthy views and concerns about the issue. This is important because even with knowledge, if persons are not convinced that climate change is real and are not concerned about the issue, then their motivation to safeguard themselves from impact would be absent. While the results are encouraging, they also indicate that more needs to be done to make the community aware of the local relevance of climate change.

Almost all respondents (97%) are convinced that climate change is real. Of these, 51% feel the issue is important to us in The Virgin Islands and 68% note that it is affecting us already; only 3% feel it is real, but not important to us (respondents were able to selection multiple answers). Another 2% stated that climate change is not real (see Figure 2.3-10). The majority of respondents (96%) is at least "somewhat concerned" about climate change; of these 54% are "highly concerned". Only 4% of respondents are not concerned (see Figure 2.3-11).

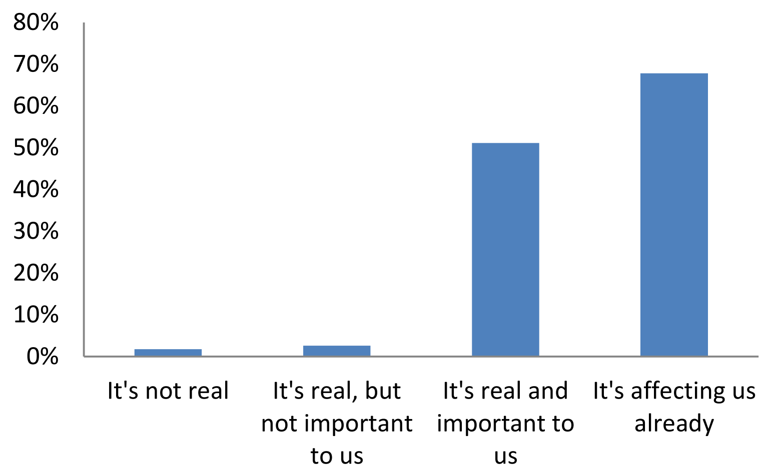


Figure 2.3-10 Respondents' views on climate change. Data based on a sample size of 233 persons. Two percent (2%) of respondents stated that climate change is not real, 3% noted that it is real but not important to us, 51% acknowledged that it is real and important to us, and 68% noted that it's affecting us already.

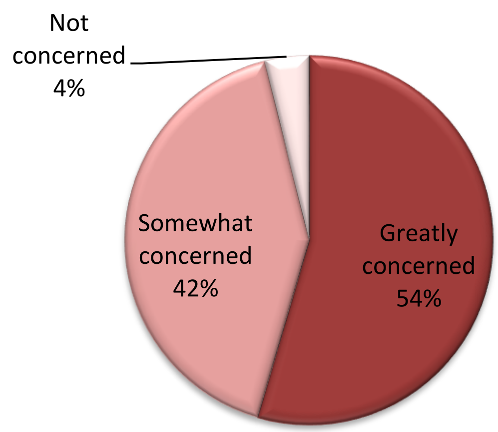


Figure 2.3-11 Level of concern respondents have about climate change. Data based on a sample size of 233 persons. 54% were "greatly concerned," 42% were "somewhat concerned" and 4% "not concerned."

Climate Change Adaptation

An important measure of the adaptive capacity is a community's ability to prepare for potential impacts and recover from those sustained, especially from natural hazards, as these are estimated to become more severe as a result of climate change. In this regard, a disaster plan, access to finance for preparation and recovery, and access to a three day supply of clean water after an event are essential.

Disaster preparation and recovery plans are very important to reduce vulnerability to climate change. The public expressed limited confidence in the disaster preparedness status of The Virgin Islands as a Territory with only 4% of respondents stating that The Virgin Islands is "well prepared" to handle strong hurricanes and floods; 43% stated that the Territory is "somewhat prepared" and the largest group, 53%, stated that the Territory is "not prepared" (see Figure 2.3-12).

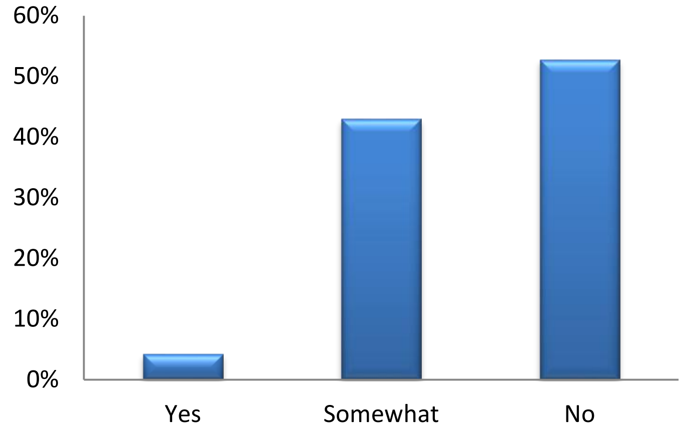


Figure 2.3-12. Respondents' opinion on The Virgin Islands preparedness to deal with natural disasters, such as strong hurricanes and floods. Data based on a sample size of 235 persons. 4% believe that the Territory is "well prepared," 43% think that the Territory "somewhat prepared," while 53% think that the Territory is "not prepared."

On a personal level, only 24% of respondents reported having a hurricane preparation and recovery plan. Thirty two (32%) of individuals were willing to develop a plan, but the majority of these (24%) would need support in doing so (see Table 2.3-2). The survey also showed that one of the most limiting factors as it relates to the preparation for and recovery from natural hazards is the availability of funds and ownership of an insurance policy. Only 29% of respondents reported being insured against hurricane events, 16% against storm surges, 17% against landslides and 23% against floods. Roughly half of survey respondents did not know their insurance status; this lack of knowledge adds to their vulnerability (see Figure 2.3-13). In addition to this, only 35% indicated that they have extra income/savings to prepare for disasters and 29% to recover from impact (see Figure 2.3-14). From this perspective, The Virgin Islands is extremely vulnerable to climate change and natural hazards and in a worst case strike the Territory's historical ability to get back on its feet quickly could be in jeopardy due to lack of finances.

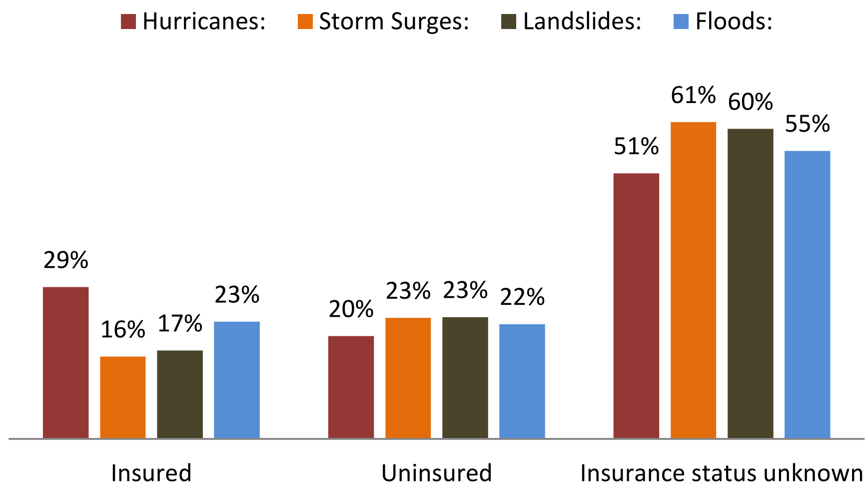


Figure 2.3-13 Respondents whose home is insured against natural disasters. Data sample size varied among events – hurricane data based on a sample size of 233 persons, storm surge data on 215 persons, landslides on 218 persons and floods on 222 persons. Respondents who live in insured homes only ranged from 16% (for storm surges) to 29% (for hurricanes). A striking percentage, 50% to 60% in all cases, did not know their insurance status.

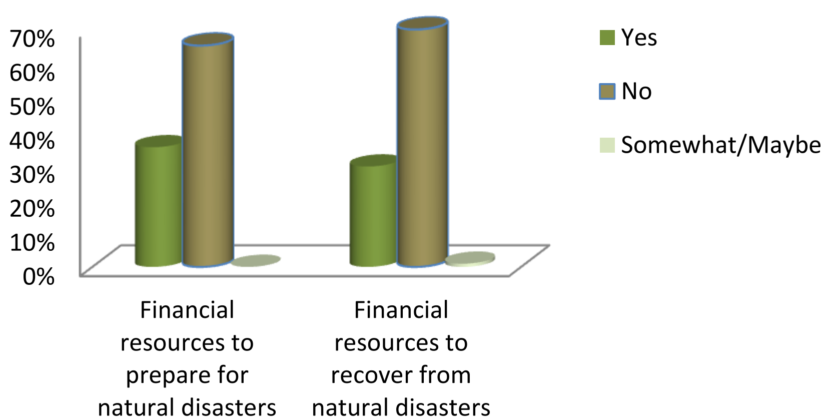


Figure 2.3-14 Respondents who have extra income/savings to prepare for and recover from natural disasters. Data based on a sample size of 228 persons for the preparation for natural disasters and 214 persons for the recovery from natural disasters. The majority (65%) of respondents do not have additional finances to prepare for natural disasters much less recover from them (70%).

Water is vital for life; it is necessary for a number of domestic purposes, proper hygiene, food preparation and hydration. In the event of a natural disaster, the community needs some means of obtaining water to continue their daily lives – ideally a three day supply. Although most homes are now connected to the public desalinated water supply, this can easily become disrupted in disasters and is unreliable even in ordinary times. The presence of and unrestricted access to a cistern in homes is, therefore, an important tool for resilience for individuals and families.

Traditionally, houses were built with cisterns and it is now required by law. The Survey found that the clear majority of persons (89% of survey respondents) have access to cistern water, with (8%) of these experiencing restricted access (for example, only access in the kitchen); 11% of persons reported having no access to cistern water. While the percentage with access seems high, by law this percentage should be 100%.

There are many actions that individuals can take in response to climate change to reduce anticipated impacts. Table 2.3-2 outlines these. While a notable percentage of individuals are taking many of the actions listed, there is significant room for improvement, especially in the actions that would enhance resilience the most by reducing vulnerability to natural hazards and protecting the environment (these types of actions, indicated with an asterisk, are only being taking by 15% to 25% and 26% to 30% of individuals, respectively).

The most common actions being taking are those that are relatively easy, inexpensive upfront and save money, including disposing of garbage properly, conserving water and energy and maintaining good sanitation to reduce risk of mosquito breeding. There is a notable willingness to take actions and demand for support in taking actions that reduce vulnerability to natural hazards and that implement use of renewable energy. Lack of finances (identified by 74% of respondents) and lack of specific information (identified by 45% of respondents) are some of the key factors hindering respondents from taking more action (see Figure 2.3-15).

Actions	Already taking	Willing to take	Need support in taking
Dispose of my garbage properly	58%	5%	13%
Conserve water	52%	13%	13%
Maintain good sanitation to reduce risk of mosquito breeding	49%	12%	18%
Conserve energy	45%	17%	13%
***Plant Trees**	30%	27%	19%
***Maintain my septic tank**	29%	18%	22%
***Minimise my impact on the environment**	26%	26%	18%
***Minimise soil erosion around my property**	25%	26%	22%
***Have a plan to prepare for and recover from hurricanes**	24%	32%	24%
***Build hurricane and flood proof homes**	21%	31%	25%
***Avoid building in hazard prone areas**	19%	24%	27%
Support climate change adaptation policies	16%	30%	21%
***Purchase adequate insurance against natural disasters**	15%	30%	24%
***Avoid anchoring on or touching coral reefs**	15%	18%	32%
Use renewable energy	9%	33%	31%
other		2%	0.4%

Table 2.3-2 Actions respondents are currently taking, willing to take and need support to take in response to climate change. Data based on 253 respondents. Actions with an asterisk (*) are vital for enhancing resilience as they reduce vulnerability to natural hazards and help to protect the environment.

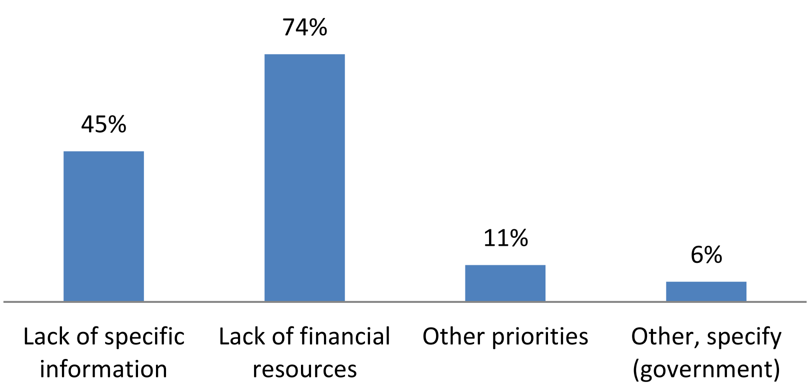


Figure 2.3-15 Factors limiting respondents in taking the appropriate actions in response to climate change. Forty five percent (45%) of respondents would be limited by lack of specific information, 74% due to lack of financial resources, 11% because of other priorities and 6% due to other issues such as government policies being a hindrance.

The survey explored energy and water conservation/efficiency techniques among the general public in more detail. Presently, the most popular means of energy and water conservation/efficiency are energy saving light bulbs and low flush toilets, used by 91% and 53% of respondents, respectively. Figure 2.3-16 shows the energy and water conservation/efficiency techniques that Virgin Islands residents are currently using. It clearly shows that most techniques are used only by a minority of respondents and, therefore, forcefully indicates the need for improvement through greater awareness and incentives.

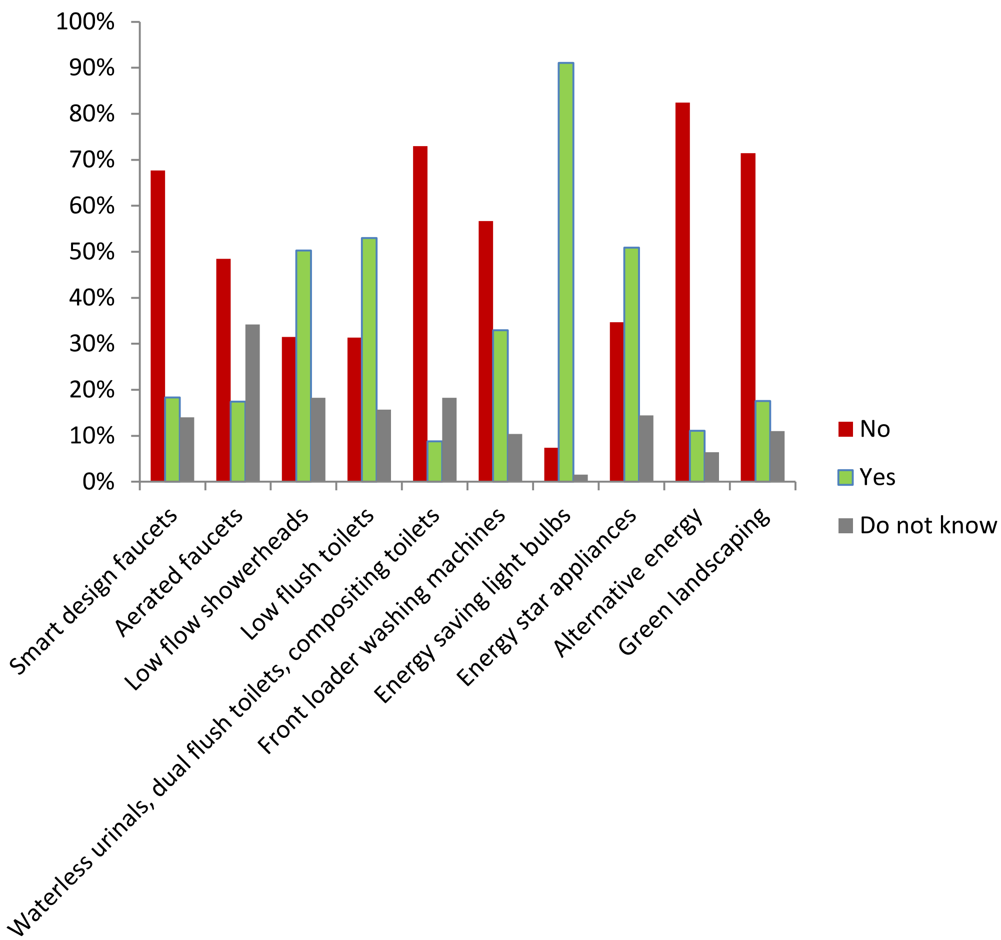


Figure 2.3-16 Measures residents are presently taking to save water and energy. The most popular means are energy saving light bulbs (91% of respondents) and low flush toilets (53% of respondents). Other methods include energy star appliances (51%), low flow showerheads (50%), front loader washing machines (33%), smart design faucets (18%), aerated faucets (17%), green landscaping (18%), alternate energy (11%) and waterless urinals/dual flush toilets/composting toilets (9%).

Although there is significant room for improvement in terms of personal actions being taken, the clear majority of individuals believe in a proactive approach to climate change with 88% of respondents opting for "early actions to reduce impacts even if they are costly" (see Figure 2.3-17). The survey also found that the majority of respondents (82%) believe that everyone (government, businesses, community organizations/NGOs and individuals) should do their part towards climate change adaptation (see Table 2.3-3).

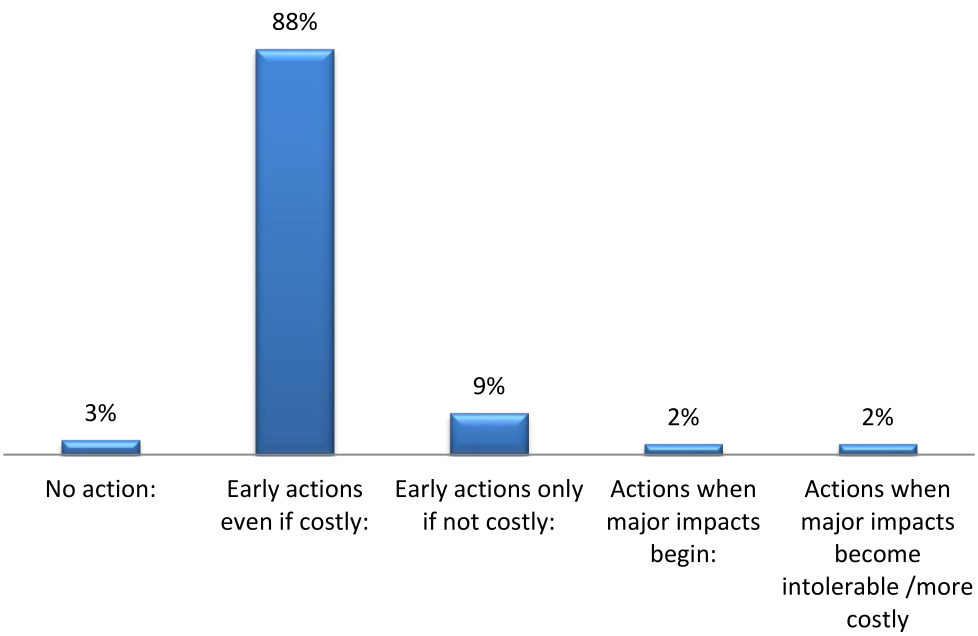


Figure 2.3-17 Respondents' views on when climate change adaptation actions should be taken. Data based on a sample size of 224 persons. Eighty eight percent (88%) stated that early actions regardless of cost should be taken, 9% declared that early actions only if they are not costly should be taken, 2% stated that actions should be taken only when major impacts begin to occur and another 2% noted that actions should be taken when major impacts become intolerable or more costly than early response measures. Three (3%) believe that no action should be taken.

PARTY RESPONSIBLE FOR TAKING ACTION ON CLIMATE CHANGE		
Government, businesses, community organizations/non-governmental organizations (NGO), individuals	191	82%
Government	12	5.1%
Other (schools, churches)	8	3.4%
Government, businesses, community organisations/NGOs, individuals, other (schools, churches)	7	3.0%
Government, businesses, individuals	4	1.7%
Government, community organisations/NGOs	3	1.3%
Government, individuals	3	1.3%
Government, businesses, community organisations/NGOs	2	0.8%
Community organisations, individuals	1	0.4%
Individuals	1	0.4%

Table 2.3-3 Respondents' opinion on who should take action on climate change. The majority of respondents (82%) believe everyone (all groups, including individuals) are responsible for taking action.

CONCLUSION

The Virgin Islands is vulnerable to climate change. Although the community has basic knowledge about the issue, it is not knowledgeable enough about the range of impacts and necessary adaptation measures to effectively deal with the threat, however, the majority is willing to learn more.

Overall, the housing stock, particularly roofs, can be considered relatively resilient to hurricanes. Most homes have concrete slap or hip roofs which are most resilient to high winds. While the majority of homes have regular glass windows which are vulnerable to wind damage, the community's practice of protecting windows with ply board has reduced historical damages; 14% of respondents reported major wind damage from hurricanes. The survey results indicate that a significant portion of the community is vulnerable to flood events, with 28% experiencing "major damage" from previous events. There is room to continue to build the resilience of the housing stock, particularly through stronger windows and improved drainage.

Knowledge of climate change has led to a high level of concern among roughly half of the community. This sort of concern early on is healthy as it is important in driving The Virgin Islands to become better equip to handle the impacts of climate change. It is, therefore, important that concern about the issue be heightened on a wider basis which can then be translated into pressure for best management policies and strategies.

The public agrees that dealing with climate change and its impact is not solely the job of Government or individual persons or organizations; everyone in the community has to do their part to safeguard themselves, their properties and the Territory's infrastructure and environment from climate change impacts.

Presently some members of the community are taking actions that are important for reducing the impacts of climate change; for the most part, however, these individuals are in the minority. This is particularly true for actions that reduce vulnerability to natural hazards and protect the environment, such as building hurricane and flood proof homes, building in areas that are less prone to natural disasters, purchasing adequate insurance, having a personal disaster plan and minimizing personal impacts to the environment. The community is most constrained in taking more action by inadequate finances and lack of specific information.

3.0 | Hazard Vulnerability and Risk Assessment

3.1 | CLIMATE ASSESSMENT

PURPOSE

The climate assessment is a fundamental tool in understanding how climate change will impact The Virgin Islands. The climate assessment quantifies and describes how key variables of the local Virgin Islands climate are projected to change at different time intervals up to the end of the Century (2090-2099). From this information local climate change impacts to tourism and supporting sectors can be better derived.

METHOD

The PRECIS climate model was used to model the future climate of The Virgin Islands. PRECIS is a regional climate model (RCM) developed by the UK Met Office Hadley Centre. PRECIS is short for Providing REgional Climates for Impact Studies (Jones, et al., 2004).

The model was run for the Eastern Caribbean by the Climate Studies Group, a team of researchers from the Caribbean Community Climate Change Centre, the University of the West Indies (Mona and Cave Hill Campuses) and the Cuban Institute of Meteorology (INSMET) at 25 km grid resolution. Two global climate models (GCMs), HADCM3 (referred to hereafter as Hadley) and ECHAM4 (referred to hereafter as Echam), were used to force the PRECIS model at its boundaries (Centella, et al., forthcoming).

Two climate scenarios from the Intergovernmental Panel on Climate Change (IPCC) were used for the modeling exercise, SRES A2 and B2. These scenarios are essentially storylines of how the world might develop and the consequences for population, economic growth, energy use and technology. SRES A2 describes a very heterogeneous world of a continuously increasing population and technological change more fragmented and slower than other storylines. SRES A2 can be summerised as the high carbon emissions scenario. SRES B2 describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, oriented towards environmental protection and social equity and focused on local and regional levels. SRES B2 can be summarised as the low carbon emissions scenario.

Together these produced four (4) model scenarios for each variable investigated as described in Table 3.1-1.

Model Scenario
Echam A2 (high emissions scenario)
Echam B2 (low emissions scenario)
Hadley A2 (high emissions scenario)
Hadley B2 (low emission scenario)

Table3.1-1. Climate change model scenarios used in the climate assessment

The climate variables modeled include rainfall, temperature (minimum, maximum, average), relative humidity, wind speed and comfort index. For each variable PRECIS produced a 29 year baseline (1961 - 1989) based on global data and modeled future monthly values for The Virgin Islands (2011 - 2099) at grid point 64.5W, 18.5N. The baseline was subtracted from the raw future monthly values to calculate the change (anomaly) for each variable, that is, the climate change scenario for The Virgin Islands. Changes were expressed as percentage increases or decreases compared to the baseline and assessed for the immediate 10 future and then for 20 year intervals until the end of the Century as shown in Table 3.1-2. By analyzing changes or anomalies in the climate as opposed to the raw future monthly values, any model biases were eliminated. In some cases, for rainfall and temperature, percentage changes were added to the observed Virgin Islands baseline to produce projected rainfall and temperature values. At all times the consensus (by way of averaging) of the model scenarios is analyzed and discussed as opposed to any singular model scenario projection.

Time Periods	Description
2011 – 2020	Immediate future
2021 – 2040	Near-term
2041 – 2060	Mid-term
2061 – 2080	Mid-term
2081 – 2099	End of Century

Table 3.1-2. Time periods used for climate assessment analysis.

UNCERTAINTY

Where noted, the following information on uncertainty is taking directly from the Hadley Centre regional climate modeling system (PRECIS) handbook (Jones, et al., 2004).

Regional climate models (RCM), including PRECIS, do not yet provide all the solutions for generating climate change scenarios. Predictions from a RCM are dependent on the realism of the global model driving it; any errors in the GCM predictions will be carried through to the RCM predictions. There will, therefore, be errors in RCM's representation of the climate system, that is, they have a degree of uncertainty (Jones et al., 2004).

Uncertainty arises from three main causes; the magnitude of future emissions, the response of climate to these emissions and natural variability. When assessing the impacts of climate change and the vulnerability of a country, it is important to use not just one climate scenario but a number which attempt to cover the range of uncertainty. Because we have an imperfect understanding of the way the earth's climate system works, no climate model can give an accurate prediction of climate change. We do not know what the true uncertainty in predictions is, but we can make an estimate of this by taking predictions from a range of climate models (Jones et al., 2004).

The PRECIS experiments used for this assessment were designed to consider and reduce two of the sources of uncertainty: the magnitude of future emissions (by using two different climate scenarios, A2 and B2) and the response of climate (by using two different global climate models, Hadley and Echam, to force PRECIS). At all times in the assessment, the consensus or average of these model scenarios, as opposed to any one model scenarios is analysed and discussed as to reduce uncertainty. As discussed by Centella et al., forthcoming, the certainty of the regional climate modeling conducted for the Caribbean could be improved by using additional global climate models to force PRECIS and even using other regional climate models. A wider range of climate scenarios could also be used (Centella et al., forthcoming).

RESULTS

THE VIRGIN ISLANDS OBSERVED CLIMATE

The Virgin Islands experience a moderate subtropical climate with an monthly average temperature of 27°C/80.6°F and an average annual rainfall of 1280mm (50 inches) (Earle, 1997). The Islands are constantly swept by the Northeast Trade Winds that have a drying effect at low elevations and produce rainfall when they intersect with land at high elevations.

Traditional Rainfall Patterns

Annual

Rainfall occurs in short showers usually resulting from the lifting and cooling of humid air as it passes over the islands (Earle, 1997). Sheltered hilltops receive the highest levels of rainfall (on average 1778 mm/70 inches per year) while low-lying, exposed and coastal areas tend to be the driest (receiving on average 1016 mm/40 inches per year; CFD & NPT, forthcoming).

The Virgin Islands has a long precipitation data set collected at Paraquita Bay, Tortola (a coastal valley) from 1901 to 1994 when the Territory depended heavily on groundwater and daily measurements were taken to determine aquifers levels there. This data set shows that The Virgin Islands receives an annual rainfall that ranges from 612mm (**24 inches**) to 2394mm (**94 inches**), with the average annual rainfall being 1280mm (**50 inches**). Most years receive a rainfall total of 1316mm (52 inches), the mode (see Figures 3.1-1 and 3.1-2). The standard deviation over the period, 301mm (11.9 inches), is relatively small, indicating that the rainfall total is fairly uniform over the period; however, the range of data, 1782mm (70 inches), shows that large variations can occur in some years.

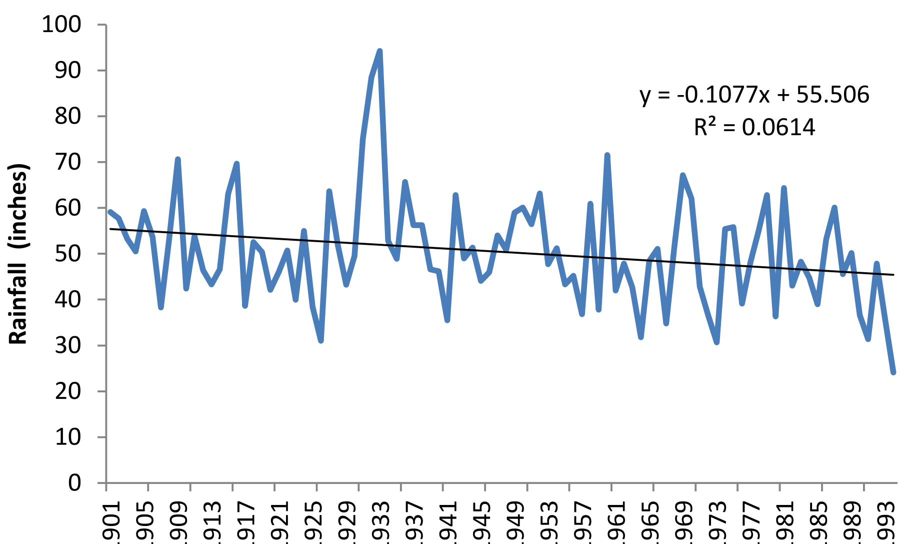


Figure 3.1-1. Observed annual rainfall (inches) from Paraquita Bay, Tortola, The Virgin Islands (1901-1994).

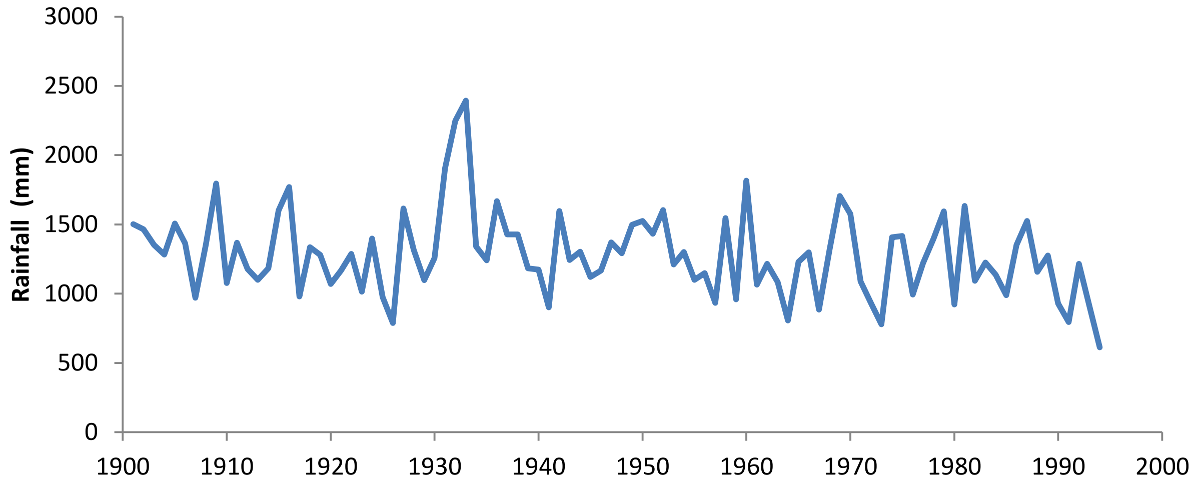


Figure 3.1-2 Observed annual rainfall (millimetres) from Paraquita Bay, Tortola, The Virgin Islands (1901-1994).

Seasonal

According to the Paraquita Bay data set, monthly average rainfall is 106mm **(4.2 inches**) and ranges from 46mm (**1.8 inches**) to 167mm (**6.6 inches**). The data shows a distinct seasonality in rainfall. The dry season dominates the year and extends from January to August with rainfall during these months typically ranging from 46mm (**1.8 inches**) to 129mm (**5.1 inches**) with an average of 83mm (**3.3 inches**). During the dry season, January to March and June to July are the driest months, with May showing an isolated rainier peak as a result of sporadic showers. The rainy season extends from September to December with rainfall during these months typically ranging from 129mm (**5.1 inches**) to 167mm (**6.6inches**) with an average of 151mm (**6 inches**). November is the wettest month (see Figure 3.1-3).

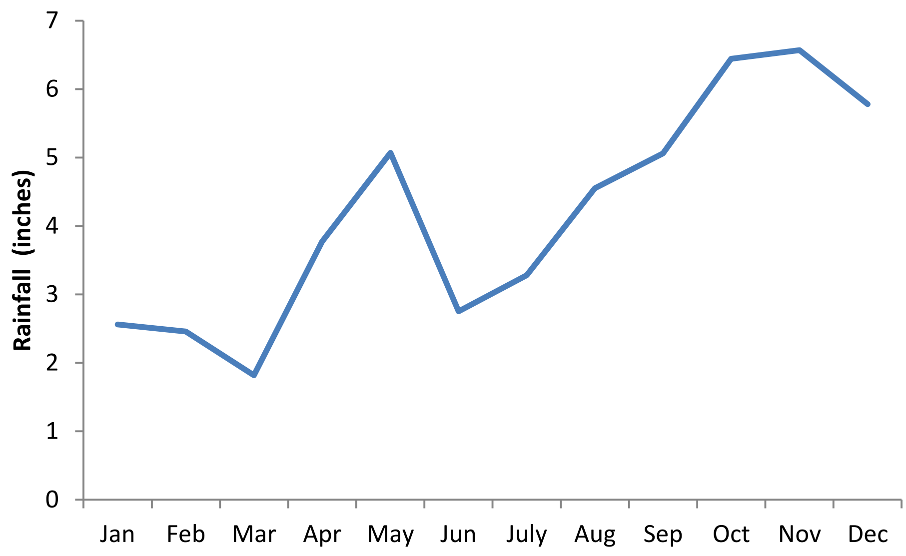


Figure 3.1-3 Observed monthly average rainfall (inches) from Paraquita Bay, Tortola, The Virgin Islands (1901-1994).

The data from the United States Virgin Islands (USVI) shows that the seasonal distribution and monthly totals of rainfall is very similar to that of The Virgin Islands (British). The average total rainfall is 1245 mm (**49 inches**), with an average maximum of 1905 mm (**75 inches**) and an average minimum of 940 mm (**37 inches**) (see Figure 3.1-4). The standard deviation is again relatively small, 279 mm (11 inches), the range of data, while only about half that of BVI, is quite large at 965 mm (38 inches).

In terms of seasonality, the notable exception is that the dry season appears to start a month earlier, in December and that October, while part of the rainy season, is noticeable drier than the month immediately preceding and following, as opposed to showing a continuous build up to November, also the rainiest month in the USVI.

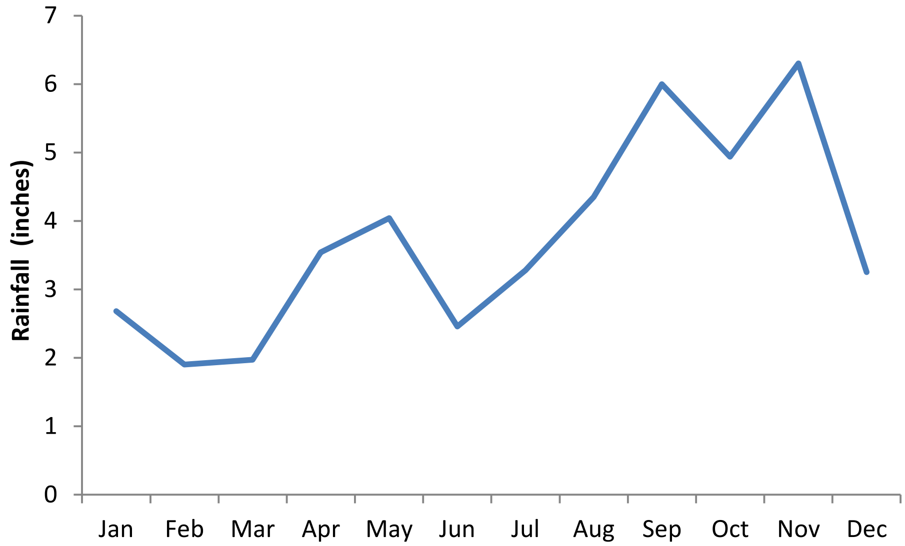


Figure 3.1-4 Observed monthly average rainfall (inches) from Cruz Bay, St. Croix, the United States Virgin Islands (1972-2009).

Traditional Temperature Patterns

Annual

Based on the Paraquita Bay record, the average monthly minimum temperature is 24°C/75.2°F, the monthly maximum temperature is 29°C/84.2°F and the monthly average temperature is 27°C/80.6°F. Over the course of the year, the islands experience a narrow range in monthly average temperature of just 4°C (25°C/77°F – 28°C/82.4°F). The range in extremes (lowest monthly minimum and highest monthly maximum temperatures) is slightly greater (10°C).

Seasonal

Monthly average temperatures are lowest from December to March and peak from July to September (the summer months). December tends to be the coolest month and August/September the hottest. Between March and July temperatures gradually increase by 3°C, however, from May to June temperature temporarily remains basically unchanged. Between September and December temperatures gradually decrease again by 3°C to the lowest point, however, from October to November temperature again temporarily remains basically unchanged (see Figure 3.1-5)

Monthly maximum temperature follows a similar pattern. The lowest maximum temperatures are experienced from December to March, the peak however occurs slightly later, from August to October (see Figure 3.1-6). Minimum average temperature follows a slightly different pattern: the lowest minimum temperatures are experienced from December to March with a small increase in January; the peak occurs earlier, in July, and only lasts for one month (see Figure 3.1-6).

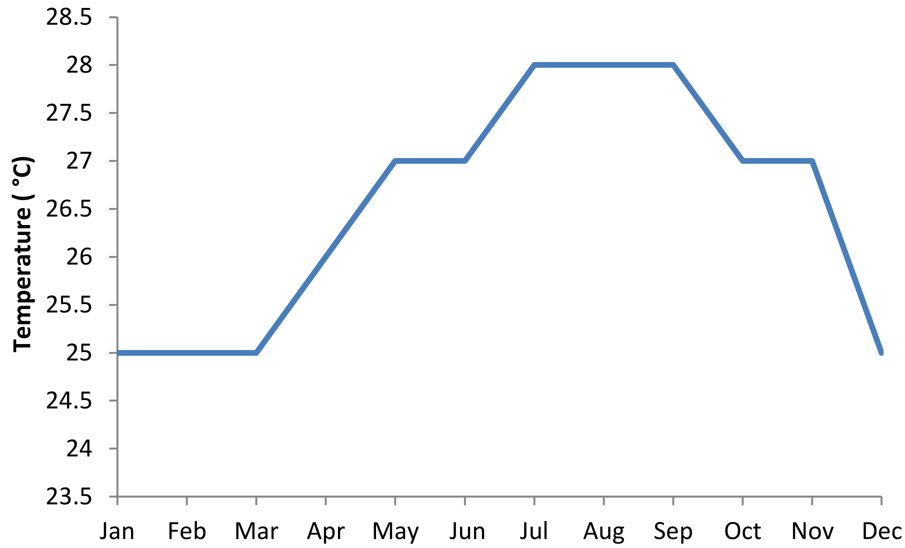


Figure 3.1-5 Observed monthly average temperature (°C) from Paraquita Bay, Tortola, The Virgin Islands (1971-1977).

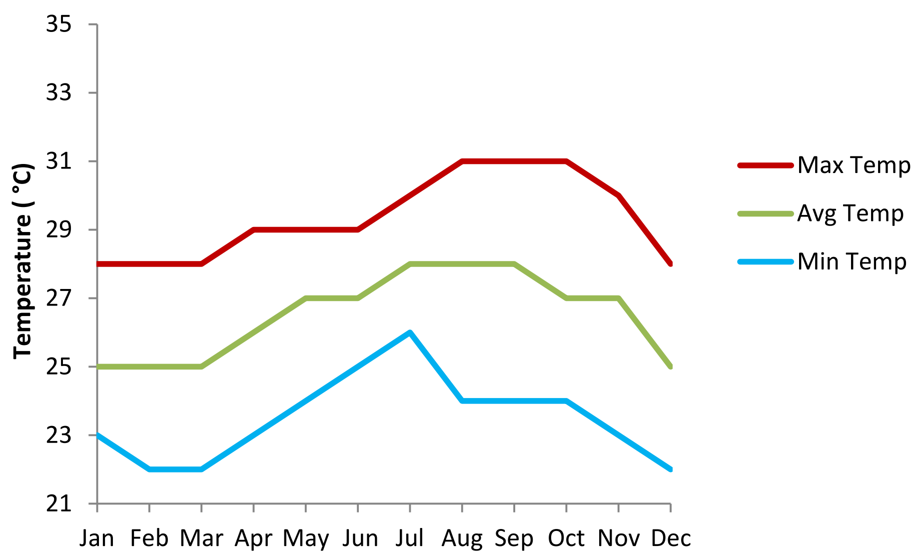


Figure 3.1-6 Observed monthly average, maximum and minimum temperatures (°C) from Paraquita Bay, Tortola, The Virgin Islands (1971-1977).

Natural Hazards

Hurricanes and earthquakes are the natural hazards of greatest threat, with flooding and landslides traditionally considered a minor threat (CDERA, 2003). The importance of the latter threats has significantly increased since 2003, however, when the Territory began experiencing an increased number of flood and landslide events.

The location of The Virgin Islands at the northeastern tip of the Caribbean places it directly in the hurricane belt. Traditionally, there is a 25 to 30 year intensity cycle of tropical cyclone activity and during that period The Virgin Islands may expect a category 4 storm and several categories 2 or 3 storms (DDM, 2002). During hurricanes and tropical storms inland flooding and coastal surge are of significant concern (CDERA, 2003). Coastal communities or settlements which are experiencing rapid population growth and development are most susceptible to hurricanes (DDM, 2002).

Table 3.1-3 summarises The Virgin Islands vulnerability to hurricanes, Table 3.1-4 summarises the damages incurred from hurricanes from 1916 to 1999, and Figure 3.1-7 shows the tropical cyclones affecting The Virgin Islands from 1851 to 2008.

HURRICANE HAZARD	EXISTING VULNERABILITY	FUTURE VULNERABILITY
Wind effects	3	3
Wave and surge effects	2	2
Rainfall effects		
- Flooding	1	1
- Landslides and rockslides	2	3
Loss of life	1	1
Vulnerability rating (mean)	2	2

Table 3.1-3 The Virgin Islands vulnerability to hurricanes. The current mean vulnerability rating of "moderate" may change with time as a result of increasing population and land development. *Vulnerability rating: 1 = Low; 2 = Moderate; 3 = High (Source: DDM, 2002)*

YEAR	HURRICANE	CATEGORY	HURRICANE CLOSEST POITION*	DATE	ESTIMATED LOSS
1916	Not Named	2	Lat. 18.0N, Long.64.8W	9 October	Fatalities and Property No Estimate Available
1924	Not Named	2	Lat. 18.3N, Long.	29 August	Fatalities and

			63.4W		Property No Estimate Available
1960	Donna	4	Lat. 18.4N, Long. 63.4W	5 September	Property No Cost Available
1989	Hugo	4	Lat. 18.2N, Long. 65.5W – 40 miles SW of The Virgin Islands	18 September	US$40 million
1995	Luis	4	Lat. 18.4N, Long. 63.0W – 37 miles NE of Anegada	6 September	No Estimates
1995	Marilyn	3	Lat.18.5N, Long.65.2W - 40 miles SW of Tortola	15 September	US$10 million
1996	Bertha	1	Lat. 18.6N, Long. 64.9W	8 July	US$2 million
1998	Georges	2	Lat.17.8N, Long.65.0W - 46 miles south of Tortola	21 September	US$12 million
1999	Lenny	4	Lat. 17.7N, Long. 64.0W – 5 miles	17 November	US$29 million
2008	Omar	3	Lat.18.2N, Long.63.9W - 40 miles east of Road Town	16 October	Minimal impacts

Table 3.1-4 Estimated losses from hurricanes known to have affected The Virgin Islands from 1916 to 1999. *(Source: DDM, 2002)*

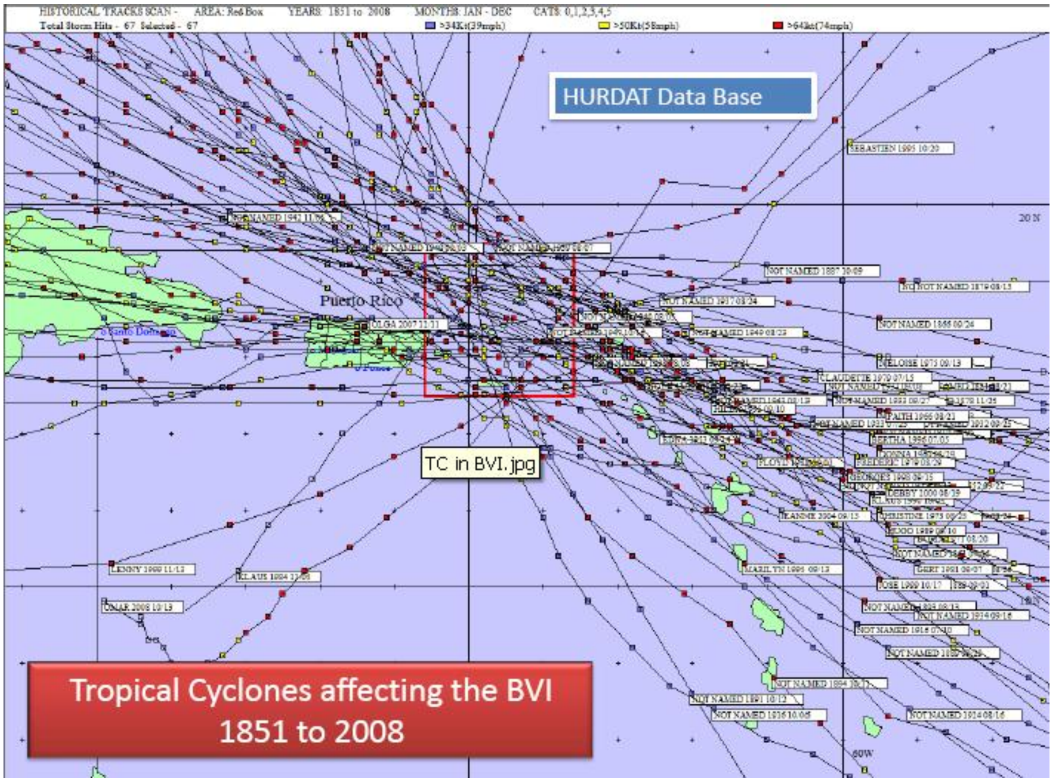


Figure 3.1-7 Tropical cyclones affecting The Virgin Islands from 1851 to 2008. (Source: Rubiera, 2009).

The northeastern Caribbean has the potential to experience earthquakes of magnitude 7.4 to 8.5 as has occurred during the 20th and 21st Centuries, on October 8, 1974 and on November 29, 2007 (CDERA, 2003). Most recently, on 12th January 2010, a 7.0 magnitude earthquake devastated Haiti. The Virgin Islands is particularly vulnerable as it sits on the northeastern edge of the Caribbean Tectonic Plate where it meets the North American Plate at the Puerto Rico Trench. This area is a “hotspot for seismic activity” including earthquakes and tremors, tsunamis and volcanic eruptions (CFD & NPT, forthcoming).

Extreme rainfall events are associated with cold fronts which occur during the winter months and with tropical waves, depressions, storms and hurricanes during the summer months from June to November (Earle, 1997). The islands are susceptible to flooding in heavy rain events due to the combination of steep slopes and shallow soils that lead to “very high water velocities and tiny times of concentration, of only about 20 minutes for the larger watersheds of the islands, which will lead to pronounced and quick runoff hydrographs, if precipitation is big enough.” (Earle, 1997).

As of 2003 there has been an increase in floods; Table 3.1-5 provides a list of these events while Figure 3.1-8 is a collection of images depicting damages incurred. Flood events tend to be associated with landslides as the most vulnerable landslide zones are located in and along the natural waterways (locally known as ghuts). These flood and landslide events have resulted in significant losses. For example, the November 2003 flood, in which an average of 20 inches of rain fell in 5 days, resulted in total losses (response/relief costs, rehabilitation costs, and reconstruction costs) estimated at US$19,147,898.00 (DDM, 2003). Images from some of the damage experienced in Road Town and Cane Garden Bay from the November 2003 and September 2010 flood are provided in Figure 3.1-8.

Table 3.1-5 Inventory of flood events affecting The Virgin Islands, 2003 to present.

Figure 3.1-8 Some of the damage experienced in Road Town (left) and Cane Garden Bay (right) from the November 2003 and September 2010 floods.

Rainfall – Annual

Over the remainder of the Century, there are important changes in annual rainfall.

The Echam A2 and Echam B2 model scenarios project a wetter future, while the Hadley A2 and Hadley B2 model scenarios project a drier future. Averaged together these model scenarios project that annual rainfall averaged over the entire period, 2011-2099, will decrease by 2.5% (see Figure 3.1-9).

Changes do not happen evenly over the remainder of the Century. Average annual rainfall is projected to remain basically unchanged over the immediate to near-term, the 2011-2020 and 2021-2040 periods, increasing by less than 1%. For the 2041-2060, 2061-2080 and 2081-2099 periods, however, average annual rainfall is projected to be progressively less than the baseline, decreasing by up to 7.7% by the last period, 2081-2099 (see Figure 3.1-10, Table 3.1-6).

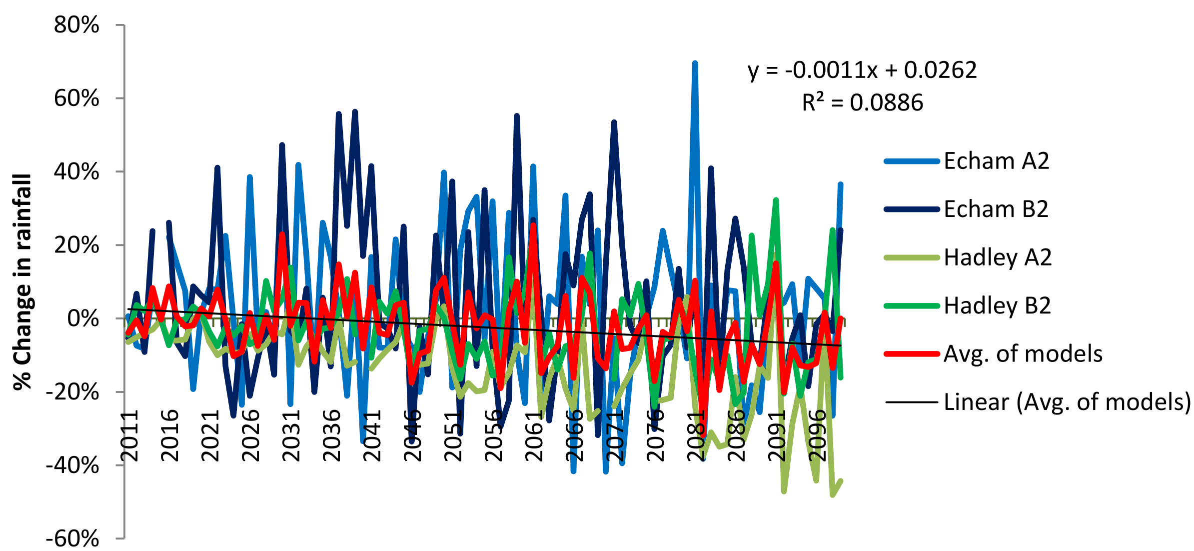


Figure 3.1-9 Percentage (%) change in annual rainfall (2011-2099) compared to the baseline. All model scenarios and average/consensus of model scenarios are shown.

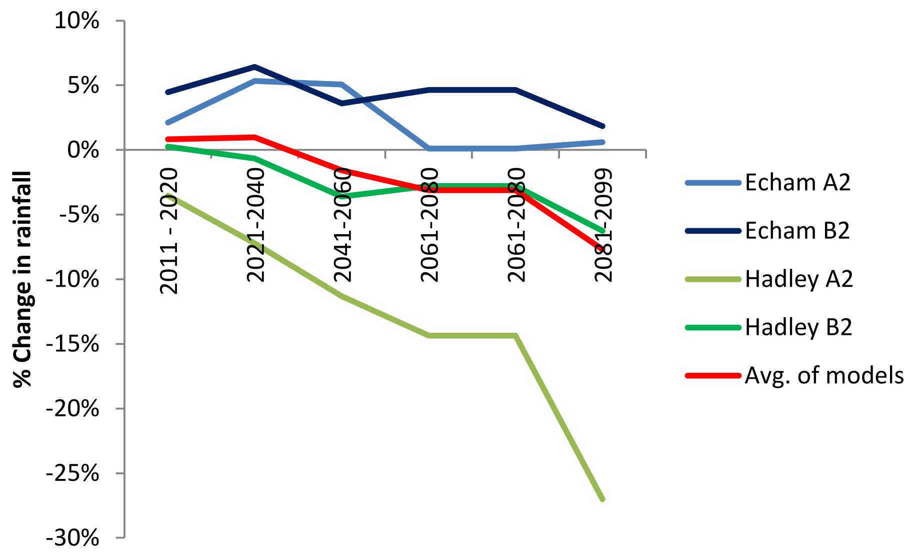


Figure 3.1-10 Average percentage (%) change in rainfall (for future time periods examined) compared to the baseline. All model scenarios and average/consensus of model scenarios are shown.

Time Period	**Average change**
2011-2020	0.8%
2021-2040	0.9%
2041-2060	-1.6%
2061-2080	-3.2%
2081-2099	-7.7%

Table 3.1-6. Average percentage (%) change in rainfall (for future time periods examined) compared to the baseline, based on the average/consensus of all model scenarios.

Beneath these averages, there are some notable changes occurring on a year to year basis. The consensus of the model scenarios shows 53 of the 88 years (60%) having net decreases in annual rainfall averaging 8.6% with a maximum decrease of 31.8% (Table 3.1-7). Over the course of the Century, each period is projected to have an increasing number of years that are drier than the baseline (i.e. experiencing net decreases in rainfall) (see Figure 3.1-11). The immediate future, 2011-2020 is projected to have 6 such years and the final period, 2081-2099, to have 14 such years (Table 3.1-8).

On the flip side 36 years (40%) are projected to have a net increase in annual rainfall averaging 6.6% with a maximum increase of 25.4% (Table 3.1-7). The immediate future, 2011-2020, is the period projected to have the least number of years (4) with net increases in annual rainfall. A peak is experienced in the 2021-2040 period in which 11 years are projected to have net increases in annual rainfall. This number is gradually reduced to 5 years by the last period in the Century (see Figure 3.1-11, Table 3.1-8).

	Greatest decrease	**Greatest increase**	**Average decrease**	**Average increase**	**Average change**
Echam A2	-41.7%	69.6%	-16.9% (n=37)	17.0% (n=51)	2.7%
Echam B2	-33.6%	56.4%	-12.8% (n=45)	22.0% (n=43)	4.2%
Hadley A2	-48.1	17.4	-15.2 (n=81)	7.1 (n=6)	-13.6%
Hadley B2	-24.6%	32.3%	-9.2% (n=55)	7.9% (n=32)	-2.9%
Average/consensus of model scenarios	-31.8%	25.4%	-8.6 (n=53)	6.6% (n=36)	**-2.5%**

Table 3.1-7. Average and greatest percentage (%) change in annual rainfall (2011-2099) compared to the baseline. All model scenarios and average/consensus of model scenarios are shown. To determine the average/consensus of the model scenarios, the average/consensus of each year within the time period was calculated and then the averages, maximums and minimums over the entire period for this new data calculated.

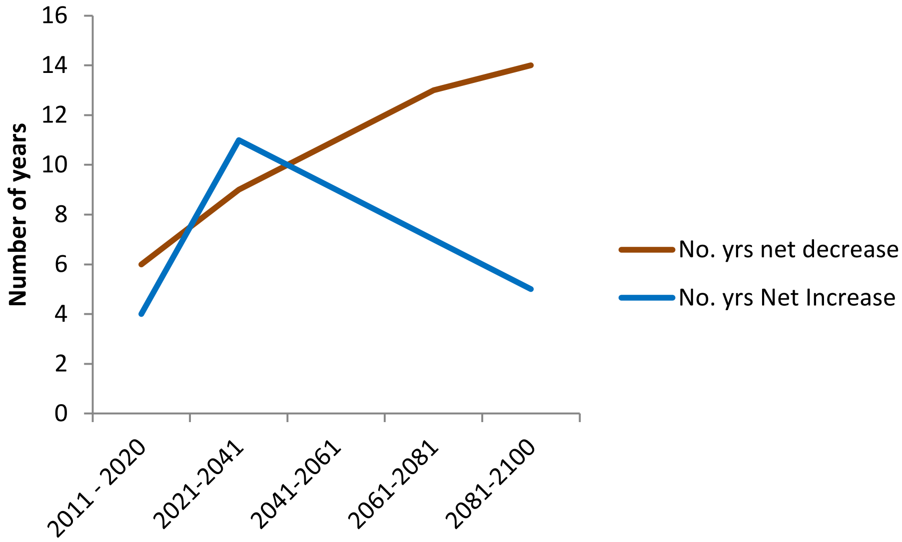


Figure 3.1-11. Number of years experiencing decreases/increases in rainfall (for future time periods examined) compared to the baseline, based on average/consensus of all model scenarios.

Time Period	Decreases in Rainfall		Increases in Rainfall	
	Avg. decrease	No. of yrs with decrease	Avg. increase	No. of yrs with increase
2011-2020	-2.3%	6	5.0%	4
2021-2040	-6.4%	9	6.8%	11
2041-2060	-7.9%	11	6.1%	9
2061-2080	-9.4%	13	8.2%	7
2081-2099	-12.5%	14	5.8%	5

Table 3.1-8. Average percentage (%) change in rainfall and number of years experiencing decreases/increases in rainfall (for future time periods examined) compared to the baseline. Data based on average/consensus of all model scenarios.

Rainfall – Seasonal

Important month to month changes in rainfall can be masked by just considering the annual data. The consensus of the model scenarios show that for the remaining periods of the Century, monthly rainfall could decrease by up to 6.1% in the immediate future and up to 28.2% by the end of the Century as compared to the baseline. On the other hand, monthly rainfall could increase from up to 11.5% in the near term to up to 28.2% by the end of the Century as compared to the baseline (Table 3.1-9).

Figures 3.1-12 to 3.1-13 show that over the course of the Century, the consensus of the model scenarios generally projects more pronounced changes in monthly rainfall. Over time, these changes occur with a more established seasonality that is not directly in sync with the traditional dry and rainy seasons. This is to say that the transitions between decreases or increases in monthly rainfall below or above the baseline do not occur at the transition points between the traditional dry and rainy seasons. Rather, the transition generally occurs at mid-year, with December to May experiencing increases in rainfall above the baseline (averaging 6.5% in 2011-2020 and 15.1% by 2080-2099) and June to November experiencing decreases in rainfall below the baseline (averaging 3.8% in 2011-2020 and 21.5% by 2080-2099).

The greatest increases in rainfall consistently occur in the dry season months of January to May, with December only being among the top 2-3 months experiencing the greatest increases in the first two periods (2011-2020 and 2021-2040) (see Table 3.1-9). The greatest decreases in rainfall also primarily occur in the dry season months of June to August with June consistently being among the top 2-3 months experiencing the biggest decreases over the Century (see Table 3.1-9). Over the remainder of the Century, therefore, the dry season is projected to experience more extremes in rainfall and, therefore, may become less predictable.

Considering all these changes in monthly rainfall, Figure 3.1-14 shows the future rainfall (mm) projected for The Virgin Islands by adding the modeled percentage changes in rainfall to The Virgin Islands observed monthly average rainfall as recorded at Paraquita Bay, Tortola (1901-1994).

The figure clearly shows an increase in monthly rainfall (mm) above the baseline from December to May (that is, these months are projected to get wetter, on average over the entire Century by 10mm/month), and a decrease in monthly rainfall below the baseline from June to November (that is, these months are projected to get drier, on average over the entire Century by 13.4mm/month). These changes are small enough so that the traditional seasonality of rainfall and the established dry and rainy seasons will remain basically the same as the observed baseline for The Virgin Islands. That is, the rainiest part of the year (the rainy season) will still extend from September to December. December, however, and not November is projected to be the wettest month. The dry season will still extend from January to August, however the rainy peak in May will become much more pronounced and comparable to rainfall amounts in the beginning of the rainy season. Figure 3.1-15 and Table 3.1-10 show how these changes result in increases in rainfall during the tourist season and decreases in rainfall during the off season.

Time Period	Largest Decrease			Average Decrease	Largest Increase			Average Increase	Average		
	%	Month	Traditional Season	%	%	Month	Traditional Season	%	Annual (%)	Dry (%)	Rainy (%)
2011-2020	-6.1	Sep	Rainy	**-3.8**	13.8	Jan	Dry	**6.5**	2.2	**2.8**	**0.9**
2021-2040	-8.3	Aug	Dry	**-5.0**	11.5	Dec	Rainy	**7.3**	2.2	**2.1**	**2.4**
2041-2060	-15.0	Jul	Dry	**-11.2**	21.4	Feb	Dry	**13.3**	1.1	**3.9**	**-4.7**
2061-2080	-21.3	Jun	Dry	**-15.1**	26.5	Apr	Dry	**16.5**	0.7	**5.3**	**-8.5**
2081-2099	-28.2	Oct	Rainy	**-21.5**	28.2	Mar	Dry	**15.1**	-3.2	**1.5**	**-12.5**
2011-2099	-15.6	Jun	Dry	**-11.7**	16.5	Feb	Dry	**12.6**	0.4	**3.2**	**-5.0**

Table 3.1-9. Average and greatest percentage (%) change in monthly rainfall (for future time periods examined) compared to the baseline. Data based on average/consensus of all model scenarios.

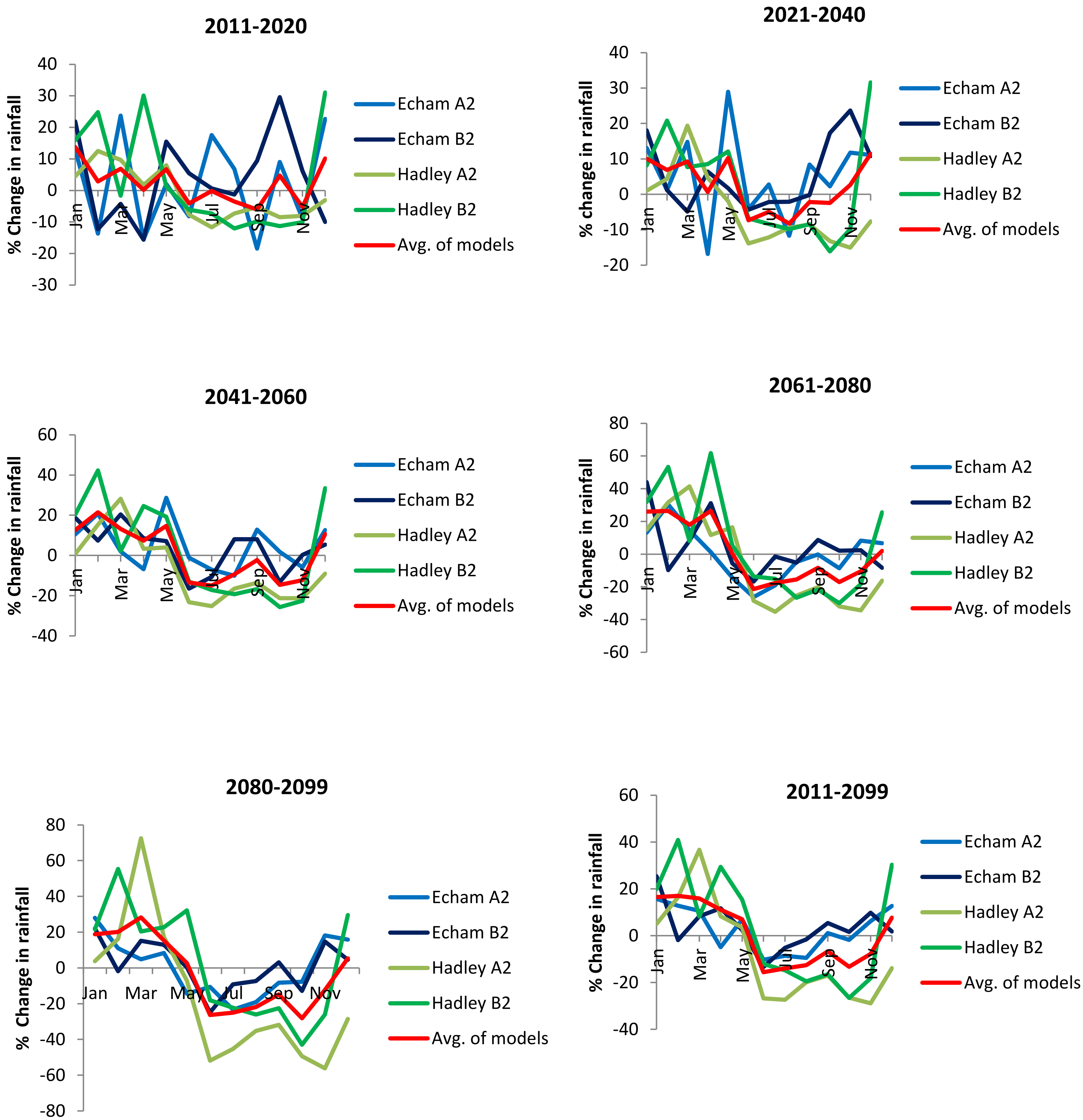


Figure 3.1-12 Percentage (%) change in monthly rainfall (for future time periods examined) compared to the baseline. All model scenarios and average/consensus of model scenarios are shown.

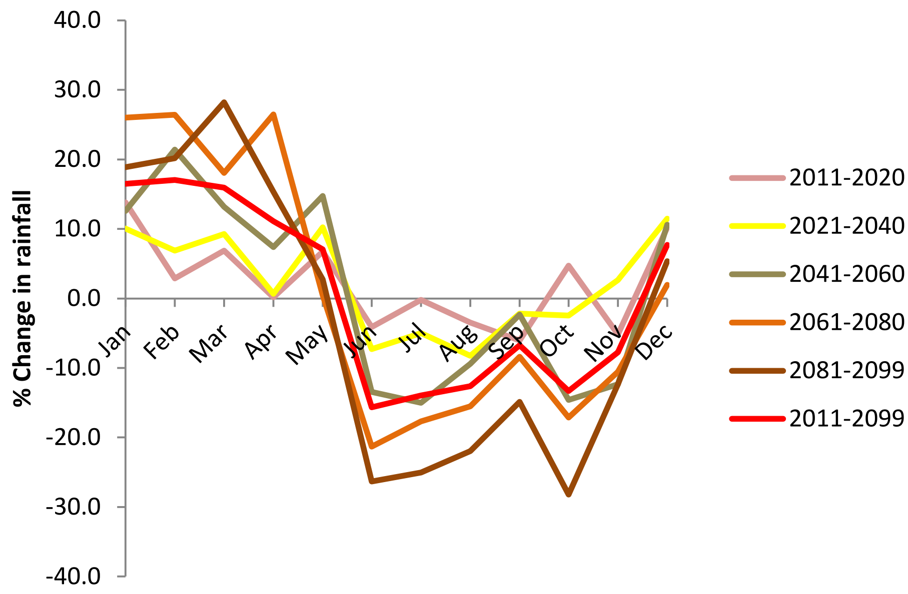


Figure 3.1-13 Percentage (%) change in monthly rainfall (for future time periods examined) compared to the baseline. Average/consensus of model scenarios only is shown.

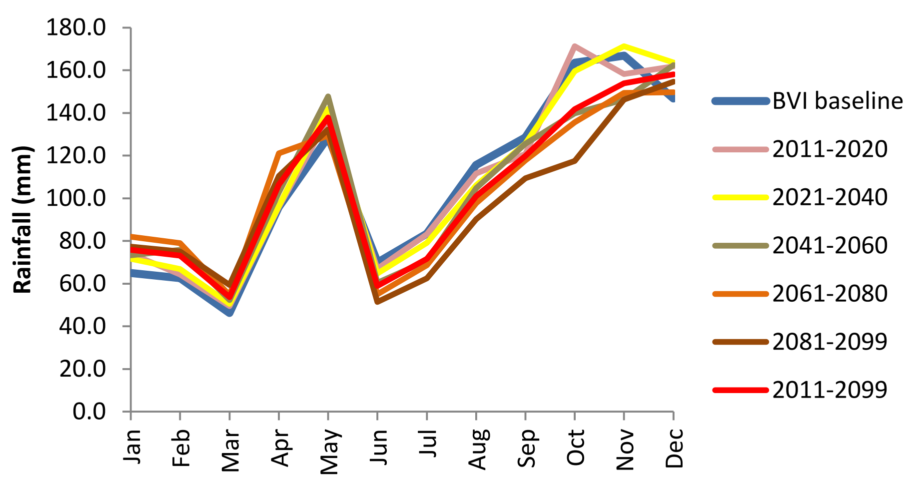


Figure 3.1-14 Future rainfall (mm) projected for The Virgin Islands (for future time periods examined) by adding the modeled percentage changes in rainfall to The Virgin Islands observed monthly average rainfall as recorded at Paraquita Bay, Tortola (1901-1994). Average/consensus of model scenarios only is shown.

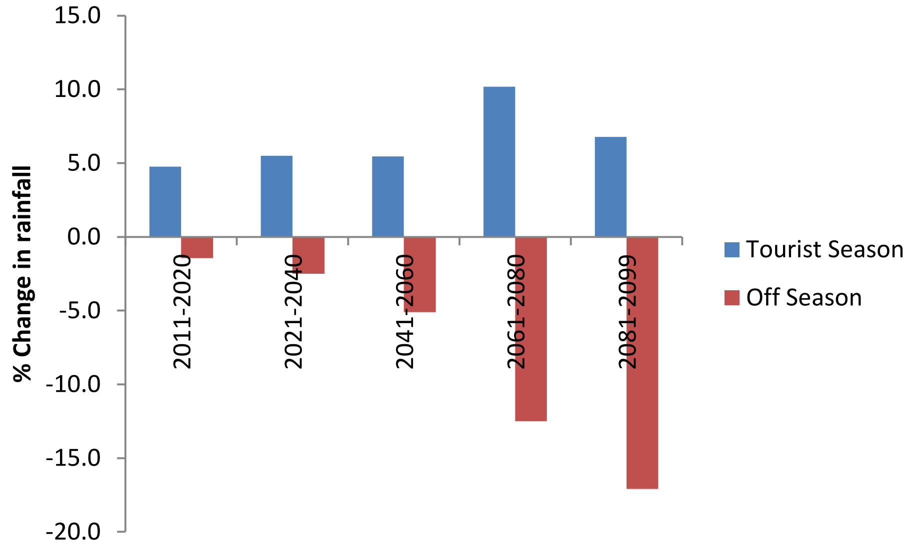


Figure 3.1-15 Percentage (%) change in rainfall during the tourist season and off season (for future time periods examined). Data based on average/consensus of all model scenarios.

Time Period	Tourist Season	Off Season
2011-2020	4.8%	-1.4%
2021-2040	5.5%	-2.5%
2041-2060	5.5%	-5.1%
2061-2080	10.2%	-12.5%
2081-2099	6.8%	-17.1%
2011-2099	6.7%	-8.4%

Table 3.1-10. Percentage (%) change in rainfall during the tourist season and off season (for future time periods examined). Data based on average/consensus of all model scenarios.

Dry Season / Rainy Season Changes

The effect of the monthly changes in rainfall described above on the traditional dry and rainy seasons over the course of the Century is clearly illustrated in Figures 3.1-16 to 3.1-17 below.

Overall, the consensus of the model scenarios shows that the traditional dry season is getting slightly wetter for all selected time intervals over the remainder of the Century. Increases in average monthly dry season rainfall range from 1.5% to 5.3% and average 3.2% over the Century with the greatest increases occurring in the 2041-2060 and 2061-2080 periods. In the immediate future (2011-2020) average dry season rainfall is projected to increase by 2.8%.

On the other hand, the consensus of the models shows the traditional rainy season getting slightly wetter in the immediate to near-term, receiving on average 0.9% more rainfall in the period 2011-2020, and 2.4% more rainfall in the period 2021-2040. The situation is reversed for the remainder of the Century, however, with the rainy season become progressively drier than the baseline, ranging from 4.7% drier in the 2041-2060 period to 12.5% drier by the end of the Century, and averaging 8.6% drier.

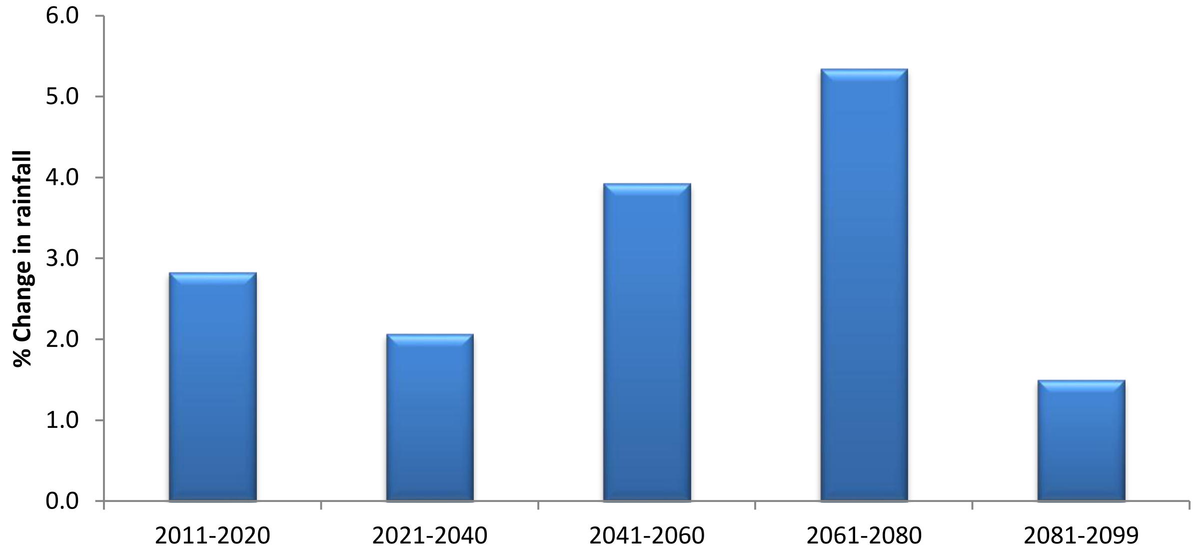


Figure 3.1-16 Percentage (%) change in average dry season rainfall (for future time periods examined). Data based on average/consensus of all model scenarios.

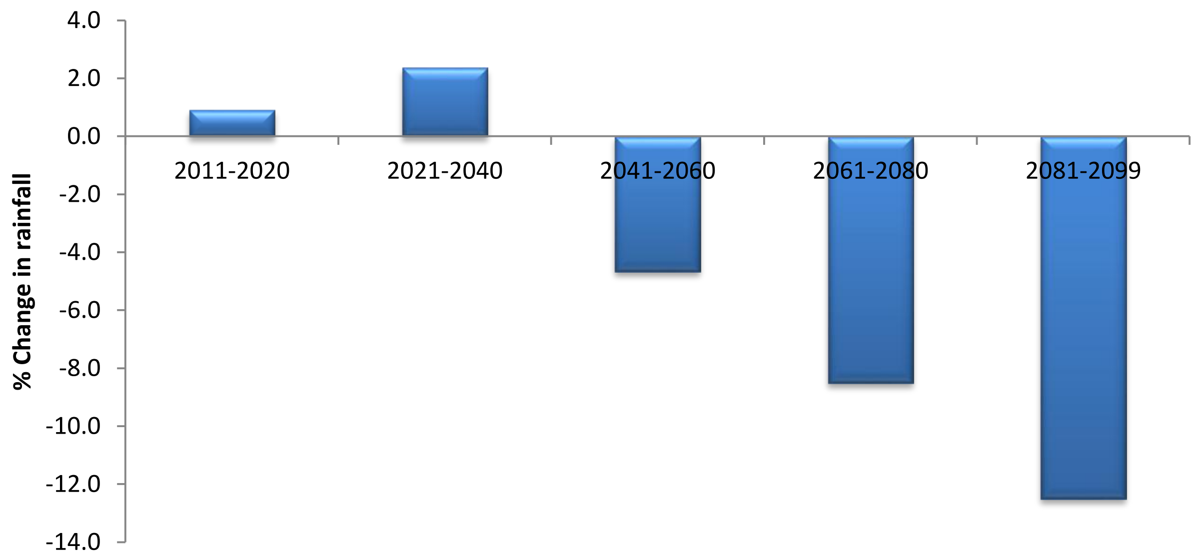


Figure 3.1-17 Percentage (%) change in average rainy season rainfall (for future time periods examined). Data based on average/consensus of all model scenarios.

Temperature –Annual

Figure 3.1-18 and Table 3.1-11 below show that over the period 2011-2099 there is a consensus among the model scenarios for important increases in annual minimum, average and maximum temperatures as compared to the model baseline.

Over the entire period (2011-2099), Table 3.1-11 shows that annual average temperatures are projected to increase between 2.2% (0.6°C, 1.1°F) and 11.6% (3.1°C, 5.6°F) with an average increase of 6.5% (1.7°C, 3.1°F). Annual minimum temperatures increase between 2.2% (0.6°C, 1.1°F) and 11.7% (3.1°C, 5.6°F) with an average increase of 6.5% (1.7°C, 3.1°F). Finally, annual maximum temperatures increase between 2.1% (0.6°C, 1.1°F) and 11.3% (3.1°C, 5.6°F) with an average increase of 6.3% (1.7°C, 3.1°F). From this it can be observed that increases in minimum and maximum temperatures are near equal contributors to the projected increase in average temperatures. Temperature increases broken down further by time periods over the Century are given in Table 3.1-11.

Figures 3.1-19 to 3.1-21 further show that the rate of warming is not even over the course of the Century. Rather average, minimum and maximum temperatures all increase more rapidly from 2041 to the end of the Century as compared to the 2011-2040 period.

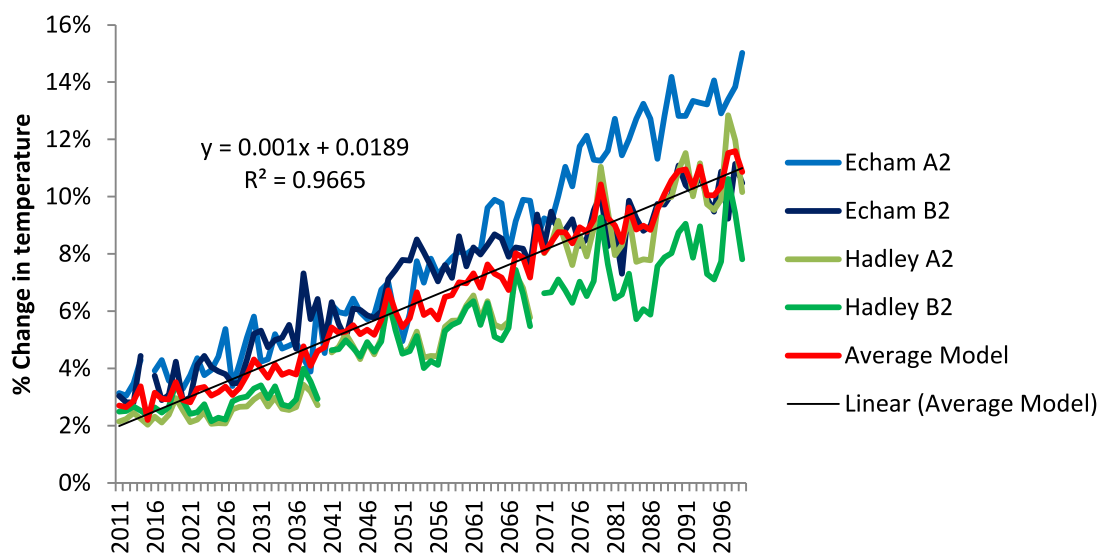


Figure 3.1-18 Percentage (%) change in annual average temperature (2011-2099) compared to the baseline. All model scenarios and average/consensus of model scenarios are shown.

	Smallest Increase			Largest Increase			Average Increase		
	%	°C	°F	%	°C	°F	%	°C	°F
2011-2020									
Annual Minimum Temp	2.2	0.6	1.1	3.5	0.9	1.6	2.9	0.8	1.4
Annual Maximum Temp	2.1	0.6	1.1	3.5	0.9	1.6	2.9	0.8	1.4
Annual Average Temp	2.2	0.6	1.1	3.5	0.9	1.6	2.9	0.8	1.4
2021-2040									
Annual Minimum Temp	2.8	0.7	1.3	4.8	1.3	2.3	3.8	1.0	1.8
Annual Maximum Temp	2.8	0.7	1.3	4.7	1.3	2.3	3.7	1.0	1.8
Annual Average Temp	2.8	0.8	1.4	4.8	1.3	2.3	3.8	1.0	1.8
2041-2060									
Annual Minimum Temp	5.2	1.4	2.5	7.0	1.9	3.4	5.9	1.6	2.8
Annual Maximum Temp	5.0	1.4	2.5	6.9	1.9	3.4	5.8	1.6	2.8
Annual Average Temp	5.2	1.4	2.5	7.0	1.9	3.4	5.9	1.6	2.8
2061-2080									
Annual Minimum Temp	6.8	1.8	3.2	10.4	2.8	5.0	8.2	2.2	3.9
Annual Maximum Temp	6.6	1.8	3.2	10.2	2.8	5.0	8.0	2.2	3.9
Annual Average Temp	6.7	1.8	3.2	10.4	2.8	5.0	8.2	2.2	3.9
2081-2099									
Annual Minimum Temp	8.4	2.2	4.0	11.7	3.1	5.6	10.1	2.7	4.8
Annual Maximum Temp	8.2	2.2	4.0	11.3	3.1	5.6	9.8	2.7	4.8
Annual Average Temp	8.4	2.2	4.0	11.6	3.1	5.6	10.1	2.7	4.8
2011-2099									
Annual Minimum Temp	2.2	0.6	1.1	11.7	3.1	5.6	6.5	1.7	3.1
Annual Maximum Temp	2.1	0.6	1.1	11.3	3.1	5.6	6.3	1.7	3.1
Annual Average Temp	2.2	0.6	1.1	11.6	3.1	5.6	6.5	1.7	3.1

Table 3.1-11 Percentage (%) increases in annual minimum, average and maximum temperatures (for future time periods examined) compared to the baseline. Data based on the average/consensus of all model scenarios.

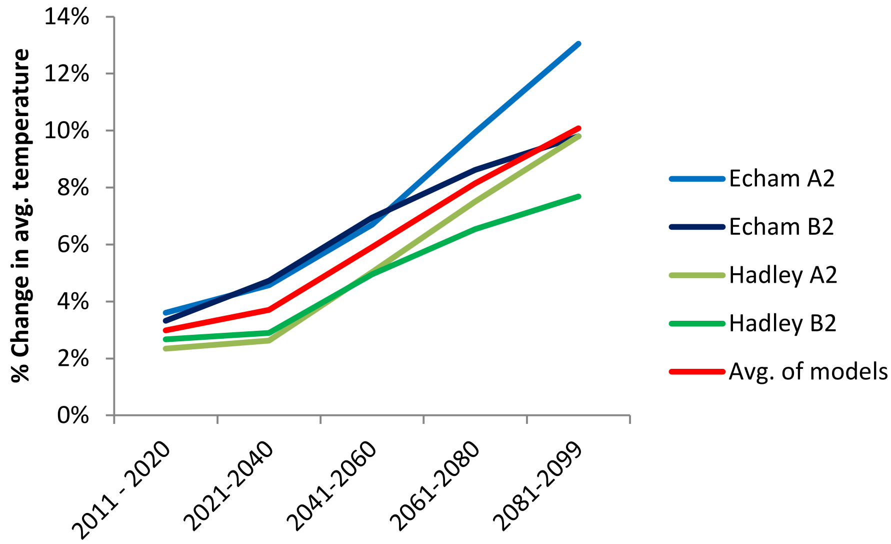


Figure 3.1-19 Average percentage (%) change in annual average temperature (for future time periods examined) compared to the baseline. All model scenarios and average/consensus of model scenarios are shown.

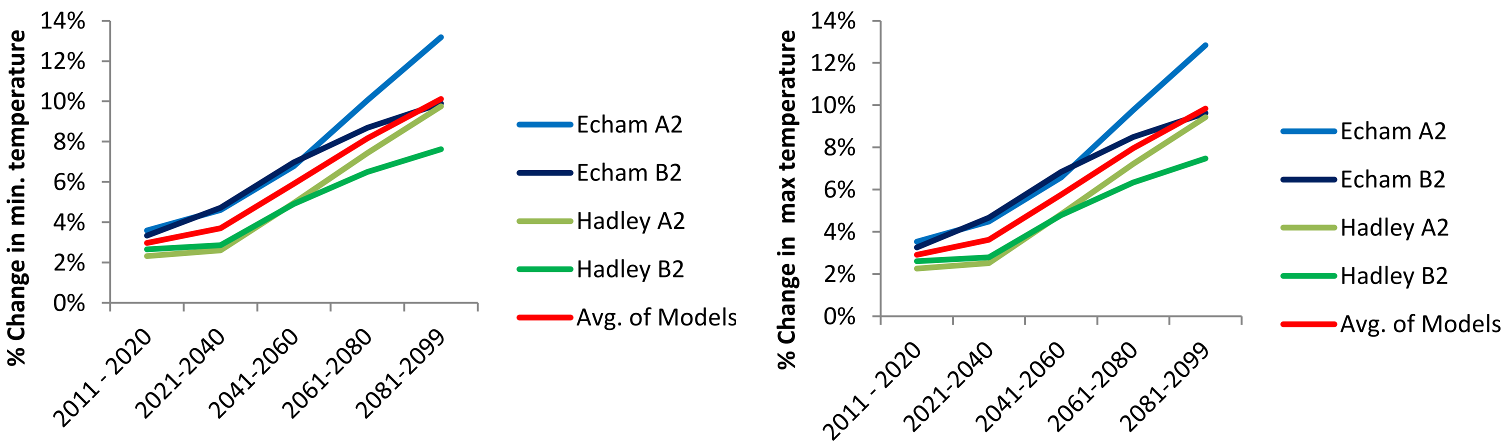


Figure 3.1-20 Average percentage (%) change in annual minimum (left) and maximum (right) temperature (for future time periods examined) compared to the baseline. All model scenarios and average/consensus of model scenarios are shown.

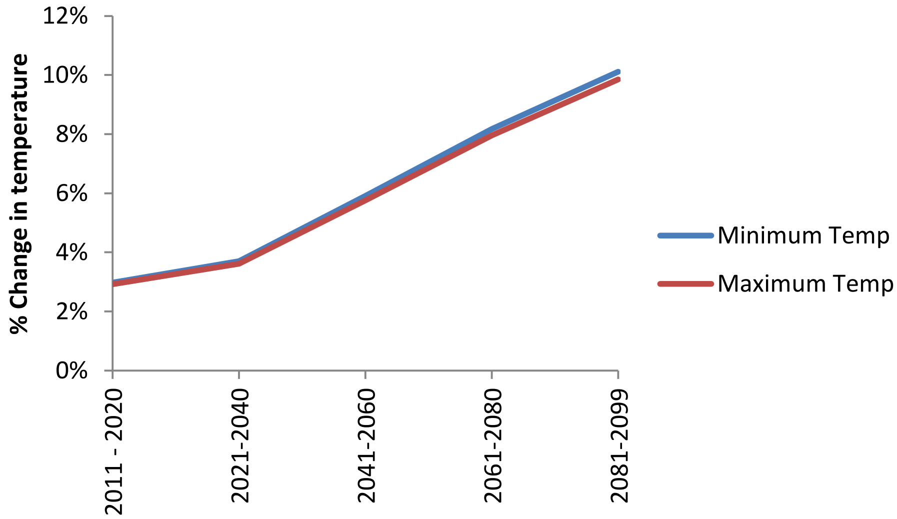


Figure 3.1-21 Percentage (%) increases in annual minimum and maximum temperatures (for future time periods examined) compared to the baseline. Data based on the average/consensus of all model scenarios.

Temperature – Seasonal

Figures 3.1.22 to 3.1-23 show that over the course of the Century, the consensus of the model scenarios projects increases in monthly average temperature that occur with an established seasonality that roughly aligns with the traditional winter/spring and summer/fall seasons.

Over the remainder of the Century, the greatest increases in monthly average temperature occur from December to April (averaging 7.1%) with a peak occurring in February. The smallest increases are projected to occur from May to November (averaging 6.1%) with July experiencing the least increase. This seasonality becomes more pronounced over the course of the Century. The immediate future shows a slight deviation from this trend with October being among the months of greatest increase and the peak increase occurring for a two month period, January to February.

In summary, therefore, the greatest increases in temperature are projected to be experienced during the winter months and the majority of spring. The smallest increases in temperature are projected to be experienced during the tail end of spring, the summer months and the fall.

Changes in minimum and maximum temperatures follow a similar seasonality (see Figure 3.1-24). Overall this would result in a trend towards summer-like conditions over a great portion of the year.

Figure 3.1-25 provides a consolidated view of changes in monthly minimum, average and maximum temperatures over the Century. The graph is an important remainder that not only average temperature, but also extremes in temperature (highs and lows) are rising over the Century. Increases in minimum temperatures play an important role in increases in average temperature.

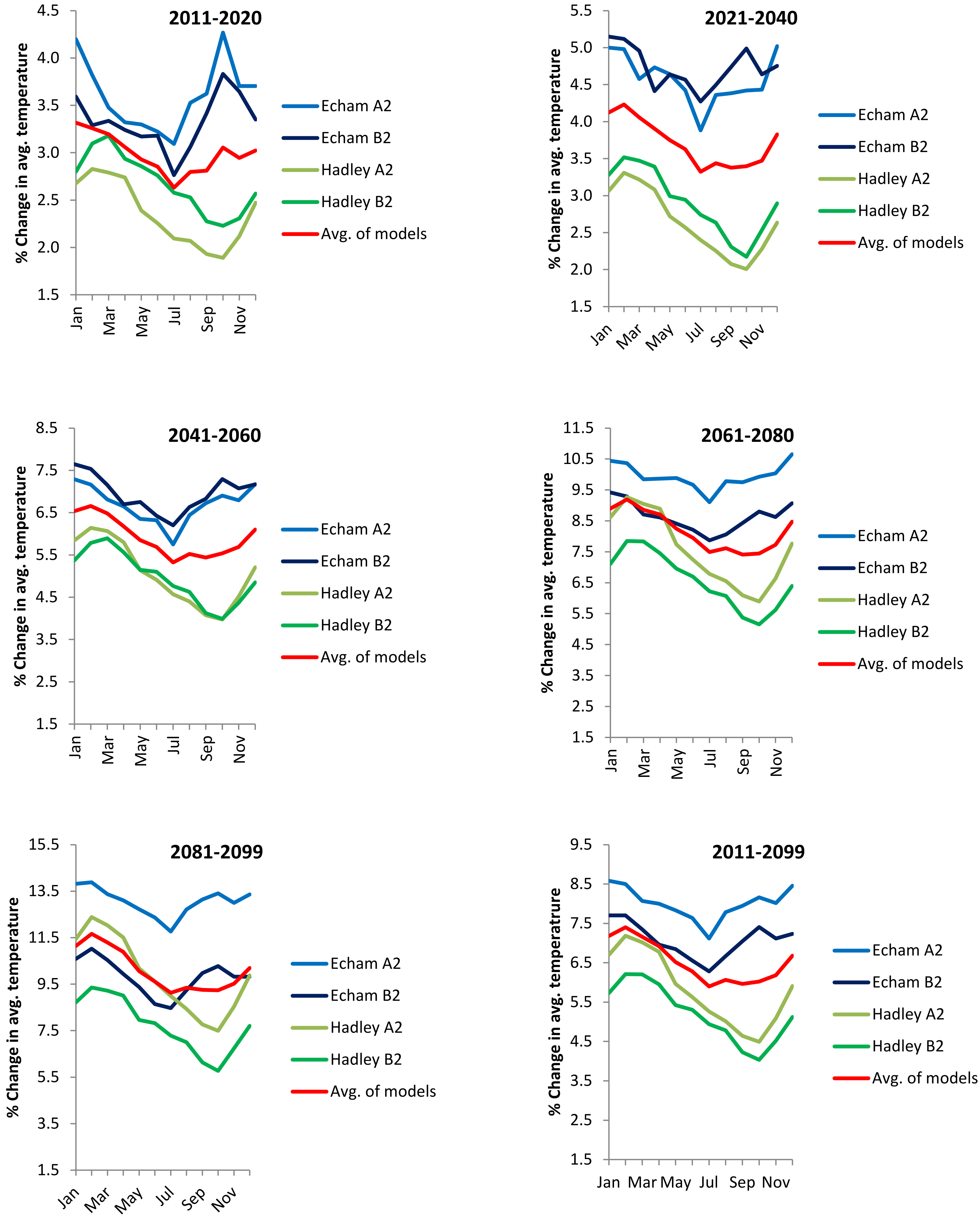


Figure 3.1-22. Percentage (%) change in monthly average temperature (for future time periods examined) compared to the baseline. All model scenarios and average/consensus of model scenarios are shown.

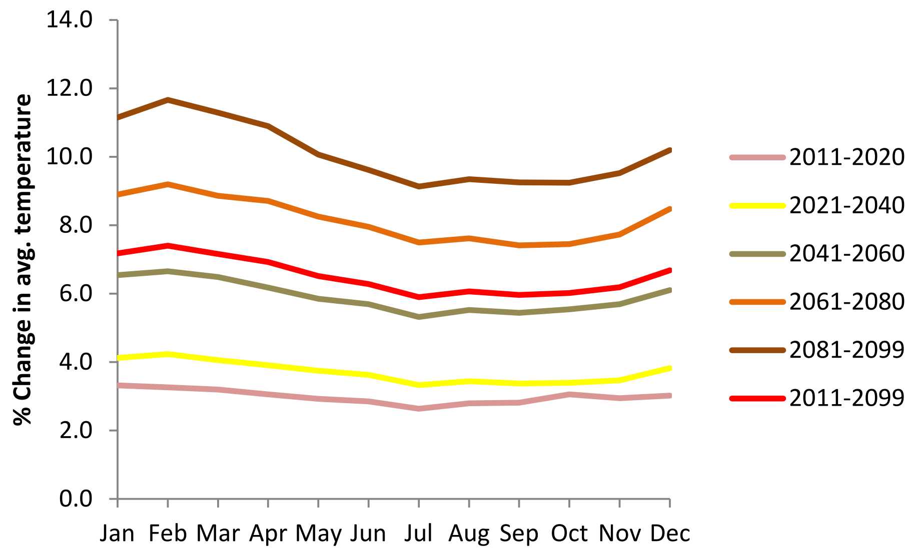


Figure 3.1-23. Percentage (%) change in monthly average temperature (for future time periods examined) compared to the baseline. Average/consensus of model scenarios only is shown.

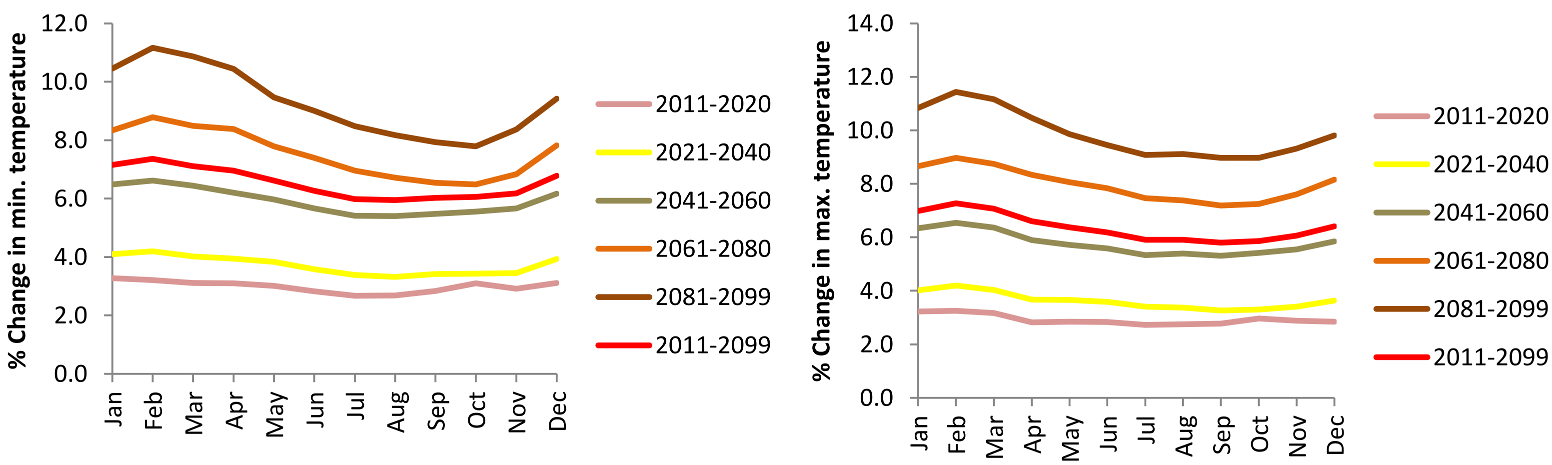


Figure 3.1-24 Percentage (%) change in monthly minimum (left) and maximum (right) temperatures (for future time periods examined) compared to the baseline. Average/consensus of model scenarios only is shown.

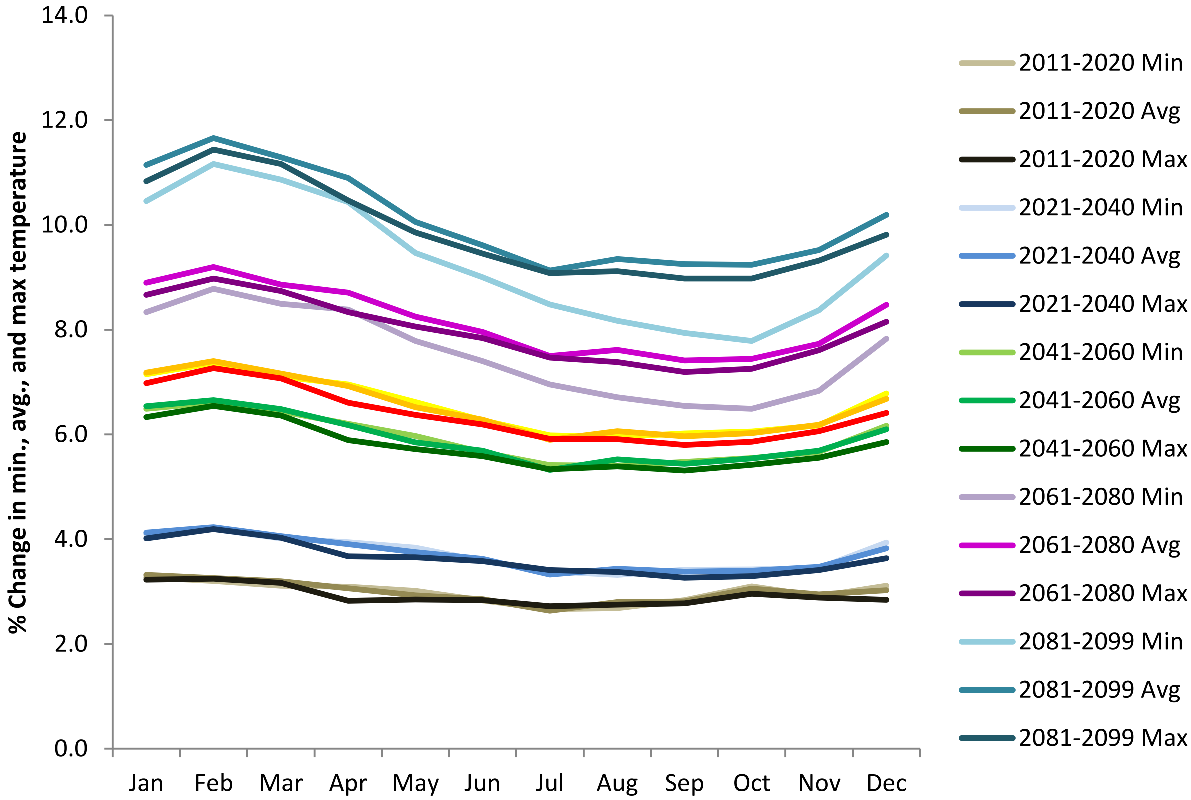


Figure 3.1-25. Percentage (%) change in monthly minimum, average and maximum temperature (for future time periods examined) compared to the baseline. Average/consensus of model scenarios only is shown.

Figures 3.1-26 to 3.1-28 show the future minimum, average and maximum temperatures projected for The Virgin Islands by adding the respective modeled percentage increases in temperature to The Virgin Islands observed monthly minimum, average and maximum temperatures as recorded at Paraquita Bay, Tortola (1901-1994) (Earle, 1997).

From these graphs it can be seen that climate change is causing monthly increases in minimum, average and maximum temperatures. While the projected seasonality of minimum, average and maximum temperatures remains essentially the same as the observed baseline, the effect of climate change is warmer temperatures throughout the year, including summer, and extended summer-like conditions.

Currently summer can be defined as extending from July to September when the warmest temperatures are experienced, averaging 28°C/82.4°F. Already by the 2011-2020 period, average summer temperatures (starting from 28°C/82.4°F) are projected to extend 1-2 months longer, from June/July to September/October. Also by this period, the classic summer period (July to September) is projected to get up to 2.7% (0.8°C/1.4°F) warmer than the baseline, averaging 28.8°C/83.8°F. By the last period of the Century, average summer temperatures are projected to extend an additional 5-6 months from March/April to November and the classic summer period temperatures projected to get up to 9.2% (2.6°C/4.7°F) warmer, averaging 30.6°C/87.1°F.

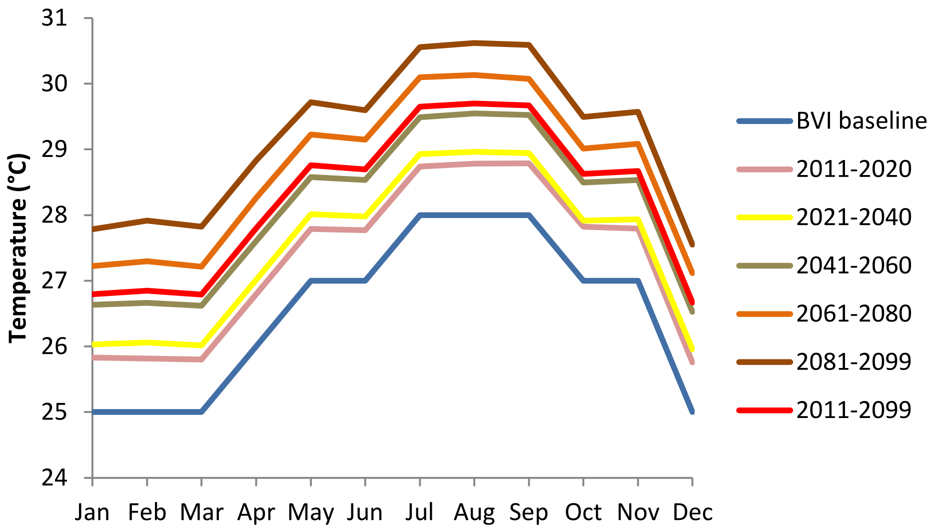


Figure 3.1-26 Future average temperatures projected for The Virgin Islands by adding the modeled percentage increases in temperature to The Virgin Islands observed monthly average temperatures as recorded at Paraquita Bay, Tortola (1901-1994). Average/consensus of model scenarios only is shown.

Maximum temperatures are increasing in every month of the year so that the baseline maximum temperatures (starting at 30°C / 86°F) normally experienced only from the start of summer (July) to November, are experienced from June/July to November in the immediate future (2011-2020) and by the 2041-2060 period onward are essentially experienced year round.

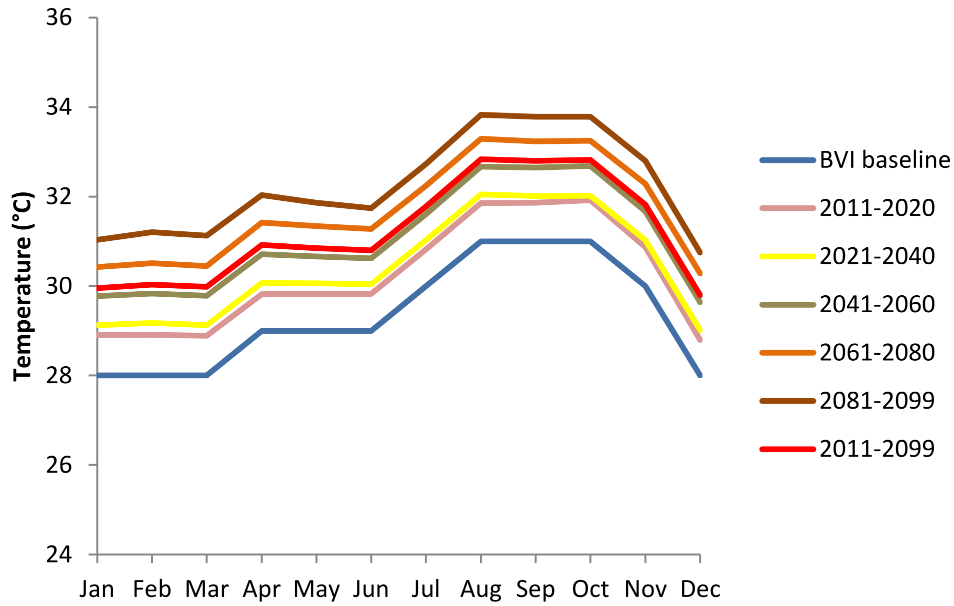


Figure 3.1-27. Future maximum temperatures projected for The Virgin Islands by adding the modeled percentage increases in temperature to The Virgin Islands observed monthly maximum temperatures as recorded at Paraquita Bay, Tortola (1901-1994). Average/consensus of model scenarios only is shown.

Similarly, minimum temperatures are increasing in every month of the year. By the 2021-2040 period the baseline peak minimum temperate (26°C/78.8°F), normally experienced only in July is experienced from June to July. By the last period of the Century, it is experienced from May to October.

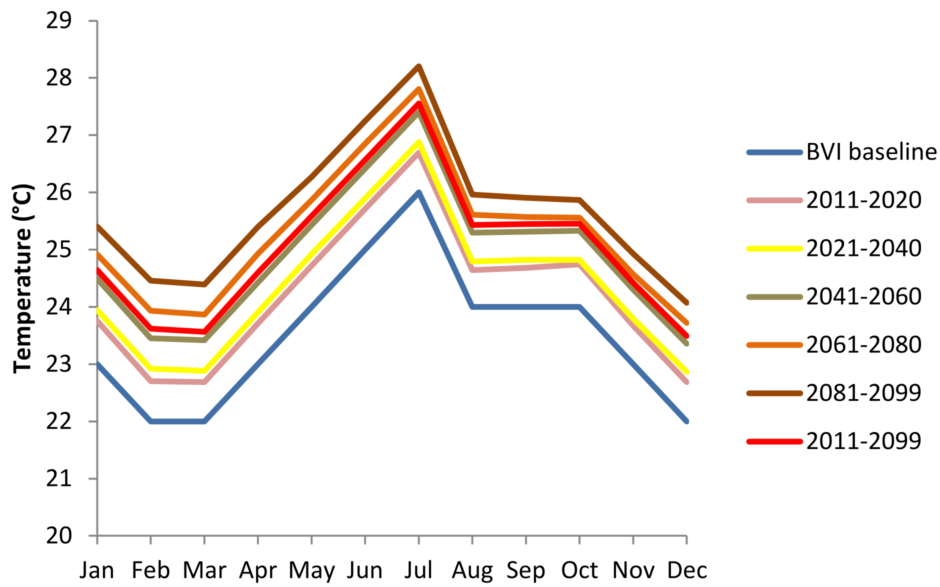


Figure 3.1-28. Future minimum temperatures projected for The Virgin Islands by adding the modeled percentage increases in temperature to The Virgin Islands observed monthly maximum temperatures as recorded at Paraquita Bay, Tortola (1901-1994; Earle, 1997). Average/consensus of model scenarios only is shown.

Figure 3.1-29 below provides a consolidated view of baseline and projected minimum, average and maximum temperatures in relation to each other. Averaged over the entire period, 2011-2099, projected average temperatures from April/May to November are similar to current average summer temperatures (28°C/82.4°F) experienced from July to September. Within this span, from May to July projected average temperatures approach the current (baseline) maximum temperatures. In January, June and July, the projected minimum temperatures approach the current (baseline) average temperatures.

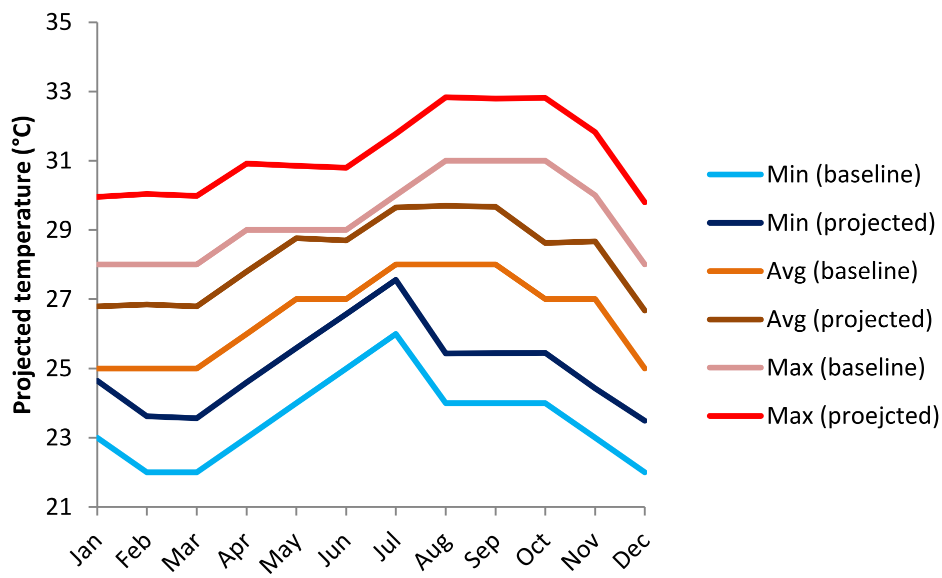


Figure 3.1-29. Future minimum, average and maximum temperatures projected for The Virgin Islands by adding the respective modeled percentage increases in temperature to The Virgin Islands observed monthly minimum, average and maximum temperatures as recorded at Paraquita Bay, Tortola (1901-1994) (Earle, 1997). Average/consensus of model scenarios only is shown.

Relative Humidity – Annual

Figure 3.1-30 below shows that over the entire period, 2011-2099, there is a consensus among the model scenarios for an increase in annual relative humidity compared to the model baseline; these changes however are minimal. Over the entire period (2011-2099), annual relative humidity is projected to increase between 0.1% and 1.6%, with an average increase of 0.8%. The only decrease in annual relative humidity, compared to the baseline, projected by the consensus of the models is very small (-0.2%) occurring for one year in the immediate future.

At a yearly scale, increases in relative humidity follow a saw-tooth type pattern as observed in Figure 3.1-30. Broken down in 10 to 20 year periods, however, over the course of the Century, relative humidity shows a gradual increase at an almost steady rate (~0.01% per year) which only slows in the last 20 years of the Century (see Figure 3.1-31 and Table 3.1-12).

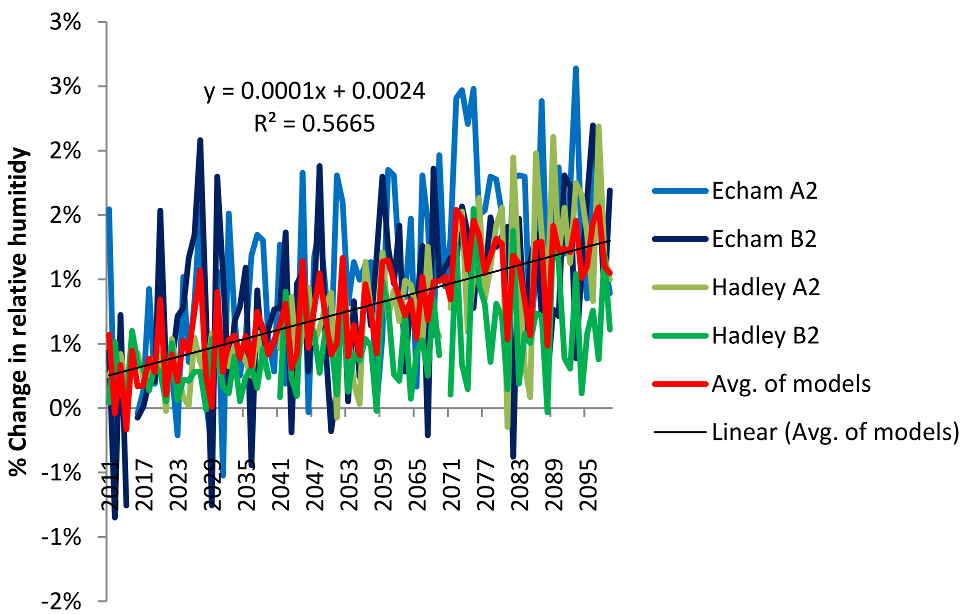


Figure 3.1-30. Percentage (%) change in annual relative humidity (2011-2099) compared to the baseline. All model scenarios and average/consensus of model scenarios are shown.

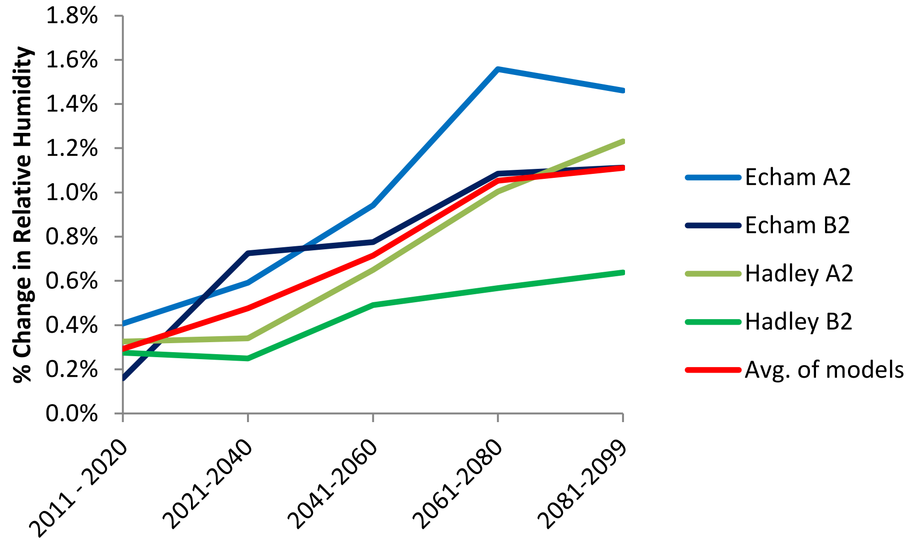


Figure 3.1-31. Average percentage (%) change in annual relative humidity (for future time periods examined) compared to the baseline. All model scenarios and average/consensus of model scenarios are shown.

	Smallest Increase	Largest Increase	Average Increase
	%	%	%
2011-2020	0.2	0.8	0.3
2021-2040	0.1	1.1	0.5
2041-2060	0.3	1.2	0.7
2061-2080	0.5	1.5	1.1
2081-2099	0.5	1.6	1.1
2011-2099	0.2	1.6	0.8

Table 3.1-12 Percentage (%) change (smallest, largest and average) in annual relative humidity (for future time periods examined) compared to the baseline. Data based on the average/consensus of model scenarios.

Relative Humidity – Seasonal

As with the case of rainfall, the immediate future and near-term show a gradual development towards a seasonality of changes in relative humidity that is strongly established from 2041 to the end of the Century (see Figures 3.1-32 to 3.1-33). Overall, like annual changes, it should be noted that seasonal changes in relative humidity are minimal.

In the immediate future (2011-2020), seasonality of changes in relative humidity shows a wide U-shape with a saw-tooth like pattern throughout. In this period, therefore, the greatest increases in relative humidity are experienced at the beginning and end of the year (December to February, averaging 0.6%) with a very slight decrease occurring mid-year (June) of 0.1% with almost constant fluctuations throughout the year. By the 2021-2040 period the saw-tooth like pattern is much less pronounced and a second peak in relative humidity (August – October, averaging 0.7%) emerges.

By 2041 and continuing to the end of the Century, the following seasonality of changes in relative humidity clearly emerges: there are two major peaks in increases in relative humidity of similar magnitude, December to February (averaging 1.5% from 2041-2099) and August to September (also averaging 1.5%). Midyear, June, is the only point when there is no increase in relative humidity. A smaller (minor) peak occurs in April (averaging 1.0%). For the remainder of the year, between peaks and the no increase point in June, (March, May, July, October, November), relative humidity increases on average by 0.6%.

Table 3.1-13 below shows how these changes correspond to traditional temperature, rainfall and tourist seasons. Both peak increases in relative humidity occur at transitions between rainfall seasons. At least one of these peaks occurs in the height of the tourist season. Figure 3.1-34 further shows the relationship between changes in relative humidity and the tourist season throughout the Century. From this graph it can be seen that increases in relative humidity are constantly higher (by 0.2% on average) during the tourist season compared to the off season.

Figure 3.1-35 below shows a comparison between the changes in seasonality of relative humidity, rainfall and temperature over the entire period 2011-2099. From this figure it can be observed that while there is some correlation between changes in relative humidity and rainfall (from December to June), rainfall and temperature changes cannot fully explain the observed changes in relative humidity, especially the second peak increase in relative humidity (August to September).

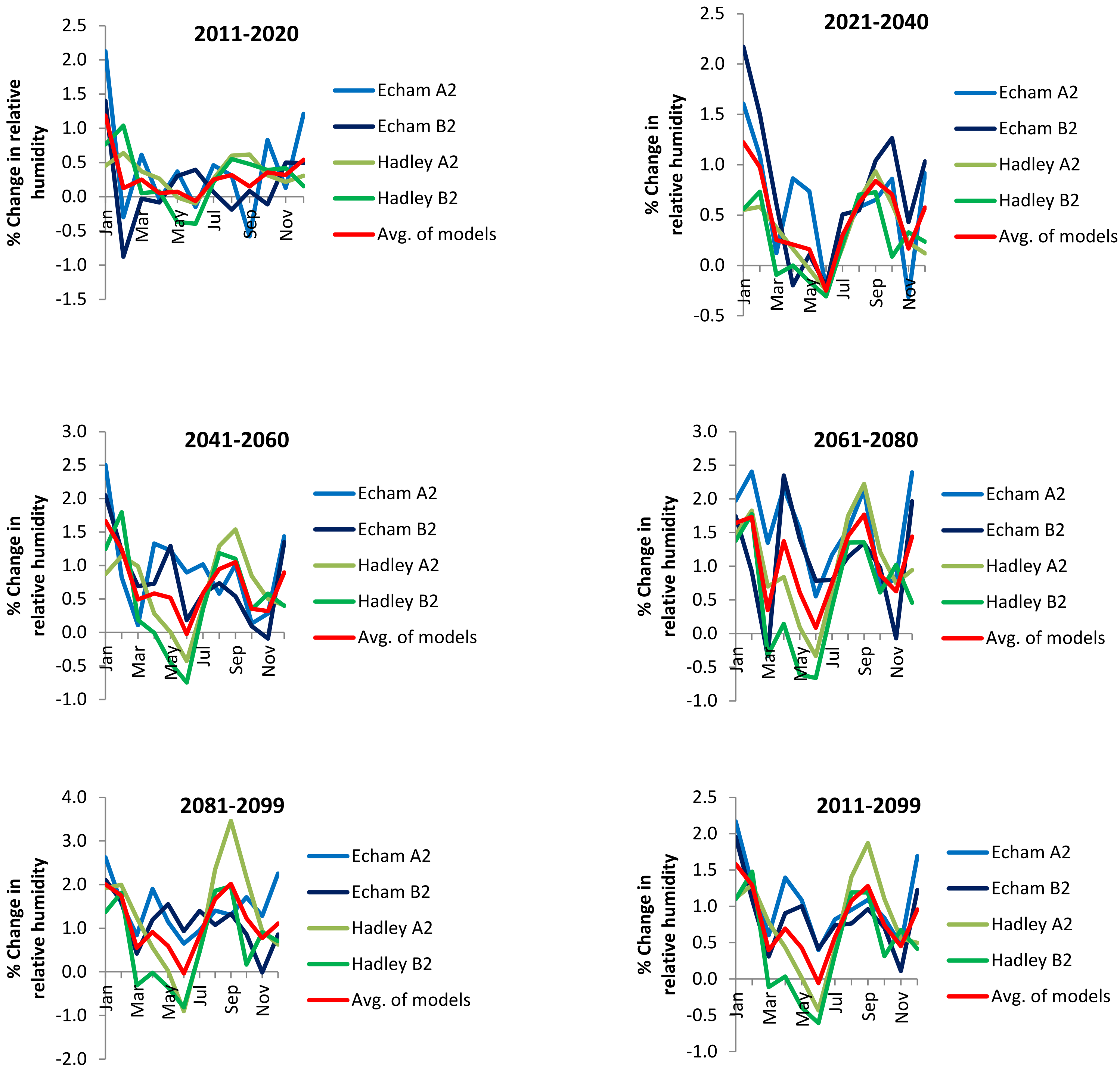


Figure 3.1-32 Percentage (%) change in monthly relative humidity (for future time periods examined) compared to the baseline. All model scenarios and average/consensus of model scenarios are shown.

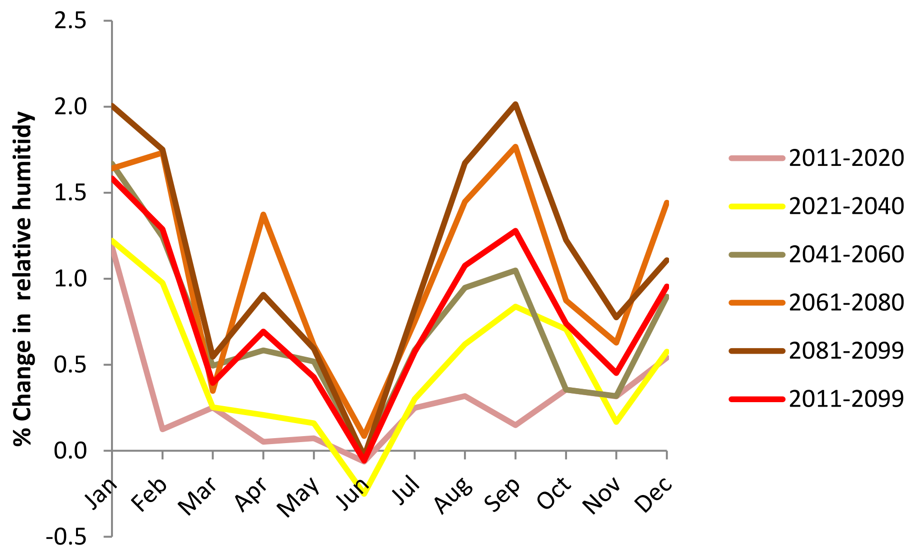


Figure 3.1-33 Percentage (%) change in monthly relative humidity (for future time periods examined) compared to the baseline. Average/consensus of model scenarios only is shown.

Change in Relative Humidity	Traditional Temperature Season	Traditional Rainfall Season	Tourist Season
Major peak increase #1 (Dec – Feb)	Winter	Rainy: Dec Dry: Jan - Feb	Yes
Major peak increase #2 (Aug to Sep)	Summer/Fall	Dry: Aug Rainy: Sep	No
Minor peak increase (Apr)	Spring	Dry	Yes
No increase (Jun)	Summer	Dry	No

Table 3.1-13 Changes in monthly relative humidity compared to traditional temperature, rainfall and tourist seasons. Data based on average/consensus of model scenarios.

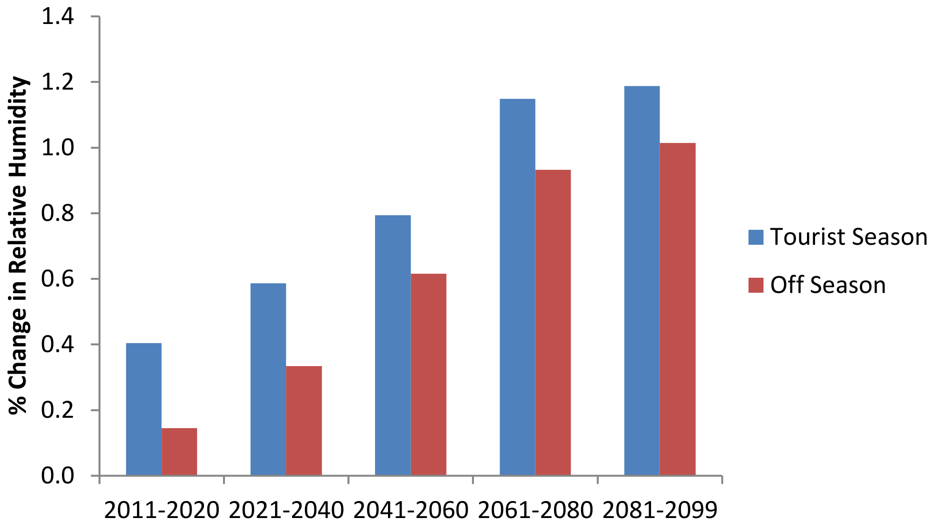


Figure 3.1-34 Changes in monthly relative humidity compared to the tourist season and off season (for future time periods examined). Data based on average/consensus of model scenarios.

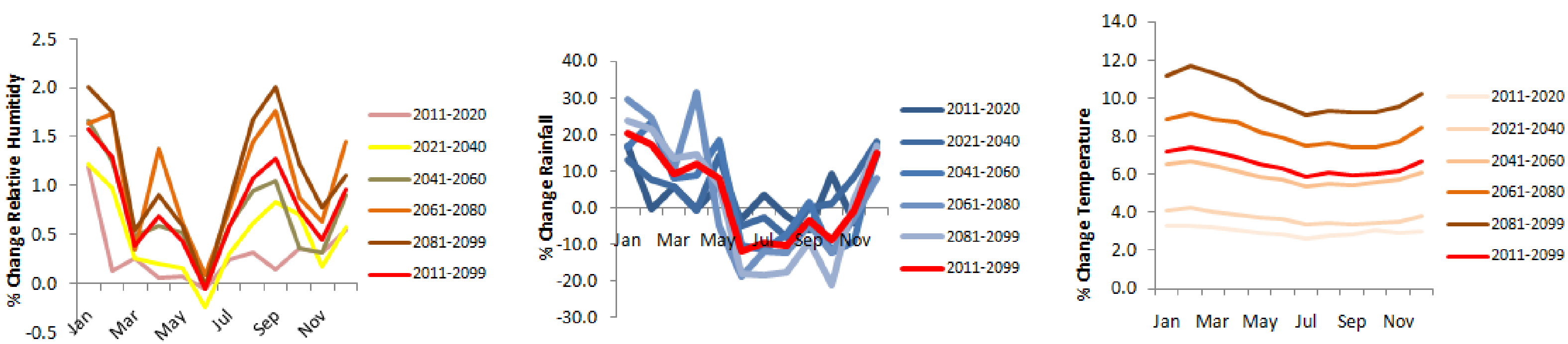


Figure 3.1-35 Comparison between changes in seasonality of relative humidity, rainfall and temperature (for future time periods examined).

Wind– Annual

Figure 3.1-36 below shows that over the entire period, 2011-2099, a very small decrease in annual wind speed of 0.8% is projected by the average/consensus of the model scenarios. During the course of the Century changes in speed wind range from a decrease of 4.5% to an increase of 2.8%

From Figure 3.1-37, it is clear that the model scenarios disagree on a trend for changes in annual wind speed over the course of the Century; the average/consensus of the model scenarios, however, projects a decrease over the entire Century with the largest decreases occurring in the 2041-2060 period.

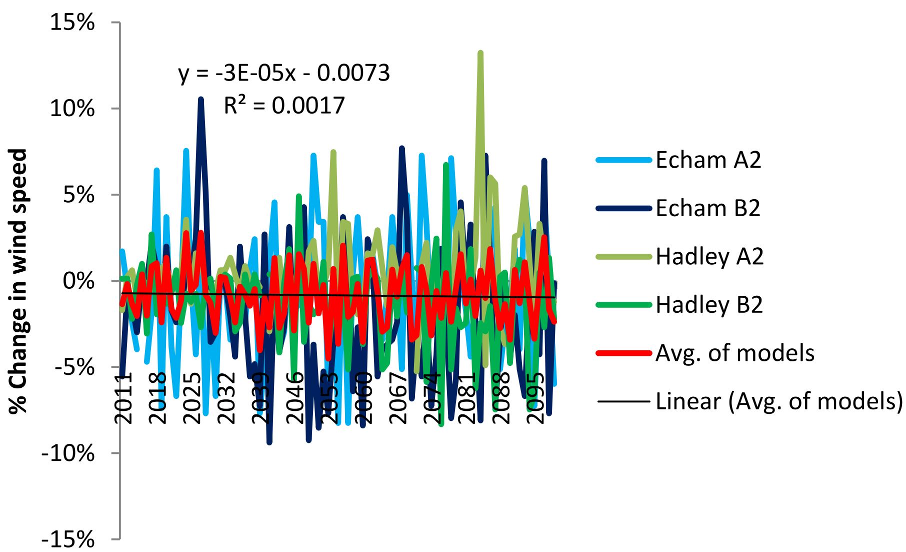


Figure 3.1-36. Percentage (%) change in annual wind speed (2011-2099) compared to the baseline. All model scenarios and average/consensus of model scenarios are shown.

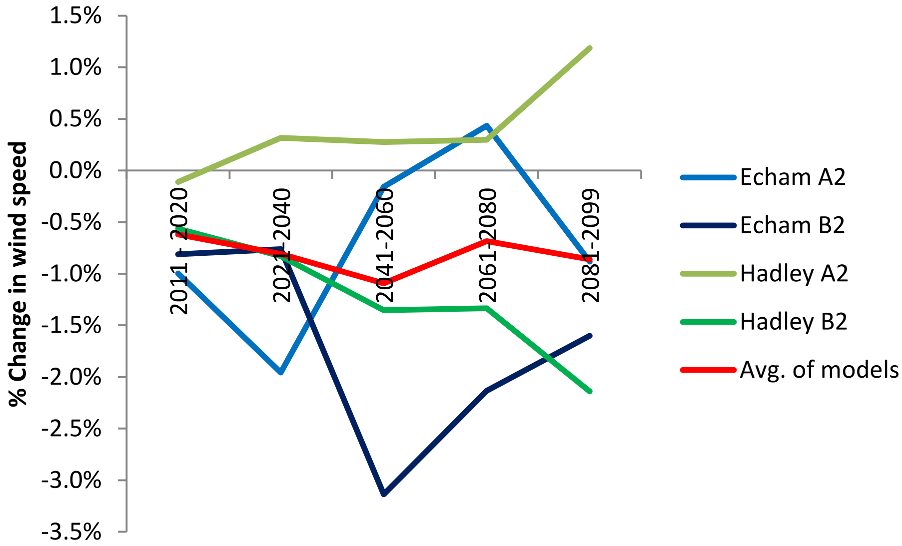


Figure 3.1-37. Average percentage (%) change in wind speed (for future time periods examined) compared to the baseline. All model scenarios and average/consensus of model scenarios are shown.

Wind– Seasonal

Again, as with the case of rainfall and relative humidity, the immediate future to near-term show a gradual development towards a seasonality of changes in wind speed that is strongly established from 2041 to the end of the Century (see Figures 3.1-38 to 3.1-39).

In the immediate future (2011-2020), the seasonality of changes in wind speed shows a saw-tooth like pattern throughout, with all changes being negative – ranging from a decrease in wind speed of 0.2% to 6.3% and averaging 3.1%. In this period, the greatest decreases in wind speed are experienced from November to December and in April. By the 2021-2040 period, an increase in wind speed from July to October, peaking at 4.1% in August, emerges.

By 2041 and continuing to the end of the Century, the following seasonality of changes in wind speed clearly emerges: from October to March there is a decrease in wind speed ranging from 0.6% to 12.7% and averaging 5.3% (for 2041-2099). In April a small increase in wind speed is experienced (averaging 2.6%), followed by very slight increases and decreases in wind speed from May to June, averaging 0.3% increase. From July to September, there is an increase in wind speed ranging from 2.8% to 12.4% and averaging 7.5%. The biggest decrease in wind speed is typically experienced in November and the biggest increase typically experienced in August.

Figure 3.1-40 shows the relationship between changes in wind speed and the tourist season throughout the Century. From this graph it can be seen that the tourist season consistently experiences decreases in wind speed over the remainder of the Century (2011-2099) ranging from 2.0% (2021-2040 period) to 4.9% (2081-2099) and averaging 3.7%.

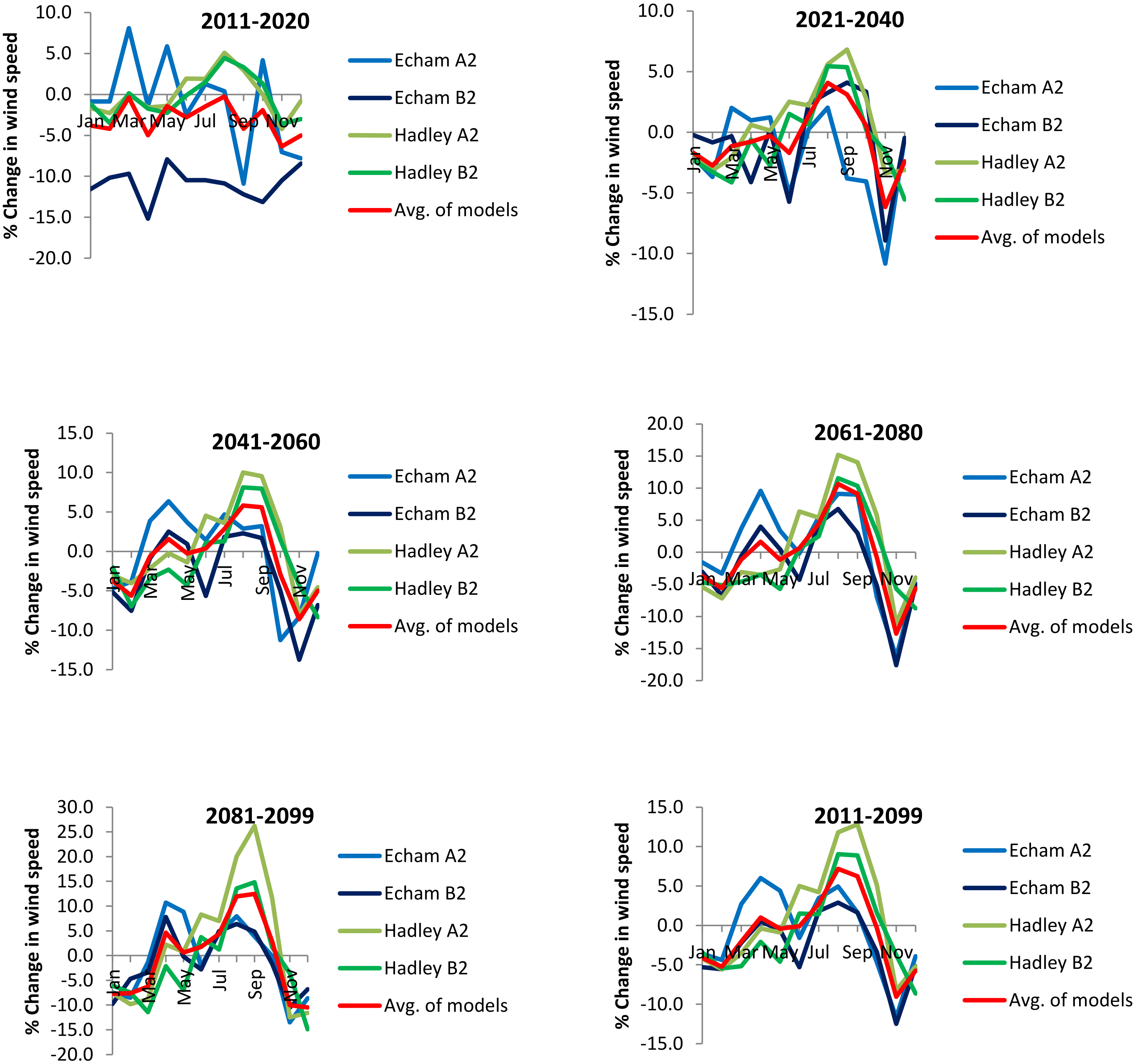


Figure 3.1-38 Percentage (%) change in monthly wind speed (for future time periods examined) compared to the baseline. All model scenarios and average/consensus of model scenarios are shown.

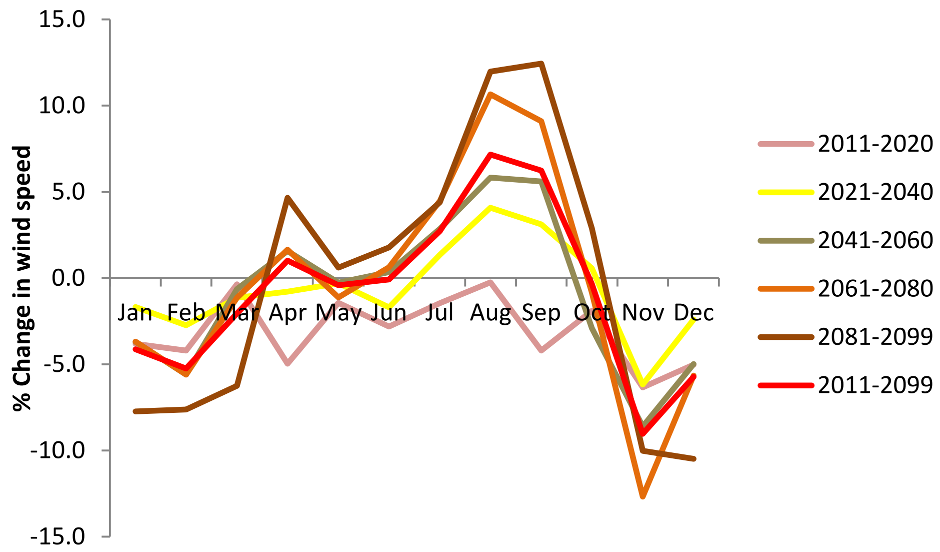


Figure 3.1-39 Percentage (%) change in monthly wind speed (for future time periods examined) compared to the baseline. Average/consensus of model scenarios only is shown.

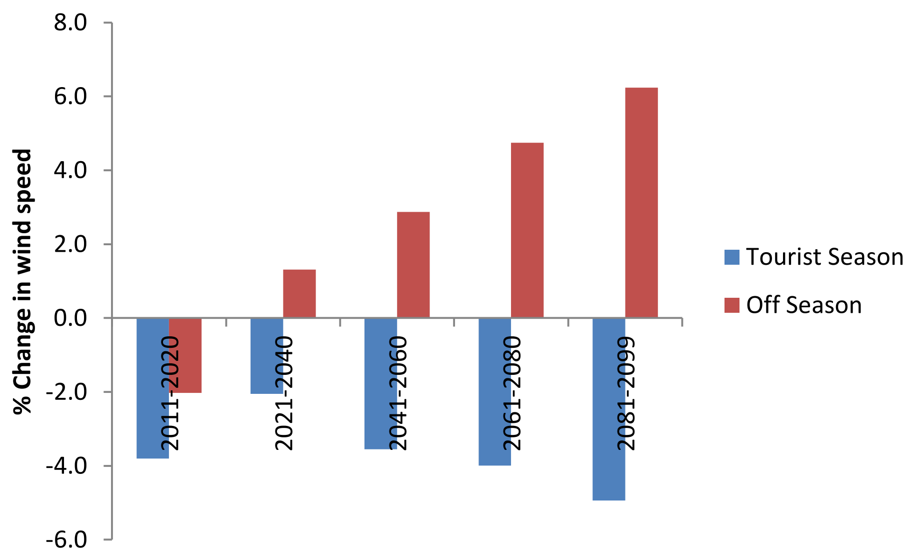


Figure 3.1-40 Changes in monthly wind speed compared to the tourist season and off season (for future time periods examined). Data based on average/consensus of model scenarios.

Comfort Index

Figure 3.1-41 is a Comfort Index created for The Virgin Islands from 2011 to the end of the Century. As the name suggests, the Comfort Index is an indicator of how comfortable conditions feel on the ground and it takes into consideration three parameters: average temperature, relative humidity and wind speed.

In the graph, time periods are given along the x-axis while the number of days with a TEE greater than 25°C is given along the y-axis. A TEE greater than 25°C means that with the two other parameters considered, average temperature feels greater than 25°C. 25°C is considered the acceptable comfort level. The graph, therefore, shows the number of days that can be considered "uncomfortable" over the remainder of the Century.

Based on the rough average/consensus of the model scenarios, as the Century progresses the number of uncomfortable days increases steadily from about mid range of the 0 - 85 day grid (equivalent to 0 – 2.8 months) to about mid range of the 170 – 255 day grid (equivalent to 5.7 – 8.5 months). The most rapid increase seems to occur in the 2041-2060 period (see Table 3.1-14).

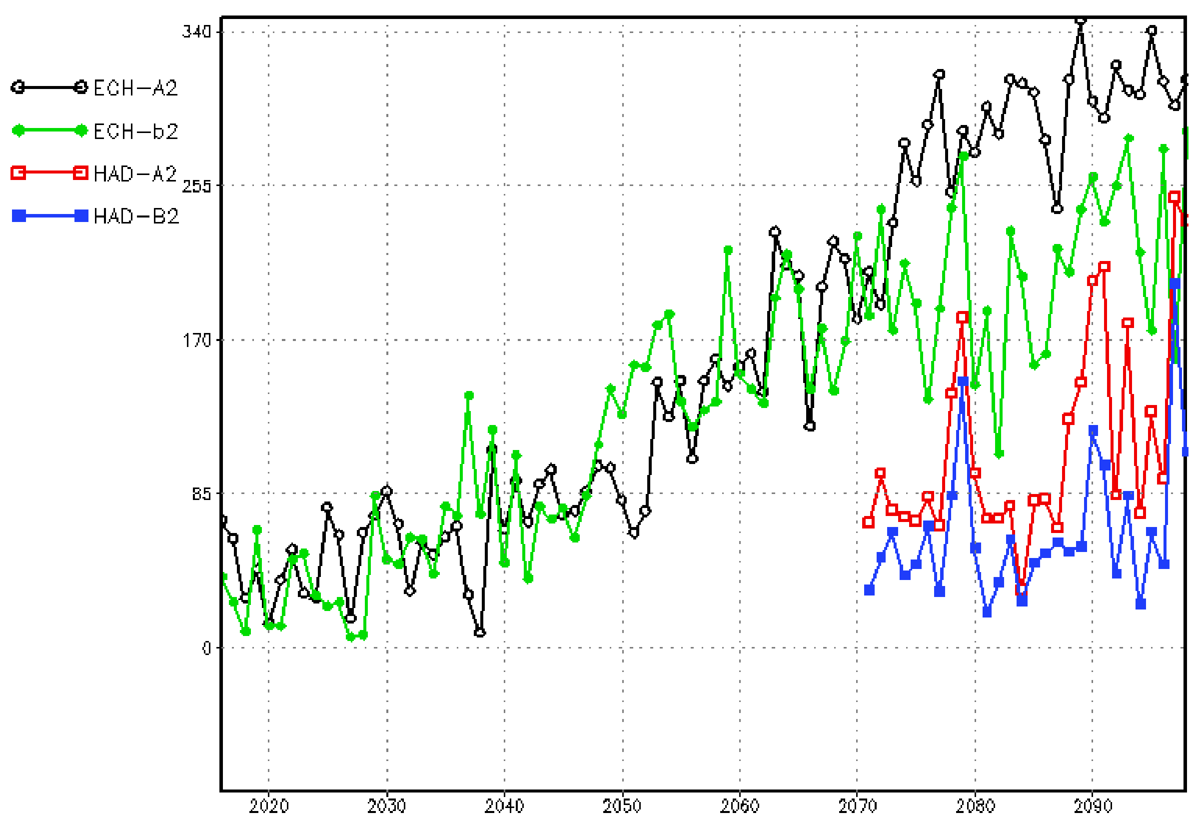


Figure 3.1-41 Comfort Index showing number of days in each year (2011-2099) with a TEE >25°C (categorized as "uncomfortable"). All model scenarios are shown.

Time Period	**Approximate average no. of days with TEE >25**			**Equivalent no. months**
	Avg. of Echam A2, B2 models	***Avg. of Hadley A2, B2 models***	***Avg. of all models***	
2011-2020	0 – 85 (mid range)	ND	NA	0 – 2.8
2021-2040	0 -85 (mid range)	ND	NA	0 – 2.8
2041-2060	85-170 (mid range)	ND	NA	2.8 – 5.7
2061-2080	170 – 255 (mid range)	Incomplete data	NA	5.7 – 8.5
2081-2099	170-255 (upper range)	85-170 (mid range)	170-255 (mid range)	5.7 – 8.5

Table 3.1-14 Approximate average number of days with a TEE >25°C (for future time periods examined). All model scenarios and average/consensus of model scenarios are shown.

DISCCUSSION – IMPLICATIONS OF FUTURE CLIMATE CHANGES TO TOURISM

Natural tourist attractions

The Tourist Perception Survey conducted as a part of the VCA, confirms that The Virgin Islands' tourism industry is based on our attractive and predictable climate as well as our environmental features, particularly our pristine coastal waters, healthy coral reefs and white sand beaches, and the activities based around them such as sailing, diving and recreational fishing.

The consensus of the climate models clearly shows that in the future the climate of The Virgin Islands will be more extreme in some regards with important annual and monthly changes. This will have a negative impact on the natural attractions and associated activities identified above. Impacts to natural attractions are discussed here while impacts to comfort level and participation in outdoor activities, special events and festivals are discussed separately below.

Coastal Water Quality

The Virgin Islands experiences a pervasive problem of sedimentation of coastal waters. This results from lack of implementation of the proper controls suited for development on the islands' hilly topography and very shallow soils. As a result, coastal water quality in many tourist areas, including Cane Garden Bay, is negatively impacted in moderate to heavy rain events and floods.

Over the remainder of the Century, average monthly rainfall is projected to increase over the entire tourist season (October to April) by 4.8% (2011-2020 period) to up to 10.2% (2061-2080 period). Increases of 5.5% to 6.8% are projected for the other periods. While these increases are relatively small, they increase the chances of sedimentation of coastal waters.

In addition, as climate change causes more intense hurricanes, The Virgin Islands could be subject to heavier flooding during such events. This is because hurricanes have significantly more near-storm rainfall for warmer climate conditions (~12% per degree Celsius) (Rubiera, J. (2009). Stronger hurricanes are, therefore, projected to pack up to 25% more rainfall by 2050 (Mimura et.al, 2007). While hurricanes typically occur during the off-season (most have occurred in mid to late September) they are still of concern as The Virgin Islands takes measures to encourage more tourists during the off season and the impact from heavy rain events on coastal water quality can linger from a few days to weeks. Furthermore, hurricanes can occur in October and November when the tourist season has already started.

Coral reef degradation

Coral reefs are extremely sensitive ecosystems, especially to changes in surrounding ocean temperatures. A coral bleaching event[1] can be triggered with just slight deviations (for a long enough period) from the average maximum ocean temperature experienced during the year (as little as 1-2 °C / 1.8-3.6 °F). Ocean temperatures will rise as the temperature of the atmosphere rises.

Coral bleaching leaves coral vulnerable to algae overgrowth and diseases such as White Plague and Black Band that have been detrimental to Caribbean reefs (Nicholls et al., 2007). If ocean temperatures do not return to normal fast enough, bleaching events could result in coral mortality. Coral bleaching, therefore, affects the reefs much longer than temperatures remain elevated.

Currently maximum temperatures are greatest from July to November when they average 30.6°C. Table 3.1-15 shows how the average maximum temperature for these months increases over the course of the Century. From the 2011-2020 period to the 2041-2060 period average maximum temperatures rise enough, 1-2°C, to trigger bleaching events. In the 2061-2080 and 2081-2099 periods average maximum temperature rise exceeds the threshold, increasing by almost up to 3°C.

Time Period	Average Maximum Temperature (°C) (July – November)	Increase in atmospheric temperature (°C)
2011-2020	31.5	0.9
2021-2040	31.6	1.0
2041-2060	32.3	1.7
2061-2080	32.9	2.3
2081-2099	33.4	2.8

Table 3.1-15 Increase in average maximum temperature from July to November (for future time periods examined) compared to the baseline. Data based on average/consensus of model scenarios.

[1] Coral bleaching describes the loss of colour in reef-building corals and the subsequent exposure of their underlying bright white skeleton. Reef-building corals are highly dependent on a symbiotic (co-dependent) relationship with microscopic algae (zooxanthellae) which live within the coral tissues and give the coral its colour and most of its "food" resources. When ocean temperatures get too hot, corals eject their zooxanthellae and or the zooxanthellae lose their chlorophyll, resulting in coral bleaching. Because zooxanthellae supply corals with up to 90% of their energy, corals are weakened and susceptible when they are bleached and can die in extreme cases (Spalding et al., 2001).

The Virgin Islands has already experienced a mass bleaching event with an economic impact to the scuba diving and snorkeling tourism sector estimated at 2005 $1,270,000 (equivalent 25% of the sector's 2005 revenue) (Hime, 2008). In the Fall of 2005 (on average the hottest year on record in the Northern Hemisphere) water temperatures in the Caribbean exceeded 29.5 °C (85.1 °F) for twelve (12) weeks, triggering a region-wide mass bleaching event (Wilkinson & Souter, 2008). The Virgin Islands was among the worst affected with close to 90% of coral being bleached (Petit & Prudent, 2008; Wilkinson & Souter, 2008). Reef Check-BVI has estimated that 35% of coral has been lost since the bleaching event (cited in Petit & Prudent, 2008).

So far, there is limited evidence to suggest that corals and their zooxanthellae (co-dependent microscopic algae) can adapt to warmer waters; therefore, it is very likely that as minimum, average and maximum temperatures increase and ocean temperatures rise 1-3 °C (1 - 5.4 °F), the frequency and mortality rates of bleaching events will increase (Nicholls et al., 2007).

In addition to bleaching events climate change could further cause coral reef degradation by increasing the physical stress to the reef from a higher percentage of stronger (category 4 and 5) hurricanes passing through the Caribbean region.

The situation is further complicated by decreased coral skeleton growth rates and weakening of existing skeletons as the ocean becomes more acidic (ocean acidification) due to increased concentrations of carbon dioxide (Mimura et.al, 2007; Wilkinson & Souter, 2008). Ocean acidification not only affects the coral itself, but the "calcareous algae" that is important to cement the reef together (Johnson & Marshall, 2007).

Sport fishery

The steady increase in average ocean temperatures will also likely have a negative impact on recreational fishing. Some species extremely important to the industry, such as Dolphin Fish (Mahi Mahi), are highly temperature sensitive and would migrate out of The Virgin Islands waters to cooler waters with just a 1°C rise in average ocean temperatures. As indicated in Table 3.1-15, a rise in atmospheric temperatures of this magnitude is projected as early as the 2011-2020 period.

Beach erosion

In the near-term, the primary climate change impact to beaches is more intense hurricanes and associated storm surges. Already, observations have shown an increase in the intensity of hurricanes in the Atlantic. The greatest level of cyclonic activity recorded in the Atlantic Basin since 1886 has been from 1995 to 2008. In this 14-year period cyclonic activity more than doubled compared to any other similar period, including 2.5 times more major hurricane occurrences (Rubiera, 2009). As the climate continues to warm, the region can expect more category 4 and 5 hurricanes (Henson, 2006; Wilkinson & Souter, 2008).

A single major hurricane can have a significant impact on beaches. Monitoring by the Conservation and Fisheries Department shows that Hurricane Hugo (1989), a category 4 hurricane when it passed 70 kilometres (43 miles) south of Tortola, caused beaches on Jost Van Dyke to erode an average of some three metres (nine feet) in width (cited in Petit & Prudent, 2008).

Over the long-term, sea level rise becomes a climate change impact of significant concern, especially if development behind the beach prevents the beach from migrating to keep up with sea level rise. By the end of the 21st Century, average global sea level is projected to rise between 0.19 – 0.58 metres (0.62 – 1.90 feet) relative to 1980 – 1999 levels (Mimura et.al, 2007).

The implications of this are serious; it would mean that significant areas of beach would be at risk of permanent inundation (flooding) (Nicholls et al., 2007). The Beach Vulnerability Assessment of Cane Garden Bay Beach, for example, indicates that between 12% and 38% of the beach area could be lost with a sea level rise of 0.18m and 0.59m respectively.

Cane Garden Bay is easily one of the most popular tourist beaches, certainly for cruise ship passengers, and a lot of tourism activity (accommodations, restaurants, water sports) is centred around the beach. Loss of such a significant percentage of beach area would, therefore, have major economic impacts for the Cane Garden Bay area and the tourism industry at large.

With the combination of more severe hurricanes and sea level rise, accelerated beach erosion is anticipated (Mimura et.al, 2007). The number of high quality easily accessible beaches for tourism is limited to a handful on the main islands. Development is already present or increasingly being proposed behind these beach areas (for example Josiah's Bay, Lambert Bay Beach, Smuggler's Cove, Brewer's Bay and Cane Garden Bay on Tortola, the Baths on Virgin Gorda, White Bay on Jost Van Dyke, and most beaches on Anegada). This trend is seriously disadvantageous to the health of beaches as long-term erosion would be significantly more on these developed beaches.

Food supply for the tourism sector

Agriculture

Agriculture is an important support sector for the tourism industry. While the potential is still minimally exploited in The Virgin Islands, the tourism industry could be a major consumer of local produce, especially with the Tourist Board exploring new tourism niches, including health tourism.

The impact of climate change on agriculture will be mixed and vary by region. Most small island developing states are expected to see a net negative impact on crop productivity (St. Lucia Ministry of Physical Development, Environment, and Housing, 2005).

While the specific impacts of the climate changes projected for The Virgin Islands on local agriculture are still to be accessed (a process in which the Department of Agriculture would take the lead), in general it can be said that in The Virgin Islands, climate change threatens to impact agricultural production through changing rainfall patterns, decreased soil integrity, increased pests and diseases, and direct damage to crops (Mimura et.al, 2007).

Over the course of the Century, climate change is projected to make The Virgin Islands drier overall. Annual rainfall averaged over the entire period, 2011-2099, is projected to decrease by 2.5%. Changes do not happen evenly over the remainder of the Century, however. Average annual rainfall is projected to remain basically unchanged over the immediate to near-term, the 2011-2020 and 2021-2040 periods, increasing on average by less than 1%. For the 2041-2060, 2061-2080 and 2081-2099 periods, however, average annual rainfall is projected to be progressively less than the baseline, decreasing by up to 7.7% by the last period, 2081-2099. This decrease is driven primarily by progressive reductions in rainy season rainfall (important to agriculture) ranging from 4.7% to 12.5%.

With The Virgin Islands traditionally experiencing a relatively dry climate, water is already a seriously limiting resource for agriculture. These changes in rainfall patterns increase the potential for water shortages which disrupts agricultural production and results in crop damage, or increases the dependence on desalinated water for irrigation, which increases the cost of production (Mimura et.al, 2007; St. Lucia Ministry of Physical Development, Environment, and Housing, 2005).

According to Mrs. Arona Fahie-Forbes, Deputy Chief Agricultural Officer of The Virgin Islands, over the last few years, the local farming community has noticed extended dry seasons; this is consistent with observations and measurements elsewhere in the region (Fahie-Forbes, A., personal communication, July 2009; Taylor et al., 2007). An interesting side effect of this locally has been increased ravaging of producer’s fields (e.g. tomato beds) by Pearly-eyed Thrashers, Sparrows, Ground Doves and other birds. The theory is that these birds have not been able to find sufficient food in the wild as the vegetation they typically feed on suffers from the extended dry seasons as well (Fahie-Forbes, A., personal communication, July 2009). While the climate assessment does not show a significant change in the seasonality of rainfall, that is, the dry season months remain essentially the same, it does show the number of years with a net decrease in annual rainfall increasing steadily over the remainder of the Century, starting with 6 years in the 2011-2020 period.

Several studies have shown that, in general, existing agricultural pests, weeds, and disease-causing pathogens will likely become more prevalent in the future due to higher concentrations of carbon dioxide (CO_2), warmer soil temperatures, and changes in humidity (Backlund et al., 2008). Over the entire period (2011-2099), annual average temperature is projected to increase between 2.2% (0.6°C, 1.1°F) and 11.6% (3.1°C, 5.6°F) with an average increase of 6.5% (1.7°C, 3.1°F). While these numbers seem small, this represents a significant change that will impact realities on the ground. Average annual relative humidity is projected to increase between 0.1% and 1.6%, with an average increase of 0.8%. Climate change could also make conditions riper for the introduction of new climate-controlled diseases, as well as invasive (foreign) microbes and pests.

As a result of sea level rise, low-lying agricultural lands may be degraded due to soil salinisation (intrusion of saltwater) (St. Lucia Ministry of Physical Development, Environment, and Housing, 2005). By the end of the 21st Century, average global sea level is projected to rise between 0.19 – 0.58 metres (0.62 – 1.90 feet) relative to 1980 – 1999 levels (Mimura et.al, 2007). Already, some agricultural land adjacent to the public road at Paraquita Bay had to be abandoned due to high salt content in the soil; it is unknown how much of this is due to sea level rise versus historical overuse of wells in the area.

All of the impacts described above will likely result in the decreased production of many important food staples in the region and The Virgin Islands. Regional models have already identified cassava, sweet potatoes, and sugar cane as three crops that could suffer negative impacts (Rivero Vega, 2009).

In addition, stronger hurricane events threaten more widespread and costly damage to crops and agricultural infrastructure from wind damage, flooding, and soil erosion (Mimura et.al, 2007). Bananas, plantain, and perennial fruit trees (such as mangoes, avocados, and breadfruit) are, of course, naturally very vulnerable to intense hurricanes (Petit & Prudent, 2008; Fahie-Forbes, A., personal communication, July 2009).

Although effects on livestock production may not be as direct, some climate change impacts are expected. A decrease in productivity may arise from physiological stress to the animals due to increased temperatures, decreased water for drinking or to maintain pastures, and increased diseases (St. Lucia Ministry of Physical Development, Environment, and Housing, 2005).

From a global perspective, local food security will be challenged by potential changes in the availability, cost, and quality of imported foods as climate change will have impacts (both positive and negative) on the major breadbaskets (food producing regions) of the world (St. Lucia Ministry of Physical Development, Environment, and Housing, 2005). The World Food Programme has expressed serious concern about what it describes as a "wave of food-price inflation moving across the globe, leaving in its wake drastically increased levels of hunger and poverty" and has identified increased energy costs and increasing climate shocks, such as droughts and floods, as two of the key factors responsible (World Food Programme, 2008). Not only will the Territory have to deal with increased costs from these factors, but also likely increased shipping costs as an indirect result of climate change and increasing fuel costs.

Fisheries

The impact of climate change on commercial and recreational fisheries has not yet been fully assessed and considerable uncertainty remains in this area. Like with agriculture, some positive impacts may occur; for example, warmer waters may increase fish larval growth rate and swimming ability while decreasing the age of metamorphosis; all of which could improve the survival of larval fish (Johnson & Marshall (eds), 2007).

Studies so far, however, also indicate cause for concern. Important commercial species in The Virgin Islands such as Yellowtail Snapper and Red Hind depend heavily on coral reefs and mangroves; these ecosystems are significantly threatened by climate change. Coral bleaching, increased incidence of disease, and reduced complexity of coral reefs, for example, will be felt right up the food chain and be reflected in reduced abundance of reef-associated fish and changes in fish species composition, favouring smaller generalist species and those lower on the food chain (Mimura et.al, 2007; Johnson & Marshall (eds), 2007). Already scientists are observing a sudden and rapid decline in Caribbean reef fish densities since 1995, on the order of 2.7 – 6% loss per year as a result of coral reef degradation from various sources, including warming waters (Cell Press, 2009). Furthermore, coral reef degradation increases the prevalence of ciguatera (fish poisoning).

Also of concern is the impact of climate change on plankton abundance, community structure, timing of seasonal abundance and geographical range (Hays et al., 2005). Plankton consists of microscopic plants (phytoplankton) and animals (zooplankton) that drift in the ocean and form the base of the marine food web. All species of fish feed on plankton during their larval (early) stage and some species continue to depend on it into their adulthood. Long-term changes in plankton such as those projected with climate change can, therefore, have a significant impact on commercial fish stocks (Hays et al., 2005). In The Virgin Islands this would include species such as Blue Runner (Hardnose), Wahoo, Yellow Fin Tuna, Dolphin Fish (Mahi Mahi) and Swordfish, all of which are extremely important for supplying the tourism sector.

Rising sea temperatures will also have a significant impact on fisheries as fish are very sensitive to slight changes (a few degrees) in ocean temperature and warming will cause migration to new areas or depths with cooler waters (Mimura et al., 2007). The habitat for Dolphin Fish, for example, will become significantly less favourable with just a 1°C (1.8°F) increase in the average temperature of the Caribbean Sea (Dr. Trotz, 2009).

Fish distribution can also be impacted if climate change causes shifts in ocean currents and other oceanographic conditions that help to determine where fish settle out in their larval stages and influence their migration patterns and other dynamics in their adult stages (Johnson & Marshall (eds), 2007). While these changes may result in the loss of established fisheries, they may also give rise to new fisheries.

The rise in ocean temperatures and change in species composition could lead to decreases in spawning opportunities, increased mortality, and increased incidence of disease in favoured commercial species such as Yellowtail Snapper and Epinephelus striatus (Nassau Grouper) (St. Lucia Ministry of Physical Development, Environment, and Housing, 2005).

Temperature changes in the ocean could also create more favourable conditions for the establishment of invasive species as natural ecosystem processes are disrupted (IUCN, n.d.). Invasive species tend to out-compete or prey on native species.

Climate change may also trigger changes in the salinity and nutrient content of the Caribbean Sea due to increased river outflows and higher rates of evaporation. Research has shown that the salinity of the surface Atlantic waters between latitudes 25°S and 35°N (the high-evaporation zone within which The Virgin Islands lies) has already increased by +0.1 to +0.4 p.s.u (practical salinity units) over the time period 1985-99 as compared to 1955-69 (Curry et al., 2003). Many studies have shown that fish development and growth is influenced by salinity (Bœuf & Payan, 2001), however, no studies were found that discuss how climate change induced increases in salinity may affect fisheries in the region.

Based on practical experience, even short term changes in water quality (salinity and nutrient content) have an impact on local fisheries. In April 2009 The Virgin Islands and Lesser Antilles waters experienced a strong influx of high nutrient freshwater runoff from the Orinoco River in Venezuela. According to Mr. Ken Pemberton, Fisheries Assistant at the Conservation and Fisheries Department, this influx temporarily impacted water quality, impairing fishing conditions and reducing catch (Pemberton, K., personal communication, October, 2009). As climate change causes increased heavier rain events in the region, the influence of the Orinoco River runoff on regional waters and their fisheries may increase.

Finally, more severe hurricane events and sea level rise could easily result in near and long-term damages to landing sites and other on-shore fisheries facilities with implications for productivity, and insurance and construction costs (St. Lucia Ministry of Physical Development, Environment, and Housing, 2005).

Comfort Level, Outdoor Activities and Special Events/Festivals

Most activities that tourists come to The Virgin Islands to enjoy are based outdoors. The Tourist Board is making a special effort to promote special events and festivals as tourist attractions, not only to increase overall visitor numbers, but to help reduce the seasonality of visitor arrivals by encouraging more tourists in the traditional off season (May to September). This would include improving and properly marketing existing events and festivals and creating new ones, both during the tourist season and the off season.

As most tourist activities, events and festivals occur in an outdoor setting they are highly susceptible to weather conditions. Given this, climate change will impact these types of events, requiring potential changes in timing and new approaches to planning.

Temperature, Relative Humidity, Comfort Index

Recalling the information presented earlier on changes in temperature: climate change is causing monthly increases in average, minimum and maximum temperatures, resulting in warmer temperatures throughout the year and extended summer-like conditions.

Currently summer can be defined as extending from July to September when the warmest temperatures are experienced, averaging 28°C/82.4°F. Already, by the 2011-2020 period average summer temperatures will extend from June/July to September/October and the classic summer period will average 28.8°C/83.8°F. By the last period of the Century, average summer temperatures will extend from April/May to November and the classic summer period will average 30.6°C/87.1°F. Baseline maximum temperatures (starting at 30°C / 86°F) normally experienced only from the start of summer (July) to November, will be experienced from June/July to November in the immediate future (2011-2020) and by the 2061-2080 period will be experienced year round.

Summer-like average and maximum temperatures are, therefore, creeping into the tourist season and warmer temperatures are becoming a more important feature of the off season. Added to this is the discomfort of increasing humidity over the entire Century, with the greatest increases experienced during the tourist season (ranging from 0.4% to 1.2%) over the remainder of the Century). In the Tourist Perception Survey, 21% of tourists indicated that they would be less likely to visit The Virgin Islands if average temperatures increased slowly by up to 4°C by the end of the Century.

While the maximum increases projected for The Virgin Islands by the PRECIS model is 3.1°C by the end of the Century, it can be safely assumed that the magnitude of the changes projected, together with increases in relative humidity, decreased wind speed during the tourism season and an increasing number of days classified as "uncomfortable" by the comfort index, will have an adverse effect on tourists' behavior. This will likely be expressed in terms of their willingness to attend or participate in outdoor activities, events and festivals, and possibly in terms of their willingness to visit or revisit.

The result of all this for tourism managers is that the industry has to find creative ways and provide additional amenities to offset or minimise the discomfort created for tourists by a warmer climate. This may include creating cooling stations and more shade and rest areas at popular tourist attractions, trails, special events and festivals and if necessary, building stadiums/centres to accommodate special events/festivals. Planners, where possible, should also focus on night festivals/events when temperatures are cooler to avoid heat stress.

Rainfall

The assessment shows the traditional seasonality of rainfall and the established dry and rainy seasons will remain similar to the baseline. For tourism managers, therefore, during the tourist season, January to April remains the safest time to plan events that are sensitive to frequent or heavy rainfall. Tourism managers should note, however, that as shown in Figure 3.1-15 above, the entire tourist season is getting wetter over the remainder of the Century with rainfall increasing from 4.8% (2011-2020 period) to up to 10.2% (2061-2080 period). Increases of 5.5% to 6.8% are projected for the other periods. While these increases are relatively small, they may interfere to some degree with many tourists' ability to enjoy outdoor activities.

On the other hand, while promoting increased tourist arrivals in the off season, tourism managers should be mindful that this period overlaps with the traditional dry season when water resources are particularly scare. This will become more pronounced as the off season is projected to see an increasing drying trend over the Century ranging from an average 1.4% decrease in the immediate future and up to a 12.5% decrease in the 2061-2080 period and

17.1% decrease by the end of the Century. Because of these changes, tourism managers need to increase water efficiency within the sector.

Wind Speed

The Virgin Islands markets itself and is known as the sailing capital of the world. Changes in wind speed, therefore, could have important impacts on the yachting sector. Figure 3.1-40 above clearly illustrates the projected decrease in wind speed compared to the baseline during the tourist season over the entire Century, ranging from 3.8% in the immediate future to 4.9% by the final period of the Century. On the other hand, over the remainder of the Century (with the exception of the immediate future) the entire off season is projected to experience increases in wind speed from 1.3% in the immediate future to up to 6.2% by the final period of the Century. Tourism planners should take this into consideration, especially in the scheduling of regattas, a good example of special events/festivals that should be promoted more in the offseason.

Hurricanes

As the result of climate change, the number of strong (category 4 and 5 hurricanes) is projected to increase (Henson, 2006; Wilkinson & Souter, 2008). Also, hurricane maximum wind intensities are likely to increase by 5% - 10% by around 2050 and peak rainfall rates by 25%. As clearly illustrated in the natural hazards section, The Virgin Islands lies directly in the hurricane belt and is, therefore, highly vulnerable to these changes.

Already, observations have shown an increase in the intensity of hurricanes in the Atlantic. The greatest level of cyclonic activity recorded in the Atlantic Basin since 1886 has been from 1995 to 2008. In this 14-year period cyclonic activity more than doubled compared to any other similar period, including 2.5 times more major hurricane occurrences (Rubiera, 2009).

The hurricane season overlaps considerably with the off season when significantly fewer tourists are present in the islands. The hurricane season, however, extends to November, and therefore, includes two months of the tourist season. Furthermore, as average temperatures increase throughout the year, the conditions necessary for hurricane formation will gradually occur earlier. As hurricane intensity increases and the sectors seek to attract more tourists year-round, tourism managers must pay special attention to improving the disaster management capabilities of the tourism sector to minimize damages and manage tourist perception. It is especially important that tourists are confident in the capacity of the Territory to handle hurricane events as the Tourist Perception Survey indicated that an increase in stronger hurricane events would have a strong influence on tourists' decision to revisit The Virgin Islands.

In general, weather conditions are an important consideration in tourists' decision to visit The Virgin Islands as evidenced by the results of the Tourist Perception Survey. In addition to all mentioned, it is important to manage tourists' expectations of The Virgin Islands weather as our climate changes.

Tourism Infrastructure and Energy

With an increase in the percentage of stronger hurricanes (category 4 and 5) developing, there is an increased chance of heavy rain events and floods. The entire tourism sector, including accommodations (which tend to be concentrated in flood prone coastal areas) and supporting infrastructure, especially roads, are extremely vulnerable to heavy rain events. This was evidenced by the series of flood events that occurred and significantly impacted the sector from 2003 to present. Due to the topography and geology of the islands, massive slope failures and landslides are a feature of flood events. Cane Garden Bay is a prime example of a popular tourist area that is highly susceptible to widespread flooding. In the 2010 flood events, for example, many accommodations in the Bay and historical attractions experienced severe flooding (with flood waters up to approximately 4-5 feet is some cases) and the beach was significantly eroded by the power of storm waters running off the land.

Stronger hurricanes, of course, pack two other elements that would have major impacts to the tourism sector infrastructure: higher wind speeds and storm surges. Stronger building codes will reduce, but not eliminate the damage to roofs, windows and other vulnerable points caused by these high category storm winds. The 2005 Quantitative Risk Assessment Project, commissioned by the Department of Disaster Management, assessed the vulnerability of 45 public buildings and shelter facilities to hurricanes. For each building a damage curve was developed that shows the percentage structural damage that can be expected for hurricanes of different intensities according to the standard Safir-Simpson scale. The study shows that for category 4 hurricanes, damages would range from 11% to 70%, with most public building and shelters falling in the upper part of that range (38% to 70% damage). For category 5 hurricanes, damages would range from 31% to 77%, again with most public buildings and shelters falling in the upper part of that range (69% to 77% damage) (Virella Crespo & Young, 2005). Assuming similar building standards, damages in this range can be expected for tourism properties which represents significant losses.

The storm surge threat is especially important as the majority of tourism facilities are located along the narrow coastal strip where they are directly exposed to this threat. Furthermore, sea level rise as a result of climate change will increase the inland reach and impact of storm surge events. Again, the static risk maps of Cane Garden Bay provide a clear example of the level of damage that can be sustained to tourism facilities located along the coastline from storm surge.

While occurring slowly over the course of the Century, by the mid to long-term sea level rise on its own will have significant impacts to the coastal tourism infrastructure that must be planned for now. The most recent and comprehensive study on the impacts of sea level rise (SLR) in CARICOM countries found that tourism will be the sector most affected. In some of the smaller CARICOM countries, such as Antigua and Barbuda, Barbados, St. Kitts and Nevis and The Bahamas, annual losses to tourism as a result of SLR would range up to 5% of GDP (Simpson et al., 2010).

Tourism centres that may be particularly vulnerable to sea level rise and stronger storm surges include: Cane Garden Bay, Sopers Hole, Wickhams Cay I and II, and Trellis Bay on Tortola and Beef Island; North Sound, the vicinity of the Virgin Gorda Yacht Harbour, The Baths, and the many high-end waterside vacation villages on Virgin Gorda; White Bay and Great Harbour on Jost Van Dyke; all centres of tourism on Anegada such as Loblolly Beach, Keel Point, and Setting Point. Smaller outer islands with tourism stock located in highly vulnerable areas include Cooper Island, Peter Island, Marina Cay, Saba Rock and Scrub Island.

The combined effect of all of the climate change impacts described is a reduced lifespan of tourism infrastructure and more costly damages. Insurance costs are also likely to increase as the industry finds its clients at greater risk to natural disasters and sea level rise, and the insurance industry adjusts itself to the realities of climate change.

Energy

As The Virgin Islands experiences warmer minimum, average and maximum temperatures as well as increases in humidity year round and reduced wind speed during the tourism season, the number of "uncomfortable days" is projected to rise steadily over the remainder of the Century (see Figure 3.1-41 and Table 3.1-14). As a result, tourists will likely use more air conditioning, take more frequent baths, and use facilities such as pools more often, thus increasing energy and water demand and associated costs.

In addition, the Territory's electricity generating and distribution infrastructure is quite exposed to the climate change impacts discussed making the electricity supply even more vulnerable. Because of this, combined with increasing energy costs and an increasing tourist demand for "greener," more efficient tourism properties, it is important for The Virgin Islands to diversity its energy production base by investing in renewable energies, especially solar and wind. The potential for solar energy should only increase over the course of the Century.

In terms of wind potential, the consensus of the model scenarios shows that over the entire period, 2011-2099, there is only a small change in annual wind speed, ranging from a decrease of 4.5% to an increase of 2.8% and averaging a decrease 0.8%. On a seasonal basis, the consensus of the model scenarios projects decreases in wind speed during the tourist season for the remainder of the Century when demand for energy will be greatest. Projected decreases in wind speed during the tourism season range from 2.0% (2021-2040 period) to 4.9% (2081-2099). While this does not at all rule out the potential for wind energy, these decreases should be taking into consideration in the planning of systems.

3.2 | Static Risk Maps – Cane Garden Bay

PURPOSE

A static risk map serves to develop a better understanding of the present physical and organizational components of risk in a particular area. The study area selected for the Vulnerability and Capacity Assessment of the Tourism Sector is Cane Garden Bay. Mapping the location of important tourism and public infrastructure, natural resources and features, natural hazards and land use patterns makes it easier to identify and understand in more detail hazard zones and critical issues and pressures within the area that would be amplified by climate change.

In the future, static risk maps will be developed for the major tourism centers on the other main islands of Anegada, Virgin Gorda and Jost Van Dyke.

METHOD

Static risk maps were created using Geographic Information Systems (GIS) mapping software (ESRI ArcMap 9.3). The boundary of the study area (outlined in bold red on maps) was defined by the 106m (348ft) contour line. Background information on the study area was collected from existing literature, in particular the 2007 Cane Garden Bay Community Profile (Town and Country Planning Department, 2007). In GIS the following themes were created using the data layers listed in Table 3.2-1: Environmental Features, Critical Infrastructure (tourism and public) and Natural Hazards.

Hazard zones were identified by overlaying the Critical Infrastructure and Natural Hazards themes in GIS. Areas where important singular natural hazards or multiple natural hazards overlap with areas of concentrated critical infrastructure were identified by eye as hazard zones and outlined.

Most of the data layers used were preexisting and date back at latest to 2001. Updates to some preexisting data layers were made in 2010 for purposes of the static risk maps, including roads (to identify unpaved roads), infrastructure, mangroves and salt ponds. Due to limited field time and poor satellite reception in some areas, the mangrove and ponds layers were not updated using GPS coordinates, but were estimated on a map. Flood prone areas were estimated and mapped based on community knowledge from experience with regular flood events from 2003 to 2010. Assistance with flood mapping was primarily provided by long-term residents and business owners in the area, Mr. Kareem Rymer and Mr. Elvet Myers. All field work was conducted between March 2010 and December 2010.

Cane Garden Bay: GIS Themes and Layers used for Static Risk Maps	
Environmental Features	• Salt ponds / wetland areas (existing) • Previous extent of salt ponds • Flood prone areas • Ghuts (intermittent drainage steams) • Outfalls (from ghuts) • Mangroves • Rock shore • Sand and rubble beach • Sandy beach • Sandy bottom • Reef crest • Dead, hard coral • Coral rubble, pavement; rock rubble • Live soft coral • Topographic base (100ft contours)
Critical Infrastructure	• Health clinic • Police station • Post office • Ivan Dawson Primary School • Sewage treatment plant • Park • Community centres / Emergency shelters • Churches • Roads (paved, unpaved) • Bridges • Historical sites (Callwood Distillery) • Hotels, guesthouses, villas • Restaurants • Residential and other buildings • Landuse
Natural hazards	• Landslide potential • Storm surge risk • Hurricane wind hazard (1 minute peak wind) • Earthquake hazard (modified peak ground acceleration)

Table 3.2-1. GIS layers (and themes) used to create the Cane Garden Bay static risk maps.

The study area – Overview of Cane Garden Bay

Cane Garden Bay is located on the northwestern section of Tortola and is one of the most important tourism centres on the island and in The Virgin Islands as a whole (see Figure 3.2-1). It is located approximately four miles from Road Town, the capital of The Virgin Islands. The study area has a complex hilly topography that is roughly defined by the 106m (348ft) contour line and totals 863,311m^2 (213 acres) The area has a narrow coastal strip bordered by a narrow area of gently sloping foothills that then rise steeply to the top of the study area (see Figures 3.2-2 and 3.2-3).

The topography of Cane Garden Bay is an important feature of the area, adding to its natural beauty, but also determining significantly the pattern of development in the area and the resulting organizational components of risk.

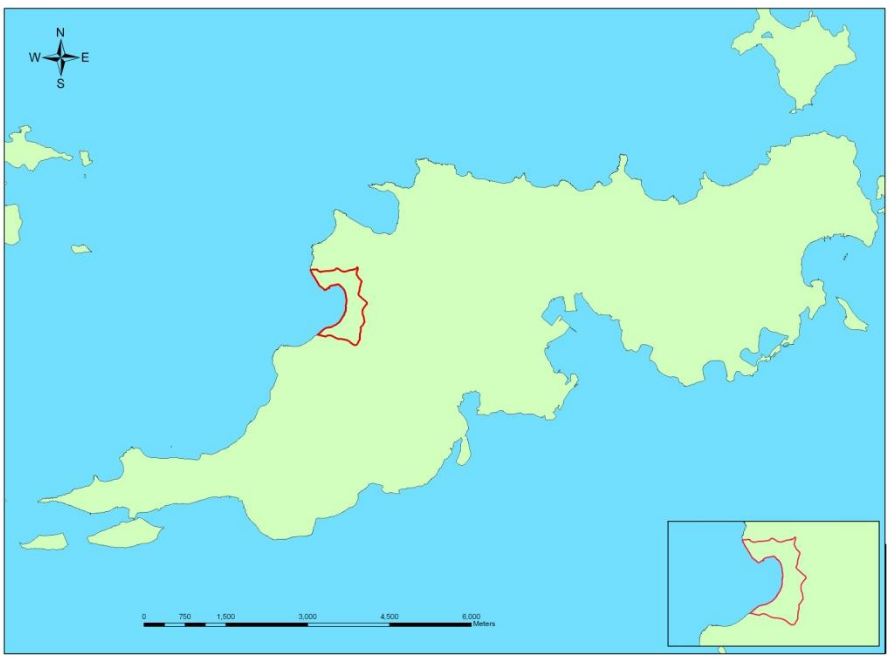


Figure 3.2-1 Location of the Cane Garden Bay study area on the island of Tortola, The Virgin Islands.

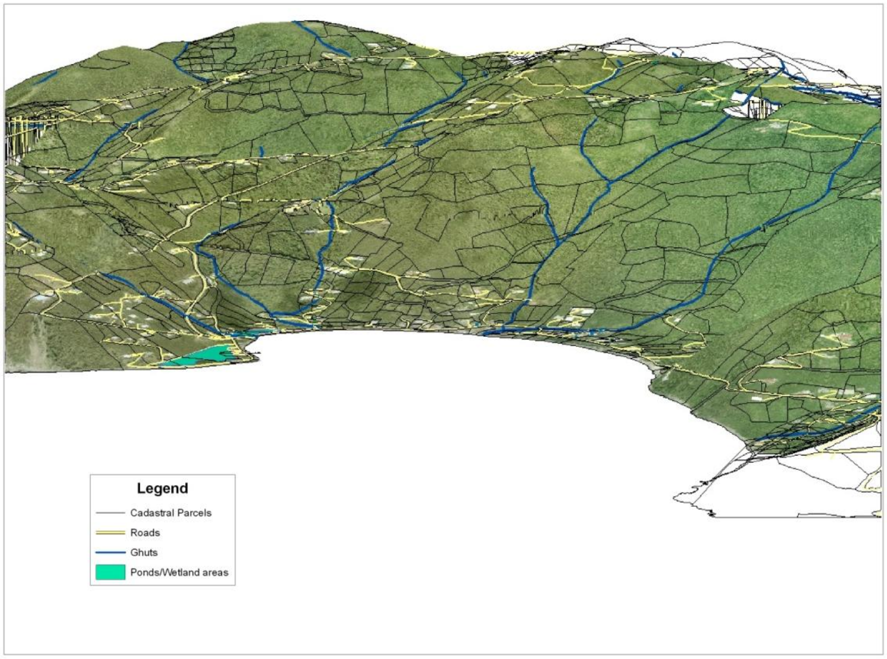


Figure 3.2-2. Three-dimensional view of the wider Cane Garden Bay area showing land parcels and natural drainage systems (ghuts and salt ponds/wetland areas).

Figure 3.2-3. Partial aerial view of the Cane Garden Bay study area.

Focus was given to the Cane Garden Bay area for a combination of reasons: -

- A high density and full range of tourism activity is present – accommodations, restaurants, historical attractions, yachting, water sports and cruise ship passengers (Cane Garden Bay is the top beach destination on Tortola for cruise ship passengers);
- Ownership of the tourism industry is primarily local (residents/descendents of Cane Garden Bay)
- A range of important natural features are present: a beach, coral reef, salt pond, mangroves and ghuts (intermittent drainage streams);
- Cane Garden Bay is an important residential area (with a population of 389 in 2006) and has a high concentration of critical infrastructure and features, including churches, a primary school, clinic, community centre, sewage treatment facility, police station, cemetery and roads forming part of the primary coastal road network of the island (TCP,2007);
- The area is presently suffering from a number of pressures – heavy development along the beach, flooding, water quality issues, over-crowding by tourists and more;
- The community has formed a Committee to address the number of developing pressures and impacts in the area.

RESULTS

Environmental Features

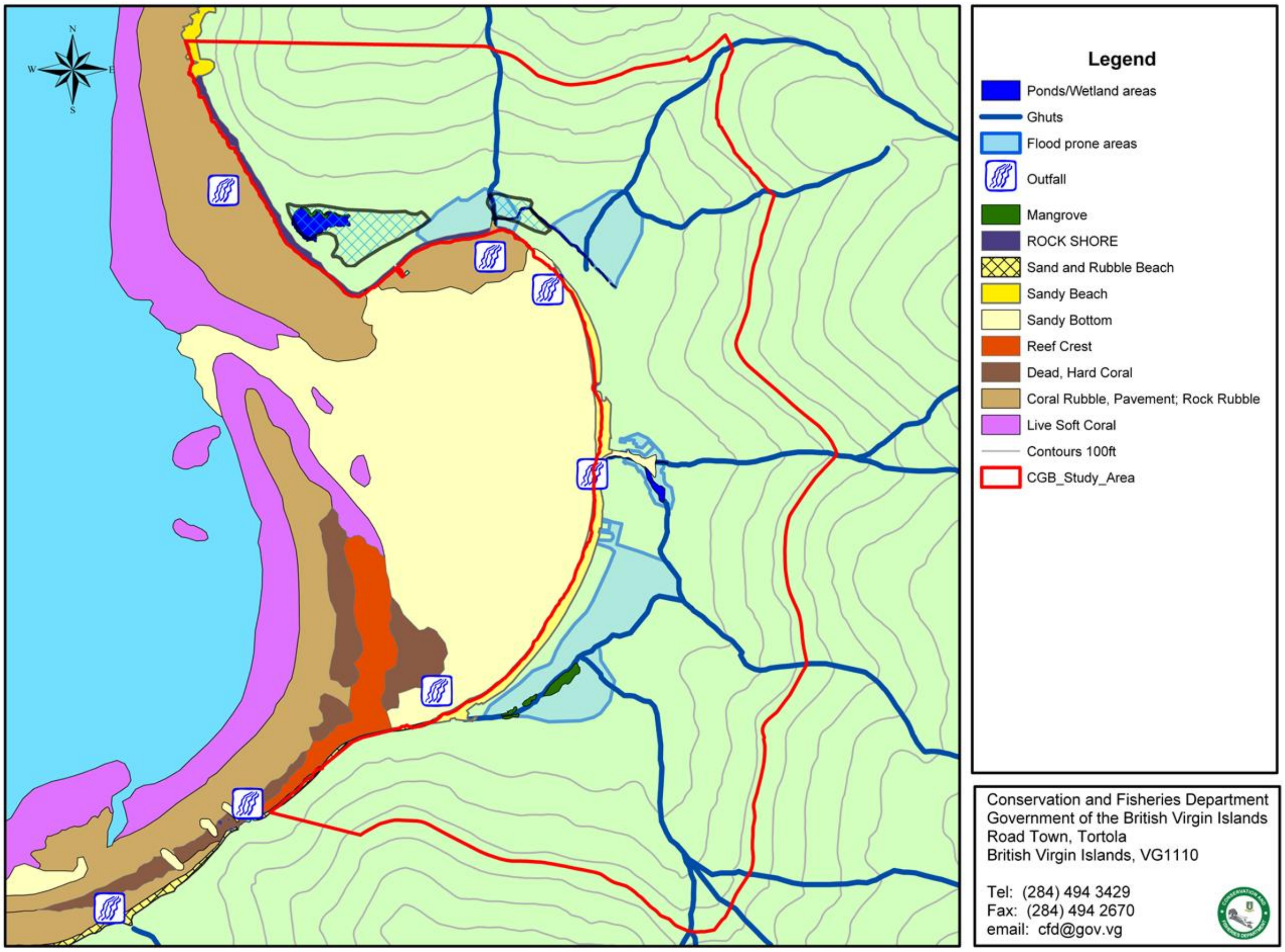


Figure 3.2-4. Cane Garden Bay environmental features.

Cane Garden Bay has several environmental features, the most important of these being the sandy beach that stretches almost 1 mile along the majority of the shoreline of the Bay (TCP, 2007). The entire tourism industry (the mainstay of the Cane Garden Bay economy) is basically built around the beach, literally and figuratively. Without of the beach, there would most likely not be a vibrant tourism sector in Cane Garden Bay. Not only does the beach provide the primary tourist attraction in the Bay, it is also an important recreational outlet for the large residential population. Currently the beach is under a number of stressors, including pollution from sediment runoff and sewage (from yachts and sewage overflows in flood events), erosion, overdevelopment and overcrowding. Figure 3.2-5 shows the beach crowded with cruise ship passengers on a typical day in the tourist season.

Figure 3.2-5. Cane Garden Bay Beach on a typical day in the tourist season. Photo credit: Conservation and Fisheries Department.

Other important environmental features in the Bay include coral reefs, salt ponds and wetland areas, including mangroves. A band of soft coral (approximately 859,675m^2/212.4 acres in area) stretches across almost the entire mouth of the Bay and surrounding coastline. Closer to shore on the West End facing (directionally south) half of the Bay is an old reef crest. Together these reef components play an irreplaceable function in the existence of the beach (protecting it from the full force of storm surges and providing it with sand) and if healthy could be sustainably developed as a snorkeling or glass bottom boat excursion site to provide an added attraction in the Bay. A rapid assessment of part of the reef by the Conservation and Fisheries Department in January 2011 found that the reef is significantly degraded with only about 5% live coral cover remaining. Given its significant value, it is critical that the Cane Garden Bay reef be restored.

Cane Garden Bay is one of the most active watersheds on the island with an annual rainfall of 55 inches and an annual water yield calculated at 57.85 million gallons in 1990/1. The area is drained by six (6) major ghuts (intermittent drainage streams) that converge to form four (4) outfall areas along the Bay, two in the East End facing (directionally north) quadrant, one in the centre, and one at the West End facing (directionally south) edge of the Bay. The major soil type in the area is sandy clay loam (Alam, 1994).

The Bay once had an extensive network of salt ponds and wetlands that provided habitat for birds and other wildlife and provided the important functions of drainage, water catchment and filtration in the Bay (see Figure 3.2-6). Unfortunately the majority of these areas (approximately 68% of the acreage) has been cut or filled in to accommodate development. In this process the majority of mangrove areas that lined these ponds and wetlands have been lost. Figure 3.2-7 below shows the last remaining sizable salt pond in the Bay that is presently facing encroachment by an adjacent landfill project.

Figure 3.2-6. Previous extent of intermittent and permanent salt ponds and other wetlands in Cane Garden Bay. Areas were determined from water bodies and dark vegetation bands present on old aerial photographs of the study area.

Figure 3.2-7. Last remaining sizable salt pond in Cane Garden Bay and encroachment presently being faced along its directionally east edge by an adjacent landfill project. Photo credit: Conservation and Fisheries Department.

Infrastructural Features and Land Use

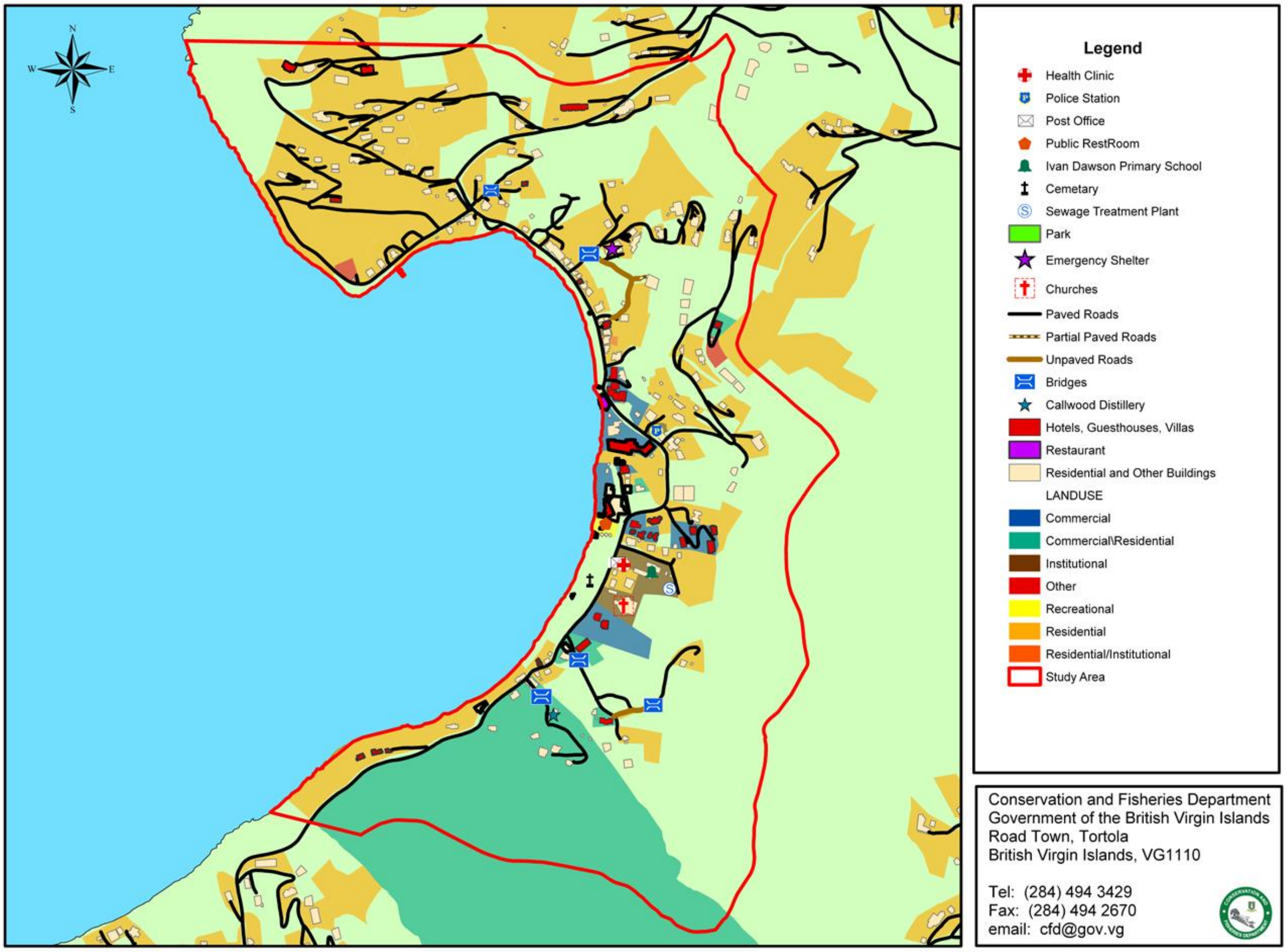


Figure 3.2-8. Cane Garden Bay infrastructural features and land use.

The primary land uses in the Cane Garden Bay study area are residential (32% of study area) and commercial (~2% of the study area). In 2006 there were 389 persons living in the area (TCP, 2007). This number will likely be revised up with the results of the 2010 census. Commercial developments are primarily tourism based (hotels, villas and restaurants); the area also has a supermarket, gas station and hair salon.

Development is concentrated in the flat coastal area and foothills. With the exception of the hill at the directionally northern most section the Bay (closest to East End) that is northwest of the primary access road from the ridge, the majority of steeper lands in the Bay remain undeveloped and a few small areas are used for agricultural purposes.

There is a high concentration of critical infrastructure in the Bay, serving the tourism sector and residential community. There are two primary access roads to the Bay located at its West End facing (directionally south) and East End facing (directionally north) boundaries. The area is serviced by a dense network of roads, in fair condition, particularly those in the flat, coastal areas. The hilly areas, however, have roads that are not adequately paved and in many instances access is via dirt tracks. Short bridges have been constructed in five locations in the flat coastal area where ghuts intersect the road network. As highlighted later on, the road network and these bridges, particularly the two access roads, are highly vulnerable to the natural hazards identified.

With the exception of a handful of villas, the map clearly shows that all critical infrastructure is located in the narrow coastal zone (approximately 150m/0.15km wide), particularly along the beachfront. There are approximately 20 hotels/villas/guesthouses (tourism accommodation businesses) in the Cane Garden Bay study area. This equates to a capacity of 166 rooms and 215 beds. Nine (9) of these properties are located 2m or less above sea level (equating to 71 rooms and 99 beds, or 43% and 46% of Cane Garden Bay's total room and bed capacity, respectively). There are 7 restaurants in the Bay and one water sports operation, all of which are located on the beachfront. The Callwood Distillery is an extremely significant historical site and tourist attraction in the Bay, being one of only two remaining rum distilleries in the entire Virgin Islands.

Public critical infrastructure is concentrated in the West End facing (directionally south) half the Bay in the strip of flat land between the main road that runs through the Bay and the foothills and includes: a small health clinic (open one day per week), police station, post office, the Ivan Dawson primary school (~116 enrollment), two churches (one serving as a secondary emergency shelter), sewage treatment plant, public restroom and bath, park (in need of proper development), community centre (serving as a the primary emergency shelter) and a cemetery (TCP, 2007).

Natural Hazards

Cane Garden Bay is prone to a number of natural hazards including large areas that experience high modified peak ground acceleration during earthquakes (see Figure 3.2-9), high wind during hurricanes (see Figure 3.2-10), storm surge during the annual Ground Sea Season (November to April) and hurricane events, as well as flood events and landslides (particularly common since 2003 when the Territory began experiencing an increased number of heavy rain events) (see Figure 3.2-11). With the exception of earthquakes, these hazards are likely to intensify as a result of climate change. In the longer term, sea level is also expected to rise as a result of climate change (possibly by up to 1-2m by the end of the Century; Simpson et al. 2010) posing a major threat to low-lying areas of the Bay.

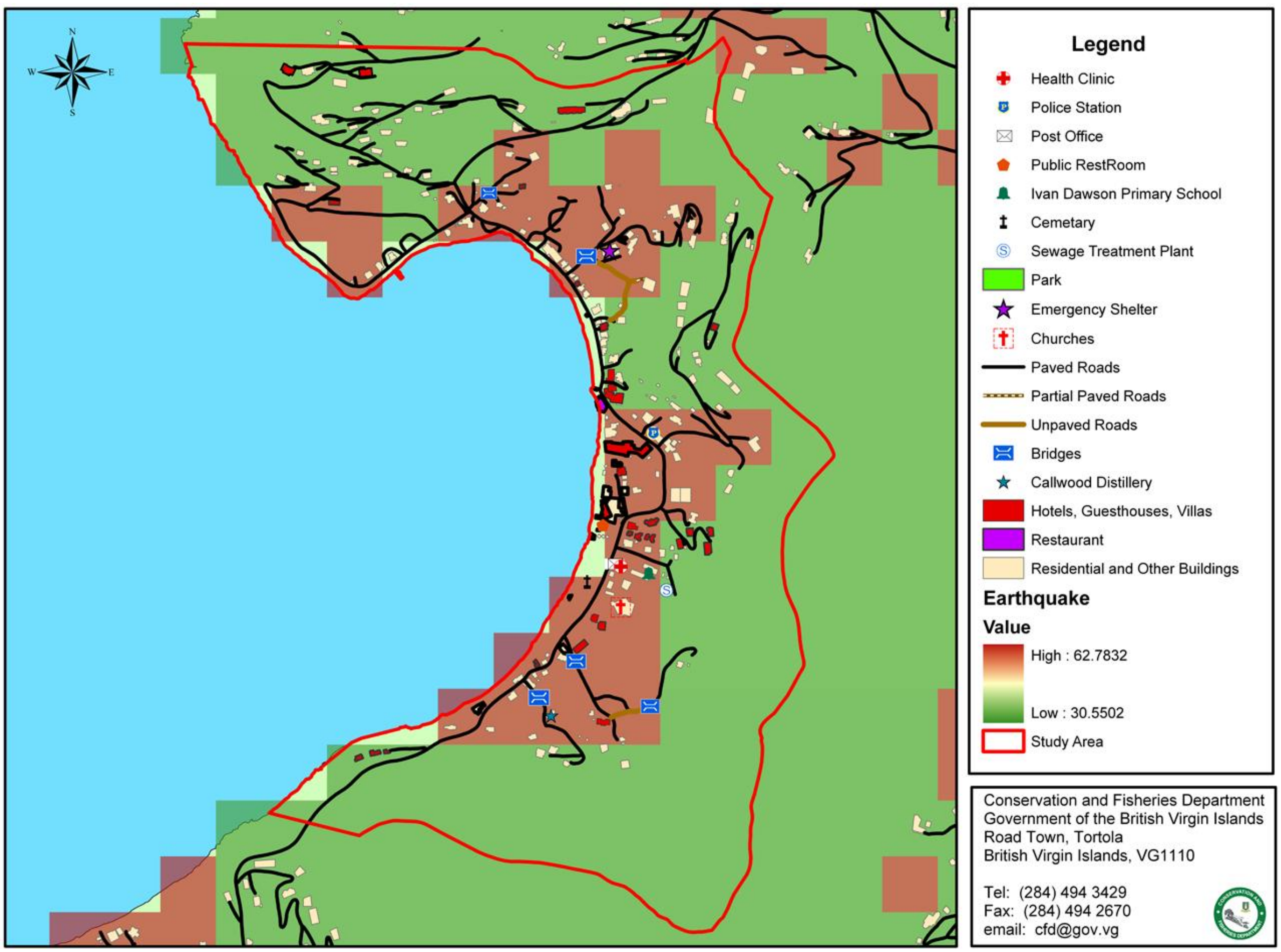


Figure 3.2-9. Cane Garden Bay earthquake hazard (as defined by modified Peak Ground Acceleration (modPGA %g) with a 10% probability in 50 years or for a 475 year return period). Peak ground acceleration is a measure of ground shaking intensify during an earthquake event.

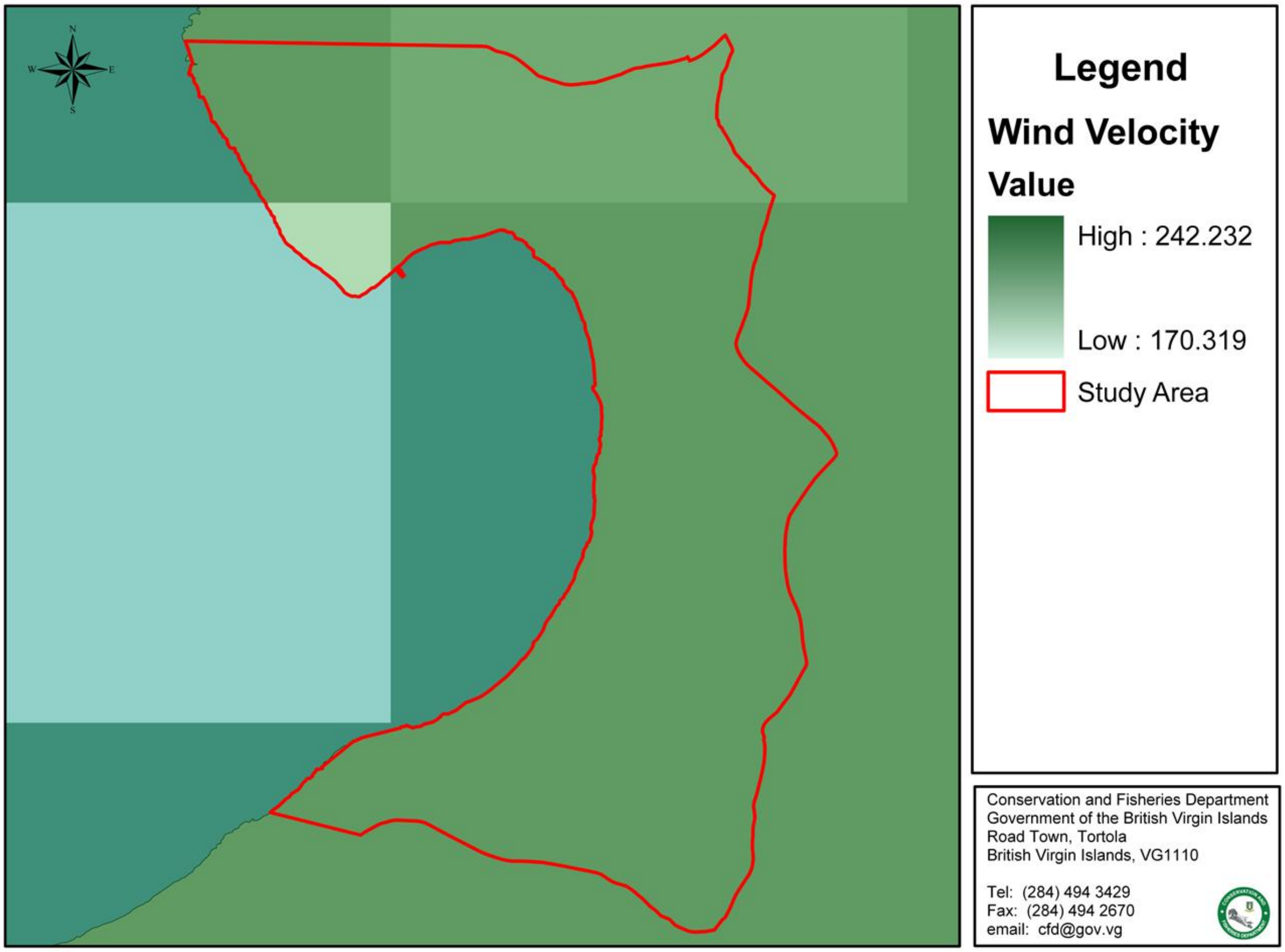


Figure 3.2-10. Cane Garden Bay hurricane wind hazard (1 minute peak wind -mph) with a 10% probability in 50 years or for a 475 year return period.

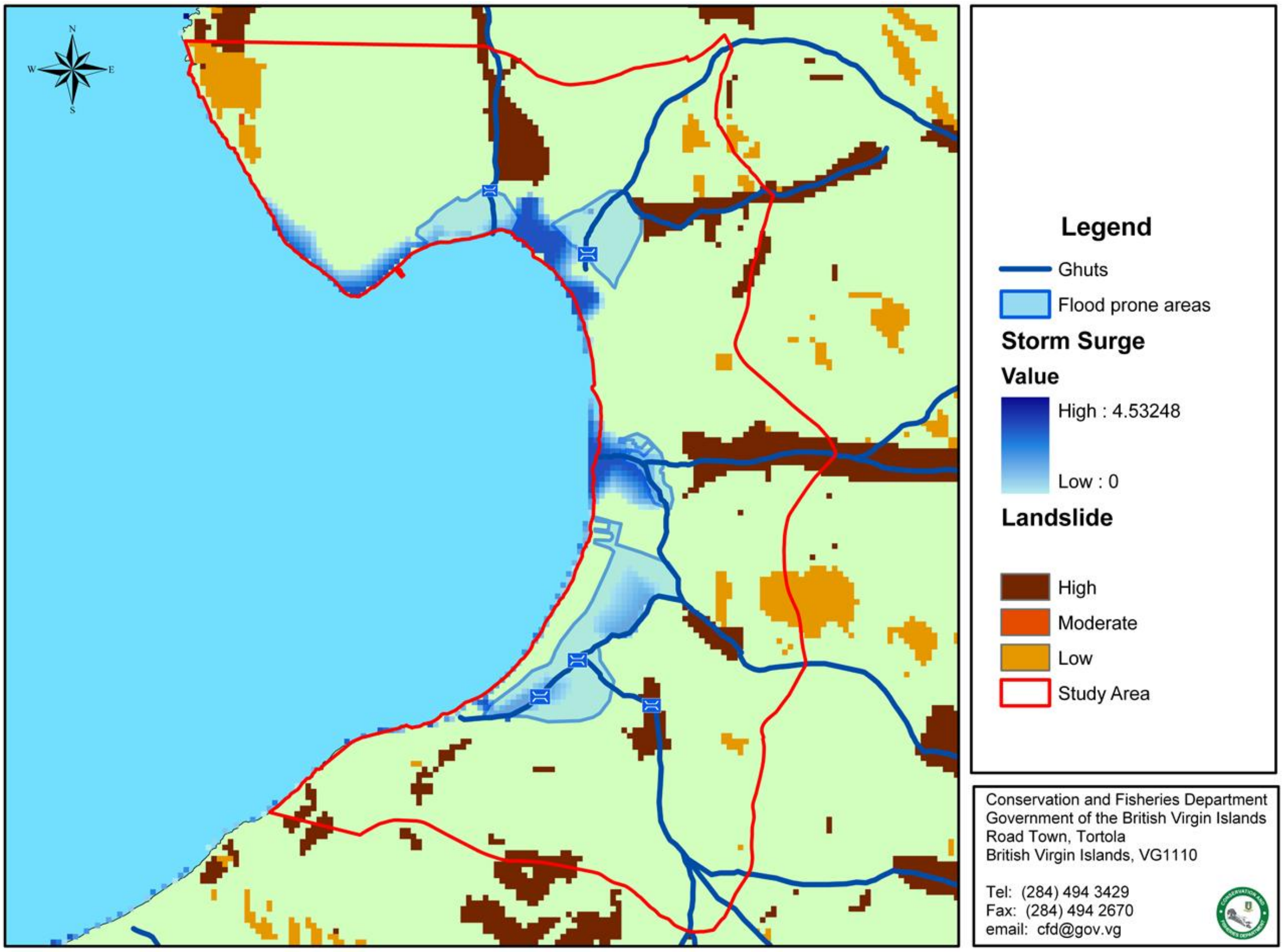


Figure 3.2-11. Cane Garden Bay flood prone areas based on community knowledge, and landslide potential and storm surge hazard with a 10% probability in 50 years or for a 475 year return period. Storm surge based on a Category 3 hurricane.

The modified peak ground acceleration data shown in Figure 3.2-9 represents a 10% probability of occurring in 50 years scenario. Peak ground acceleration is a measure of ground shaking intensity in a given geographic area during an earthquake event. Areas of high modified peak ground acceleration directly correlate to where ghuts flow into the flat coastal areas and have deposited loose sediments over time or areas of historic salt ponds/wetlands. The high modified peak ground acceleration areas overlap significantly with development in the study area, particularly that in the flat coastal zone.

The hurricane wind velocity data (1 minute peak wind -mph) shown in Figure 3.2-10 represents a 10% probability of occurring in 50 years scenario generated using the TAOS wind field model. Approximately 80% of the study area experiences high winds ranging up to 242 mph. The remaining 20% of the study area, restricted to the directionally northernmost (East End facing) hillside of the study area, experiences medium range peak wind velocities.

The storm surge data shown in Figure 3.2-11 represents a 10% probability of occurring in 50 years scenario and is based on a Category 3 hurricane event. The entire stretch of the coastline is prone to storm surge, except the area behind the short elevated road stretch between the two high storm surge areas in the East End facing (directionally north) half of the coastline (area close to Quito's Gazebo). The East End facing tip of the coastline (directionally northwest), the curve in the East End facing section (directionally north) and the centre area experience the highest storm surge impact. The West End facing (directionally south) half of the coastline is much more sheltered due to the reef crest that extends across this section of the mouth of the Bay. The presence of the open ghut mouth at the West End facing tip of the beach area (directionally south), however, provides an entrance for storm surge to affect the inland areas that border the section of the ghut that drains the coastal lowlands.

There are four major flood prone areas in Cane Garden Bay and all are located where the 6 major ghuts that drain the area flow into the flat coastal strip and overlap significantly with the previous extent of salt ponds and wetland areas. Residents of the area identified the West End facing section (directionally south) as the most severe, with flood waters ranging between approximately 3 to 5 feet in the worst areas. Flood waters in the other areas were estimated to reach up to approximately 1 foot. The flood prone areas tend to overlap with areas impacted by storm surge.

Areas of high landslide potential are, for the most part, directly associated with ghuts and their immediate surrounding areas (Joyce, 2003).

Hazard Zones

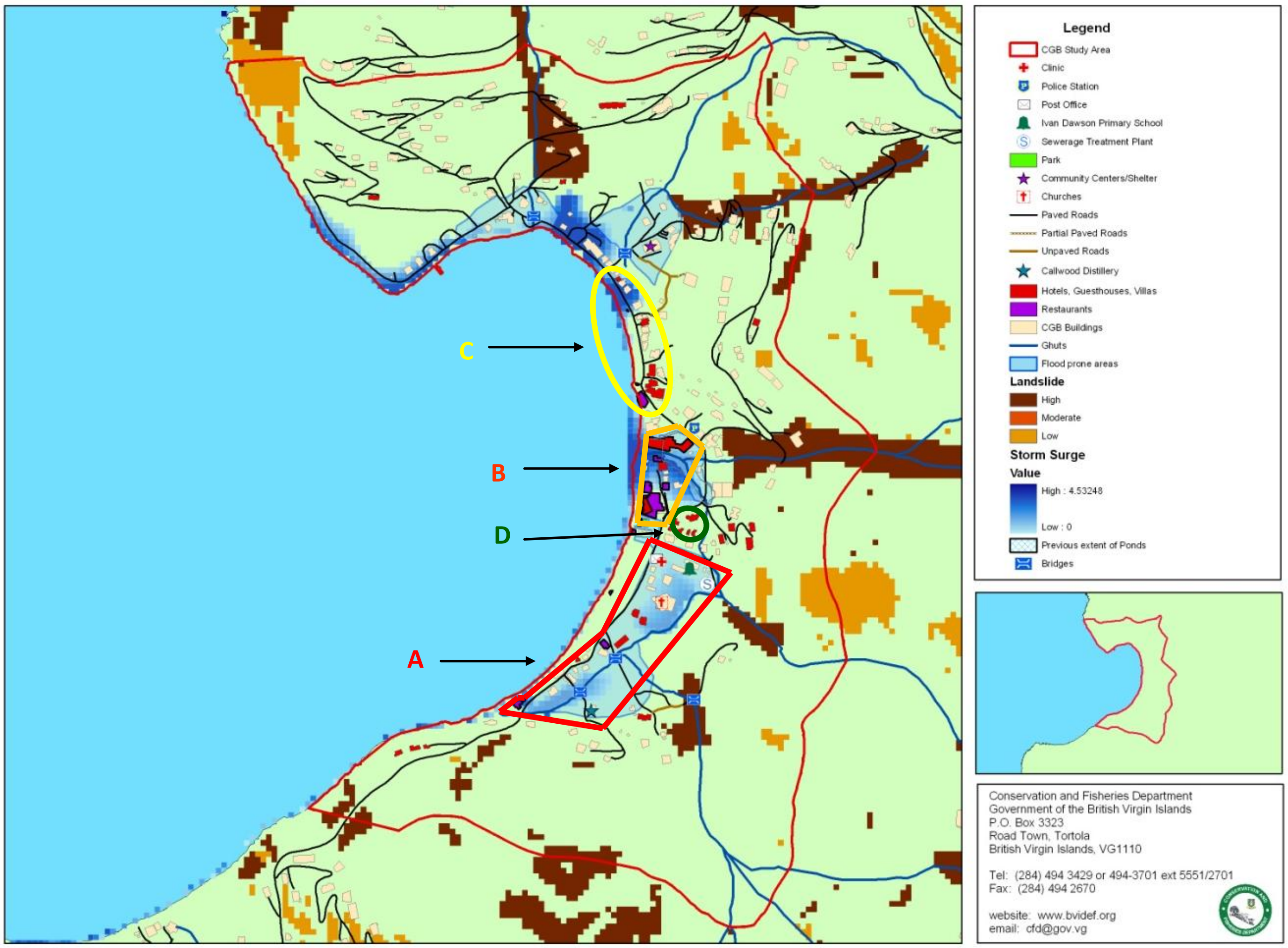


Figure 3.2-12. Cane Garden Bay hazard zones (areas of high natural hazards and concentrated development).

For the purposes of this Assessment, hazard zones were identified from a tourism sector and critical infrastructure perspective. Four hazard zones were identified of varying degrees, labeled A through D on the map.

In the "high" hazard zones, A and B, all hazards are combined and intersect with a high concentration of critical public infrastructure and tourism properties. The intersection of high modified peak ground acceleration, high wind, storm surge and flood hazard are visible from Figures 3.2-9, 3.2-10 and 3.2-11. While the high potential landslide areas do not physically intersect these zones on the map, they will nonetheless be impacted by flood induced landslide events as the areas lie directly in the path of ghuts that would wash mud and debris from landslides into these areas. Furthermore, given their close proximity to the coastline or interaction with the sea through ghut mouths, in the longer term, these areas are vulnerable to sea level rise.

Hazard zones A and B account for 6 of the 20 tourism accommodation businesses in the study area (equivalent to 49 rooms and 63 beds, or 30% and 29% of Cane Garden Bay's total room and bed capacity, respectively), 6 restaurants of the 7 in the study area, the 1 water sports operation and all public critical infrastructure except the police station and community centre. Of important note is that the sewage treatment plant is located in a flood prone area, causing storm waters and coastal waters to be contaminated in flood events. The primary school is located directly next to the sewage plant and is impacted every time it rains, posing a significant health hazard to students.

In the "medium" hazard zone C, there is a high concentration of tourism accommodations combined with high wind hazard. The East End facing section (directionally north) of hazard zone C and the beach front property in its West End facing section (directionally south) are highly vulnerable to storm surge and sea level rise; storm surge in this area regularly occurs during the annual Ground Sea Season (November to April). The other properties in this zone are less vulnerable to this threat due to their higher elevation. Hazard zone C contains 4 tourism accommodation businesses (equivalent to 28 rooms and 40 beds, or 17% and 19% of Cane Garden Bay's total room and bed capacity, respectively) and 1 restaurant.

In the "low" hazard zone D, there are tourism accommodations combined with high wind hazard and high modified peak ground acceleration. Exposure to the other hazards experienced in hazard zone C is relatively low in this zone. Unlike the hazard zones A and B, the earthquake hazard in this area is less likely to be affected by climate change as this area is not in the path of a ghut and, therefore, not receiving ghut deposits. Hazard zone D represents 2 tourism accommodation businesses (equivalent to 2 rooms and 4 of beds, or 1.2% and 2% of Cane Garden Bay's total room and bed capacity, respectively).

Though not located in an identified hazard zone, an important note is the location of the gas station in a storm surge and flood prone area, the combination of which is of concern as it could result in an oil spill in the Bay during a significant event such as a strong hurricane.

Overall the four hazard areas identified account for 11 tourism accommodation properties (equivalent to 79 rooms and 107 beds, or 48% and 50% of Cane Garden Bay's total room and bed capacity, respectively), 7 restaurants, 1 water sports operation and all public critical infrastructure except the police station and community centre.

DISCUSSION

From a hazard perspective it is clear from the static risk maps that tourism properties and public critical infrastructure are concentrated in the worst possible areas where they are particularly vulnerable to the combined threat of storm surge and flooding (with associated landslide impacts) in the immediate to near term, and sea level rise over the longer term as polar glaciers melt and the ocean expands as a result of climate change. Excessive flooding not only destroys local residential homes and businesses, it has deteriorated the quality of sand on the beach as well as water quality, the health of the coral reef and fishery resources within the Bay. Safe access to the Bay has been compromised as large sections of pavement of the two primary access roads have been eroded and areas of the road undermined. In the lowlands, segments of the road that are directly exposed to the sea experienced regular damage from storm surge. The sea wall built to protect these areas is ineffective.

All of the hazards discussed are likely to increase as a result of climate change, some more than others. The percentage of stronger hurricanes (categories 4 and 5) passing through the region are projected to increase as ocean temperatures rise as a result of climate change. The Virgin Islands lie directly in the hurricane belt and are, therefore, prone to hurricanes. Stronger hurricanes will naturally increase the flood and wind hazard in the Bay and increase the height and inland extent of storm surge. As discussed before, floods tend to be accompanied by landslide events as the areas of high landslide potential coincide with the ghuts and their immediate surrounding lands (Joyce, 2003). Finally, while less likely, modified peak ground acceleration could increase if there are increased sediment deposits from ghuts in the coastal lowland areas.

With 45% of the population in Cane Garden Bay falling in the dependent age groups of 19 and under or 70 and older, the ability of the community to respond to natural disasters is reduced. In the tourist season, the tourism population most also be considered a dependent population in the face of natural disasters. Despite this, the Cane Garden Bay Community has historically been very independent and in the face of recent disasters proven quite resilient.

Notwithstanding this, given the high concentration of natural hazards in the Bay, the chance of increased threat due to climate change, and the high overlap of natural hazards with tourism properties and public critical infrastructure, it is critical that the disaster management capacity in Cane Garden Bay be strengthened, particularly at the community and tourism sector levels, with leadership from government. In fact, unless significant changes within both Government and the community are made, either a major disaster will occur or the economically valuable natural resources of CGB will be irreversibly destroyed.

To a large extent, the hazard zones in Cane Garden Bay are by design, particularly by building too close to the shoreline and removing the natural drainage ponds in the area which has created the flooding problem. A large part of the solution in the Bay, therefore, most include redesigning the Bay so that developments are concentrated in the lower hazard areas, in particular areas away from the shoreline, flood prone areas and ghuts.

This process of relocating development is obviously a costly one that must be done over time. The Cane Garden Bay community has the advantage in this regard that most tourism properties are owned by residents/decedents of the Bay that in many cases are land owners of other areas in the Bay that businesses could potentially be relocated to. Furthermore the business community, recognizing the many hazards threatening the Bay, has united to help address the issues. The Cane Garden Bay Community with consultation from the Conservation and Fisheries Department has developed an initial plan for the rehabilitation of the Cane Garden Bay Community. The Plan is attached as Appendix 4 and includes recommendations that would significantly reduce the vulnerability of the Bay to natural hazards and improve the area generally.

An important first step in the process to redesign the Bay is creating and enforcing strict zoning in the Bay to prevent further tourism properties and public critical infrastructure being located in the identified hazard zones. Another immediate and extremely important action that can be taken is the remediation of drainage issues in the Bay. Towards this end, the Conservation and Fisheries Department is engaging a consulting firm with expertise in the field to conduct a detailed assessment of the Cane Garden Bay area and devise the best strategy for providing adequate drainage of stormwater in the area, including through restoration of salt ponds and wetland areas where necessary.

3.3 | Beach Vulnerability Assessment

PURPOSE

The Beach Vulnerability Assessment was conducted to determine the areas of popular/potential tourist beaches under threat from various sea level rise scenarios. Results from the study are intended to inform land-use planning reforms needed to protect key beaches, inform direction of future planning of tourism resources and tourist traffic, and help inform business/home owners of potential risks to their properties.

The study was limited to beaches on Tortola (due to transportation limitations and other logistical issues) and included 5 beaches as described in the table below and shown in Figure 3.3-1. Beaches were selected to represent varying levels and types of tourism activity, human disturbance and basic physical characteristics as described in Table 3.3-1 and demonstrated further in the results.

STUDY BEACH	DESCRIPTION
Beef Island Beach (Long Bay) Tourist activity: LOW Human disturbance: LOW Wave action: LOW	Not traditionally heavily used as a tourist beach, but currently being explored for such Very limited development on beach (open wooden bar) Intact vegetation line and salt pond Turtle nesting beach Room for inland migration. Land directly behind beach is publicly owned
Lambert Bay Tourist activity: MEDIUM Human disturbance: HIGH Wave action: HIGH (during Ground Sea Season – November to April)	Currently used as a tourist beach; primarily by guests of Lambert Beach Resort. Heavy development on the beach (resort built on the dunes and on the beach slope in some areas, retaining boulders along ~20% of beach length) Vegetation disturbed (pruned) Important turtle nesting beach Limited room for inland migration

Josiah's Bay Tourist activity: MEDIUM Human disturbance: HIGH Wave action: HIGH (during Ground Sea Season – November to April)	Currently used as a tourist beach; primarily attracts surfers. Moderate level of development (beach bar and house on the East End facing end of beach) Extensive history of heavy sand mining Vegetation line and salt pond disturbed (outlet partially blocked) Turtle nesting beach Currently room for inland migration, however, the land directly behind the beach is privately owned leaving a big potential for future development
Brewer's Bay Tourist activity: HIGH Human disturbance: HIGH Wave action: HIGH (during Ground Sea Season – November to April)	Currently used as tourist beach; cruise ship passengers and overnight guests Heavy development on the beach (sea wall along about a third of the beach length, beach bar, campground) Vegetation line disturbed No room for inland migration (heavy development along beach and road behind beach)
Cane Garden Bay Tourist activity: HIGH Human disturbance: HIGH Wave action: HIGH (during Ground Sea Season – November to April)	Currently heavily used as a tourist beach; primarily cruise ship passengers, also overnight guests. Dense development along the beach without any set back (beach bars, restaurants, villas, water sports shop, cemetery, retaining wall etc.) Vegetation line disturbed No room for inland migration (heavy development along entire beach length and road behind beach)

Table 3.3-1. Characteristics of study beaches.

Figure 3.3-1. Location of study beaches.

METHOD

The Assessment repeated the basic methodology to determine beach area under threat by sea level rise used by Fish et al in their study "Predicting the Impact of Sea-Level Rise on Caribbean Sea Turtle Nesting Habitat."

The profile of each beach was measured in a grid-like fashion using differential Global Positioning Systems (GPS). The profile grid used varied depending on how rapidly each beach slope changed; the more dynamic the beach profile, the smaller the grid size used. Grid size was measured roughly, with one giant step representing a metre. Any obvious changes in the beach profile or special features that fell outside of the grid were also captured by measuring the start and end of the change/feature. Profiles were started at the vegetation line or retaining wall, where present. Where a natural step occurred in the water near the swash zone, the profile was measured to the step. If no natural step occurred, the profile was measured to the seaward extent of the swash zone. Table 3.3-2 below records the date(s) each beach was profiled, the grid used, and the end point of the beach profile.

Beach	**Profile date(s)**	**Profile grid**	**Profile end point**
Beef Island Beach (Long Bay)	15 July, 2010	End points and two middle points along the beach length X 3m along the beach width	First natural step in water
Lambert Bay	13 Sep, 2010	30m along the length X 3m along the width from beach crest seaward. From vegetation line to beach crest, only end and middle points were taken (due to flat profile)	First natural step in water
Josiah's Bay	14 Sep, 2010	30m along the length X 3m along the width. Complete profile of width was taken for eastern half of beach. For western half of beach complete profile was taken every other 30m with profiles in between starting at the beach crest (due to flatter profile of western half)	Seaward extent of swash zone
Brewer's Bay	28 Sep, 2010	10m along the length X 5m along the width (from West End facing end to bridge) 30m along the length X 5m along the width (from bridge to East End facing end of beach)	First natural step in water
Cane Garden Bay *(West End facing, directionally south, section from Quito's Gazebo to The Wedding).*	12-13 October, 2010	30m along the length X 3m along the width	Seaward extent of swash zone

Table 3.3-2. Profiling details of study beaches.

A Geographic Information System (ESRI Arc GIS v9.3) was used for analysis. Five sea level rise (SLR) scenarios were used to determine beach area under threat. These were the 0.18m, 0.39m and 0.59m rise by 2090 to 2099 scenarios derived from the range of projections given in the

Intergovernmental Panel on Climate Change (IPCC) 2007 report (the lowest, highest and mid-point of the range of projections were taken). The other scenarios used were 1m and 2m rise by the end of the Century based on research findings since the 2007 IPCC report which account for observations of rapid ice sheet melt (Greenland and Antarctic).

Triangulated irregular network (TIN) models were created for each beach using the profile data. The TIN models were converted to 1m horizontal and 0.1m vertical resolution digital elevation models (DEMs) for analysis.

The Spatial Analyst application was then used to create contour lines of 0.18m, 0.39m, 0.59m, 1m and 2m intervals. New individual polygons were drawn from the 0m line to the first 0.18m contour, the first 0.39m contour, the first 0.59m contour, the first 1m contour and the first 2m contour. These polygons represent the beach area that would be inundated with a 0.18m, 0.39m, 0.59m, 1m and 2m sea level rise respectively. The area of each polygon and the percentage of the entire beach area it represents were calculated. In the analysis it was assumed that the current beach profile would be maintained in the future and the beaches are not able to retreat with sea level rise.

RESULTS

Beef Island Beach (Long Bay)

Beef Island Beach (Long Bay) measures an area of 12,214m^2/3.0 acres. The average beach width is 20.4m, the average elevation along the vegetation line is 2.4m, the highest elevation along the beach is 3.4m, and the average beach slope is approximately 6.7°.

The GIS analysis determined the beach area that would be inundated by various degrees of sea level rise as follows (see Figure 3.3-1 below).

0.18m = 3,719m^2/0.9acres (30%)
0.39m = 4,707m^2/1.2acres (39%)
0.59m = 5,465m^2/1.4acres (45%)
1m = 7,124m^2/1.8acres (58%)
2m = 9,831m^2/2.4acres (80%)

Lambert Bay

Lambert Bay measures an area of 14,751m^2/3.6 acres. The average beach width is 29.5m, the average elevation along the vegetation line is 1.4m, the highest elevation along the beach is 2.2m, and the average beach slope is approximately 2.8°.

The GIS analysis determined the beach area that would be inundated by various degrees of sea level rise as follows (see Figure 3.3-2 below).

0.18m = 4,896m^2/ 1.2acres (33%)
0.39m = 6,563m^2/1.6acres (44%)
0.59m = 8,321m^2/2.1acres (56%)
1m = 10,781m^2/2.7acres (73%)
2m = 15,156m^2/3.7acres (103%)

Josiah's Bay

Josiah's Bay measures an area of 11,322m^2/2.8acres. The average beach width is 24.9m, the average elevation along the vegetation line is 2.5m, the highest elevation along the beach is 3.3m, and the average beach slope is approximately 5.7°.

The GIS analysis determined the beach area that would be inundated by various degrees of sea level rise as follows (see Figure 3.3-3 below).

0.18m = 817m^2/ 0.2acres (7%)
0.39m = 1,395m^2/0.3acres (12%)
0.59m = 1,887m^2/0.5acres (17%)
1m = 5,432m^2/1.3acres (48%)
2m = 9,613m^2/2.4acres (85%)

Brewer's Bay

Brewer's Bay measures an area of 9,476m^2/2.3acres. The average beach width is 16.0m, the average elevation along the vegetation line is 0.8m, the highest elevation along the beach is 1.9m, and the average beach slope is approximately 2.9°.

The GIS analysis determined the beach area that would be inundated by various degrees of sea level rise as follows (see Figure 3.3-4below).

0.18m = 3,628m^2/ 0.9acres (38%)
0.39m = 5,004m^2/1.2acres (53%)
0.59m = 6,897m^2/1.7acres (73%)
1m = 8,829m^2/2.2acres (93%)

2m = >>9,479m²/>>2.3acres (>>100%) – unable to calculate area as highest elevation of beach is less than 2m.

Cane Garden Bay Beach

Cane Garden Bay Beach measures an area of 10,636m²/2.6acres. The average beach width is 17.7m, the average elevation along the vegetation line is 1.4m, the highest elevation along the beach is 3.8m, and the average beach slope is approximately 4.5°.

The GIS analysis determined the beach area that would be inundated by various degrees of sea level rise as follows (see Figure 3.3-5below).

0.18m = 1,294m²/ 0.3acres (12%)
0.39m = 2,552m²/0.6acres (24%)
0.59m = 3,960m²/1.0acres (37%)
1m = 7,202m²/1.8acres (68%)
2m = 10,966m²/2.7acres (103%)

Comparison of beaches

The basic beach characteristics and areas inundated under various sea level rise scenarios are compared for the five beaches studied in Tables 3.3-3 to 3.3-5 below.

The range and average area inundated by various sea level rise scenarios for the five study beaches are as follows:

0.18m = 7% to 38% (avg. 24%)
0.39m = 12% to 53% (avg. 34%)
0.59m = 17% to 73% (avg. 46%)
1m = 48% to 93% (avg. 68%)
2m = 80% to >>100% (avg. 94%)

With the minimum rise of 0.18m, over a third of beach area is lost from the most vulnerable beaches while the average loss from all five study beaches is close to a quarter (24%). With a 0.39m rise, close to a half of beach area is lost from some beaches while the average loss is close to a third (34%). In the 0.59m scenario, the most vulnerable beach losses close to three quarters (75%) of its area while the average beach area loss is close to a half (46%). In the higher 1m rise scenario, the most vulnerable beach losses almost all its area (93%) while the average loss is close to two-thirds (68%). In the most extreme 2m rise scenario, the most vulnerable beach losses more than its entire area while the average loss is close to the entire beach area (94%).

In the lower sea level rise scenarios (0.18m, 0.39m and 0.59m), Brewer's Bay Beach is the most vulnerable beach followed by Lambert Bay, Beef Island Beach (Long Bay), Cane Garden Bay and Josiah's Bay, in that order (see Table 3.3-4).

In the higher rise scenarios (1m and 2m) Brewer's Bay Beach remains the most vulnerable followed by Lambert Bay. In both these higher rise scenarios, however, the vulnerability of Cane Garden Bay Beach significantly increases as compared to Beef Island Beach (Long Bay), almost doubling and tripling from the 0.59m scenario, respectively. As a result, unlike in the lower level scenarios, Cane Garden Bay Beach becomes more vulnerable than Beef Island Beach (Long Bay). In the most extreme (2m) scenario, Beef Island Beach (Long Bay) with the steepest slope (6.7°) becomes the least vulnerable beach as opposed to Josiah's Bay (see Table 3.3-5).

Beach	**Beef Island Beach (Long Bay)**	**Lambert Bay**	**Josiah's Bay**	**Brewer's Bay**	**Cane Garden Bay**
Avg. width (m)	20.4	**29.5**	24.9	16.0	17.7
Avg. elevation along vegetation line (m)	2.4	1.4	**2.5**	0.8	1.4
Slope	**6.7°**	2.8°	5.7°	2.9°	4.5°
Total beach area (m^2)	12,214	**14,751**	11,322	9,476	10,636
Area (m^2) inundated (0.18m rise)	3,719 **(30%)**	4,896 **(33%)**	817 **(7%)**	3,628 **(38%)**	1,294 **(12%)**
Area (m^2) inundated (0.39m rise)	4,707 **(39%)**	6,563 **(44%)**	1395 **(12%)**	5,004 **(53%)**	2,552 **(24%)**
Area (m^2) inundated (0.59m rise)	5,465 **(45%)**	8,321 **(56%)**	1,887 **(17%)**	6,897 **(73%)**	3,960 **(37%)**
Area (m^2) inundated (1m rise)	7,124 **(58%)**	10,781 **(73%)**	5,432 **(48%)**	8,829 **(93%)**	7,202 **(68%)**
Area (m^2) inundated (2m rise)	9,831 **(80%)**	15,156 **(103%)**	9,613 **(85%)**	>>9,479 **(>>100%)**	10,966 **(103%)**

Table 3.3-3. Comparison of basic beach characteristics and areas of study beaches inundated under various sea level rise scenarios (0.18m, 0.39m, 0.59m, 1m and 2m).

	0.18m Scenario		0.39m Scenario		0.59m scenario	
Rank	***Beach***	***Inundated***	***Beach***	***Inundated***	***Beach***	***Inundated***
1 (most inundation)	Brewer's Bay	38%	Brewer's Bay	53%	Brewer's Bay	73%
2	Lambert Bay	33%	Lambert Bay	44%	Lambert Bay	56%
3	Beef Island	30%	Beef Island	39%	Beef Island	45%
4	Cane Garden Bay	12%	Cane Garden Bay	24%	Cane Garden Bay	37%
5 (least inundation)	Josiah's Bay	7%	Josiah's Bay	12%	Josiah's Bay	17%

Table 3.3-4. Comparison of the vulnerability of the five study beaches to the 0.18m, 0.39m and 0.59m sea level rise scenarios.

In all scenarios, Brewer's Bay Beach is the most vulnerable beach followed by Lambert Bay, Beef Island Beach (Long Bay), Cane Garden Bay and Josiah's Bay in that order.

	1m scenario		2m scenario	
Rank	***Beach***	***Inundated***	***Beach***	***Inundated***
1 (most inundation)	Brewer's Bay	93%	Brewer's Bay	>>100%
2	Lambert Bay	73%	Lambert Bay	103%
3	Cane Garden Bay	68%	Cane Garden Bay	103%
4	Beef Island Beach	58%	Josiah's Bay	85%
5 (least inundation)	Josiah's Bay	48%	Beef Island Beach	80%

Table 3.3-5. Comparison of the vulnerability of the five study beaches to the higher 1m and 2m sea level rise scenarios.

In both scenarios Brewer's Bay Beach remains the most vulnerable followed by Lambert Bay. Unlike in the lower level scenarios, Cane Garden Bay Beach becomes more vulnerable than Beef Island Beach (Long Bay). In the most extreme (2m) scenario, Beef Island Beach (Long Bay) becomes the least vulnerable beach as opposed to Josiah's Bay.

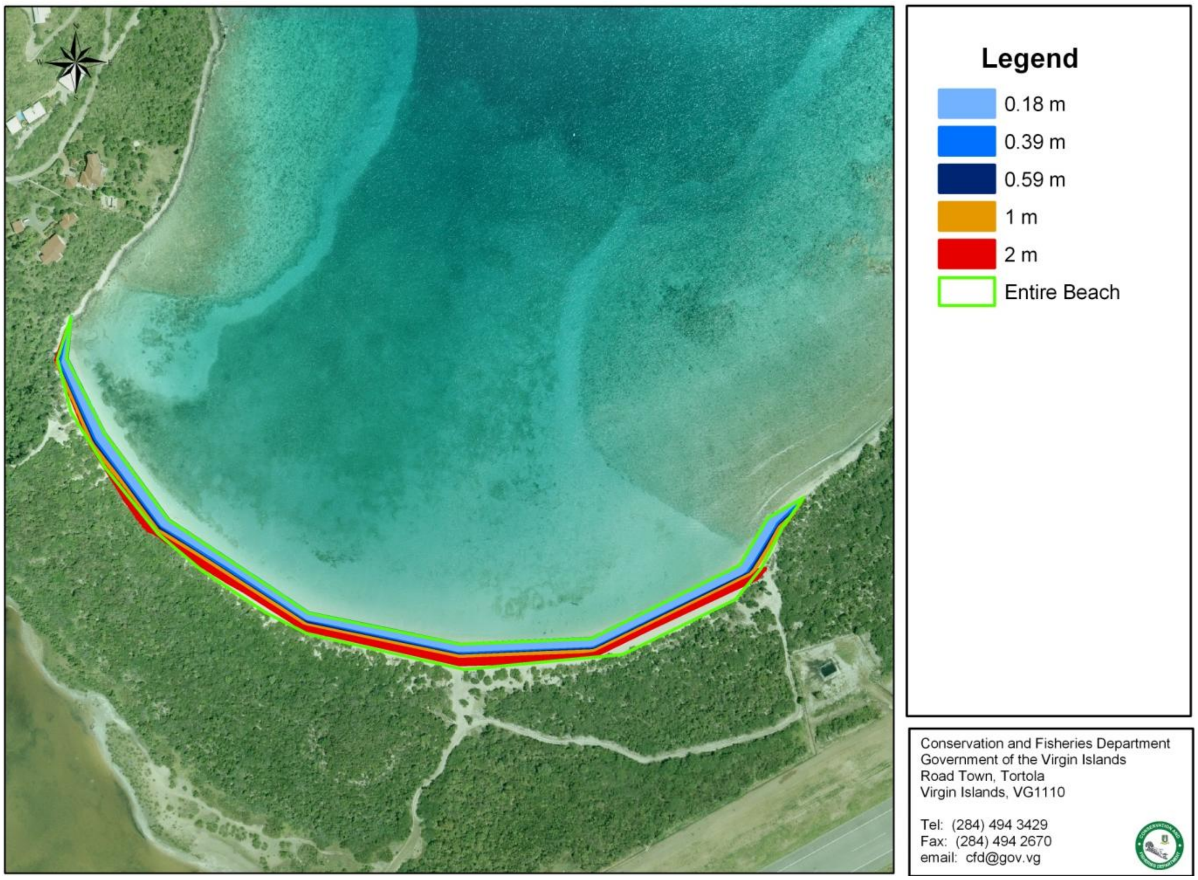


Figure 3.3-2. Areas of Beef Island Beach (Long Bay) that would be inundated by various sea level rise scenarios. A 0.18m rise results in 30% beach area loss, 0.39m rise results in 39% loss, 0.59m rise results in 45% loss, 1m rise results in 58% loss and 2m rise results in 80% loss by 2090-2099.

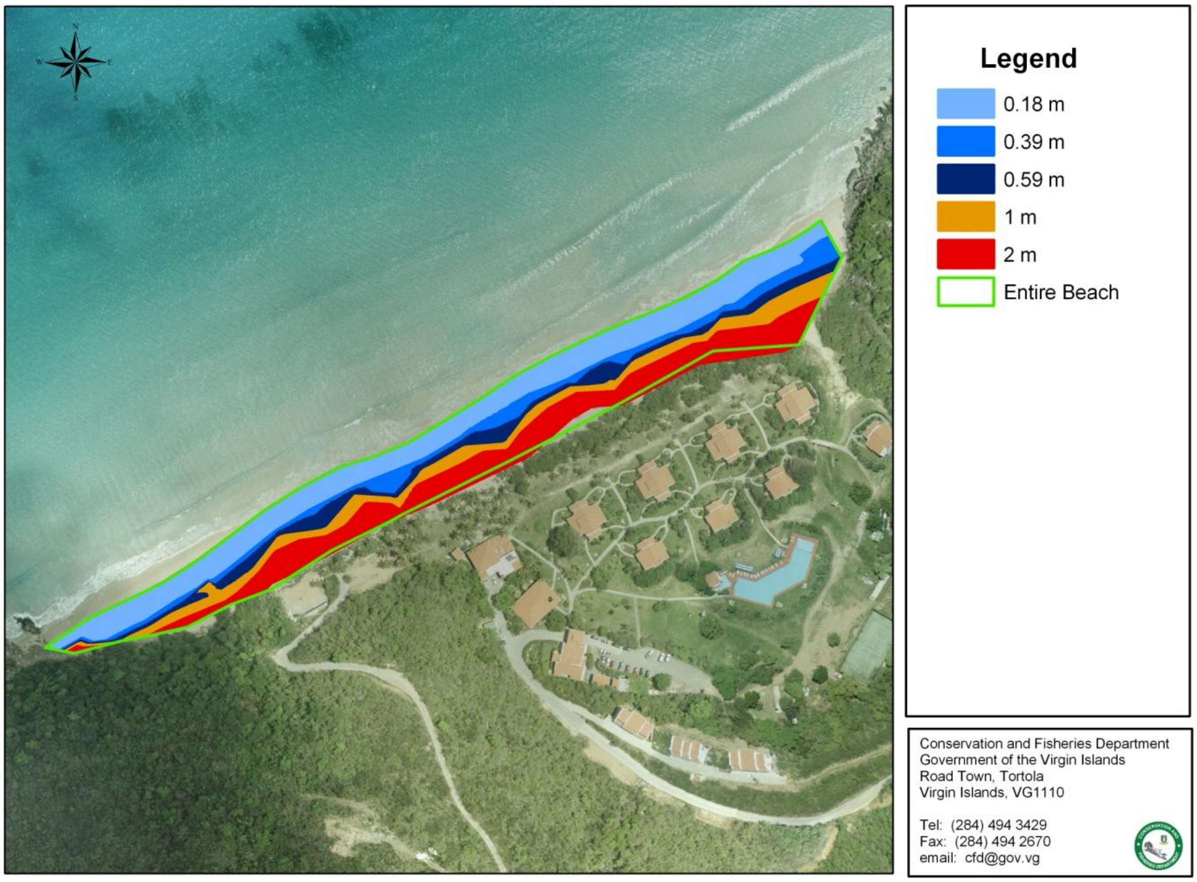


Figure 3.3-3. Areas of Lambert Bay that would be inundated by various sea level rise scenarios. A 0.18m rise results in 33% beach area loss, 0.39m rise results in 44% loss, 0.59m rise results in 56% loss, 1m rise results in 73% loss and 2m rise results in 103% loss by 2090-2099.

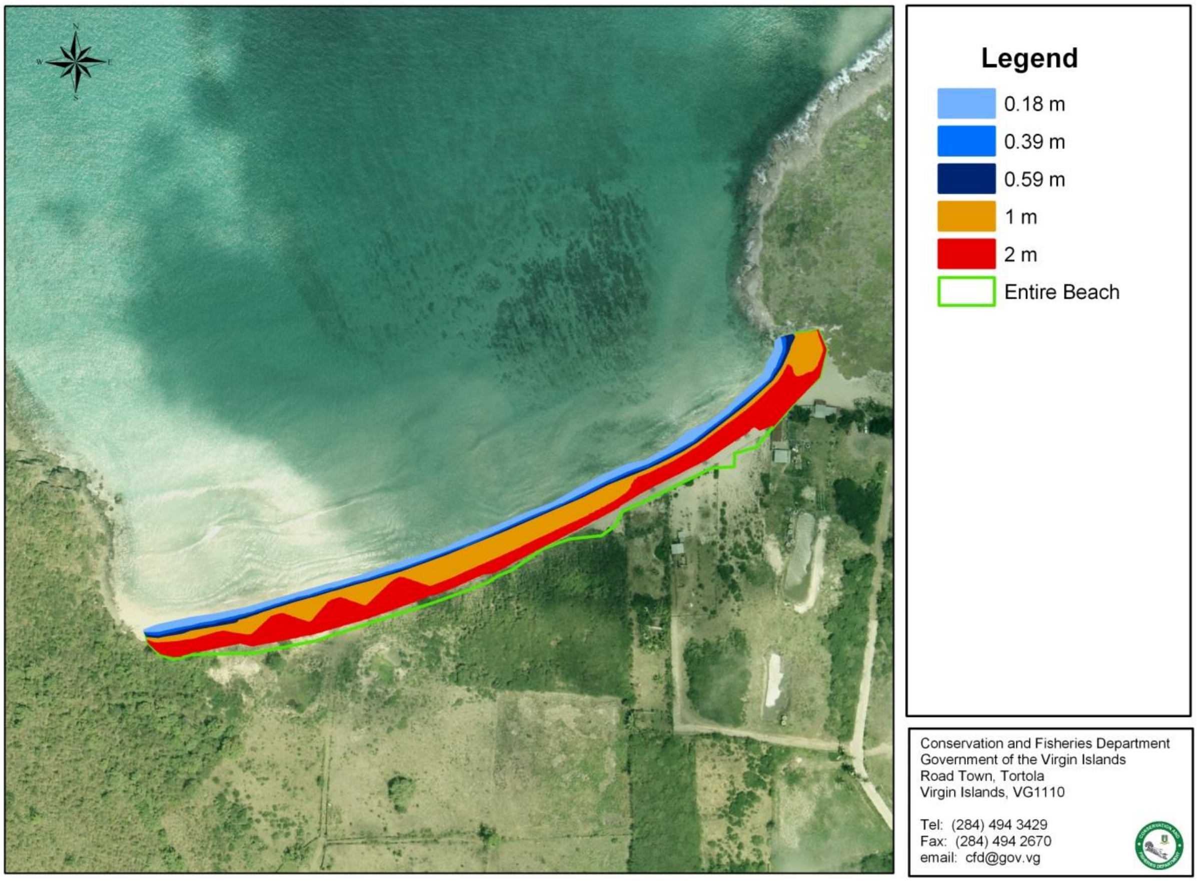


Figure 3.3-4. Areas of Josiah's Bay that would be inundated by various sea level rise scenarios. A 0.18m rise results in 7% beach area loss, 0.39m rise results in 12% loss, 0.59m rise results in 17% loss, 1m rise results in 48% loss and 2m rise results in 85% loss by 2090-2099.

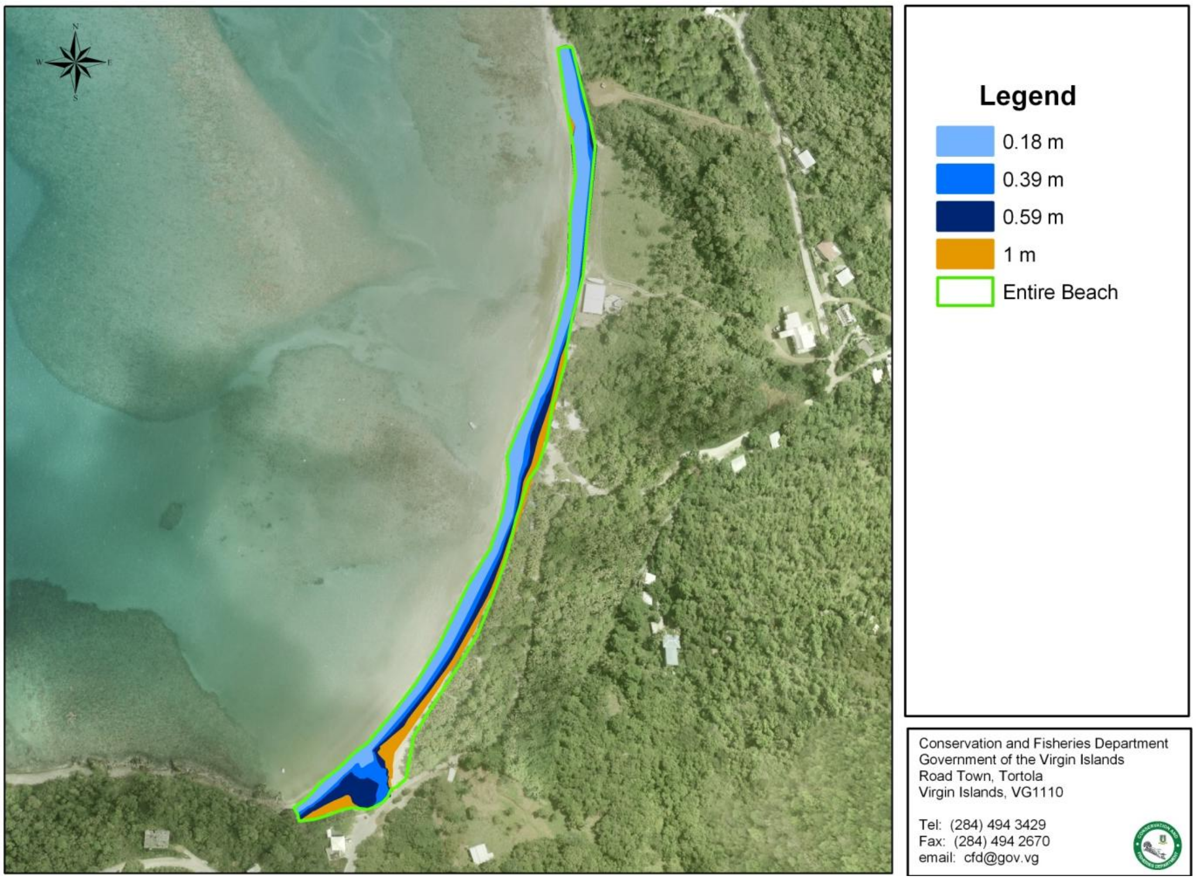


Figure 3.3-5. Areas of Brewer's Bay that would be inundated by various sea level rise scenarios. A 0.18m rise results in 38% beach area loss, 0.39m rise results in 53% loss, 0.59m rise results in 73% loss, 1m rise results in 93% loss and 2m rise results in >>100% loss by 2090-2099.

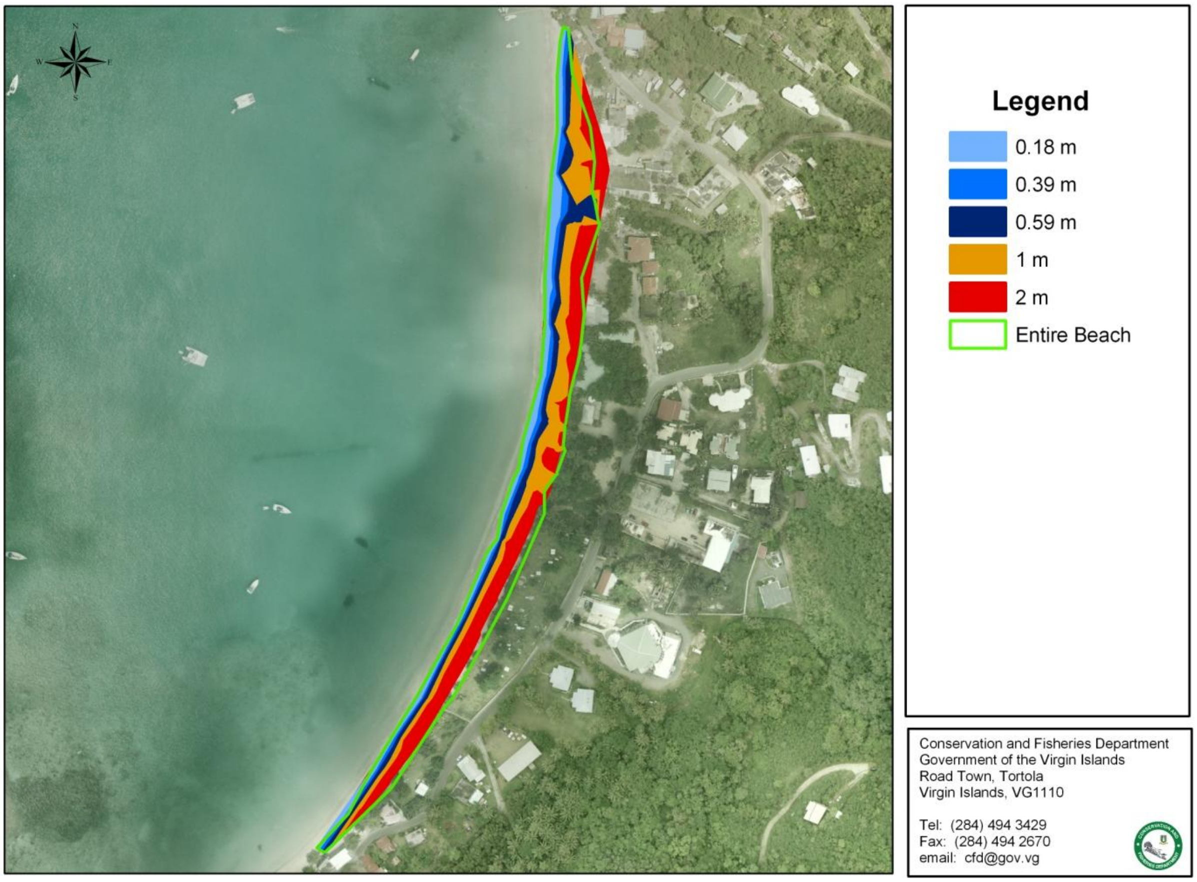


Figure 3.3-6. Areas of Cane Garden Bay Beach that would be inundated by various sea level rise scenarios. A 0.18m rise results in 12% beach area loss, 0.39m rise results in 24% loss, 0.59m rise results in 37% loss, 1m rise results in 68% loss and 2m rise results in 103% loss by 2090-2099.

DISCUSSION

Understanding the long term impacts of sea level rise on beaches is particularly important because beaches play such a key role in the tourism product and the recreational life of residents. This is certainly the case with the five study beaches selected.

As stated in the 2007 IPCC Forth Assessment Report (AR4), the upper value of the sea level rise range given (0.59m) should not be considered the upper bound for sea level rise. This is because some important factors, such as changes in ice sheet flow, were not fully considered because of a lack of published literature and full scientific understanding of sea level rise at the time of the IPCC AR4 Report. Recent studies accounting for observations of rapid ice sheet melt (Greenland and Antarctic) have led to greater and more accurate estimates of SLR than in the IPCC AR4 projections. There is an approaching consensus that sea level rise by the end of the

21st Century will be between 1-2m above present levels (Simpson et al., 2010). This study, therefore, considered the sea level rise projections of the IPCC report and those subsequent to its publication.

The vulnerability of a beach to sea level rise is determined primarily by its detailed profile, average width, average slope, and freedom to retreat inland as sea level rises. The results of the study suggest that for the lower rise scenarios (0.18m, 0.39m and 0,59m) the detailed profile of the beach is a strong indicator of vulnerability. In the longer term, for the higher rise scenarios (1m and 2m), the average beach width, average slope and freedom to retreat inland become more important. This would, for example, account for why Beef Island Beach (which is wider and on average has a steeper slope) appears to be more vulnerable than Cane Garden Bay Beach in the lower rise scenarios, but less vulnerable in the higher rise scenarios.

It should also be considered that beaches are extremely dynamic ecosystems and their average width, average slope and detailed profile change seasonally. The beach measurements for this study were taken between mid July and mid October, 2010 when beaches are typically recovered from the winter swells (locally referred to as the “ground sea”) period and are at their widest. At the time of some measurements, however, major flooding at had caused a degree of erosion at some of the study beaches (Brewer’s Bay Beach and Cane Garden Bay Beach in particular). This primarily resulted in gullies forming along the beach as opposed to reductions in beach width or changes in beach slope.

Because of this dynamicity, particularly in the detailed beach profile, too much emphasis should not be placed on comparisons between the study beaches, especially for the lower rise scenarios before conducting longer term studies which can take into account how the beaches change over time. Instead, focus should be given to the bigger picture, particularly the range and average losses that can be expected under various sea level rise scenarios.

This study considered a diverse set of beaches in terms of their detailed profile, average width, average slope and freedom to migrate. This ranged from very narrow beaches, such as Brewer’s Bay, to wide beaches such as Lambert Bay; from very gently sloping beaches, again such as Brewer’s Bay, to very steeply sloping beaches such as Beef Island Beach; from beaches with a fairly consistent profile such as Cane Garden Bay to beaches with more complex profiles such as Beef Island Beach again and Josiah’s Bay; and from beaches with no freedom to migrate such as Cane Garden Bay to beaches with no present physical barriers to migration such as Beef Island Beach.

The calculations under various sea level rise scenarios show significant average beach area loss for all scenarios, ranging from roughly a quarter to all of the beach area. For the 0.18m rise scenario, the average beach area loss is close to a quarter (24%). For the 0.39m scenario, the average beach area loss is close to a third (34%) and in the 0.59m scenario it is close to a half (46%). In the higher level rise scenarios (1m and 2m), average beach area loss is close to two-thirds (68%) and a whole (94%), respectively.

These results must be considered against the background erosion rate of these beaches which is unpublished at the time of this report. It should also be considered that the ecosystem function of beaches may not necessarily decrease in a linear fashion with beach area, but that there may be a tipping point in beach area loss after which ecosystem function for recreation, tourism, turtle nesting habitat and other functions decreases at an increased rate. This potential "tipping point" effect was not assessed in this study.

Some of the beaches included in this study, such as Cane Garden Bay, are very popular tourist beaches already experiencing overcapacity/overcrowding. As such, any loss of beach area, especially of the significant percentages predicted, would represent a major degradation in the quality, attractiveness and usability of the beach and could result in major losses to the tourism sector. It is hard to determine the relationship between loss of beach area and reduced tourist visitation, however, The Virgin Islands Tourist Perception survey and regional surveys have established a strong connection. In The Virgin Islands survey, 56% of respondents reported that erosion of beaches would have a "significant influence" on their decision to make future visits to the islands (see Section 2.1). A survey conducted in Barbados and Bonaire in 2005 found that 80% of tourists would be unwilling to revisit the destination at the same price should there be reduced beach area as a result of sea level rise (Uyarra, 2005).

Furthermore, erosion of beaches as a result of sea level rise will greatly increase the storm surge hazard to developments along the beach and could lead to the eventual undermining of these structures. This concern is applicable to Lambert Bay, Josiah's Bay, Brewer's Bay and Cane Garden Bay, all of which have tourism related properties (hotels, bars or restaurants) built on the beach.

In this study it was assumed that the current beach profile would be maintained in the future and that beaches are not able to retreat with sea level rise. In the case of all of these beaches, except Beef Island Beach (Long Bay), this is a reasonable assumption. Cane Garden Bay Beach, Brewer's Bay and Lambert Bay are already developed along their entire lengths. While development at Josiah's Bay is currently limited to its eastern end, the land adjacent to the beach is private and could potentially be developed. On the other hand, the land adjacent to Beef Island Beach (Long Bay) is Crown land giving the Government more leverage to protect this area from development and save the beach in the long run.

The only real adaptation option for beaches in the face of sea level rise is retreat. If the beaches studied and all other beaches are to keep pace with sea level rise they must be able to retreat/shift inland. Strong policies, therefore, need to be created to ensure a sufficient buffer zone between beaches and development is maintained by preventing further development directly along beach fronts. Creative means need to be considered to eventually relocate existing developments, perhaps after their meaningful lifespan has expired. Additional studies using models to predict shoreline response to sea level rise would be necessary to determine appropriate development setbacks.

3.4 | Sea Level Rise Vulnerability Assessment

PURPOSE

The purpose of this section is to better understand the impacts of projected sea level rise on the coastline of The Virgin Islands and the tourism properties and critical infrastructure located there.

METHOD

The potential impact of sea level rise on The Virgin Islands is discussed based on a review of the latest literature on the impacts of sea level rise in the Caribbean, “'Quantification and Magnitude of Losses and Damages Resulting from the Impacts of Climate Change: Modeling the Transformational Impacts and Costs of Sea Level Rise (SLR) in the Caribbean,” by Murray et al. In addition, simple sea level rise maps (not taking into account the added threat to storm surge) were created for the four main islands, Tortola, Virgin Gorda, Anegada and Jost Van Dyke to determine coastal areas at risk of inundation with a sea level rise of 0.59m (the highest estimated provided in the IPCC AR4 report), 1m and 2m (the degree of rise suggested by more recent studies under mid and high emissions scenarios).

According to the authors of the regional report it, “provides the most detailed analysis to date of the damages and costs associated with SLR for CARICOM nations. The methodology incorporates top-down and bottom-up approaches (i.e., macro, meso- and micro-scales analyses) to model impacts on the economies of each CARICOM country individually. A unique strength of the economic study is that it is based on the most detailed geographic reality of coastal geomorphology and development that determine vulnerability to SLR.

Specifically, this report provides a detailed and vigorous assessment of the losses and damages associated with sea level rise impacts on the population, ecosystems and key economic sectors in CARICOM nations. Advancements in understanding of the consequences of sea level rise at the regional level were accomplished through:

- utilisation of newly available higher resolution geospatial data of coastal areas (satellite based Digital Elevation Models);
- improved inventories of coastal infrastructure and other assets at risk;
- the first quantification of the extent of SLR-induced erosion risk in unconsolidated coastal areas;
- a more comprehensive understanding of combined SLR and storm surge risk; and,

- the first quantification of the extent and cost of structural protection works required to protect coastal cities in CARICOM countries from SLR” (Simpson et al., 2010).

Sea level rise maps for the four main islands of The Virgin Islands (Tortola, Virgin Gorda, Anegada and Jost Van Dyke) were created using a geographic information system (ESRI Arc GIS v9.3). Three sea level rise (SLR) scenarios were used to determine beach area under threat based on the highest estimate provided in the IPCC Fourth Assessment Report (0.59m by 2090-2099) and projections (based on research conducted since the IPCC report) used by Murray et al. in the latest report on sea level rise in the Caribbean (1-2m by 2100).

Triangulated irregular network (TIN) models were created for each island. The Spatial Analyst application was then used to create contour lines of 0.59m, 1m and 2m intervals. New individual polygons were drawn from the 0m line to the first 0.59m contour, the first 1m contour and first 2m contour; the area of each polygon was calculated. These polygons represent the land area that would be inundated with a 0.59m, 1m and 2m sea level rise respectively.

In the analysis it was assumed that the current beach profile would be maintained in the future.

RESULTS AND DISCUSSION

Sea level rise projections

The regional report on impacts and costs of sea level Rise (SLR) in the Caribbean reported the following key findings of observed and projected changes in sea level (quoted directly from the report) (Simpson et al., 2010):

- Studies of previous sea level responses to climate change reveal that SLR of 1m per century has not been unusual and that rates up to 2m per century have been observed.
- Although present rates of global sea level rise are not yet approaching 1m per century, they are observed to be accelerating in response to increased global warming.
- Recent studies accounting for observations of rapid ice sheet melt (Greenland and Antarctic) have led to greater and more accurate estimates of SLR than in the IPCC AR4 projections. There is an approaching consensus that sea level rise by the end of the 21st Century will be between 1-2m above present levels.
- Moderate to high GHG emission scenarios pose a major threat to the stability of the world’s ice sheets and introduce the possibility of rapid SLR on a decadal timescale up to ten times the rate observed a century ago.

- Global temperature and the magnitude of SLR are strongly linked. With a 2°C or 2.5°C global temperature rise, the current rate of SLR will continue or even accelerate.
- The Caribbean is projected to experience greater SLR than most areas of the world due to its location closer to the equator and related gravitational and geophysical factors.
- Even in the absence of increased intensity or frequency of tropical storms and hurricanes, SLR will intensify their impact on coastlines in the Caribbean.
- SLR will continue for centuries after 2100, even if global temperatures are stabilized at 2°C or 2.5°C and, therefore, represents a chronic and unidirectional, negative threat to coastal areas in the Caribbean and globally.

Regional impacts of projected sea level rise

The impacts of SLR will be experienced differently by each CARICOM nation. As a general rule, however, the proportional impacts of SLR (losses compared to GDP) are higher for smaller CARICOM economies, such as Barbados and Antigua and Barbuda and increase significantly towards the end of the Century (Simpson et al., 2010).

Tourism will be the sector most affected by sea level rise, accounting for the majority of annual losses determined by the regional study. In some of the smaller CARICOM countries, such as Antigua and Barbuda, Barbados, St. Kitts and Nevis and The Bahamas, annual losses to tourism as a result of SLR would range up to 5% of GDP (Simpson et al., 2010).

The study assessed impacts to tourism in terms of resort damages as well as loss of income due to beach loss. Capital costs were generally dominated by rebuild costs, especially in the smaller CARICOM countries. This is not surprising as, for example, the study projects a combination of SLR and a 1 in 100 year storm surge event to result in possible damage to 50% of the major tourism resorts in Antigua and Barbuda, Belize, Haiti, St. Kitts and Nevis, St. Vincent and the Grenadines, and The Bahamas (Simpson et al., 2010).

Table 3.4-1 below provides the total rebuild costs for tourist resorts in 2050 and 2080 under the mid and high emission scenarios (with and without the impacts of erosion considered) as well as the annual costs to tourism due "reduced amenity value" from beach loss. It should be noted that all estimated given are in the absence of adaptation measures to reduce the impacts of seal level rise.

	Total rebuild costs for tourist resorts *(without impact of erosion)*	**Total rebuild costs for tourist resorts *(with impact of erosion)***	**Annual costs due to "reduced amenity value" from beach loss**
Mid-range SLR scenario **(2050)**	$10 billion	Not calculated	Not calculated
High SLR scenario **(2050)**	$23.3 billion	Not calculated	Not calculated
Mid-range SLR scenario **(2080)**	$23.5 billion	$48.4 billion	$12.4 billion
High SLR scenario **(2080)**	$74 billion	$122.5 billion	$17.1 billion

Table 3.4-1 Total costs of impacts of sea level rise to tourism in all CARICOM countries. All figures are 2010 US prices. *(Source: Simpson et al., 2010)*

In additional to these losses from resort damage and beach loss, tourism would also be impacted by SLR from flood risk to the majority of CARCICOM country airports and flood damage to a high percentage of the islands' coastal road network, both critical support infrastructure for tourism (Simpson et al., 2010).

Local impacts of projected sea level rise

Figures 3.4-1 to 3.4-5 below visually show the land areas on the four main islands and Beef Island that would be inundated with a 0.59m, 1m and 2m sea level rise as well as critical infrastructure and tourism properties (accommodations, marinas/docks) located in these areas. Table 3.4-2 gives the land area that would be inundated on the four main islands as a result of a 2m sea level rise in absolute terms and as a percentage of the total land area.

It should be noted that these maps provide only a rough first estimate of inundation by sea level rise. The mapping is based on a 1m interval topographic map which may not be 100% accurate, especially in the coastal zone, and that only extends to the coastal vegetation line, therefore, not including beaches. For this reason, these maps do not take into account the protective services, for example, that beach berms may offer from sea level rise which is observed at the resolution at which the beach vulnerability assessment was conducted.

It is recommended that further studies of sea level rise inundation be conducted at the island scale using higher resolution and more accurate topographic data and more sophisticated GIS modeling techniques to inform planning decisions.

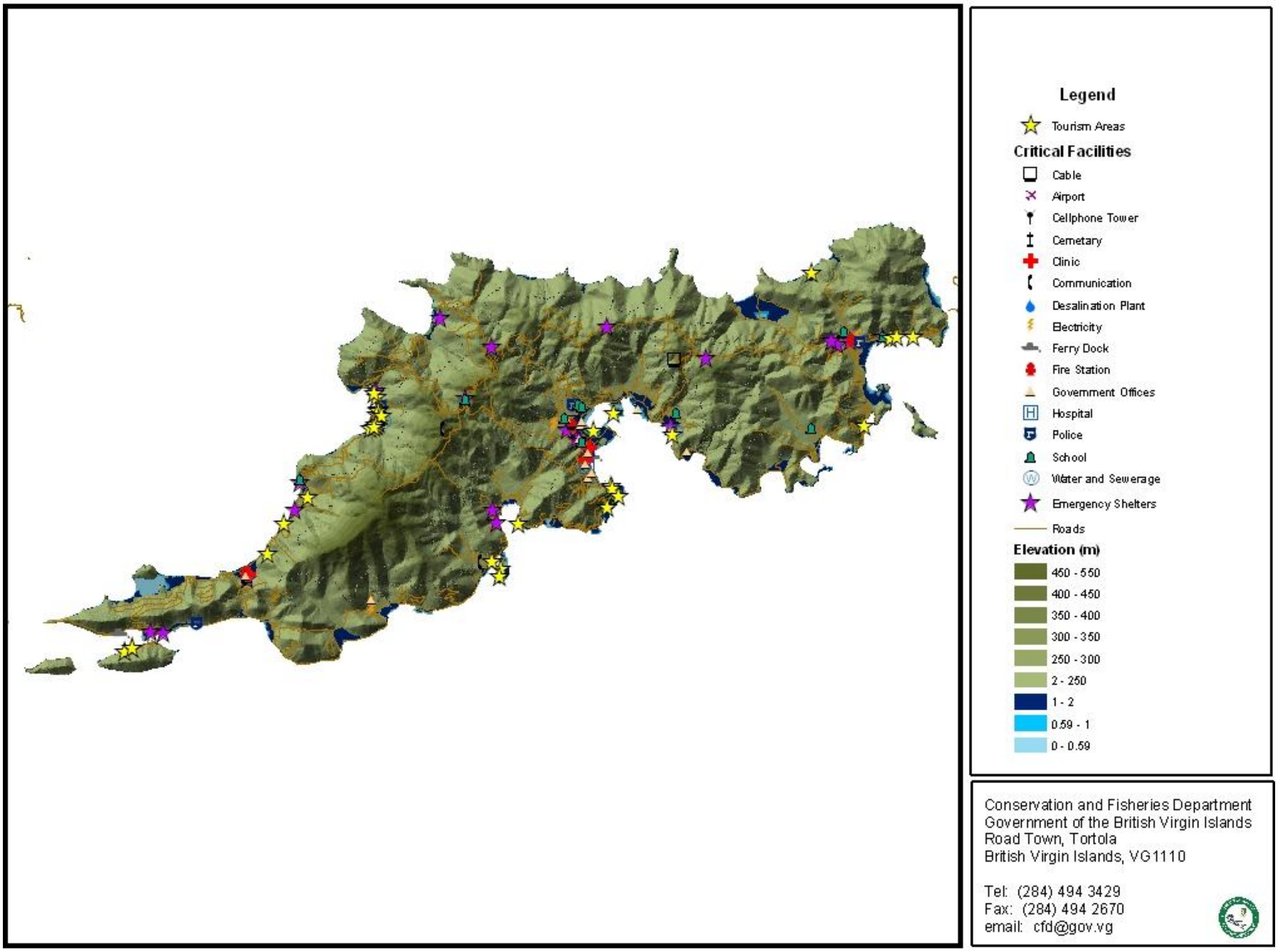


Figure 3.4-1 Land area, critical infrastructure and tourism properties on Tortola that would be inundated with a 0.59m, 1m and 2m sea level rise.

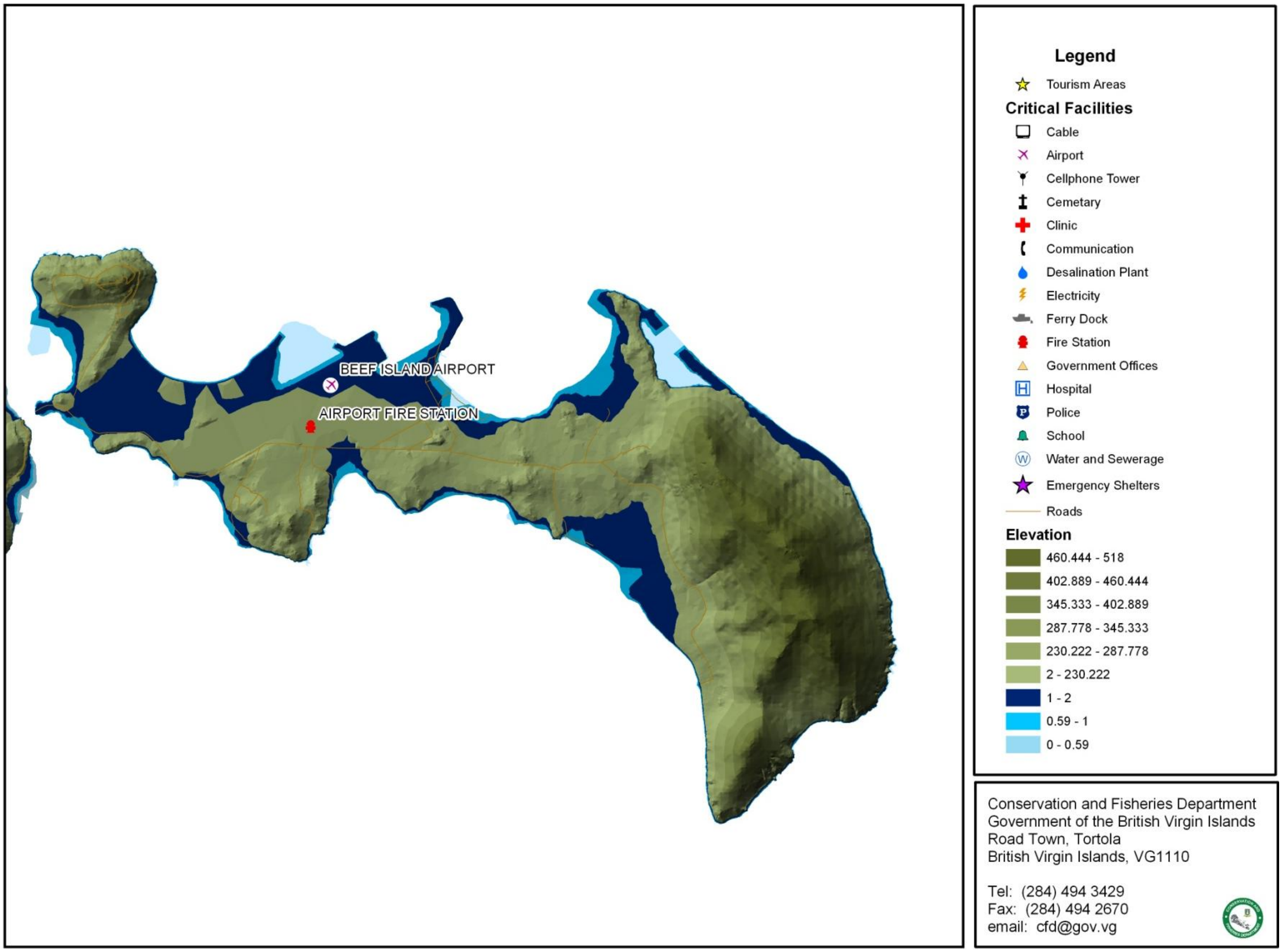


Figure 3.4-2 Land area, critical infrastructure and tourism properties on Beef Island that would be inundated with a 0.59m, 1m and 2m sea level rise.

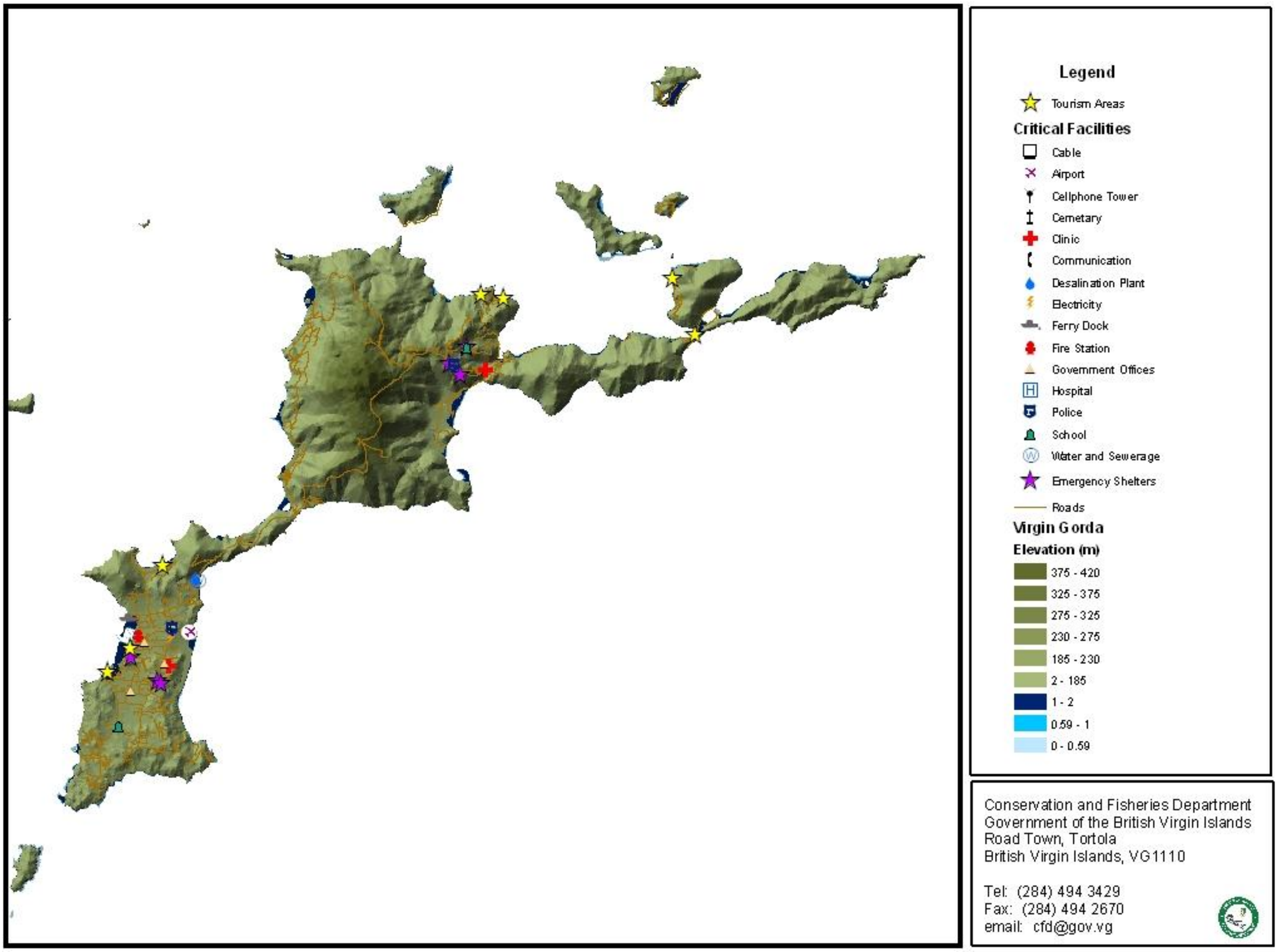


Figure 3.4-3 Land area, critical infrastructure and tourism properties on Virgin Gorda that would be inundated with a 0.59m, 1m and 2m sea level rise.

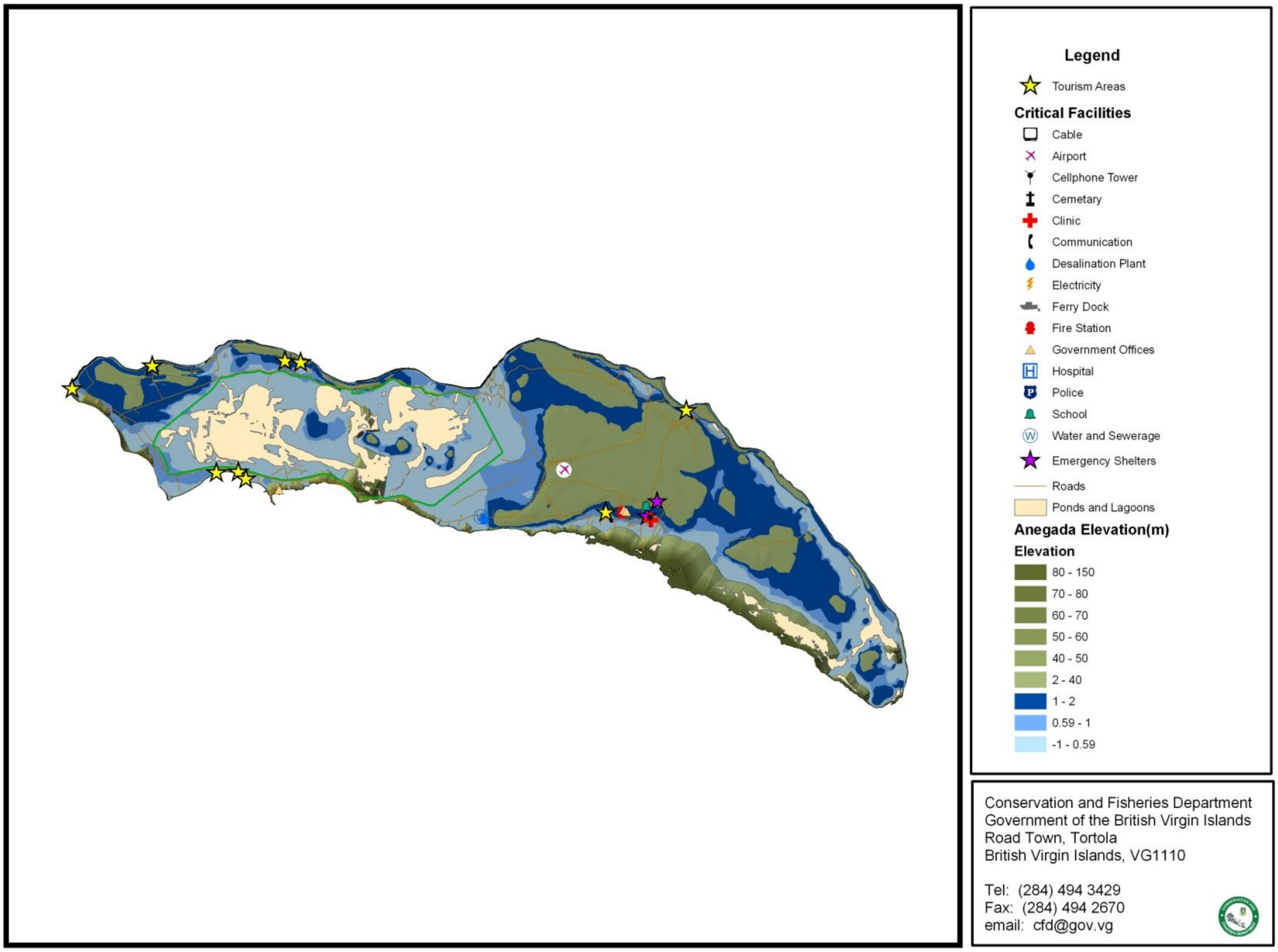


Figure 3.4-4 Land area, critical infrastructure and tourism properties on Anegada that would be inundated with a 0.59m, 1m and 2m sea level rise.

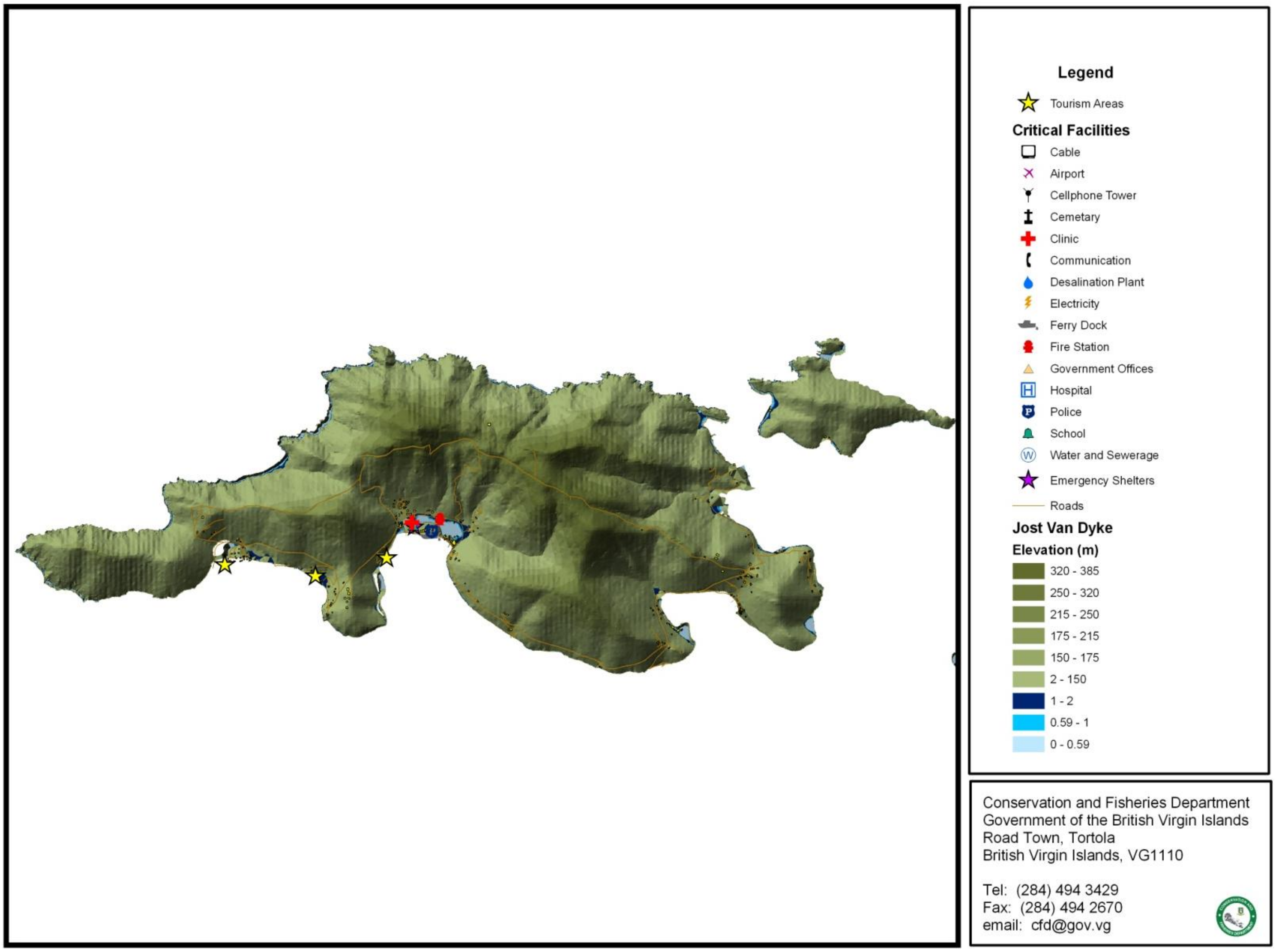


Figure 3.4-5 Land area, critical infrastructure and tourism properties on Jost Van Dyke that would be inundated with a 0.59m, 1m and 2m sea level rise.

Island	Land area that would be inundated with a 2m sea level rise		
	km²	*acres*	*% of total area*
Tortola	3.4	837	6.3%
Virgin Gorda	0.7	169	1.8%
Anegada	16.3	4, 024	77.6%
Jost Van Dyke	0.2	42	2.2%

Table 3.4-2. Land area on Tortola, Virgin Gorda, Anegada and Jost Van Dyke that would be inundated with a 0.59m, 1m and 2m sea level rise.

The degree of vulnerability to sea level rise and storm surge is primarily controlled by elevation and setback from the coastline as well as the existence of natural or man-made coastal defenses.

The tourism sector of The Virgin Islands is set to be heavily impacted by sea level rise. While a more detailed study would be needed to determine the economic costs of impacts, it can generally be observed that, as with the CARICOM countries considered in the regional report, most of The Virgin Islands' tourist accommodations and critical support infrastructure (hotels, marinas, ports of entry, roads etc.) are located in the low-lying coastal zone where they are extremely vulnerable to the combined effect of sea level rise and storm surge.

A list of some critical infrastructure and tourism properties on the four main islands vulnerable to the various sea level rise scenarios is presented in Table 3.4-3 below. Several tourism related beach-side restaurants on the four main islands and tourism properties on the smaller outer islands are also located within these zones, but are not listed here.

	Tourism Accommodation Properties and Marinas/Docks	**Critical Infrastructure**
TORTOLA	Sugar Mill Hotel	Cane Garden Bay Health Clinic
	Coconut Point Vacation Villas	Capoon's Bay Health Clinic
	Shans Bungalow	Road Town Fire and Rescue Station
	Jip's Place	Capoons Bay Fire and Rescue Station
	Rhymers Beach Hotel	Royal Virgin Islands Police Force Headquarters
	Elm's Beach Suites	Royal Virgin Islands Police Force Marine Base
	Myetts Enterprises	House of Assembly
	Indigo House	Government Central Administration Complex
	Bayside House	Government offices *(Conservation and Fisheries Department, Training Division, Government Information Services, Audit Department, Department of Information Technology, Department of Youth Affairs and Sports, Ministry of Finance -Procurement Office, Immigration and Labour Department, Civil Registry, Social Security Building, Water and Sewerage Department, Department of Disaster Management Warehouse)*
	Cane Garden Bay Cottages	Cane Garden Bay Cemetery
	Columbus Sunset Vacation	Cane Garden Bay Post Office

	Lambert Beach Resort	Isabella Morris Primary School
	Prospect Reef Hotel	Ivan Dawson Primary School
	Sebastian's on the Beach	Cane Garden Bay public restrooms
	Maria's by the Sea	Cane Garden Bay Sewerage Treatment Plant
	Nanny Cay Hotel	Capoon's Bay Water Desalination Plant
	Frenchman's Cay Marina	Ocean Conversion Desalination Plant
	Sophers Hole Wharf	BVI Ports Authority
	Penn's Landing/Round Rock	West End Ferry Dock
	Harbour View Marina	Road Town Ferry Dock
	Hodge's Creek Marina	ZBVI Radio Station
	The Moorings	ZROD Radio Station
	Village Cay Marina	
	TMM Charters	
	Conch Charters	
	Nanny Cay Marina	
	Peter Island Ferry Dock	
VIRGIN GORDA		
	Virgin Gorda Yatch Harbour	
	Leverick Bay Marina	
	North Sound Jetty	
	Bitter End Yacht Club	
	Fischer's Cove	
	Little Dix Bay Hotel	
	Biras Creek Resort	
ANEGADA		
	Anegada Beach Club	Health Clinic
	Anegada Reef Hotel	Fire and Rescue Station
	Cow Wreck Beach Resort	Government Administration Building
	Anegada Seaside Villas	Water and Sewerage Department
	Anegada Seaside Villas	Water Desalination Plant
	Neptune's Treasure	Electricity Corporation
	Whistling Pine	Cable and Wireless substation
	Ocean Range Hotel	Cellphone Tower
	Loblolly Beach Cottages	
JOST VAN DYKE		
	Great Harbour Jetty	Fire and Rescue Station
	Mahoney's Water Sports	
	Ivans Camp Ground	

Table 3.4-3 Critical tourism infrastructure, tourism accommodation properties and marinas vulnerable to a 0.59m, 1m or 2m rise in sea level. Several tourism centred beach side restaurants on the four main islands and several tourism properties on the smaller outer islands are also located within the zones that would be inundated by various sea level rise scenarios, but these are not listed here.

Furthermore, as the beach vulnerability assessment has found, popular tourist beaches in The Virgin Islands will experience loss of significant beach area under all sea level rise scenarios, averaging a loss of 24% in the minimum (0.18m rise) scenario and a loss of 94% in the most severe (2m rise) scenario.

The following discussion attempts to identify tourism centres and road networks vulnerable to sea level rise and stronger storm surges.

Tourism centres that may be particularly vulnerable to sea level rise and stronger storm surges include: Cane Garden Bay, Sopers Hole, Wickhams Cay I and II, and Trellis Bay on Tortola and Beef Island; North Sound, the vicinity of the Virgin Gorda Yacht Harbour, The Baths, and the many high-end waterside vacation villages on Virgin Gorda; White Bay and Great Harbour on Jost Van Dyke; all centres of tourism on Anegada such as Loblolly Beach, Keel Point, and Setting Point. Smaller outer islands with tourism stock located in vulnerable areas include Cooper Island, Peter Island, Marina Cay, Saba Rock, and Scrub Island.

The coastal road network, the primary mode of transport in the Territory, is highly vulnerable to sea level rise as large segments are low-lying and directly adjacent to or very near the sea. On Tortola these road segments particularly include those on the western section of the south coast from West End to the Waterfront in Road Town and the coastal villages on the northwest of the island from Long Bay to Brewer’s Bay. During hurricanes, significant damage is regularly sustained to the stretch of coastal road between Towers and Pockwood Pond from storm surge for instance, which is critical for connecting the western communities to the capital. This type of damage can be expected to become greater as a result of sea level rise. On Virgin Gorda, particularly vulnerable road segments can be found in the South Sound and pockets of The Valley. On Anegada, the road segment on the southern coast from Pomato Point to the Settlement is particularly exposed, and on Jost Van Dyke road segments of most concern are in the Great Harbour and White Bay areas.

RECOMMENDATIONS FOR ADAPTATION

Adaptation to sea level rise is primarily an issue of early and wise planning to avoid continued development in vulnerable areas, to relocate existing vulnerable developments where feasible, and finds means to protect developments where relocation or loss is not feasible or acceptable option.

The following key recommendations for adaptation to sea level rise taken directly from the regional study are endorsed by this report (Simpson et al., 2010):

Commence coastal protection and adaptation planning early. The development of coastal project systems has been shown to take 30 years or more. The detailed local level planning for coastal protection needs to begin within the next 15 years if the environmental assessments, financing, land acquisition, and construction is to be completed by mid-century, so that the economic benefits of damage prevention are optimized.

Integrate SLR into the design of all coastal structures. Environmental assessments and construction permits for coastal structures should be required to take into account the most current estimates of SLR from the scientific community.

Integrate SLR into insurance policies. Insurance policies that account for the long-term risks of SLR will enable landowners to properly assess coastal protection and retreat options. [Schemes] to insure coastal properties that suffer repeated losses or are at high risk of SLR inundation and erosion will encourage maladaptative decisions by property owners and a continued expense to national economies.

Review and develop policies and a legal framework to support coordinated retreat from high-risk coastal areas. Existing policy and legal frameworks should be reviewed to assess the responsibilities of the state and landowners for the decommissioning of coastal properties continually damaged by the impacts of SLR. Examine the utilisation of adaptive development permits that allow development based on current understanding of SLR, but stipulate the conditions for longer-term coastal retreat if sea level increases to a specified level. Re-assess current coastal set-back regulations in light of the SLR projections.

Incorporate SLR into local and regional land use development plans as well as tourism master plans. Undertake national-level consultations with government ministries responsible for land use planning, tourism planning and development agencies to utilise the broad scale results of this study and higher-resolution local scale studies to guide reviews and updates of official land use plans. Consider the development of official SLR risk maps to further guide future coastal development.

Communication, awareness and education activities for key target groups. Embark on a communication campaign to inform and raise awareness of SLR impacts and costs for policy makers, media, developers, architects, planners, private sector and communities.

Assess adaptation strategies to address the multitude of cross-sectoral impacts. An in-depth examination and costing of practical adaptation strategies is required to meet the challenges of SLR and erosion on economies and livelihoods. A sectoral approach is recommended to take account of the integral and interrelated nature of the wide-ranging impacts.

Complete a focused analysis of the vulnerability of tourism dependent small island economies and develop adaptation strategies. A critical finding of this analysis was that while the absolute size of economic losses is generally much greater in the larger CARICOM economies, the proportional impacts (losses compared to the size of the national economy) are generally higher in the smaller economies of St. Kitts and Nevis, Antigua and Barbuda, Barbados, St. Vincent and the Grenadines and Grenada. Tourism infrastructure is particularly vulnerable in these nations and with tourism contributing a greater proportion to the national economies of these nations, the capacity of the economies in these countries to absorb and recover from proportionately higher economic losses is expected to be lower. Determining the secondary and tertiary economic impacts of damages to the tourism sector and possible adaptation strategies for the tourism sector should be a priority for future research.

3.5 | Coral Reef Vulnerability Assessment

PURPOSE

Scientists and laymen alike have in many ways described coral reefs as one of the biological wonders of the world. Two authors on marine ecology remarked: "Coral reefs are a naturalist's paradise. Diving amount them is like entering another world (Barnes and Hughes 1999)."

Coral reefs play an important role in The Virgin Islands tourism industry, both in terms of attracting visitors to the island and in terms of revenue generated by scuba dive and snorkel tour operators. In The Virgin Islands Tourist Perception Survey discussed earlier (see section 2.1) 73% of tourists reported that healthy coral reefs have a "significant influence" on their decision to visit The Virgin Islands. In 2005 scuba diving and snorkeling operations had a combined revenue of about $5 million.

Despite their high biological and economic value, coral reefs have traditionally been faced with a number of anthropogenic threats in The Virgin Islands that have forced them into a precarious status. These include over fishing and destructive fishing practices, trampling, anchor damage, siltation, and nutrient pollution from sewage outfalls and disposal of yachting waste. In addition to these long standing threats, today, coral bleaching ranks as one of the major threats impacting coral reef ecosystems on a global scale (Rosenberg and Loya, 2004; Kleypas et al., 2006). Some articles have warned that coral bleaching could eliminate most coral reefs by 2100 (Pockely, 1999).

Coral bleaching is a phenomenon that works on the micro level of the coral polyp-zooxanthellae relationship, but with macro effects for coral reef ecosystems. Coral bleaching is defined as the loss of the symbiotic zooxanthellae from coral polyp tissues (Jokiel, 2004). Polyp tissue is transparent and corals actually derive their colour from the photosynthetic pigments of their zooxanthellae (Sorokin, 1993). When zooxanthellae bail out occurs the stark white calcium carbonate skeleton beneath the polyps is exposed creating a 'bleached' appearance (Jokiel, 2004).

While coral bleaching does not necessarily immediately result in death of coral polyps and colonies, death is likely to occur if water temperatures do not return to normal and zooxanthellae are not replaced quickly (Jokiel, 2004). This is because on average coral polyps obtain 70% of their energy and nutrient needs from the photosynthate products of their endosymbiotic zooxanthellae (Sorokin, 1993). Death of coral leads to the reef being overgrown by algae making it even harder for the reef to recover and reduces diversity at all levels of the reef, including fish species. Coral bleaching occurs when the sea surface temperature exceeds the narrow range in which most coral species can survive (26-29°C) (Aronson et al., 2000). The severity of bleaching depends on the extent to which this temperature was exceeded and for how long.

The incidence and geographical extent of coral bleaching events has increased significantly over the past 30 years (Jokiel, 2004; Ward and Lafferty, 2004). This trend is expected to continue as climate change causes the average sea surface temperature to rise.

The purpose of this study is to understand the scale of impact that future mass coral bleaching events will have on Virgin Islands reefs and consequently the dive and snorkel tourism sectors, both in terms of tourists' willingness to engage in these activities and how much they are willing to pay to do so, by using the impact of the 2005 Caribbean mass bleaching event as a proxy. Original research was not conducted for this part of the VCA, rather we depend on the PhD thesis of Stephanie Patricia Hime, submitted to the University of East Anglia, UK, part of which investigated this very question; all methods and findings reported are credited to (Hime, 2008).

METHOD

Hime used a very comprehensive and detailed methodology, the basic steps of which are outlined below.

The 2005 Caribbean bleaching event

The Virgin Islands experienced the 2005 Caribbean bleaching event from roughly August 2005 to November 2005. The National Oceanographic and Atmospheric Administration (NOAA) defines the bleaching threshold as 4 degree heating weeks (DHW) which was exceeded in the 2005 event for a total of 10 weeks (Hime, 2008).

Coral cover assessment

Hard coral cover at 13 reefs used as dive and/or snorkeling sites was estimated using photoquadrats along the typical diver's/snorkeler's path before (February and June 2005) and after (March and May 2006) the 2005 bleaching event. The reefs assessed and their locations are listed in Table 3.5-1.

Study Reefs	Location
Angel Fish	near Norman Island
Indians	near Norman Island
Rainbow Canyons	near Norman Island
Kelly's Cove	near Norman Island
Coral Gardens	near Peter Island
DCW	near Peter Island
Painted Walls	near Salt Island
Chromis Reef	near Cooper Island
Thumb Rock	near Cooper Island
Cistern Point	near Cooper Island
Devil's Kitchen	near Cooper Island
Alice in Wonderland	near Ginger Island
Alice's Backstep	near Ginger Island

Table 3.5-1. Location of study reefs used to determine impact of the 2005 mass bleaching event.

Assessing the economic impacts of coral decline

Two choice experiments were administered to scuba divers and snorkelers visiting the Territory in 2006. The surveys were designed to estimate scuba diver and snorkeler willingness to pay (WTP) for marginal changes in coral cover and included 12 scenarios in which coral cover and diversity, fish abundance and diversity, group size and excursion price varied. WTP for coral cover (15.4%) observed before the bleaching event and coral cover (9.6%) observed after the bleaching event was determined using various econometric formulas.

Based on records from the majority (9) of scuba dive operators and 4 snorkeling operators the frequency of diving and snorkeling excursions in The Virgin Islands was determined.

Predicting the change in probability of individuals choosing not to purchase an excursion

Data from the choice experiments were analyzed using LIMDEP 8.0 Econometric Software to determine the "change in the probability of respondents not choosing to dive/snorkel" based on the calculated change in coral cover following the bleaching event (i.e. in 2006 versus 2005). This was expressed as a change in the number of excursions purchased (taking into consideration the number of excursions actually available for purchase).

Calculating the overall annual revenue loss from decreasing coral cover

The estimated total revenue loss as a result of coral cover change was calculated by multiplying the change in the number of excursions types purchased by its current (2005) mean price. This was then added to the loss in WTP determined for that change in coral cover. All figures reported are 2005 values.

RESULTS

Between January, 1 2005 and January 1, 2006 there were approximately 29,500 two-tank dive excursions and 43,600 snorkel tours conducted by dive and snorkel operators in The Virgin Islands. This resulted in a total revenue of just under $5,100,000 (2005 currency values).

The 2005 bleaching event had a significant impact on coral cover and consequently revenue of dive and snorkel operators. The 13 dive/snorkel study sites experienced an average decline in hard coral cover from 15.4% to 9.6% due to the bleaching event.

As a result of the calculated coral cover loss, the maximum amount scuba divers and snorkelers were willing to pay (WTP) for a typical two-tank dive excursion or typical snorkeling trip decreased by $14.30 and $12.60 from $184 and $169 respectively.

In addition, coral cover loss affected person's willingness to purchase an excursion at all. It was estimated that the proportion of scuba divers choosing not to purchase an excursion at the average 2005 price of $100 increased by 2.1% (from 11.7% to 13.8%) after the bleaching event. The same percentage increase (from 10.1% to 12.2%) was estimated for snorkelers.

Taken together the decrease in willingness to pay (WTP) and the estimated decrease in purchases of excursions resulted in a total estimated decrease in value of $1,270,000 ($1,050,000 from scuba divers and $220,000 from snorkelers) which is equivalent to 24.9% of the scuba and snorkeling sector's 2005 revenues.

DISCUSSION

The results confirm that scuba divers and snorkelers place a high value on the quality of reefs and changes in quality do affect how much persons are willing to pay for an excursion and if they are willing to take the excursion at all.

The 2005 mass coral bleaching event can be taken as a good proxy of the impact of future mass bleaching events. Based on this it can be projected that future mass bleaching events will have a significant impact on coral cover and consequently a major economic impact on the scuba diving and snorkeling tourism sector. The 2005 event resulted in a total estimated decrease in value of almost 25% ($1,270,000) of 2005 sector revenues. Ideally further research would be conducted to determine the actual loss of revenues in 2006.

While the loss is a relatively small percentage of overall tourism GDP, it represents a significant blow to that particular sector (scuba diving and snorkeling tourism) which in addition to its present contribution to GDP is an important source of employment and provides an important portion of tour excursions available to cruise ship passengers in particular.

It should be noted also that there are potential sources of economic loss not estimated in Hime's study such as additional operating costs to travel to reefs not as severely affected by bleaching events that may be further offshore.

Also, the overall economic impact of bleaching events extends further than the immediate and direct impact to the scuba diving and snorkeling tourism sector. Globally, there is an increasing demand for marine based activities (such as diving and snorkeling); between 2000 and 2005, for example, there was a 45% increase in PADI scuba diver certifications (PADI, 2007). The economic impact of coral bleaching, therefore, may also be reflected in slower business growth rates (number of excursions per year) than may be expected given the increasing number of divers and snorkelers. Additionally, the economic loss would extend further than the formal dive and snorkel tourism sector as many tourists enjoy these activities informally as a part of their land-based or yachting vacation and, as the data from the Tourist Perception Survey indicates, degradation of coral reefs would have a significant influence on 59% of tourists in general (not just divers or snorkelers) decision to make future visits to the islands.

The predicted increase in frequency and severity of bleaching events, especially given the low recovery rate of reefs, and the high economic impact of bleaching events makes the need for improved reef management to increase reef resilience by reducing other controllable impacts even more urgent.

3.6 | Risk Assessment

PURPOSE

Given the Territory's limited financial and technical resources it will be impossible to address all climate change impacts at once, if at all. Therefore, for the practical purposes of allocating resources and action timeframes, a stakeholder-based risk assessment was conducted to prioritize climate change impacts to The Virgin Islands.

METHOD

Prioritisation was based on stakeholder input (representatives from the tourism, agriculture, fisheries, renewable energy and development sectors, relevant Government departments to represent all impact areas, and NGOs) during the Territory's Second Climate Change Stakeholder Consultation held October 2009.

During the Consultation, a matrix was used to determine priority climate change impacts across all impact areas by rating the *national significance*, *certainty*, *severity*, and *urgency* of each. In all cases, 1 represented the highest importance rating and 5 the lowest rating.

The *national significance* of impacts was broken down into 4 dimensions: social, environmental, economic, and cultural. Climate change impacts that affected all four dimensions were given the highest priority rating of 1 for that indicator, while impacts that affected none of the dimensions was given the lowest priority rating of 5 and so forth, as shown in the key to the matrix in the results section.

The total score across all indicators of priority was calculated for each impact. Those impacts with the highest priority rating (that is, the lowest total score) were identified and grouped into three tiers/clusters of priority for action, with tier 1 impacts having the absolute highest priority rating and so forth (see results matrix).

RESULTS

Climate Change Impact Area	Specific Climate Change Impact	National Significance [a]	Certainty [b]	Severity of threat/impact [c]	Urgency [d]
1st Tier Priority Impacts (total score of 4 across all priority indicators) ★★★					
Natural Resources *(Coastal & Marine Resources / Forestry & Biodiversity)*	Coral reefs experiencing increased bleaching, structural damage, disease and death	1	1	1	1
	Biodiversity threatened by habitat loss, invasive species, and hurricanes	1	1	1	1
Tourism	Diminished natural tourist attractions, e.g. coral reefs, beaches and wildlife	1	1	1	1
Water Resources and Hydrological Characteristics	Changes in water quality and quantity	1	1	1	1

2nd Tier Priority Impacts (total score of 5 across all priority indicators) ☆ ☆					
Tourism	Loss of or more costly damage to tourism infrastructure and properties from floods, stronger hurricanes and storm surges, and sea level rise	1	1	1	2
Food Security: Fisheries	Degradation of critical fish habitat, such as coral reefs, mangroves, and seagrass beds	1	1	1	2
3rd Tier Priority Impacts (total score of 6 across all priority indicators) ☆					
Tourism	Rising overheads in energy, water, and insurance	3	1	1	1
Food Security: Fisheries	Migration of some fish species to cooler waters	1	2	2	1

Beach and Shoreline Stability	Increased beach and shoreline erosion from sea level rise, and stronger hurricanes and storm surges	1	1	2	2
Water Resources and Hydrological Characteristics	Decreased rainwater (as the region becomes up to 25% drier and rainfall patterns change) leading to greater dependency on the desalinated public water supply and an increased threat of water shortages in emergencies.	1	1	3	1

Other Impacts (total score of 7 or more across all priority indicators)					
Natural Resources (Coastal & Marine Resources / Forestry & Biodiversity)	Decreased growth of seagrass beds and increased stress and mortality.	1	2	2	3
	Shrinking upland forests and reduction of associated biodiversity (as a result of warmer temperatures, drought, and stronger hurricanes)	1	3	3	4

	Increased invasive species which tend to out-compete or prey on native species	3	1	2	3
	Degradation of turtle nesting habitat (sandy beaches) and creation of unbalanced sex ratios	2	1	3	2
Critical Infrastructure and Human Settlements	Homes, critical facilities, roads, and developable lands (both inland and in low-lying coastal areas) at great risk of damage from flooding from heavy rain events and sea level rise	1	2	2	3
	Increased landslide damages to roads, retaining walls and buildings, and interruption of electricity and communication services	2	2	2	2
	Increased damage to homes, critical facilities, roads and electricity and communication systems due to stronger hurricanes and storm surges	1	3	3	3

Energy Security	Increased demand for electricity and gasoline as warmer temperatures trigger increased demand for cooling of buildings and cars	2	1	2	2
	Electricity system at great risk of damage from floods, stronger hurricanes and storm surges, and seal level rise	2	2	3	2
	Switch to smarter energy production and consumption patterns as international pressures to "green" mount, and the cost of importing fossil fuels increases	2	3	4	4
Food Security: Agriculture	Crop damage and disruption in agricultural production from stronger hurricanes, droughts and floods	1	3	2	2

	Increase in agricultural pests, weeds, diseases and invasive species due to increased concentrations of carbon dioxide (CO_2), warmer soils and changes in humidity.	1	3	3	4
	Soil degradation from saltwater intrusion and soil erosion / leaching, resulting in decreased yields.	2	3	3	2
	Increased stress to livestock from heat, drought, and disease	3	2	4	3
	Changes in imported food availability, cost and quality	2	2	2	2
Food Security: Fisheries	Changes in plankton, a crucial source of food for fish	1	3	2	3
	Potential changes in spawning opportunities and rates of mortality and disease	1	2	2	2

	Increased damage to landing sites, on-shore facilities, boats and equipment from stronger hurricanes and storm surges and sea level rise.	1	3	3	3
Human Health	Increase in Dengue Fever outbreaks (frequency and severity) due to warmer temperatures, changes in humidity, and more, heavier rain events	3	2	3	1
	Increase in respiratory diseases, such as asthma, due to increased plant pollen, mold, flooding, and thicker Sahara Desert dust clouds	2	2	3	1
	Increase in risk of diarrhea and other water, food and rodent borne illnesses	2	3	3	2
	Increase in potential for heat stress as temperatures potentially rise by up to 10.4°F by 2100	2	3	3	5

	Increase in prevalence of ciguatera (fish poisoning) as warmer waters and degraded reefs support the ciguatoxin	1	3	2	4
	Greater threat of epidemics and pandemics as warmer temperatures and changing rainfall patterns trigger the spread of pathogens into new regions	3	2	2	4
Insurance & Banking	Increased insurance rates, potentially leading to uninsurance or underinsurance as damages from natural disasters increase and sea level rise occurs	3	1	2	2
	Increased strain on banking system. Increased interest rates and difficulty in obtaining construction loans due to increased risk	2	1	2	2

Tourism	Sport fisheries and fresh produce at risk from warmer waters, stronger hurricanes, and changes in rainfall patterns	2	2	3	3
	Changes to our alluring climate - hotter, less predictable, more frequent heavier rain events	2	1	2	4
	Decreased demand for winter getaways as winters in tourism source markets become warmer	2	3	1	3
	Potentially reduced demand for long distance flights as international pressures to reduce carbon emissions increase	2	4	1	3
Water Resources and Hydrological Characteristics	Groundwater resources shrinking as rainfall decreases and saltwater intrudes with sea level rise	3	1	4	2

	Increased cost of desalinated water as the price of fossil fuels rises in response to climate change and depleting resources	3	1	2	1

Table 3.6-1. Prioritization of climate change impacts as determined at the Second Public Stakeholder Climate Change Consultation held October 2009 under the Enhancing Capacity for Adaptation to Climate Change in the UK Caribbean Overseas Territories (ECACC) Project.

[a] **National Significance** (Dimensions = Social, Environmental, Economic, Cultural)
1= Four dimensions 2=Three dimensions 3=Two dimensions 4=One dimension
5= None

[b] **Certainty**
1 = Absolutely 2 = Very Likely 3 = Likely 4 = Less Likely
5 = Unlikely

[c] **Severity of threat/impact**
1 **=** Extreme 2 = Very High 3 = High 4= Low
5**=**Very Low

[d] **Urgency**
1 = Happening regularly 2 = Happening now (once per season)
3 = Happening <5yrs (immediate threat) 4 = Happening 5-10yrs (short-term threat)
5 = Happening 10-50yrs (long-term threat)

DISCUSSION

The specific climate change impacts that were identified as priorities as a result of the rating exercise fell under the following impact areas:

Beach & Shoreline Stability	–	One 3rd tier priority impact identified
Coastal & Marine Resources	–	One 1st tier priority impact identified
Food Security: Fisheries	–	One 2nd tier and one 3rd tier priority impact identified
Forestry & Biodiversity	–	One 1st tier priority impact identified
Tourism	–	One 1st tier, one 2nd tier and one 3rd tier priority impact identified
Water Resources & Hydrological Characteristics	–	One 1st tier and one 3rd tier priority impact identified

Four of these six priority impact areas (Beach & Shoreline Stability, Coastal & Marine Resources, Forestry & Biodiversity and Fisheries) fall directly under the banner of the environment/natural resources, indicating the serious risks associated with the predicted magnitude of environmental degradation resulting from climate change. Coral reef degradation and biodiversity loss stand out as the most important environmental threats from climate change.

Tourism, as one the Territory's two main economic pillars and as a highly sensitive industry, persistently appears as a priority impact area with degradation of natural attractions perceived as the greatest threat. This perception is well founded as a report commissioned by The World Bank titled "Assessment of the Economic Impact of Climate Change in CARICOM Countries," found that reduced tourism demand could account for 15% - 20% of rough estimates of total losses across all sectors in the region by 2050 – 2080 (1999 US$1.4 - $9.0 billion) under low impact and high impact climate change scenarios respectively (Margaree Consultants, 2002).

Local data from the Tourist Perception Survey supports high priority being placed on this issue. For example, climate change impacts identified would have a significant influence on 30% to 60% of tourists' decision to make future visits to the Islands (see Section 2.1).

The other priority impact area identified was Water Resources & Hydrological Characteristics. Changes in the quantity and quality of rainfall were the main concern in this respect. The Climate Assessment (see section 3.1) projects 53 of the remaining 88 years in this Century (60%) having net decreases in annual rainfall averaging 8.6%, with a maximum decrease of 31.8% (Table 3.1-7). Over the course of the Century, each 20 year period is projected to have an increasing number of years that are drier than the baseline (i.e. experiencing net decreases in rainfall) (see Figure 3.1-11). On the flip side, 36 years (40%) are projected to have a net increase in annual rainfall averaging 6.6%, with a maximum increase of 25.4% (Table 3.1-7).

These changes may increase the likelihood of drought and flood events. The Territory is traditionally dry and, despite the wide use of desalinated water, is still heavily reliant on cisterns for rainfall capture, storage and use. On the flip side, since 2003 the Territory has experienced frequent severe flood events, including the worst flood in living memory in 2010. The economic impact of such events is significant; for example, the November 2003 flood cost the Territory US$19,147,898).

Impact areas not represented in the "priority" impact group include, Critical Infrastructure & Human Settlements, Energy Security, Agriculture, Human Health and Insurance & Banking.

In interpreting the results of the Risk Assessment it should be noted that the stakeholders representing environmental interests/impact areas were the best represented at the Consultation and that some other sectors were under-represented. This uneven representation of stakeholders at the Consultation may have skewed the results of the Risk Assessment. Despite this, the results of the Risk Assessment reflect the general consensus in the literature of the most critical sectors that would be impacted by climate change.

To support the results of the Risk Assessment and to fairly represent the importance of climate change impacts across all impact areas, for policy making purposes it is recommend that a second level sector by sector risk assessment by conducted. This assessment would consider each impact area in its own right and prioritize the various specific climate change impacts within each.

4.0 | Capacity Assessment

4.1 | Institutional Framework

Climate change adaptation will require an ongoing collaborative effort between Government, the private sector, and communities. There are at least seventeen (17) Government Departments, Statutory Bodies, or associated Agencies amongst all five Ministries and the Governor's Office that will be integral in the Territory's adaptation to climate change.

In addition, there are several Territory-level inter-agency committees and bodies whose portfolios allow them to have a direct influence on policies and decisions relevant to climate change adaptation. These are the Inter-agency Planning Review Committee (Pre-Planning Authority), Planning Authority, Building Authority, Technical Review Committee, Health Services Authority, and Disaster Management Council. Under the ECACC Project, Cabinet approved the formation of a National Climate Change Committee. This Committee will draw on membership from the existing committees mentioned and will be key in guiding the Territory's long-term adaptation to climate change.

The Town and Country Planning Department (TCPD), the Inter-agency Planning Review Committee (Pre-Planning Authority), Planning Authority (formally the Development Control Authority), and the Building Authority oversee land development in the Territory. In development matters concerning the seabed, the Technical Review Committee under the Ministry of Natural Resources and Labour is also involved. The Committee makes recommendations to the Minister regarding the granting of seabed licenses that are requisite for any development on or over the seabed.

The Planning Authority is comprised of civil servants from diverse agencies, including the TCPD, Conservation and Fisheries Department, Department of Disaster Management, the Tourist Board, Survey Department, Public Works Department, Royal Virgin Islands Police Force, and Fire and Rescue Services, as well as stakeholders from the private sector. The Planning Authority meets on average once per month as member schedules allow. In any one sitting, the Authority may review and decide upon up to fifty (50) development applications.

Constraints facing these important players tend to be similar:

- Insufficient funding and equipment to carry out tasks (especially in the environment which historically has been least funded);
- Insufficient highly trained technical officers to handle the volume of work or the level of analysis (as a result, a small circle of senior officers tends to be overcommitted and certain important processes, such as the development review process, are not as thorough and well managed as they could be);
- Limited law enforcement powers and personnel;
- Data collection and management issues;
- Poor communication, information flow, and collaboration between Departments

Environmental management, in particular, suffers from a fragmented institutional framework where functions are spread across several Departments and Statutory Bodies under multiple Ministries, including primarily the Conservation and Fisheries Department, the BVI National Parks Trust, Solid Waste Department, Water and Sewerage Department, Environmental Health Department, and the Town and Country Planning Department.

The future vision as expressed in the National Environmental Action Plan (NEAP) (2004) and outlined in the draft comprehensive Environmental Management and Conservation of Biodiversity Bill is for a "restructured and strengthened environmental management agency" to coordinate and manage all issues and matters related to the environment and natural resources (Law Reform Commission, 2008). According to the draft Bill, such an Agency would be formed by the joining of the Conservation and Fisheries Department and the BVI National Parks Trust, the two main agencies that deal with environmental management, to form a statutory Environmental Management Trust (Law Reform Commission, 2008).

4.2 | LEGAL FRAMEWORK

There is a lot to be desired in the legislative framework, especially that governing the environment and physical development.

The existing environmental legislative framework is diffuse. While there are several pieces of legislation on the statute books, weak penalties and enforcement are major constraints that inhibit their effectiveness (DPU, 1999). Noticeable gaps are in the areas of coastal resources protection and waste management.

The Law Reform Commission has identified environmental law as one of the priority areas for reform. The Commission notes that most of the environmental laws need minor amendments to improve their enforcement provisions, or may require appropriate subsidiary laws to make them more effective (Law Reform Commission, 2008). In their 2008 review of existing environmental laws, the Commission agreed that what is direly needed in the Territory is a comprehensive environmental management law.

Towards this end, the Commission drafted the Environmental Management and Conservation of Biodiversity Bill, 2008 still up for review by Cabinet. The Bill addresses environmental management (environmental impact assessments, natural resources and species protection, trade in species, hazardous substances, air and noise pollution, water pollution, wastes), the coastal zone (beach and coral reef protection), protected areas, and multilateral environmental agreements.

The existing environmental laws are summarised in Appendix 5. In addition to local environmental laws, the Territory is signatory to a number of regional and international treaties and agreements such as the St. Georges Declaration, the Cartagena Convention, the Specially Projected Areas and Wildlife (SPAW) Protocol, the Pollution from Land-Based Sources and Activities (LBS) Protocol, the Convention on Biological Diversity (CBD), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Bonn Convention, the World Heritage Convention, and the Ramsar Convention on Wetlands (DPU, 1999).

The passage of the 2004 Physical Planning Act represented a significant improvement in the laws governing the physical development process, especially as it relates to the environmental impact assessment (EIA) process.

The Physical Planning Act, 2004 together with the Development Control Guidelines, 1972, the Building Ordinance, 1955 and the Building Regulations, 1999 regulate the entire development process. The Physical Planning Act makes provision for "the orderly and progressive development of land in both urban and rural areas and for the protection of the environment and improvement of the amenities therefore."

Schedule 3 of the Physical Planning Act specifies types of development that require an EIA including the following: a) hotels of more than twelve rooms, b) any industrial plant which in the opinion of the Authority is likely to cause significant adverse environmental impact, c) quarrying and other mining activities, d) marinas, e) airports, ports and harbours, f) dams and reservoirs, g) hydro-electric projects and power plants, h) desalination plants, i) water purification plants, j) sanitary land fill operations, solid waste disposal sites, toxic waste disposal sites and other similar sites, k) gas pipeline installations, l) any development projects generating or potentially generating emissions, aqueous effluent, solid waste, noise vibration or radioactive discharges, m) any development involving the storage and use of hazardous materials, n) coastal zone developments, and o) development in wetlands, marine parks, national parks, conservation areas, environmental protection areas or other sensitive environmental areas.

The Development Control Guidelines of 1972 are still in use and need to be updated to reflect the new legislation; this is currently underway. The Buildings Ordinance, 1955 and Building Regulations, 1999 are also outdated and in need of an overhaul. In this regard, work is being done towards having the Territory adopt the International Building Code and produce a local supplement to address climate specific hazards, energy efficiency, water efficiency, indoor air quality and "green" building standards.

Systems of enforcement for both planning and building legislation are in need of improvement.

In regards to planning legislation, for example, enforcement officers of the Town and Country Planning Department have powers to issue Stop Orders and Compliance Notices to address construction in violation of the law or the conditions of planning approval. If, however, developers do not comply with these measures, enforcement officers have to wait on an often long and convoluted court process to unfold before any tangible action is taken against the developer, in which time irreversible damage may be done.

4.3 | Management Framework

Existing management plans, policies, and processes in the areas of the environment, physical planning, and disaster management are summarised below, followed by an identification of key management gaps in these areas.

There has never been a formally approved national integrated development plan or comprehensive physical development plan for the Territory, although several drafts have been made. As a result of this gap, rapid development over the last twenty plus years does not fully reflect an integrated approach where developmental, environmental and disaster reduction needs are appropriately balanced. In addition, coastal development in The Virgin Islands has been significantly influenced by large tourism developments by foreign investors (DPU, 1999).

The National Integrated Development Strategy (NIDS) was developed as a framework to promote the sustainable development of the Territory for the period 1999–2003.

Though never formally adopted, the NIDS represents the first formal attempt at national planning. Its major purpose is to establish the broad strategies, policies, and the implementation framework to promote integrated development.

One of the eleven development objectives of the strategy is to ensure environmental sustainability. This is to be achieved through a broad policy thrust to enhance the overall development potential by human resource development, improved management of the environment, physical space improvement, and sound economic management (Orion Consultancy Services Ltd, 2004).

Under the physical development control process, before any development (whether private or commercial) can begin, the developer must seek approval.

Applications are screened by the TCPD and the Pre- Planning Authority and forwarded to the Planning Authority for a final decision. In the case of tourism developments valued over $10 million the Premier has the final decision making power.

An overview of the development control process is provided in Figure 4.3-1. Part of the screening process by the TCPD is to determine if the proposed development would require an environmental impact assessment (EIA) under the Physical Planning Act, 2004. Applications requiring an EIA go through a more detailed approval process.

There is some concern that more contextual information should be provided about each development proposal in a user-friendly format in order to improve the decision making process. There is further concern that the current review process looks at each application in isolation and does not consider the overall impact that developments in a given area make.

The physical development review process, therefore, needs improvement through a more holistic approach to decision making guided by a comprehensive physical development plan with zoning. In the case of large-scale tourism developments, there is still a concerning level of confusion and interference in the development review and approval process by the practice of signing “development agreements” between the Government and the developer, granting approval in principle for the project, before the relevant planning approvals have been granted.

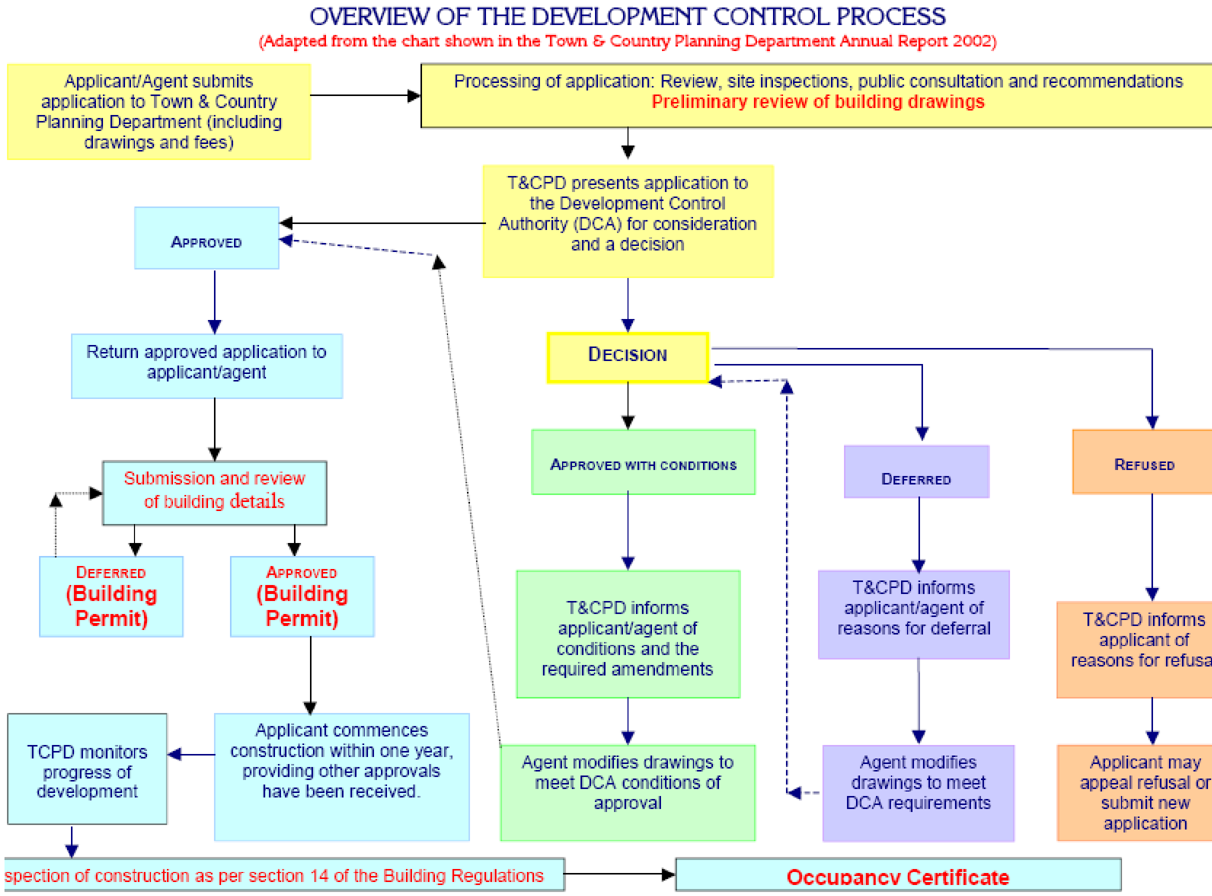


Figure 4.3-1. Overview of the development control process. *(Source: Tony Gibbs Consulting Engineers Partnership & Wason, 2004)*

Generally, the environment is not managed as effectively as possible. While a number of initiatives are underway to address environmental concerns, they are generally underfunded and uncoordinated, and are being implemented without adequate institutional capacity and human resource capability (DPU, 1999).

NEAP (2004), again never formally adopted by Government, further set out the framework within which The Virgin Islands' environment can be managed in a responsible and sustainable manner. The objectives of NEAP were as follows:

- Identify, prioritise and quantify (where possible) environmental problems;
- Provide a state-of-knowledge overview of the environmental conditions in the Territory;
- Propose solutions to immediate environmental problems in the form of programmes and projects, studies, issues and actions, strategies and activities, institutional and

legislative reform, funding requirements and human resources capacity building needs;

- Establish a clear indication of Government's priorities with respect to the environment so as to guide and give proper orientation to donor intervention in this field;
- Establish a framework for environmental information management and dissemination;
- Provide a framework for continuous development and environmental policy dialogue within the Territory and with donor partners;
- Establish a framework which provides coherent directions for the process of environmental management, monitoring, action planning in the future; and
- Identify human resources needs for the effective review and efficient implementation and management of the NEAP.

The Protected Areas System Plan (approved by Cabinet January 2008) sets out all of the areas which are to be managed for sustainability and provides the policy framework for the management of protected areas in The Virgin Islands. It provides:

- the goals for the system of protected areas;
- the institutional arrangements to be established for protected area management;
- the support systems needed for system development and management during the Plan Period;
- priorities in protected area management for the next ten (10) years; and
- a process for evaluating progress in protected areas system development over the next five (5) years.

Although approved in 2008, the newly included protected areas under the Plan have not as yet been declared as protected areas.

The Territory has a strong disaster management programme singled out as possessing "the most comprehensive programme of all UK Caribbean Overseas Territories" (CDERA, 2003).

The National Disaster Management Plan (NDMP) was originally approved by the Executive Council (now called Cabinet) in 1997 and details the framework and responsibilities of disaster recovery operations in the event of a disaster.

The NDMP was updated in 2008 and approved in 2009. It has been redesigned to include support functions, hazard indexes, and a new National Disaster Organisation structure. National Emergency Operating Centre standard operating procedures were also updated in keeping with the Incident Command System structure.

The Mitigation and Development Planning Framework developed in 2002 is meant to provide the framework within which Government agencies, the private sector and communities can work together to reduce the impact of natural hazards and unnecessary damage during a disaster event.

This Plan is a first in a series for integrating hazard mitigation activities into the development process. It provides the conceptual framework for the reduction of losses from disasters. The major thrust of this Plan is to bring together the public sector agencies to ensure that:

- they work together as a cohesive group;
- public sector related mitigation activities are coordinated; and
- public sector agencies have a well developed approach to mitigation so that community actions and activities can be supported.

The second phase of the Plan development will be the preparation of community hazard mitigation plans.

There is a need to revise the 2002 edition of the Mitigation and Development Planning Framework in keeping with the Physical Planning Act, 2004. This will ensure better definition of mitigation goals, objectives, strategies and programmes for the next 5-10 years. There is also a need for the revision of the Disaster Management Act 2003, which will take place in 2010, including the development of regulations to support the Act.

4.4 | IMPORTANT MANAGEMENT GAPS

A comprehensive land use and physical development plan inclusive of zoning

Steps taken towards filling gap:

- The preparation of a draft plan in 2009 inclusive of basic zoning;
- The establishment of a National Geographical Information System (NGIS) across the Town and Country Planning Department, Survey Department, Conservation and Fisheries Department, and Department of Disaster Management to improve the management and analysis data relevant to the planning process; and
- Institutional strengthening of the Town and Country Planning Department through recruitment, training, and reorganisation.

A comprehensive coastal zone management plan

Steps taken towards filling gap:

- Development of a GIS based Coastal Resources Inventory System (CRIS) in 1992.
- Ongoing coral reef monitoring and updating of CRIS data layers

Specific management plans for beaches

Steps taken towards filling gap:

- Work towards re-starting of beach monitoring programme;
- Thesis by Shannon Gore (marine biologist at Conservation and Fisheries Department) on a beach management framework for The Virgin Islands and continued PhD research on Virgin Islands beaches.
- Establishment of a Cabinet sanctioned Beach Commission and formation of a multi-agency Beach Management Working Group.

Sustainable management programme for fish stocks

Steps taken towards filling gap:

- Continuous collection of fisheries catch data.
- Current efforts to develop management plans for fisheries protected areas

Management plans for Fisheries Protected Areas

Steps taken towards filling gap:

- Development of a standard rapid assessment protocol for Fisheries Protected Areas

5.0 | Risk Reduction Options

Adaptation refers to any action aimed at reducing the local impacts of climate change; it is distinct from climate change ***mitigation*** efforts that attempt to reduce carbon emissions, the primary cause of climate change.

Adaptation and mitigation are, however, inextricably linked as the extent of international mitigation measures directly affects the degree of adaptation required. In some instances, mitigation and adaptation actions may overlap. For instance mangrove reforestation serves as both an adaptation and mitigation action – mangroves provide important coastal protection against sea level rise and stronger storm surges while also serving as a carbon sink. In addition, given the high cost of and the intensive use of energy in the Territory, mitigation actions are important to reduce the percentage of GDP expended on energy and redirect those savings into climate change adaptation.

Many institutions, a body of legislation, policies and programmes already exist and can be built upon and strengthened to ensure that the Territory effectively adapts to climate change. In large part, climate change adaptation boils down to *seriously implementing* the measures and taking the precautionary steps long identified, and in some cases already integrated in policies and legislation, to protect ecosystems, build resilience in key industries and develop wisely, especially in the coastal zone (CANARI, 2008 a).

Through wide stakeholder consultation a series of climate change adaptation strategies (risk reduction options) have been identified for the tourism sector and supporting sectors. These strategies are summarized in the table below. An initial plan for the rehabilitation of the Cane Garden Bay Community prepared by the Cane Garden Bay Community with consultation from the Conservation and Fisheries Department is also included as Appendix 4.

The adaptation strategies presented in Table 5.0-1 are by no means novel and are based on long standing best management practices and actions that have successfully been taken or that are proposed in similar countries. In many cases implementation of the adaptation strategies outlined will require technical cooperation and support on a regional and wider basis.

Impact Areas and Potential and Existing Climate Change Impacts	General Guiding Adaptation Principles and Specific Adaptation/Risk Reduction Options
BEACH & SHORELINE STABILITY	✓ Avoid undermining natural beaches/shorelines or creating vulnerable man-made ones. ✓ Protect beaches and vulnerable shorelines with natural defences where practical. ✓ Allow for natural adjustments in beaches/shorelines as sea level rises, to the greatest extent practicable. Avoid constructing in destructive and or vulnerable locations too close to beaches and the shoreline.
☆ Sea level rise and stronger hurricanes and storm surges causing: - Increased beach erosion and shrinkage; - Shoreline erosion and increased flood risk to low-lying coastal areas.	1. Pass the draft Environmental Management and Conservation of Biodiversity Bill before the end of 2011 and supporting regulations within the next two (2) years. 2. Allocate the necessary financial and technical resources to implement the Bill by establishing a "carbon levy" on visitors earmarked specifically for climate change adaptation and mitigation. 3. Improve and strictly enforce planning and building laws/regulations, especially increasing coastal development setbacks. 4. Protect Crown lands adjacent to or surrounding beaches to allow for the long-term migration and health of beaches. 5. Develop and implement beach management plans. 6. Increase beach monitoring activities. 7. Educate construction industry about environmentally-friendly practices for the coast. 8. Increase protection and restoration of shallow reefs that act as coastal defences. 9. Protect and invest in "soft" protective measures (such as mangroves) along shorelines.
COASTAL & MARINE ECOSYSTEMS	✓ Enhance the resilience and natural adaptive capacity of coastal and marine ecosystems by increasing legal protections, enhancing management and monitoring and educating the public to reduce local impacts.
☆ ☆ ☆ Coral reefs experiencing increased bleaching, structural damage, disease and death due to increased ocean temperatures,	1. Pass the draft Environmental Management and Conservation of Biodiversity Bill before the end of 2011 and supporting regulations within the next two (2) years. 2. Allocate the necessary financial and technical resources to implement the Bill by establishing a "carbon levy" on visitors earmarked specifically for climate change adaptation and mitigation. 3. Declare and transfer all of the areas in the approved British Virgin Islands Protected Areas

ocean acidification, and more intense hurricane events and storm surges.	System Plan 2007-2017 before the end of 2011. 4. Enhance management of Marine Protected Areas (MPAs). 5. Decrease damage from divers and snorkelers by introducing mandatory orientations. 6. Decrease anchor damage - mandate an orientation for skippers and bareboat charters, implement stricter controls on mega yacht/small cruise ship anchoring, and increase capacity and maintenance of the buoy system and mandate its use. 7. Decrease sedimentation – require timely paving of roads/driveways, create permit system for the regrading of roads and land clearing, restrict vegetation clearing to the construction footprint and require timely landscaping, and improve capture and reuse of stormwater. 8. Decrease marine nutrient pollution - improve sewage management through constructing tertiary treatment systems and pump out stations. Decrease agricultural runoff. 9. Increase monitoring of coral reefs. 10. Increase public awareness about coral reefs. 11. Develop coral nurseries to repair damaged reefs and rear species resilient to bleaching.
Landward migration or inundation of mangroves. Increase in mortality from stronger hurricanes.	12. Strongly protect all remaining mangrove forests. 13. Expand and enhance the mangrove reforestation programme. 14. Land use planning to allow room for landward migration of mature mangrove forests. 15. Shelter young mangroves from storm surges by protecting natural coral reefs and, where suitable, constructing artificial reefs in priority areas.
Decreased growth of seagrass beds and increased stress and mortality.	16. Enhance legal protections for seagrass beds. 17. Protect seagrass beds from high-energy waves by protecting coral reefs.
CRITICAL INFRASTRUCTURE AND HUMAN SETTLEMENTS	✓ Enhance physical and spatial planning, lands management, building standards, drainage design, disaster management and relevant human capacity to increase the resilience of existing and future critical infrastructure and human settlements to climatic events, disasters and sea level rise.
Road network, critical facilities, utilities, developable lands and homes at	**Enhance the physical planning/building legislation and regulations** 1. Update and improve the Building Regulations 1999 by adopting the International Building Code and producing a local supplement to address climate specific hazards, energy efficiency, water efficiency, indoor air quality and “green” building standards by 2014.

greater risk of damage from floods, stronger hurricanes and storm surges, and sea level rise. Increased operational disruptions to critical services (airports, sea ports, utilities, waste management) from weather extremes and rebuilding after significant damage).	2. Revise the Buildings Ordinance 1955 to explicitly require review and approval for all Government projects by the Building Authority. 3. Ensure that Certificates of Occupancy are issued by the Building Authority and that such Certificates are required by banks and the electricity and water utility before provision of amenities. 4. Revise the *Building Ordinance 1955* to increase fines for violations. 5. Implement measures to significantly increase the efficiency with which violations of the *Physical Planning Act 2004* are addressed. This should include implementation of a ticketing system for violations, assignment of a dedicated legal person/team to the Town and Country Planning Department to handle violations and other measures to speed up the legal process. 6. Include in the new *Physical Planning Act Regulations* increased setback requirements for coastal developments based on localized storm surge and sea level rise mapping and beach management best practices. 7. Include in the new *Physical Planning Act Regulations* setback requirements for developments in relation to natural drainage areas (ghuts and ponds) based on hydrological studies and flood records (increasing the 30 feet minimum setback noted in the Draft Subdivision Guidelines 2010 where necessary). 8. Include in the new *Physical Planning Act Regulations* requirements for minimum elevation of buildings above sea level to minimize impact from flooding, sewage backup and sea level rise. 9. Include in the new *Physical Planning Act Regulations* controls on the minimum lot size for development and building footprint according to the slope of the land, underlying geology, natural hazard threats and Local Area Plans (referred to below). 10. Revise the *Physical Planning Act 2004* to require that cutting and paving of roads be the responsibility of the sub-divider of a parcel. 11. Include in the new *Physical Planning Act Regulations* limitations on the clearing of vegetation and removal of soil and measures to minimize foundation cuts during development. 12. Include in the new *Physical Planning Act Regulations* a stipulation that requires all developments to implement soil erosion control measures during the construction phase and post construction as necessary. **Enhance the physical planning/building framework** 13. Develop and approve a National Physical Development Plan within 5 years (2016) to regulate the use of land and allowed types and density of development in different areas, taking into consideration planning objectives, natural hazard threats and environmental features.

	14. Develop and approve Local Area Plans for major settlements and towns urgently, with identified priority areas completed within 5 years (2016). 15. Enhance the human capacity of the Town and Country Planning Department. 16. Allocate the necessary human and financial resources to support the development of a National Physical Development Plan and Local Area Plans. 17. Create financial incentives that extend to consumers to encourage "climate proof" buildings. For example, lower custom duties on the importation of impact resistant windows and hurricane straps. 18. Improve the design and integrity of buildings by requiring registration of architects and engineers and by better regulating and educating contractors and heavy equipment operators. Develop minimum requirements for individuals/companies responsible for carrying out Environmental Impact Assessments (EIAs). 19. Require developments of a certain size to be designed by a registered architect/engineer. 20. Build local capacity in various engineering and other disciplines by encouraging pursuit of degrees, continuing education and experience abroad in geotechnical, mechanical, electrical, plumbing, civil, structural, fire protection, traffic, coastal and environmental engineering, project/construction management, physical planning, disaster management and environmental management. 21. Develop and approve specific standards for the construction and maintenance of Government buildings, both owned and rented. 22. Develop and approve a contingency plan for the continuation of all Government services and operations following prolonged impact from natural disasters or long-term abandonment of areas with existing government facilities. **Improve drainage** 23. Enhance local weather monitoring to provide early flood warning notification by installing additional weather stations to complement the existing network. 24. Complete flood risk mapping and modeling exercise of Road Town watershed and provide recommendations for future development by 2015. 25. Conduct basic flood risk mapping and modeling exercise for significant watersheds and communities in the Territory by 2015. 26. Require the development of Flood Action Plans for all major flood prone communities by 2015. 27. Develop and approve a National Drainage Plan within the next 5 years (2016) to accommodate a 100 year flood event.

	28. Develop and approve Local Area Drainage Plans, based on the National Drainage Plan, for the greater Road Town area and all other major towns and settlements urgently to accommodate a 100 year flood event, with identified priority areas developed and approved within the next 5 years (2016). 29. Revise the *Physical Planning Act 2004* to require Site Specific Drainage Plans for all developments based on the Local Area Drainage Plans (once Plans have been developed). 30. Develop a strong, comprehensive policy on stormwater management and sedimentation control within the next year. 31. Implement a programme to reforest cleared/degraded lands with trees of high water and soil conservation value. 32. Develop and approve policies to minimise impervious surfaces to reduce stormwater runoff, such as requiring use of permeable pavement systems for sidewalks and parking lots and encouraging green roofs where suitable. 33. Implement a policy against paving the bottom of natural waterways (locally referred to as ghuts). Policy could allow for gabion baskets to be installed along the sides of ghuts to control erosion of ghut banks. Implementing a programme and necessary resources to maintain and clean identified ghuts on a regular basis. 34. Encourage the declaration of ghuts as Protected Areas under the Protection of *Trees and Conservation of Soil and Water Ordinance* and as Environmental Protection Areas under the *Physical Planning Act 2004*. 35. Revise the *Roads Ordinance* to meet modern standards for road design and construction that take into consideration the hydrologic and hydraulic characteristics of an area and drainage requirements for a 100 year flood event. 36. Use existing legislation to acquire lands as necessary to improve drainage along existing roads and new roads to me*et approved standards for road design and construction referred to above.
ENERGY SECURITY	✓ Implement policies to reduce energy use by promoting energy efficiency and conservation through education and incentives. ✓ Implement policies to encourage greater energy independence through the integration of renewable energy technologies. ✓ Enhance electricity sector performance and generating power efficiencies. ✓ Enhance the resilience of the electricity generation and distribution system to climate change impacts.
Increased electricity demand due to increased incidents of heat extremes	1. Formally establish a National Energy Committee before the end of 2011 with the necessary resources and authority to conduct research and create policies on energy to achieve enhanced energy efficiency and conservation, the meaningful integration of renewable energies, enhanced electricity sector performance and generating power efficiency and the

(i.e. increased cooling demand) and rising demand for desalinated water. Increasing fossil fuel prices and eventual reductions in supply.	reduction of energy use in the transport sector. 2. Create a National Energy Desk with at least two dedicated energy officers to support the work of the National Energy Committee by the first quarter of 2012. 3. Require the National Energy Committee to develop an initial Stage 1 National Energy Policy for immediate implementation by the end of 2012. 4. Require the National Energy Committee to develop a comprehensive Stage 2 National Energy Policy by early 2014 to direct all aspects of energy consumption and production in The Virgin Islands. 5. Implement an ongoing public education programme on energy conservation and efficiency and renewable energy technologies. **Stage 1 National Energy Policy** *Energy Conservation, Efficiency and Education* a) Adopt energy efficiency standards for appliances (e.g. Energy Star), equipment (e.g. air conditioning systems), building products and materials and vehicles; b) Create financial incentives that extend to consumers to encourage importation and use of building materials, products and technologies that result in higher energy efficiency (for example, duty importation concessions on Energy Star appliances); c) Revise the relevant legislation to promote the importation and use of smaller, more fuel efficient and alternatively powered vehicles; and d) Facilitate retiring of old energy inefficient vehicles from the active vehicle fleet. *Renewable Energy Integration and Promotion* a) Identify available renewable energy sources and technologies that are practical, commercially viable and suited to the culture and economy of The Virgin Islands; b) Establish feasibility of small scale grid-tie renewable energy integration as implemented in the USVI by WAPA at the residential and private sector scale; c) Require utility accommodation of renewable energy powered grid-interactive inverters so that the electric grid can safely handle distributed power production; d) Develop a standard application process to enable the BVI Electricity Corporation to evaluate requests for renewable energy production into the electrical grid by private producers; e) Commission a waste to energy feasibility study; f) Update the British Virgin Islands Electricity Corporation Ordinance to enable regulatory and legislative enactments to create an environment that encourages the utilization of grid-tie renewable energies (especially solar, small wind and ocean current); g) Start a Territory-wide solar water heater programme that encourages installation of solar water heaters on all new buildings and retrofitting of existing building, using a locally appropriate version of the Barbados model; h) Make revisions to the Customs Duties Ordinance that promote energy efficient and renewable energy technologies through duty importation concessions on favoured technologies; i) Consider imposing a Carbon Levy (Carbon Offset) on tourists that would go towards a Trust

	Fund in part dedicated to reducing the carbon footprint of The Virgin Islands. (This Levy may be imbedded in accommodation/travel fees or captured at Ports of Entry/Departure etc.); and j) Promote energy conservation and efficiency and renewable energy curriculum development throughout all levels of the educational system. **Stage 2 National Energy Policy** *Energy Conservation, Efficiency and Education* a) Update and improve the Building Regulations 1999 by adopting the International Building Code and producing a local supplement with energy efficiency and "green" building requirements by 2013; b) Require existing buildings to be retrofitted to meet (to the extent feasible) new energy efficiency standards within a specified time period; c) Work with utilities to create suitable incentive programmess or revise tariff schemes to encourage greater water and energy conservation and efficiency practices in government and the residential and commercial sectors; d) Increase supply-side energy efficiencies by upgrading the energy infrastructure where necessary; and e) Create a wide reaching, efficient and dependable national public transport system. *Renewable Energy Integration and Promotion* a) Commission a national renewable energy feasibility study that considers feasibility at the utility scale (BVI Electricity Corporation); b) Evaluate financial incentive best practices and create a Virgin Island's approach to encourage the public's and private sector's investment in renewable energy technologies; c) Evaluate the existing revenue model for BVI Electricity Corporation and revise it accordingly to ensure that it is suitable/sustainable for going forward in a renewable energy mix future; d) Consider alternative revenue streams and energy conservation incentives such as a vehicular fuel tax; e) Promote renewable energy installations on school buildings/campuses to increase exposure to and learning about renewable energy; f) Encourage short and long-term programmes for active research, development and training in renewable energy technologies and designs, including training employees of the BVI Electricity Corporation (for example through the United States Virgin Islands Water and Power Authority); g) Work with utilities to create suitable incentive programmess or revise tariff schemes to encourage greater water and energy conservation and efficiency practices in government and the residential and commercial sectors; h) Revise the relevant legislation to promote the importation and use of smaller, more fuel efficient and alternatively powered vehicles; and i) Work with the taxi industry to convert their bus stock to biodiesel.
Electricity system at greater risk of damage from floods,	*6.* Test and update safety measures and hurricane contingency plans for energy facilities. 7. Avoid building new energy infrastructure in vulnerable areas or with vulnerable designs or materials.

stronger hurricanes and storm surges, and sea level rise.	8. Climate-proof existing/planned fuel terminals and critical or vulnerable electricity generation/distribution systems to reduce vulnerability to climate threats. 9. Improve drainage around the main electricity generation plant at Pockwood Pond. 10. Bury electrical lines where it is determined to be strategic. 11. Plan for the future relocation or retrofitting of electricity generation stations and sub-stations that will be inundated by sea level rise or flooded by stronger storm surges.
FOOD SECURITY: AGRICULTURE	✓ Expand and increase resilience of local agricultural production (through best management practices for water efficiency, erosion control, pest management, hurricane resilience and environmental sensitivity) ✓ Implement policies that encourage agricultural growth and diversification, use of new technologies and local capacity building.
Decrease in agricultural yield (or increased cost of production) due to decreased overall rainfall.	1. Enhance infrastructure for water capture and storage for agricultural purposes. This will include commissioning a watershed assessment of Paraquita Bay to develop a detailed engineering plan to capture, store and distribute rainwater and sustainably harvest and store groundwater before the end of 2011. Assessments of other agricultural watersheds would follow. 2. Implement a agricultural water conservation and efficiency programme to mainstream best management practices and less water intensive agricultural methods, such as mulching, drip irrigation, shade houses, greenhouse organic recirculation hydroponic systems and automatic watering systems for animals. 3. Hire a full time soil and water engineer to provide the relevant technical support and training of agricultural producers necessary for mainstreaming water conservation and efficiency techniques and related best management practices. 4. Implement policies to encourage use of traditional cultivars that are adapted to local climate and new species of drought resistant crops, grasses and legumes as well as drought resistant livestock and poultry.
Increase in agricultural pests, weeds, diseases and invasive species due to increased concentrations of carbon dioxide (CO_2), warmer soils and changes in humidity.	5. Develop and approve a standard protocol for responding to pests, diseases and invasive species, including a good reporting and alert system. 6. Develop and enact a stringent Food Safety Policy and supporting regulations. 7. Enhance programmes to mainstream Integrated Pest Management. 8. Encourage producers to plant a variety of crops to increase resilience instead of a mono cropping approach. 9. Implement policies to encourage use of traditional cultivars that are adapted to local climate and new species of pest resistant crops, grasses and legumes as well as drought resistant livestock and poultry.

Increased stress to livestock from heat, drought and disease.	10. Introduce greenhouses with organic hydroponic recirculation systems for high value vegetables such as tomatoes. *(Hydroponics aids by isolating crops from the soil, thus reducing exposure to diseases, pests, weeds, etc. and has additional advantages such as reduced water, fertiliser, pesticide and land area demand).* 11. Depend more heavily on agriculture in controlled environments (e.g. shade houses, poultry units, pig units, small stock units, feedlots and dairy units). 12. Develop an outdoor agricultural research, training and development facility to support mainstreaming of best practices and educational programmes.
Soil degradation from saltwater intrusion and soil erosion / leaching, resulting in decreased yields.	13. Encourage best management practices for erosion control. 14. Introduce greenhouses with organic hydroponic recirculation systems for high value vegetables. 15. Implement policies to encourage use of traditional cultivars that are adapted to saline environments and new species of salt tolerant crops, grasses and legumes. 16. Develop an outdoor agricultural research, training and development facility to support mainstreaming of best practices and educational programmes.
Crop damage and disruption in agricultural production from stronger hurricanes, droughts and floods.	17. Revise and update the Agricultural Small Holding Act to require best management practices for soil erosion control and conservation, forestry restoration, irrigation, water conservation and hurricane resilience and preparedness (e.g. natural windbreaks). 18. Allocate the necessary human, technical and financial resources to implement the revised Agricultural Small Holding Act. 19. Develop an outdoor agricultural research, training and development facility to support mainstreaming of best practices and educational programmes. 20. Conduct a feasibility study to determine the most feasible insurance/crop recovery approach for producers. 21. Promote development of intensive/semi-intensive production systems among the agricultural community (e.g. greenhouses with organic hydroponic recirculation systems, shade houses, poultry units, pig units, small stock units, feedlots and dairy units). 22. Make provisions for hurricane resistant storage facilities for produce and equipment. 23. Enhance local weather monitoring and modeling to provide early flood warning systems and ensure that information is shared between relevant agencies. 24. Improve drainage of agricultural lands, especially the Agricultural Station.
Changes in imported food availability,	25. Work towards greater agricultural self-sufficiency.

cost, and quality.	26. Approve the 2006 Draft National Agricultural Policy before the end of 2011. 27. Enhance legal protections of agricultural lands, including passing regulations on authorized uses of agricultural lands. 28. Actively pursue further designation of lands for agricultural purposes through outright purchase, lease agreements, conservation easement type agreements or incentives for maintaining lands in agricultural production. 29. Work with the banking sector or Small Business Bureau to deliver a low interest small loans scheme/programme to help persons invest in agricultural production. 30. Integrate agricultural studies into the school curriculum at all levels. 31. Revitalize the school gardens programme and start a community garden programme.
FOOD SECURITY: FISHERIES	✓ Place greater emphasis on protection of fisheries habitat and sustainable fisheries management and practices. ✓ Explore new fisheries methods and species.
☆☆ Degradation of critical fish habitat and changes in plankton food resources.	1. Update the Fisheries Act 2007 to reflect and better manage climate change induced impacts to fisheries. 2. Pass the draft Environmental Management and Conservation of Biodiversity Bill before the end of 2011 and supporting regulations within the next two (2) years. 3. Allocate the necessary financial and technical resources to implement the Bill by establishing a "carbon levy" on visitors earmarked specifically for climate change adaptation and mitigation. 4. Implement stricter controls on fishing techniques and marine recreational activities that impact coral reefs and mangroves. 5. Enhance enforcement against illegal fishing and overfishing. 6. Reduce stress on natural habitats and fish stocks through investing in sustainable aquaculture and aquaponics.
☆ Migration of some fish species to cooler waters.	7. Develop fisheries that are less temperature sensitive or that will become more favourable as climate changes.
Increase in opportunities for establishment of marine invasive species.	8. Develop and approve a standard protocol for responding to invasive species, including a good reporting and alert system.

Increased damage to landing sites, on-shore facilities, boats and equipment.	9. Construct new landing sites and onshore facilities to withstand stronger hurricanes and storm surges and sea level rise. 10. Allocate the necessary financial resources to enhance the existing physical structures of the fisheries sector to withstand climate change impacts. 11. Conduct a feasibility study to determine the most feasible insurance/vessel and equipment recovery approach for fishermen. 12. Improve hurricane preparedness measures.
FORESTRY & BIODIVERSITY	✓ Enhance protection of wildlife and associated habitats. Engage in habitat restoration. ✓ Add value to wildlife preservation through tourism.
☆ ☆ ☆ Decline in health and abundance of marine resources.	1. Pass the draft Environmental Management and Conservation of Biodiversity Bill before the end of 2011 and supporting regulations within the next two (2) years. 2. Allocate the necessary financial and technical resources to implement the Bill by establishing a "carbon levy" on visitors earmarked specifically for climate change adaptation and mitigation. 3. Declare and transfer all of the areas in the approved British Virgin Islands Protected Areas System Plan 2007-2017 before the end of 2011. 4. Improve management of Marine Protected Areas (MPAs). 5. Work with neighbouring islands to create protected migration corridors for marine species in the Caribbean basin.
Degradation of turtle nesting habitat (sandy beaches) and creation of unbalanced sex ratios.	6. Minimise beach development, beach erosion and marine habitat loss.
☆ ☆ ☆ Shrinking upland forests and reduction of associated biodiversity.	7. Conduct a forest/terrestrial biodiversity inventory. Expand protected areas to target vulnerable species and sensitive areas. 8. Restrict vegetation clearing to construction footprint and require timely landscaping with primarily native species. 9. Enhance legal protection and management of remaining forested areas. 10. Start concerted reforestation programme of native dry and moist forest species and endangered and rare species.

Bird migration and reproduction patterns disrupted. Increased mortality.	11. Enhance protection of bird stopover habitats such as salt ponds and mangroves. 12. Reduce introduced bird egg predators such as cats, rodents and mongoose. 13. Add value to biodiversity protection by developing bird watching trails and lookouts as a key tourist attraction.
Increased invasive species.	14. Develop and approve a standard protocol for responding to invasive species, including a good reporting and alert system.
HUMAN HEALTH	✓ Emphasize a preventative versus treatment approach to managing health. ✓ Increase the resilience of the population to natural disasters and associated health impacts. ✓ Enhance the health care sector legal and policy framework to address climate change impacts. ✓ Enhance the health care sector capacity to monitor and respond to climate change impacts.
Increase in Dengue Fever outbreaks (frequency and severity)	1. Build strong community cooperation in reducing mosquito breeding grounds. 2. Encourage the incorporation of mosquito screens and nets in homes. 3. Strengthen dengue fever reporting and early warning system for outbreaks. 4. Adopt an integrated approach to management of vector borne diseases, and only use fumigation when there is an epidemic or high level of infestation. 5. Amend the Nuisance Regulations to allow for a ticketing system to enhance enforcement of the Regulations by the end of 2011.
Increase in prevalence of ciguatera (fish poisoning).	6. Conduct an assessment to identify high-risk fishing grounds and conditions for ciguatera. 7. Enhance detection (testing), monitoring and reporting system for ciguatera.
Increase in respiratory diseases, such as asthma.	8. Increase early detection of asthma and develop standard guidelines for treating patients. 9. Establish legislation, regulations, institutions and programmes to address indoor and outdoor air quality. 10. Update and improve the Building Regulations 1999 by adopting the International Building Code and producing a local supplement to reflect and better manage health issues resulting from poor building design and indoor air quality by 2014.
Increase in risk of diarrhea and other	11. Increase community resilience to hurricanes and flood events that increase the risk of such illnesses.

environmentally transmitted illnesses.	12. Enhance capacity of emergency response services. 13. Improve the safety of the potable water supply by enhancing the protection and management of water sources (including coastal waters and cisterns) and processing systems. 14. Enhance management of sewage waste, including improved regulation and maintenance of septic systems and implementation of a national sewage collection and treatment system. 15. Improve garbage collection and treatment systems to reduce and control rodent populations.
Increase in potential for heat stress.	16. Increase public awareness about heat stress and survival strategies. 17. Incorporate "green" design into buildings to maximise natural light and ventilation. 18. Install backup air conditioning units and power supply in critical public buildings, especially those for children, the elderly and the sick.
Increase in risk of damage to health care facilities from stronger hurricanes, storm surges and flood events.	19. Conduct a vulnerability assessment of the design and location of existing clinics and proposed polyclinics to natural hazards and climate change impacts. Relocate and retrofit clinics as necessary.
Increase in risk of personal injury/loss of life from stronger hurricanes, storm surges and flood events.	20. Increase community resilience to hurricanes and flood events. 21. Enhance the emergency response services of the health care system in natural disasters. 22. Strengthen system to transport sick/injured persons in natural disasters.
Greater threat of epidemics and pandemics.	23. Fully implement the Port Health Programme by the end of 2012, including by providing the necessary technical, human and financial resources needed. 24. Pass the revisions to the Infectious Disease Notification Act before the end of 2011. 25. Pass the revisions to the Quarantine Act before the end of 2011. 26. Mandate annual national testing (and revising where necessary) of plans and strategies to deal with epidemics and pandemics. 27. Allocate the necessary resources to fully implement plans and strategies to deal with epidemics and pandemics. 28. Focus on increased wellness and resilience of the population. 29. Encourage continuous good hygienic practices.

Combination of impacts detailed above.	30. Integrate climate change considerations into health sector policies and planning. 31. Strengthen inter-agency collaboration on health issues. 32. Establish observatories and information centres on climate change and health. 33. Strengthen existing health surveillance systems. 34. Strengthen the human capacity of the health care system on an ongoing basis. 35. Reinstitute a dedicated and properly trained Health Education Unit within the Ministry of Health and Social Development. 36. Enhance and broaden the range of services provided by community health care clinics. 37. Enhance monitoring of invasive species and capacity of health sector to respond to dangerous invasive species.
INSURANCE & BANKING	✓ Build resilience to minimise vulnerability of insured and mortgaged properties to climate change impacts. ✓ Depend less on global insurance companies and look towards more regional and local solutions to risk pooling and disaster recovery.
Increased insurance rates, potentially leading to uninsurance or underinsurance. Increased interest rates and difficulty in obtaining construction loans due to increased risk.	1. Reduce the exposure of The Virgin Islands insurance and banking sector by updating and improving the Building Regulations 1999 by adopting the International Building Code and producing a local supplement to address climate specific hazards by 2014. 2. Require the establishment of climate change risk management protocols for the finance sector. 3. Increase the Disaster Relief Fund by implementing a small fee for incorporation of BVI Business Companies that do not trade in the BVI and registration of foreign vessels (and potentially residents) that is earmarked and managed specifically for disaster recovery. This can be managed under the Carbon Levy Trust Fund described under the Tourism section. 4. Periodically reconsider membership in the Caribbean Catastrophic Risk Insurance Facility (CCRIF). 5. Conduct a feasibility study on the establishment of alternative insurance models including, micro-insurance schemes and mutual insurance schemes. 6. Collaborate with the banking sector to establish readily accessible financing options to install solar water heaters and other forms of renewable energy.

TOURISM	✓ Take strong “no regrets” measures to protect the quality of natural and historical attractions from existing local impacts and additional climate change impacts. ✓ Enhance the resilience of tourism infrastructure and facilities to climate change impacts. ✓ Create a more environmentally responsible tourism industry.
☆☆ Loss of or more costly damage to tourism infrastructure and properties from floods, stronger hurricanes and storm surges, and sea level rise.	1. Enhance industry hurricane preparedness, including preparation, evacuation and recovery plans. 2. Develop best practice guidelines for developers to protect their properties from climate impacts. 3. Encourage adequate insurance coverage of critical tourism infrastructure and properties. 4. Require all tourism developments (new and existing) to have drainage plans in keeping with local area drainage plans (proposed under the Critical Infrastructure and Human Settlements section). 5. Increase coastal setback and elevation of tourism infrastructure/facilities to protect them from sea level rise, storm surges and flooding. 6. Educate developers about the increasing risk of building in low-lying coastal areas. 7. Undertake National risk mapping exercise to identify critical tourism infrastructure at risk to sea level rise, storm surge, flooding and high wind. 8. In highly vulnerable areas, establish “no build areas” for critical tourism infrastructure and properties, including proposals for accommodations in or over the ocean. 9. See other measures under the Critical Infrastructure and Human Settlements section.
☆☆☆ Diminished natural tourist attractions, e.g. coral reefs, beaches, wildlife.	10. Enhance protection and management of natural tourist attractions and supporting ecosystems, such as coral reefs, beaches, mangroves, seagrass beds and salt ponds. (See measures under the Beach & Shoreline Stability, Coastal & Marine Ecosystems and Forestry & Biodiversity sections). 11. Diversify the base and increase the resilience of tourism industry by developing and promoting less vulnerable land-based attractions and activities (e.g. national parks, historical sites, museums, cultural events and hiking). a) Approve the draft Historical Site Registrar; b) Restore priority historical sites as visitor attractions within the next 5 years, including installing information kiosks/plaques where appropriate; c) Approve a museum policy, development and promotion plan; d) Create a National museum and historical site management board with an allocated budget; e) Create a series of hiking trails to explore the ghuts, especially those in communities with

	tourism development or suitable for tourism activity. For example Garden Ghut in Carrot Bay and several ghuts in Cane Garden Bay and Brewer's Bay; and f) Develop cultural villages in various communities across the Territory, such as Carrot Bay, East End and Road Town with exhibits about various aspects of history and culture. (The Festival Grounds in Carrot Bay, Greenland and Road Town can be developed to accommodate the Festival activities as well as function as cultural villages/living museums year round).
Rising overheads in energy, water and insurance.	12. Increase energy and water conservation and efficiency in tourism properties. 13. Encourage use of renewable energies in tourism properties. 14. Incorporate "green" design in tourism properties, e.g. natural cooling and lighting. 15. Encourage use of more efficient cooling systems (and proper maintenance of systems). 16. Reduce insurance claims by ensuring "climate-ready" structures.
Deterrents to travelers including, warmer winters, less comfortable and stable VI climate, higher airfares and increased Dengue Fever Outbreaks.	17. Reframe/reposition The Virgin Islands as more than just a winter getaway. 18. Offer incentive packages and develop events to reduce the seasonality of tourism. 19. Reorient the industry towards more resilient high-end and adventure driven tourists. 20. Enhance dengue fever prevention and control programmes to maintain high traveler confidence.
More tourists seeking carbon neutral or energy efficient destinations.	21. Develop and enforce energy efficiency standards for the tourism sector. 22. Enact energy and water conservation and efficiency measures, create incentives for the use of renewable energies in tourism properties and engage in regional projects to move The Virgin Islands tourism sector towards being carbon neutral within in the next 15 years (2026). 23. Create incentives for the use of energy and water conservation and efficiency devices throughout the tourism sector. These may include revising the Hotel Aid Ordinance to extend duty importation concessions only to fixtures/devices that are energy or water efficient and tying the income tax holiday period for hotels to meeting energy and water efficiency standards. Extending similar duty importation concessions to the yachting sector for such energy/water efficient devices, as well as for wind generators, solar paneling and the like. 24. Make tourism industry more environmentally friendly to attract the growing number of environmentally conscious travelers. 25. Encourage industry certification in environmental good practice by internationally recognized bodies such as Green Globe and Blue Flag.

	26. Require tourism facilities to develop and implement disaster and climate change risk management and business continuity plans attached to licensing of tourism businesses and the income tax holiday period for hotels. This would include hurricane evacuation and recovery plans. 27. Develop opportunities for tourists to "offset" their vacation carbon emissions.
Combination of impacts detailed above.	28. Develop, approve and implement a National Tourism Policy and Development Master Plan that includes among other considerations: a) Base standards for design, construction, environmental management, water and energy conservation and efficiency in the tourism sector that moves the Territory towards "green" tourism b) Carrying capacities and management plans for individual tourism attractions c) Desired/allowed types, style and density of tourism developments 29. Impose a Carbon Levy (Carbon Offset) on tourists that would go towards a Trust Fund dedicated to reducing the carbon footprint of the tourism industry, implementing measures that would reduce the vulnerability of the tourism sector to climate change impacts and protecting the natural resource base of tourism. (This Levy may be imbedded in accommodation/travel fees or captured at Ports of Entry/Departure). 30. Create a Management Board to oversee the administration of the Carbon Levy Trust Fund. The Board could include among others representation from the Conservation and Fisheries Department, National Parks Trust, Tourist Board, Chamber of Commerce and Hotel Association, Charter Yacht Society, Department of Disaster Management and a financial institution.
WATER RESOURCES & HYDROLOGICAL CHARACTERISTICS	✓ Increase resilience of infrastructure, homes and sectors to rainfall extremes - heavy rain events and drought. ✓ Enhance the management of freshwater resources. ✓ Use water more conservatively and efficiently.
Increased likelihood of flood events.	1. See measures related to improving drainage under the Critical Infrastructure and Human Settlements section.
☆ ☆ ☆ Decreased availability of rainwater leading to greater dependency on the desalinated public water supply and an increased threat of water	2. Develop a sustainable freshwater, watershed and coastal waters management and pollution prevention plan based on a water carrying capacity study and other studies. 3. Manage groundwater resources for sustainable agricultural applications. 4. Require desalination plants to use seawater intake (whether direct or from near shore seawater wells) and not source from groundwater supplies (in order to protect groundwater table).

shortages in emergencies.	5. Implement strict water conservation and efficiency programmes, including through education and use of incentives, such as duty concessions on import of water saving devices and revisions to the water tariff. 6. Improve methods of household capture, storage and use of rainwater through education about best practices and low-tech methods to divert the first flush of rainfall from roofs to improve cistern water quality. 7. Include in the new *Physical Planning Act Regulations* a requirement for commercial buildings to have cisterns for rainwater capture. Retain the requirement for residential buildings to have cisterns for rainwater capture. 8. Repair and expand public infrastructure for water capture, storage and delivery within the next 10 years. Storage capacity should meet international standard of a 3 day minimum supply. 9. Enhance the capacity of the Water and Sewerage Department (with periodic independent assessments) to continue and expand the leak and theft detection programme for the water distribution system with the goal of reducing unaccounted for water to 20 percent within the next 15 years (2026). 10. Install bulk meters at different zones of the water distribution system to better account for water and detect leaks/theft. 11. Commission a study to explore options for the capture, treatment and reuse of stormwater for applications such as cooling, irrigation, flushing toilets etc.
Increased cost of desalinated water.	12. Conduct an economic study to determine how many desalination companies the market can bear. 13. Encourage use of alternative energy sources (e.g. solar) to power desalination plants. 14. Increase water conservation and efficiency to reduce overall water demand.

Table 5.0-1. General guiding adaptation principles and specific adaptation options for climate change impacts.

Appendix 1A - Tourist Perception Survey 2009 Version

Climate Change Tourist Perception Survey

Dear Visitor:

This survey is a part of an assessment to understand the impacts of climate change on tourism in the British Virgin Islands (BVI). The findings of the assessment will feed directly into policies to help protect our islands and peoples – and ultimately the experience you've enjoyed – from anticipated changes in climate. Any meaningful tourism policy, of course, must consider the opinion of you, the visitor. All information provided is strictly confidential and will be treated in the highest professional manner. We truly value your inputs and thank you for your participation. We hope you've enjoyed your visit!

ABOUT YOU

1) What is the primary reason for your visit to the BVI?

a) Family / personal vacation
b) Yacht charter holiday
c) Business travel
d) Festival / event
e) Honeymoon / wedding
f) Cruise
g) Visiting friends or relatives
h) Other

2) Which region are you visiting from?

a) North America
b) South America
c) Europe
d) Asia
e) Caribbean
f) Other ________

3) Have you visited the BVI before?

a) No
b) Once
c) Twice or more

IMPRESSIONS OF THE BVI

4) Based on your experience, how would you describe the quality of the following in the BVI?

a) Overall environmental quality	pristine / fair / degraded
b) Coastal and marine waters	pristine / fair / degraded
c) Beaches	pristine / fair / degraded
d) Coral reefs	pristine / fair / degraded
e) National Parks	pristine / fair / degraded

Comments

____

____

5) If you are a repeat visitor, have you noticed a change in environmental quality since your last visit?

a) Improvement
b) No change
c) Degradation

Would a degradation in environmental quality impact your decision to return to the BVI?

a) No
b) Somewhat
c) Yes

6) How did you find the atmosphere / ambiance at popular visitor attractions? Please circle all that apply.

a) Relaxing / comfortable
b) Cramped / congested / crowded
c) Clean / tidy / attractive
d) Dirty / unattractive
e) Exciting / fun
f) Boring / dull
g) Appropriate signage
h) Lack of signage

Comments
____
____

YOUR MOTIVATIONS AND CONCERNS

7) On a scale from 1 to 10, how influential were each of the following in attracting you to the BVI? (Benchmarks: 1 = No influence; 5 = Some influence; 10 = Significant influence)

a) General serenity / tranquility ____
b) Overall environmental quality ____
c) Recreational opportunities ____
(sailing/diving/snorkeling/fishing; circle all that apply)
d) Pristine coastal waters ____
e) Healthy coral reefs ____
f) Geography and scenery _____
g) Good and predictable weather / climate ____
h) Entertainment / special events ____
i) White sand beaches ____
j) Price and quality of accommodations ____

8) Climate change will likely have a number of impacts on the BVI including those listed below. Please rate how much each may influence your desire to visit the BVI in the future. (Benchmarks: 1 = No influence; 5 = Some influence; 10 = Significant influence)

a) Erosion of beaches ____
b) Decline in fisheries ____
c) More severe hurricane events ____
e) Coral reef degradation and bleaching (i.e. corals lose their colour) ____
f) Increased climate variability (i.e. more unpredictable weather) ____
g) Increased flood events ____

9) Would you be less likely to take winter vacations to tropical destinations like the BVI if:
a) winters become noticeably milder in your area of residence? No____ Yes____
b) average temperatures in the BVI increase slowly by up to 5.8°C by the end of this century?
No____ Yes____

10) Carbon emissions are the primary cause of climate change. Do you care about the carbon footprint of the BVI's tourism industry?
a) No b) Somewhat c) Yes

11) Because of concerns over climate change and the linkage to carbon emissions, are you inclined to travel less?
a) No b) No; I offset my emissions c) Yes

12) Would you be willing to support a voluntary environmental levy, collected upon arrival or departure, that would go towards issues related to climate change and sustainable development?
a) No b) Yes

If yes, what is the maximum that you would be willing to volunteer per visit?
a) $1 b) $5 c) $10 d) $15 e) $20 f) other _____

13) Do you care about the environmental practices of the BVI's tourism industry?
a) No b) Somewhat c) Yes

14) Would a guarantee of good environmental practices from internationally recognized certification bodies like "Green Globe" or "Blue Flag" provide an added incentive to choose a particular vacation destination or accommodation?
a) No b) Somewhat c) Yes

15) Is it important to you that beach fronts and other coastal environments remain natural / undeveloped?
a) No b) Somewhat c) Yes

Comments
____
____

16) On a scale from 1 to 10, how important is staying at a beachfront hotel to you? ____
(Benchmarks: 1 = Not important; 5 = Somewhat important; 10 = Extremely important)

17) On a scale from 1 to 10, how much would you favour the following adaptation policies for the BVI tourism sector? (Benchmarks: 1 =Don't favour; 5 = Somewhat in favour; 10 = Extremely in favour)
a) Artificial reefs ____
b) Sea walls (for coastal defense) ____
c) Mangrove replanting (for coastal defense) _____
d) Beach nourishment (i.e. replacing beach sand that has eroded)____
e) Building further away from beaches and the coastline (to prevent flooding from sea level rise and to allow beaches room to migrate and adapt to sea level rise) _____
f) Decreasing the carbon emissions of the tourism sector _____
g) Greening and managing the tourism sector to decrease existing impacts on reefs, beaches etc. ____
h) Encouraging a more historical and cultural visitor experience to supplement the impacted "sand and sea" experience ____

Appendix 1B - Tourist Perception Survey 2010 Version

Climate Change Tourist Perception Survey

Dear Visitor:

This survey is a part of an assessment to understand the impacts of climate change on tourism in the British Virgin Islands (BVI) and determine whether options are available for the tourism sector to reduce its carbon footprint, thereby playing its part in global efforts to reduce greenhouse gas (GHG) emissions. The findings of the assessment will feed directly into policies to help protect our islands and ultimately the experience you've enjoyed from anticipated changes in climate. Any meaningful tourism policy, of course, must consider the opinion of you, the visitor. All information provided is strictly confidential and will be treated in the highest professional manner. We truly value your inputs and thank you for your participation. We hope you've enjoyed your visit!

ABOUT YOU

Age Group: under 20____ 20-30____ 31-40____ 41-65____ over 65____

Gender: Male____ Female____

1) What is the primary reason for your visit to the BVI?

a) Family / personal vacation
b) Yacht charter holiday
c) Business travel
d) Festival / event
e) Honeymoon / wedding
f) Cruise
g) Visiting friends or relatives
h) Other

2) Which region are you visiting from?

a) North America b) South America c) Europe d) Asia e) Caribbean f) Other ________

3) Have you visited the BVI before?

a) No b) Once c) Twice or more

IMPRESSIONS OF THE BVI

4) Based on your experience, how would you describe the quality of the following in the BVI?

a) Overall environmental quality	pristine / fair / degraded
b) Coastal and marine waters	pristine / fair / degraded
c) Beaches	pristine / fair / degraded
d) Coral reefs	pristine / fair / degraded
e) National Parks	pristine / fair / degraded

Comments
____
____

5) If you are a repeat visitor, have you noticed a change in environmental quality since your last visit?

a) Improvement b) No change c) Degradation

Would degradation in environmental quality impact your decision to return to the BVI?

a) No b) Somewhat c) Yes

6) How did you find the atmosphere / ambiance at popular visitor attractions? Please circle all that apply.

a) Relaxing / comfortable
b) Cramped / congested / crowded
c) Clean / tidy / attractive
d) Dirty / unattractive
e) Exciting / fun
f) Boring / dull
g) Appropriate signage
h) Lack of signage

Comments
____
____

YOUR MOTIVATIONS AND CONCERNS

7) On a scale from 1 to 10, how influential were each of the following in attracting you to the BVI?
(Benchmarks: 1 = No influence; 5 = Some influence; 10 = Significant influence)

a) General serenity/tranquillity ___
b) Overall environmental quality ___
c) Recreational opportunities ___
(sailing/diving/snorkelling/fishing; circle all that apply)
d) Pristine coastal waters ____
e) Healthy coral reefs ____
f) "Green" or environmentally conscious tourist facilities ____
g) Geography and scenery ____
h) Good and predictable weather/climate ___
i) Entertainment / special events ____
j) White sand beaches ____
k) Price and quality of accommodations ___

8) Climate change will likely have a number of impacts on the BVI including those listed below. Please rate, on a scale from 1 to 10, how much each may influence your desire to visit the BVI in the future. (Benchmarks: 1 = No influence; 5 = Some influence; 10 = Significant influence)

a) Erosion of beaches ____
b) Decline in fisheries ____
c) More severe hurricane events ____
d) Increased dengue fever outbreaks (mosquito borne illness) ____
e) Coral reef degradation and bleaching (i.e. corals lose their colour) ____
f) Increased climate variability (i.e. more unpredictable weather) ____
g) Increased flood events ____
h) Water shortages ____

9) Would you be less likely to take winter vacations to tropical destinations like the BVI if:

a) winters become noticeably milder in your area of residence? No____ Yes____
b) average daily temperatures in the BVI increase slowly more than 4.0°C by the end of this century? No____ Yes____
c) BVI experiences more incidents of severe hurricanes? No____ Yes____

10) Carbon emissions are the primary cause of climate change. Do you care about the carbon footprint of the BVI's tourism industry?

a) No
b) Somewhat
c) Yes

11) Because of concerns over climate change and the linkage to carbon emissions, are you inclined to travel less?

a) No
b) No; I offset my emissions
c) Yes

12) Would you be willing to support a voluntary "carbon levy", collected upon arrival or departure, that would go towards:

(a) reducing the carbon footprint of BVI's tourist industry? No____ Yes____
(b) implementing measures that would reduce BVI's vulnerability to climate change impacts? No____ Yes____
(c) implementing measures to protect BVI's natural environment? No____ Yes____

If yes to any of the above, what is the maximum that you would be willing to volunteer per visit?

a) $1 b) $5 c) $10 d) $15 e) $20 f) other _____

13) If you answered "No" to any part of question 12, would you be willing to support a voluntary "carbon levy" if the funds were managed by a trusted financial institution such as the World Bank?

a) No____ b) Yes____

14) Do you care about the environmental practices of the BVI's tourism industry?

a) No b) Somewhat c) Yes

15) Would a guarantee of good environmental practices from internationally recognized certification bodies like "Green Globe" or "Blue Flag" provide an added incentive to choose a particular vacation destination or accommodation?

a) No b) Somewhat c) Yes

16) Is it important to you that beach fronts and other coastal environments remain natural / undeveloped?

a) No b) Somewhat c) Yes

Comments

____

____

17) On a scale from 1 to 10, how important is staying at a beachfront hotel to you? ____
(Benchmarks: 1 = Not important; 5 = Somewhat important; 10 = Extremely important)

18) On a scale from 1 to 10, how much would you favour the following policies for the BVI tourism sector that would reduce vulnerability to impacts from climate change? (Benchmarks: 1 =Don't favour; 5 = Somewhat in favour; 10 = Extremely in favour)

a) Artificial reefs ____
b) Sea walls (for coastal defense) ____
c) Mangrove replanting (for coastal defense) _____
d) Beach nourishment (i.e. replacing beach sand that has eroded)____
e) Building further away from beaches and the coastline (to prevent flooding from sea level rise and to allow beaches room to migrate and adapt to sea level rise) _____
f) Conserving energy and decreasing the carbon emissions of the tourism sector _____
g) Greening and managing the tourism sector to decrease existing impacts on coral reefs, beaches etc. ____
h) Conserving water and reducing water use in tourism facilities_____
i) Encouraging a more historical and cultural visitor experience to supplement the impacted "sand and sea" experience ____

Appendix 2 - Climate Change Tourism Sector KAP Survey

Climate Change Tourism Sector Survey

The Ministry of Natural Resources and Labour, Conservation and Fisheries Department, Department of Disaster Management and BVI Tourist Board are conducting a survey to collect information on the tourism sector's knowledge, attitudes and practices regarding **Climate Change (also known as Global Warming)**.

The information gathered from this survey will be utilized to develop awareness programmes, and policies and strategies for Climate Change.

Managers are asked to answer all questions below. The survey takes 10 minutes. Thank you for your participation.

---

1) Business category? *Tick all that apply.*

a. Marina
b. Independent charter yacht
c. Souvenir / gift shop
d. Restaurant / bar
e. Guesthouse / home rental
f. Hotel / resort
g. Villa
h. Water sports rental
i. Tour/taxi operator
j. Other_____________

2) Size/capacity of operation? (Use local market for comparison)

a. Number of buildings______
b. Number of rooms ______
c. Number of beds ______
d. Number of charter boats______
e. Number of slips _____
f. Number of seats *(restaurants/bars)*______
g. Number of employees ______
h. Number of vehicles _____(diesel)_____(gas)

3) Business location? *Tick all that apply.*

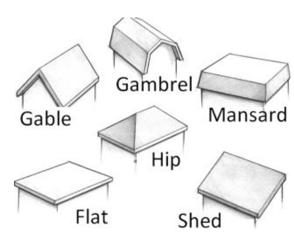
a. Immediately along the coastline
b. Flat inland area
c. At the bottom of a hill/valley
d. On a hill
e. In a flood prone area
f. Next to a natural drainage "ghut"
g. Based at sea

4) Structural integrity of the building that houses your business? (Answer on a scale from 1 to 5, where 1 = Very Weak and 5 = Very Strong)

a. 1 b. 2 c. 3 d. 5 e. 6

Comments____

5) Type of roof (see pictures at right) and windows in your business property?



a. **Roof shape** ________________
b. **Are any of your porch roofs attached to your main roof?** Yes / No
c. **Windows**: glass (regular)__ glass (impact resistant)__ wood__ aluminum__
d. **Do you have hurricane shutters?** Yes / No

6) Do you have access to cistern water?

a. Yes
b. Restricted (e.g. only in kitchen, only on certain days)
c. No

7) Do you have problems with water pooling around your property?

a. Major, widespread pooling
b. Minor, limited pooling
c. No pooling

Comments____

8) **Do you have drainage accommodation at your property?** Yes / No

9) **Do you have a retaining wall at your property?** Yes / No

10) **If yes, does the wall have drainage holes?** Yes / No

Comments ____

11) **Is the access to your business paved?** Yes / No

12) **Does your business have a plan to prepare for natural disasters?**
a. Yes b. No c. No, but want help to create one

Comments____

13) **Does your business have a plan to recover from natural disasters?**
a. Yes b. No c. No, but want help to create one

Comments____

14) **Tick which natural hazards/events have impacted your business and how.**

Extent of damage	Flooding (✓)	Storm surge (✓)	Landslides (✓)	Hurricanes (✓) (wind damage)
Major structural damage (e.g. roof damage, flooded floor)				
Minor structural damage (e.g. cracked window, leaking roof)				
Financial stress				
Forced layoffs				
No major impact				

Comments____

15) **Is your business insured against climate hazards such as:**

i. Hurricanes	a. Yes	b. No	c. Do not know
ii. Storm surges	a. Yes	b. No	c. Do not know
iii. Landslides	a. Yes	b. No	c. Do not know
iv. Floods	a. Yes	b. No	c. Do not know

16) **Do you have extra income or savings to:**
i. Prepare for natural disasters (e.g. hurricanes and floods) Yes / No
ii. Recover from natural disasters Yes / No

Climate Change Knowledge and Views

17) **What is Climate Change?** *Circle your choice.*
a. Moving to another climate, e.g. moving from the VI to Russia
b. An increase in the size of the ozone hole
c. Warmer global temperatures and changes in weather patterns
d. Shorter and cooler summer month

18) **What is the primary cause of Climate Change?**

a. Aerosol spray cans
b. Energy use (producing greenhouse gases)
c. Toxic chemicals (e.g. asbestos)
d. The Ozone Hole
e. Natural cycles
f. Volcanic eruption

19) **How much do you know about Climate Change?**

a. Highly informed
b. Somewhat informed
c. Not informed

20) **What is your view about Climate Change?** *Tick all that apply.*

a. It's not real
b. It's real, but not important for us
c. It's real and important for us
d. It's affecting us already

21) **Which do you think are local impacts of Climate Change? Rate your concern about all relevant impacts in the table. (Select N/A if not a local impact of Climate Change).**

Climate Change Impacts	N/A	Not	Somewhat concerned	Extremely concerned
Stronger earthquakes				
More volcanic eruptions				
More tsunamis				
More frequent floods				
Less overall rainfall				
Stronger hurricanes				
Coral bleaching				
Sea level rise				
Rising temperatures				
Beach erosion				
Increased damage to tourism				
Increased dengue fever				
Loss of biodiversity				
Black sand beaches				
Migration of important fish				
Water shortages				
Increased insurance costs				
Increased energy costs				
Greater demand for "green" tourism				
Increase in tourist spending				
Cooler winter months				
Less tourists seeking winter getaways				

22) **How do you think Climate Change affects (or will affect) your business? Please explain your selection(s) below.**

a. Directly
b. Indirectly
c. Not at all

Comments____

23) Overall, how concerned are you about Climate Change?

a. Greatly concerned b. Somewhat concerned c. Not concerned

24) Would you learn about Climate Change impacts on tourism? Yes / No

25) How did you learn about Climate Change? If you want to know more about Climate Change, please indicate your preference for learning. *(Tick all that apply).*

Information Source	Prior knowledge (✓)	Preference for Learning More(✓)	Information source	Prior Knowledge (✓)	Preference for learning more (✓)
Television			Information packages		
Video distribution			Exhibitions		
Radio			Workshops		
Newspaper			Website		
Presentations			Email		

Taking Action / Practices

26) What actions should the tourism sector take on Climate Change?

a. No action
b. Early actions to reduce impacts, even if they are more costly
c. Early actions to reduce impacts, only if they are not costly
d. Actions when major impacts begin to occur
e. Actions when major impacts become intolerable or more costly than early actions

Comments ____

27) Who should take action on Climate Change? *Tick all that apply.*

a. Government b. Businesses c. Community orgs / NGOs d. Individuals e. All listed
f) Other ____

Comments ____

28) What role do you think natural hazards should play in the site selection and construction of a business?

a. None, in any case insurance will cover losses / reconstruction costs
b. A big role, one should build to maximise resilience to natural hazards
c. Never thought about natural hazards as a consideration for site selection/construction

29) The following actions will help the Virgin Islands respond to Climate Change impacts. Please tick which actions you are already taking, would be willing to take, or need support in taking.

Adaptation actions	Already taking	Willing to take	Not willing to take	Need support in taking	N/A
Avoid operating in hazard prone areas					
Build hurricane and flood proof structures					
Purchase adequate insurance against natural disasters					
Have a plan to prepare for and recover from hurricanes					
Minimise business's overall impact on the environment					
Minimise soil erosion around the property to reduce sedimentation					
Maintain good sanitation to reduce risk of mosquito breeding					
Avoid anchoring on or touching coral reefs					
Dispose of solid waste and sewage properly					
Build industry & political support for key actions					
Conserve energy					
Use renewable energy sources e.g. solar/wind					
Conserve water					
Participate in relevant "green" certification programmes E.g. Green Globe and Blue Flag					

Comments ____

____

30) What, if anything, would affect your business taking the actions identified above? *Please tick all that apply.*

a. Lack of specific information
b. Lack of financial resources
c. Lack of human resources (quantity /expertise)
d. Other priorities
e. Other (please specify)____________________

____

31) **Would you support tourists paying a voluntary "carbon levy" or "environmental levy" collected upon arrival or departure, that would go towards:**
   a) implementing measures to reduce BVI's vulnerability to climate change impacts**?** Yes / No
   b) implementing measures to protect BVI's natural environment? Yes / No
   c) increasing energy efficiency and renewable energy use in BVI's tourism industry? Yes / No

32) **If you would support the "carbon levy" or "environmental levy," how much do you think tourists should pay?**
   a. $1
   b. $5
   c. $10
   d. $15
   e. $20
   f. Other (please specify) ____________

33) **If you support the "carbon levy" or "environmental levy," where do you think it should be collected from tourists?**
   a. Port of entry
   b. Port of departure
   c. Accommodation

   Comments ____

34) **Do you use the following water and energy saving measures at your business? If yes, estimate prevalence. as a percentage of fixtures, energy supply etc**

Water / energy saving measures currently used	Yes (✓)	No (✓)	Don't Know (✓)	Less than 50% (of fixtures / energy supply (✓)	More than 50% (of fixtures / energy supply) (✓)
Smart design faucets *(e.g. timed/metered or motion sensitive)*					
Aerated faucets *(use 0.5 - 2.75 gals/min vs. standard faucets at 3.5 -7 gals/min)*					
Low flow showerheads *(use 1.5 – 2.5 gals/min vs. standard showerheads at 4.5 - 8 gals/min)*					
Low flush toilets *(use 1.6 gals/flush vs. standard toilets at 5 gals/flush)*					
Waterless urinals, dual flush toilets, composting toilets					
Front loader washer machines *(use 25-30 gals/load vs. a standard top loader at 35-55 gals/load)*					
Energy saving light bulbs (compact fluorescent light bulbs)					
Energy star appliances					
Alternative energy (e.g. solar, wind)					
Green landscaping (e.g. smart sprinkler system, mulching, drought tolerant plants)					
Green design (to maximise natural cooling and lighting)					

Other ____

35) **Is your business willing to participate in stakeholder consultations to develop strategies to respond to Climate Change in the tourism sector?** *Circle your answer.* Yes / No

Appendix 3 - Climate Change General Public KAP Survey

Climate Change
General Public Survey

The Ministry of Natural Resources & Labour, the Conservation & Fisheries Department and the Department of Disaster Management are conducting a survey to collect information on the local community's knowledge, attitudes and practices regarding **Climate Change (also known as Global Warming)**.

The information gathered from this survey will be used to develop public awareness programmes, and policies and strategies for Climate Change. **Please answer all questions. Thank you for your participation!**

1. Age Group

a. 18 – 24 yrs b) 25 - 30 yrs c) 31 – 40 yrs d) 41-50 yrs e) over 50 yrs

2. Gender

a. Male b) Female

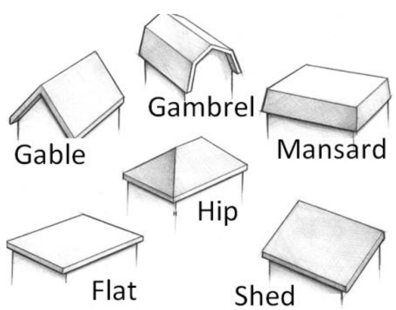
3. Education level

a. High school diploma or equivalent b) Associate's degree c) Bachelor's degree or higher

4. Where do you live? *Circle all that apply.*

a. Immediately along the coastline
b. Flat inland area
c. At the bottom of a hill/valley
d. On a hill
e. In a flood prone area
f. Next to a natural drainage "ghut"
g. On a boat

5. Type of roof (see pictures below) and windows in your home?



a. **Roof shape**: ________________

b. **Is your porch roof separate from your main roof?** Yes / No

c. **Windows**: glass (regular)____ glass (impact resistant)____
wooden____ aluminum____

d. Do you have hurricane shutters? Yes / No

6. Do you have access to cistern water?

a. Yes b. Restricted (e.g. only in kitchen) c. No

7. Do you have problems with water pooling in your yard?

a. Major, widespread pooling b. Minor, limited pooling c. No pooling

8. Do you have a retaining wall at your home? Yes / No

i. If yes, does the wall have drainage holes? Yes / No

9. Have you seen any changes in the Virgin Islands weather patterns over the last 5-10 years?

a) Yes (please explain) ____ b) No

10. Tick which natural hazards have impacted your home and how? *If none, tick here_____.*

Extent of damage	Flooding (✓)	Storm surge (✓)	Landslides (✓)	Hurricanes (✓) (wind damage)
Major structural damage (e.g. roof damage, flooded floor)				
Minor structural damage (e.g. cracked window, leaking roof)				
Financial stress				
No major impact				

11. Is your home insured against climate hazards such as:

v. Hurricanes a) Yes b) No c) Do not know
vi. Storm surges a) Yes b) No c) Do not know
vii. Landslides a) Yes b) No c) Do not know
viii. Floods a) Yes b) No c) Do not know

12. Do you have extra income or savings to:

iii. Prepare for natural disasters (e.g. hurricanes and floods) Yes / No
iv. Recover from natural disasters Yes / No

Climate Change Knowledge

13. What is Climate Change? *Circle one.*

a. Moving to another climate, e.g. moving from the VI to Russia
b. An increase in the size of the ozone hole
c. Warmer global temperatures and changes in weather patterns
d. Shorter and cooler summer months

14. How much do you know about Climate Change? *Circle one.*

a) Highly informed b) Somewhat informed c) Not informed

15. What is the primary cause of Climate Change? *Circle one.*

a) Aerosol spray cans
b) Energy use (producing greenhouses gases)
c) Toxic chemicals (e.g. asbestos)
d) The Ozone Hole
e) Natural cycles
f) Volcanic eruptions

16. Which are local impacts of Climate Change? *(Tick all that apply in the table).*
Rate your concern about selected impacts. 3 = extremely concerned, 2 = somewhat concerned, 1 = not concerned

Climate Change Impacts	(✓)	Rating	Climate Change Impacts	(✓)	Rating
Stronger earthquakes			Increased damage to tourism infrastructure/properties		
More volcanic eruptions			Increased dengue fever		
More tsunamis			Loss of biodiversity		
More frequent floods			Black sand beaches		
Less overall rainfall			Migration of important fish		
Stronger hurricanes			Water shortages		
Coral bleaching			Increased insurance costs		
Sea level rise			Increased energy costs		
Rising temperatures			Increase in tourist spending		
Beach erosion			Less tourists seeking winter getaways		

17.i. How did you learn about Climate Change? *(Tick all that apply in the table)*

ii. Do you want to learn more about Climate Change? Yes / No

iii. If yes, how should we provide more information? (*Tick all that apply in the table)*

Source	Existing knowledge (✓)	Preference for learning more (✓)
Television		
Video distribution		
Radio		
Newspaper		
Lectures /presentations		
Brochures / information packages		
Exhibitions		
Workshops		
Website		
Email		

Your Views and Concerns

18. How does (or will) Climate Change affect you? Please explain your selection(s) below.

a) Directly b) Indirectly c) Not at all

______________________________ ______________________________ ______________________________

______________________________ ______________________________ ______________________________

______________________________ ______________________________ ______________________________

19. Are you concerned about Climate Change?

a) Greatly concerned b) Somewhat concerned c) Not concerned

20. What is your view about Climate Change? *Circle all that apply.*

a. It's not real
b. It's real, but not important for us
c. It's real and important for us
d. It's affecting us already

21. Is the Virgin Islands well prepared for natural disasters, such as strong hurricanes and floods?

a) Yes b) Somewhat c) No

Comments ____

Taking Action

22. What actions should the Virgin Islands take on Climate Change?

a. No action
b. Early actions to reduce impacts, even if they are more costly
c. Early actions to reduce impacts, only if they are not costly
d. Actions when major impacts begin to occur
e. Actions when major impacts become intolerable or more costly than early measures

23. Who should take action on Climate Change? *Circle all that apply.*

a) Government b) Businesses c) Community orgs / NGOs d) Individuals e) All listed
f) Other ____

24. The following actions will help the Virgin Islands respond to Climate Change impacts. Please tick which actions you are already taking, would be willing to take, or need support in taking.

Adaptation actions	Taking (✓)	Willing (✓)	Support (✓)	Adaptation actions	Taking (✓)	Willing (✓)	Support (✓)
Avoid building in hazard prone areas				Avoid anchoring on or touching coral reefs			
Build hurricane and flood proof homes				Dispose of my garbage properly			
Purchase adequate insurance against natural disasters				Maintain my septic tank			
Have a plan to prepare for and recover from hurricanes				Use renewable energy e.g. solar or wind			
Minimise my impact on the environment				Conserve energy			
Minimise soil erosion around my property. *E.g. pave my driveway, plant trees*				Conserve water			
Plant trees				Support climate change adaptation policies			
Maintain good sanitation to reduce risk of mosquito breeding				Other ______________ ____________________ ____________________			

25. What, if anything, would stop you from taking the actions above? *Please circle all that apply.*

a. Lack of specific information
b. Lack of financial resources
c. Other priorities
d. Other (please specify)____

26. Do you use the following water and energy saving measures at your home? If yes, estimate prevalence of use.

Water / energy saving measures currently used	Yes (✓)	No (✓)	Don't Know (✓)	Prevalence (e.g. % of total faucets)
Smart design faucets *(e.g. timed/metered or motion sensitive)*				
Aerated faucets *(use 0.5 - 2.75 gallons/min versus standard faucets at 3.5 -7 gallons/min)*				
Low flow showerheads *(use 1.5 – 2.5 gallons/min versus standard showerheads at 4.5 - 8 gallons/min)*				
Low flush toilets *(use 1.6 gallons/flush versus standards toilets at 5 gallons/flush)*				
Waterless urinals, dual flush toilets, composting toilets				
Front loader washer machines *(use 25-30 gallons/load versus a standard top loader at 35-55 gallons/load)*				
Energy saving light bulbs (compact fluorescent light bulbs)				
Energy star appliances				
Alternative energy (e.g. solar, wind)				
Green landscaping (e.g. smart sprinkler system, mulching, drought tolerant plants)				
Other____				

27. How much do you know about the Virgin Islands Government's Climate Change programme?

a. Highly informed b. Somewhat informed c. Not informed

Appendix 4 - Initial Plans for the Rehabilitation of the Cane Garden Bay Beach Community

INITIAL PLANS FOR THE REHABILITATION OF THE CANE GARDEN BAY BEACH COMMUNITY

PILOT PROJECT TO INTEGRATE SUSTAINABLE DEVELOPMENT WITH BEACH POLICY & PARTICIPATORY MANAGEMENT

Prepared by the Cane Garden Bay Community with consultation from the Conservation & Fisheries Department
17 SEPTEMBER 2010

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EXECUTIVE SUMMARY

The Cane Garden Bay (CGB) beach and the surrounding communities are under severe growing threats from adverse effects of environmental, socio-cultural and economic impacts. Up to this point, piecemeal efforts to mitigate some of these impacts have only proven to be temporary in nature while other efforts have completely failed. This is primarily due to limited and outdated legislation used to manage beaches since no specific beach management plans exist in the BVI. Unless significant changes within both Government and the community are made, either a major disaster will occur or the economically valuable natural resources of CGB will be irreversibly destroyed.

Considering CGB was once slated to be a National Park and has long since been revoked as a proposed park, it has been a long time coming but the community has come together as one voice to demand that Government aids the community in regaining the environmental and socio-economic quality it once displayed. To begin with, a proposed beach policy framework is utilized in this document to identify and better understand the nature of many complex issues in CGB. The framework also helps to reveal how past and present activities and developments have failed to achieve the goal of even the most basic of definitions for sustainability, meeting "the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987).

Numerous consultations and a recent CGB community meeting have elicited this initial plan of action. Although there are over 100 issues identified within this document, environmental and socio-cultural goals have become priority within the community since there has been such an imbalance caused by Government's push towards obtaining economic goals within the Territory, all at the detriment of the natural environment.

The first priority is from an environmental perspective, the re-establishment of the wetland areas in CGB to alleviate flooding. Excessive flooding not only destroys local residential homes and businesses, it has deteriorated the quality of sand on the beach as well as water quality, the health of the coral reef and fishery resources within the bay.

The second priority of this plan is the community's safety, specifically dangerous road structure and crime. Currently there are only two roads that enter CGB from the Ridge Road, neither of which is safe to use and currently lacking adequate plans for repair. With the upcoming tourism season, the conditions of the roads will most likely result in a serious accident. A detailed road plan is needed, complete with proper drainage and designed by a qualified engineer.

Crime is on the rise despite a new police facility within the community. Dinghy theft and personal belongings from yachts continues yet nothing has been done except for charter companies deterring visitors from visiting CGB. Even local residents are experiencing theft of their personal property. The community is starting to look at crime watch programmes but an increase in police staff is still needed, in order to have a presence in the area and to patrol the area during all times of the day and night.

The third priority lies mainly in the hands of Government. In the meantime, the community is in the process of organizing their own authoritative panel that identifies particular roles and responsibilities within the community. The Government needs an over-arching beach policy, individual management plans and a unit devoted strictly to implementing and enforcing such plans. Without this type of commitment to reverse the adverse impacts our beaches have already endured, our future generations will not have the opportunity to even know what a beach is.

BACKGROUND

Over the past year, a small group of Government employees from the Ministry of Natural Resources and Labour, Tourist Board, National Parks Trust, Conservation & Fisheries Department, Environmental Health Department, Trade Department have met on numerous occasions primarily to identify ways in which Brandywine Bay could be developed in order to alleviate over-crowding pressures experienced in Cane Garden Bay. (Hereafter referred to as the beach management group or BMG). However, this same group has identified numerous issues concerning many of the other beaches throughout the Territory. Within the group, a consensus was made that there is a need for an over-arching beach policy in which all beaches and subsequent development within beach communities would follow to ensure the future sustainability of these natural resources.

One issue that arose during the development of the beach policy framework was defining what 'sustainability' means *specifically* to the British Virgin Islands. "Sustainable development" was first defined by the United Nations in 1987 as a 'development which meets the needs of the present without compromising the ability of future generations to meet their own needs". This definition continues to be widely used today and has been expanded to encompass and require a balance between environmental, socio-cultural, economic and governance aspects. However, because sustainability is only relative to its locale, identifying what "sustainable development" is in one area will not necessarily work in other areas because every environ has its own unique and limited resources.

How does the BVI define 'sustainable development' without having any specific goals to measure the accuracy of the statement? Identifying environmental, socio-cultural, economic and governance goals and the measures that can be applied to each component in order to ensure 'the needs of the present without compromising the ability of future generations to meet their own needs' is the first step towards achieving sustainable development locally.

Because sustainability requires a balance between environmental, socio-cultural, economic and governance components, the policy framework was formulated based on specific goals for each of these aspects but specifically for the BVI. The policy framework was further defined to include objectives for each of the goals to help guide the development of individual beach management plans, all based on each beach community's' specific environmental and socio-economic conditions.

The BMG has reviewed and approved of the framework although Government has not approved the policy. The use of the framework is used here to help guide the development of beach management plans in Cane Garden.

MOVING FORWARD

The Government is asked to review this beach policy framework as the basis for a Territory wide action plan towards ensuring sustainable development within all the beach communities throughout the BVI, not just Cane Garden Bay. This top down management approach will not be successful if each beach community does not participate in developing beach management plans for their respective beaches. The combination of using both top down and bottom up approaches has been identified as one of the most sustainable management schemes for coastal zone management throughout the world.

The CGB community has already begun working together and participating in developing a framework for beach management plans specific to CGB. An 'inventory' has been taken because without knowing what exists to begin with, managing an area becomes difficult and mitigation measures and resolutions become ineffective. With a comprehensive list of issues identified and preliminary recommendations made, a priority list has been devised. It is this list that requires the support of the Government.

To begin with, the acceptance and adoption of a Virgin Islands Beach Policy will not only benefit CGB, but the entire Territory. Secondly, the implementation of a governmental unit devoted specifically to beach management planning, implementation and enforcement is critical. Without a governing body held accountable for ensuring goals are met towards sustainable development, further uncontrolled exploitation of our natural resources will render our economic dependence on tourism invalid.

Next, the Government's support is needed to begin mitigation on issues identified in this document. Restoration of the wetland areas will be the most costly in the short term but in the long term will be justified by fewer funds having to be used for repairs from constant flooding, which is only expected to worsen as climate change continues. For now, the community needs temporary measures put in place prior to the rainy season. A long-term project to fully restore the wetlands will come in the future once land is acquired. A team of engineers, hydrologists and wetland restoration experts are currently being sought in order to begin temporary works with long term plans in mind in order to do this in the most sustainable manner from the beginning.

The cost for such work, not including the purchase of lands will be approximately $10 million to begin this process. While other funding opportunities are being sought through grants, this will aid in bringing in the most qualified people possible to implement and mitigate one of the most damaging problems in CGB. Excess funds will be put towards infrastructure such as road works and public safety.

While costs are high, opportunities exist to raise this type of funding. Environmental levies on cruise ships or departing visitors, or taxes on financial services are just a few. In order to reverse the damage already caused to our beaches and to ensure continuing tourism based on our natural resources, we have reached a critical point in which action is needed immediately. If we continue to exploit the very resources people come to visit our islands, we will not be leaving the same legacy our forefathers gave to us.

On the following pages you will find a synopsis of the issues and recommendations already identified to work from. The presentation given at the community meeting is also printed with photos depicting the issues. Next you will find an image showing where the ponds once existed in CGB. Lastly, you will find minutes from the community meeting held 9 Sept. 2010 as well as several complaint letters from visitors.

	POLICY GOALS	KEY OBJECTIVES	CGB / BB MANAGEMENT ISSUE	RECOMMENDATIONS
ENVIRONEMENTAL	**1. Improved management of marine & fisheries resources** *Fisheries Act 1997* *Fisheries Regulations 2004* *National Parks Act 2007* *National Parks Regulations 2008* *Protected Areas systems Plan 2007-2017* *Protection of Trees & Conservation of Soils & Water Ordinance (1954)* *Public Health Ordinance 1977*	**Maintain optimum water quality for bathing and coral reefs throughout the year**	• Water is contaminated with pollution from runoff • Sewage pipe only extends 40ft into the bay • Sewage from boats is pumped directly into the bay	• Proper legislation regarding *required use of holding tanks* on yachts must be established • Water quality standards (bathing and marine life) needed for the BVI • Sewage effluent pipe needs to be extended from current location of 40ft off the beach to 100ft beyond the reef crest to ensure dilution of effluent • Pump-out station needed in CGB • All drainage from roads needs to be properly engineered to redirect water flow to ponds, or some type of permeable catchment / settling area • Waterfront road needs drainage and graded away from the beach • All buildings bordering the waterfront road need to be inspected for leaking sewage problems and mitigated by the Environmental Health Department's recommendations • "Noxious substance" under the VI Fisheries Regulations 2003 needs to be clearly defined • Penalties for emitting "noxious substances" into the fishery waters must be raised to $10,000.
		Reduced anthropogenic stressors	• Lack of proper maintenance of moorings in bay • Lack of "No Wake" signs between dock and entrance to the bay	• Moorings policy set forth by NPT needs implementation • Moorings need to be inspected once a month • "No Wake" signs need to be placed within the bay • A Marine Spatial Zoning plan is needed • Fines (minimum $1000) need to be established for all vessels exceeding speed limit (including jet skis, dinghies, etc)
		Preservation / protection of marine habitats & species	• Increased garbage accumulation found inside the bay along the reef	• Legislation regarding coral damage is only $1000, this fine needs to be increased to $5000 *per square meter* of damage • Establish bi-annual dive clean ups in the bay

ENVIRONMENTAL	**2. Reduction of vulnerability to climate change** *Beach Protection Ordinance 1985* *Land Development Guidelines 1972* *Planning Act 2004* *Climate Change Adaptation Strategy*	**Ensure coastal stability / resiliency in the event of a natural disaster**	• Recurrent flooding throughout the low-lying areas • Seawalls are collapsing • Sand / rock over-wash on waterfront road during swell events • Heavy rainfall causes falling rock along roads	• Engineering plans required for water flow to be redirected into temporary settlement ponds until wetland areas are re-established (TEAM OF ENGINEERS, HYDROLGISTS AND WETLAND EXPERTS REQUIRED) • Engineering plans required for seawalls to diffuse incoming waves (sediment transport analysis required along with a qualified coastal engineer) • Geo-tech engineer required to survey CGB /BB to make recommendations
		Reduced consumption of nonrenewable resources	• Excessive use of plastics, polystyrene containers end up on the ground in public areas • Recycling is non-existent • Composting has not been implemented	• Require all CGB /BB businesses (grocery stores, restaurants) to begin using biodegradable plastic bags, cups, containers and plastic ware • Implement a composting programme
		Implementation of a "Climate Change Response Plan"	Lack of plans (funds) for businesses, homes that become condemned in the event of storm surge or tsunami, sea level rise • Lack of a bleaching warning system	• Establish a plan of action for future structural collapses (i.e. demolition, alternate style of structure) • Establish a "local conditions" board for visitors to see what may be going on in the bay, to include bleaching warnings(See Environmental Education section)

ENVIRONMENTAL	**3. Improved watershed management** *Building Ordinance 1955* *Disaster Management Act 2003* *Government Salt Ponds Ordinance (1904)* *Hazard Mitigation Policy* *Planning Act 2004* *Plant Protection Ordinance (1953)-Cap 93* *Protection of Trees & Conservation of Soils & Water Ordinance (1954)* *Ramsar* *World Heritage*	**Maintain natural hydrology of the watershed**	• During rainfall, excessive fresh water flows directly into the bay (often contaminated with pollutants) • Increased impermeable areas due to increased development within the watershed • Ghuts blocked with debris	• **THIS WILL REQUIRE A TEAM TO INCLUDE AT LEAST A HYDROLOGIST, WATERSHED PLANNER, ENGINEER AND WETLAND SPECIALIST QUALIFIED AND EXPERIENCED WITH TROPICAL ISLANDS** • Produce a watershed assessment (include landscape / landform characteristics, flow pathways, watershed elevations, discharge calculations for major storm events, upper watershed, etc) • Produce a phasing plan for implementation of a storm water / wetland restoration with buffer zones (first phase is temporary and only for the purpose to minimize damage in the short term)
		Wetland / salt pond restoration / preservation	• Four ponds in CGB have been filled in and are no longer functional • Lack of buffer zones	
		Storm-water management	• Past piecemeal efforts to reduce flooding have been ineffective	
		Reduction of island erosion	• Removal of vegetation is currently not mitigated with silt fencing, especially on hillsides • Trucks consistently dump	• Implement a fine of at least $500 for any development within the entire CGB watersheds that are not using silt fencing. Roads paved within 10 days of excavation are exempt • ALL developments must be required to submit a plan for removal and disposal of all excavated material

	Convention		excavated material off the side of ridge roads	• Fines of at least $5000 required for any material being disposed of off / over hillsides, ridge roads
ENVIRONMENTAL	**4. Preservation of biodiversity** *Endangered Animals & Plants Ordinance* *Plant Protection Ordinance (1953)* *Protection of Animals Act (1935)* *Protection of Trees & Conservation of Soils & Water Ordinance (1954)* *Wild Birds Sanctuary Order (1959)* *Ramsar Convention* *Bonn Convention* *Convention on the International Trade of Endangered Species(CITES)* *Convention on Biological Diversity*	**Endangered, threatened or locally important flora / fauna and their habitat is preserved / protected**	• Lack of a localized recognition of endangered, threatened and locally important species (will be used in conjunction with the IUCN's Red List, CITES) • Loss of abundance of bird life within the bay / degraded wetland areas	• Proper legislation identifying what are the endangered, threatened and locally important species in the BVI is required
		Maintain habitat representation	• Lack of detailed mapping of vegetation of all CGB watersheds	• As part of the watershed restoration project, production of maps depicting vegetation types , including areas of importance (endangered, threatened or locally important species)
		Restoration / enhancement of degraded areas	• Numerous waterfront buildings in need of structural repair for aesthetic purposes • Music Fest grounds are in a derelict state and aesthetically displeasing	• Establish a Homeowners Association that will require building standards for the CGB /BB community (see also Maintaining / Increasing property value) • Re-establish Music Fest grounds in to a green space (complete removal of sand, gravel, tamarind, etc.) Vendors are not allowed in this area
		Reduce or eradicate invasive species	• Lionfish currently a threat in the BVI • Wild Tamarind currently growing on the beach, potential to cover entire	• Identify locations of invasive species, produce an Action Plan for removal • Provide lionfish markers / information at local restaurants for snorkelers (see Environmental education section) • Establish a beautification plan to begin clearing out parasitic weeds and noxious plants

	(CBD)		beachfront area	
ENVIRONMENTAL	**5. Improved environmental awareness** *No legislation regarding environmental education*	**Physical presence of educational material about the environment**	• Lack of *any* information regarding the beach (historical locations, water quality, emergency services, etc) • Lack of participation from the school	• Implementation of a Territory wide environmental curriculum in primary & secondary schools • Implement an "Adopt a beach" programme (such as Sandwatch) at the Ivan Dawson Primary School • Establish informational boards in at least two locations in CGB for residents and visitors that includes a map of CGB / BB, water quality for the week, locations of emergency services, emergency contact phone numbers • Establish educational signs throughout CGB about coral reefs, wetlands, birds, etc)
		Implement a monitoring programme	• Lack of water quality testing on a regular basis • Lack of reef monitoring	• Establish CGB / BB as one of the ReefCheck sites • Establish regular scheduled water quality testing • Establish monitoring protocols for water quality, coral reefs, wetlands, avifauna, invasive species, terrestrial habitats of importance
		Application of up-to-date scientific knowledge for policy & management	• Lack of gov't / non gov't agency that strictly deals with beach management • Limited access to scientific literature; lack of University level support	• Establish a governmental unit strictly devoted to beach policy / management • Establish membership with various scientific databases (e.i. ScienceDirect, etc) for up to date scientific literature on beach processes, management, biodiversity, etc

SOCIO-CULTURAL	**6. Improved quality of life for the individual / visitor** *Building Ordinance 1955* *Planning Act 2004* *Tourist Board Ordinance 1968*	**Implementation of a social beach carrying capacity**	• Excessive / uncontrolled numbers of tour operators visiting CGB • Lack of alternative activities near the beach	• Develop a Cruise Ship Policy that limits the number of cruise ships per day to the Territory • Set the maximum number of cruise ship passengers visiting CGB to a total of 750 people per day (Calculation derived from Baud-Bovy & Lawson, 1998 where each person has approximately $8m^2$ of space per person at a regular public beach but at a 'high standard' beach, each person has approx. $20m^2$ of space. The calculation of 750 people is classified to be between a 'high standard' public beach and a regular public beach). • Identify a plan of action for establishing walking trails / tours throughout CGB
		Ensure public recreational green space and public access	• Aside from the sandy area of the beach, no space for sitting in the shade / rest areas	• Identify 4-5 'green space' areas such as location of the 2010 Music Fest area and develop into public parks spaces (restored wetland areas may be used as part of these 'green spaces')
		Initiate conflict resolution measures	• Lack of zoning on land • Lack of harassment laws • Competitive vendors clearly exploiting visitors • Excessive traffic from safari buses, taxis	• Remove all illegal vendors, structures currently existing on the beach • Establish zones along the beach where activities can / not occur (EXAMPLE: no beach chairs / vendors directly in front of the cemetery) • Limit the number of beach chairs on the beach to 500 • Establish Trade Laws where the penalties include confiscation of all products being sold from an illegal vendor, second offence being $5000. • Provide a 'code of conduct' in the same place where environmental information is located (see Environmental Education) • Stringent anti-harassment laws need to be established to reduce conflict between locals and visitors • Increase the presence of the police in CGB during cruise ship season

		Maintain / improve basic way of life	• Very few public restrooms – must be able to accommodate 750 people (max number of people under the calculated carrying capacity) • Poorly maintained restrooms • Lack of lighted sidewalks • Degraded waterfront road • Ivan Dawson needs modernizing • Lack of parking areas • Lack of youth programmes	• Establish / upgrade public restrooms to at least 5 toilets for each male & female facilities with at least 1 handicapped facility • Hire restroom attendants during cruise ship days • Repair the waterfront road (grade away from the beach) and include a sidewalk for the entire length of the bay • Upgrade school facilities • Implement zoning for public parking areas • Devise community youth programmes, possible participation in beach management
	7. Improved overall environmental health *Public Health Ordinance 1977*	**Improved air / noise quality**	• No regulations regarding burning • No clear regulations regarding bonfires • Late night loud music	• Establish specific times when burning is allowed • Enforce the Noise Abatement Act • Establish areas specifically for bonfires
		Improved management of water, sewage, solid & hazardous waste	• Excessive derelict vehicles and boats throughout the community • Sewage problems at Ivan Dawson • Limited beach warden staff & equipment (funding issue) • Lack of garbage receptacles throughout the waterfront • Unsightly display of dumpsters	• Inform the community of the Derelict Vehicle Act and notify Solid Waste to devise a plan of action • Inform Environmental Health to complete a full inspection of the school • Design and plan for locations of various sizes of garbage receptacles • With a separate unit devoted specifically to beach management, beach wardens and lifeguards would fall under this new unit; funding opportunities either through an environmental levy placed on cruise ships, environmental tax for financial services or through the airport tax

		Reduced risk of disease	• Uncontained livestock (chickens) • Feral cats & dogs • Excessive rats • Presence of excessive mosquito infestations during certain times of the year	• Initiate regular fogging schedule for mosquitoes • Removal of all uncontained livestock • Notification to the humane society to remove stray dogs (Possible establishment of a 'pets from paradise programme' for overseas adoption) • Establish a rat eradication programme
SOCIO-CULTURAL	**8. Strengthening of community infrastructure** *Resolution No. 7 of 1989 (Access to a beach*)	**Improved access**	• Ballast Bay is not currently fully included with the CGB community • Eastern road is in dire need of resurfacing and proper drainage • Western road (Ballast Bay) is undermined and dangerous • Lack of public transportation for local residents	• Engineering plans from a qualified engineer and hydrologist to improve road structure & drainage • Western access road needs to be redesigned to withstand heavy rainfall • A new access road in / out of CGB needs to be created in the event current road access is impaired (such as the current situation) • Identify district allocation for financing a local service for CGB residents • Ballast Bay must be included for all CGB management plans

		Improved public utilities	• Too few restrooms and most are poorly maintained • Lack of functional public telephones • Lack of public fresh water access • Exposed / derelict electrical lines	• Establish / upgrade public restrooms to at least 5 toilets for each men & women and at least 1 handicapped facility • Hire restroom attendants during cruise ship days • Establish outdoor showers for rinsing salt water off • Identify locations for fresh water fountains (drinking water) • Repair broken phones • Increase vandalism fines to $1000 • Begin phasing to bury electrical / phone lines
		Improved emergency services & safety	• Increased incidents of theft of dinghies, personal property from yachts, local residents • Poor police response within CGB area despite new facility • Lifeguards lack proper facilities for handling minor injuries, equipment storage, Lack of shaded and raised lifeguard towers • Lack of information regarding emergency contacts for visitors • Lack of emergency phones for visitors	• Develop a lifeguard facility within CGB • Construct at least 2 raised towers for lifeguards • Establish a method of accountability of police officers stationed at CGB • Provide visible public information regarding general emergency information, including contact numbers • Introduce a community crime watch programme • Increased lighting throughout the low-lying areas • Repair broken phones
	9. Preservation of cultural heritage *Planning Act 2004* *World Heritage Convention*	**Preservation / restoration of historical assets**	• Historical ruins are in state of disrepair • Lack of historical documentation of CGB community for educational purposes • Loss of traditional functions, behaviors seine boat skills • Fishing boats are hauled in a haphazard manner	• Establish an action plan for restoration / preservation of historic ruins • Establish a working group to produce a book documenting the history of CGB • Identify zones for fishing boats to be hauled on the beach, possibly have them painted in an aesthetically pleasing manner

		Community engagement and co-management of the beach environment	• Lack of communication amongst community • Lack of means to build capacity within the community	• Establish a means of communication through a public notice board • Establish a means of communication through an internet list serve • Development of a website • Introduce capacity building presentations for the community (potential work with college students)
ECONOMIC	**10. Reduction of economic vulnerability** *Disaster Management Act 2003* *Hazard Mitigation Policy*	**Ensure resiliency against natural disasters (flooding, storms, hurricanes, earthquakes, landslides and tsunamis)**	• Lack of updated storm surge vulnerability assessments • Limited data regarding beach morphology • Lack of a complete hazard vulnerability assessment based on geologic characteristics (i.e. areas more prone to rock fall, etc)	• Engineer water flow from hillsides, roads to be redirected into re-established wetland areas • Re-engineer seawalls to diffuse incoming waves (sediment transport analysis needed along with a qualified coastal engineer) • Geo-tech engineer required to survey CGB to make recommendations • Develop storm surge vulnerability maps, including various degrees of sea level rise
		Expand, upgrade and diversification of products and services to maintain international competitiveness	• Current businesses need to be upgraded • Customer service needs improvement • Competition needs to have capped pricing • Alternative activities at the beach (trails, hikes) • Fewer & fewer visitors CGB	• Introduce customer service workshops for business owners, employees • Produce an action plan for developing hiking trails • Identify potential snorkeling trails • Identify potential historical tours through CGB / Ballast Bay
	11. Maintain or increase property and habitat value *Planning Act 2004*	**Property & aesthetic values remain the same or increase**	• Current waste in neighboring yards decreasing property values • Commercial areas are devoid of vegetation and any aesthetic value • General condition of CGB is turning “ghetto”	• Develop a plan of action for community clean-up with solid waste • Clear chain fencing around the Park in CGB • Development of a CGB /BB master plan

		Habitat value (functionality) remains the same or is enhanced	• Sand is beginning to look dull / gray, not as 'white' as it once was • Lack of accommodation space for the beach to retreat landward due to sea level rise • Setback regulations of 50 ft from the high water mark (dated from 1972)are not current with scientific knowledge of development impacts on the beach	• Setback regulations need to be reviewed and sight specific conditions need to dictate what the setback should be • The term 'foreshore' needs to be defined to include the dynamic nature of the shoreline • As wetlands are re-established, a mangrove reforestation programme needs to be implemented • Create 30' buffer zones around wetland areas and behind the vegetation line of the beach
GOVERNANCE	**12. Effective use of legislation & regulations** *Includes numerous laws of the Virgin Islands*	**Maintain compliance under laws / regulations of the BVI**	• Nepotism prevalent, "lawless country" • Lack of knowledge of laws	• Produce a code of conduct book for CGB / BB that includes how to deal with legal issues, who to call, etc
		Creation of mechanisms for noncompliance	• General lack of understanding of how to resolve legal issues • Lack of respect for leadership • Lack of who plays what role within the community	• Produce a code of conduct book for CGB / BB that includes how to deal with legal issues, who to call, etc
	13. Accountability *No legislation regarding accountability*	**Create beach Management Plans for individual beaches**	• Lack of overarching beach policy and any management plans for CGB • Lack of an authority solely dedicated to beach management	• Implementation of an over-arching beach policy (framework outlined within this document) and the development of a Cane Garden Bay / Ballast Bay Beach Management Plan • Introduce a 'secret shopper' programme in CGB to identify continual and emerging issues
		Ensure transparency & collaboration amongst	• Lack of trust between the Community needs & Government's actions	• Establish a list-serve for community interaction through the internet • Creation of a CGB / BB website • Establish clear roles and responsibilities within the community as well as through Government or a governmental unit strictly devoted to beach

		stakeholders (clarify roles)		management
		Implement adaptive management strategies to changing environmental, economic and social conditions	• Publicly available, easily accessible records of plans, reports, standards	• Establish a location within the community website for housing reports, standards, etc • House all reports, standards, plans, etc within governmental unit strictly devoted to beach management

Appendix 5 - Summary of Environmental Laws Relevant to Climate Change Adaptation & Mitigation

Title of Statue	Objective	Limits (as information from prior reviews was available)	Responsible Agency
The Beach Protection Ordinance 1985	Prohibits the removal of natural sea barriers, beach sand or any other removal that is likely to result in shoreline erosion. This Act also applies to the fouling of the foreshore.	-Exceptions can be made at the Minister's discretion upon application in writing for a permit. -Fails to prohibit destructive activities that can adversely affect the coastal zone such as the removal of vegetation -Lacking management systems - Provides no authority to close the beach for the purposes of preserving any element of the environment.	Conservation and Fisheries Department

Title of Statue	Objective	Limits (as information from prior reviews was available)	Responsible Agency
Wild Birds Protection Act 1959	This ordinance provides protection for approximately 31 species of rare or endangered wild birds, their eggs, nests, and young, except as authorised by the Governor for the purposes of bona fide research, at any time and under any conditions. Environmentally significant is the power to designate bird sanctuaries (S. 11) and the prohibition of certain activities within the sanctuary (20 sanctuaries already designated). Enforcement is by the Police Force and any others so designated by the Governor.	-Needs updating reflect current bird population	Conservation and Fisheries Department
The Turtles Ordinance, (1986) and the Turtles Act (1992) (CAP. 87)	In 1992, the Turtle Ordinance was replaced with the Turtles Act (1992). The Act protects Leatherback, Green and Hawksbill Turtles (those with a shell length greater than 24 inches) and their eggs at all time. The capture of turtles is prohibited on onshore areas and 100 yards thereof at all times.		Conservation and Fisheries Department
Virgin Islands National Parks Act 2006	This Act is the most recent and far-reaching of the legislative instruments dealing directly with protected areas, and repeals the National Parks Ordinance (Cap. 243) and the Marine Parks and Protected Areas Ordinance (Cap. 85). It introduces provisions for the management of historical sites by the National Parks Trust, provides guidance on management planning, and specifically requires the preparation of a protected areas system plan (Section 13(1).		National Parks Trust

Title of Statue	Objective	Limits (as information from prior reviews was available)	Responsible Agency
Fisheries Act No. 4 of 1997	To protect and preserve the fishing industry and to monitor and control the use and harvesting of fish, the location where and the manner in which fish are caught as well as the vessels and equipment used in fishing. Provisions give authority for licensing and associated fees. The Minister is also given authority to declare any area a fishing priority area or a protected area and penalties attach for anyone not respecting these designations.		Conservation and Fisheries Department
Protection of Trees and Conservation of Soil and Water Act, (Cap 86) 1954	S. 3 provides for the declaration by Order of any tree to be a protected tree or any area to be a protected area, forestry area or water area. Areas can be protected for purposes of preservation and protection of trees, prevention of soil erosion and interference with agricultural land as well as the maintenance of water supply, prevention of silting and avoidance of water pollution. There is great opportunity to protect threatened or endangered trees in the Territory such as the century tree and mangroves.	Protection of a tree or area depends mainly on the results of public enquiry.	Agricultural Department
Endangered Animals and Plants Act 1987	Local enabling legislation for the Convention on International Trade of Endangered Species (CITES)— stipulates what animals and plants are classified	-Lists coral but needs to be updated with a list of Caribbean species needing protection	Conservation and Fisheries Department

Title of Statue	Objective	Limits (as information from prior reviews was available)	Responsible Agency
	as endangered and how these species are to be managed. The Act stipulates penalties with respect to removal or unauthorised treatment of endangered animals.		
Plant Protection Act, (Cap 93) 1941	The Act gives general control over the importation and exportation of and general dealing with plants (defined) and by-products. In particular, it aims to prevent, eliminate or minimise the entry, existence or effect of pests or diseases into the environment and where needed, to stipulate quarantine areas.		Agricultural Department, Customs Department
Agricultural and Small Holdings Act (Cap. 83) 1939	This Act applies to contracts of tenancy for agricultural purposes in regards to properties ranging from ¼ acre to not more than 25 acres. It also aims to protect rules of good husbandry, conservation of soil, maintenance of fertility and preservation of the capital value of the holding.		Agricultural Department
British Virgin Islands Ports Authority Act 1990	The Act is generally directed to the safe use and management of waterways and harbours. It addresses the mooring, docking or moving of vessels and how to deal with wrecks.		Virgin Islands Ports Authority

Title of Statue	Objective	Limits (as information from prior reviews was available)	Responsible Agency
Importation Prohibition (Epidemic Diseases) Act (Cap 179) 1903	The aim of this legislation is to prevent diseases from being brought into the country. By this Act, Health authorities may require visitors from certain countries to be screened before being allowed to enter into the Territory without infringing.	It may also be useful to include insects in the provisions.	Environmental Health, Public Health
Infections Diseases Notification Act (Cap 180) 1990	The legislation requires all persons suffering or suspected to be suffering from an infectious disease to be reported to the proper authorities.	The penalties for failing to so report are negligible. Additional provisions addressing quarantine and the establishment of an infectious disease ward/clinic should be introduced. It would also be prudent to address the treatment of persons at ports of entry suspected to be suffering from or to have been exposed to infectious diseases.	Environmental Health, Public Health
Public Health Act, (Cap 194) 1977	There are broad regulation making powers in relation to: the control and destruction of termites, mosquitoes and other insects, rodents or vermin; sewers;		Public Health Department

Title of Statue	Objective	Limits (as information from prior reviews was available)	Responsible Agency
Water Supply Act 1956	The Governor is given authority to declare any area within the Territory a water supply area and to appoint superintendents of any such area.		Water and Sewerage Department
Buildings Ordinance (Cap 234) 1955	Control and monitors the erection and removal of buildings on land, including building standards. It also addresses sanitary arrangements and water storage facilities. The Act can be extended to the establishment of a zoning system.		Building Authority
Virgin Islands Physical Planning Act 2004 (note: Regulations from Land Development Control Act 1969 still in effect until new regulations developed)	Makes the provisions for the orderly and progressive development of land and to preserve and improve amenities. Requires environmental impact assessment (EIA) with application for major developments or developments in the coastal zone	-Requires the EIA unless Authority otherwise determines but does not state what conditions may apply -Building set backs from coastline not sufficient -Does not sufficiently address building in floodplains -more oriented towards regulating the use and development of land rather than for overall physical development	Town and Country Planning Department

Title of Statue	**Objective**	**Limits (as information from prior reviews was available)**	**Responsible Agency**
Land Acquisition Act (Cap 222) 1957	This legislation authorises the Governor in Council to acquire land for public purpose. It provides for the procedure and compensation for so doing along with appeal provisions.		
Wickhams Cay Development Authority Act 1975	This legislation establishes the Wickhams Cay Development Authority to promote and manage the Development of Wickham s Cay. The authority is given all necessary powers to effect the development and management of the Wickham s Cay area. (note: Wickham's Cay is the main financial and administrative district of the country)	The Wickhams Cay projects involved reclaiming and development of land. There does not appear to be any contemplation of the environmental impact of such a project.	Wickhams Cay Development Authority
Disaster Management Act 2003	An Act to provide for the more effective organisation of the mitigation of, preparedness for, response to and recovery from, emergencies and disasters in The Virgin Islands and other matters connected therewith.		Department of Disaster Management
Tourist Board Ordinance 1968	Provides the institutional framework for the development, promotion and management of tourism within The Virgin Islands. Implies obligations to protect and enhance the	-Does not grant the Board authority to protect the coastal zone.	Office of the Premier, Tourist Board

Title of Statue	Objective	Limits (as information from prior reviews was available)	Responsible Agency
	environment of The Virgin Islands as a tourist amenity		
British Virgin Islands Electricity Corporation Ordinance 1979	Establishes the BVI Electricity Corporation and rules for its governance and the production of power.	Does not allow businesses or individuals to use alternative energy as a primary energy source.	BVI Electricity Corporation

Source: (Orion Consultancy Services Ltd. & Samuels Richardson and Co. Ltd., 2004; Gore 2007)

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