# CLIMATE CHANGE ADAPTATION PLANNING ASSESSMENT AND IMPLEMENTATION

## FINAL VULNERABILITY AND RISK ASSESSMENT REPORT

**A REPORT PREPARED BY THE UNIVERSITY OF THE VIRGIN ISLANDS, AND THE UNIVERSITY OF THE WEST INDIES, MONA**

**Project Title: Climate Change Adaptation Planning Assessment and Implementation**

**U.S. Department of Interior Grant Award Number D18AP0048**

**Project years: September 2016-September 2019**

**Investigators:**
**Dr. Camille McKayle**
Provost and Vice President for Academic Affairs
University of the Virgin Islands
#2 John Brewers Bay
St Thomas, VI 00802
cmckayl@uvi.edu

**Dr. Greg Guannel**
Director, Caribbean Green Technology Center
University of the Virgin Islands
#2 John Brewers Bay
St Thomas, VI 00802
gregory.guannel@uvi.edu

**Dr. Michael Taylor**
Dean, Faculty of Science and Technology
University of the West Indies
Mona, Jamaica
michael.taylor@uwimona.edu.jm

**Dr. Tannecia Stephenson**
Head of Department,
Department of Physics
University of the West Indies
Mona, Jamaica
tannecia.stephenson02@uwimona.edu.jm

# Contents

**LIST OF FIGURES** ..... **6**

**LIST OF TABLES** ..... **9**

**LIST OF ACRONYMS** ..... **10**

**1 INTRODUCTION** ..... **12**

1.1 PURPOSE ..... 12
1.2 THE PROJECT OBJECTIVE AND RATIONALE ..... 12
1.2.1 Project Objective ..... 12
1.2.2 Project Rationale ..... 12

**2 CONTEXTUAL SETTING** ..... **13**

2.1 THE UNITED STATES VIRGIN ISLANDS TERRITORY ..... 13
2.1.1 St. Thomas ..... 13
2.1.2 St. John ..... 14
2.1.3 St. Croix ..... 15
2.2 CLIMATE CHANGE AND CLIMATE CHANGE ISSUES ..... 16
2.2.1 Global Setting ..... 16
2.2.2 Regional Setting ..... 17
2.2.3 Local Setting ..... 17
2.3 SOCIOECONOMIC SETTING ..... 18
2.4 ECONOMIC SECTORS ..... 19
2.4.1 Tourism ..... 20
2.4.2 Agriculture ..... 22
2.5 POLICY LEGAL AND INSTITUTIONAL SETTING ..... 24

**3 METHODOLOGY** ..... **26**

3.1 ASSESSMENT OF SELECTED APPROACHES TO VULNERABILITY ASSESSMENT ..... 26
3.2 SENSITIVITY ANALYSIS ..... 27
3.2.1 Climate Sensitivity/Risk ..... 27
3.2.2 Sector Sensitivity ..... 27
3.3 HAZARD MODELLING ..... 30
3.4 ADAPTIVE CAPACITY ANALYSIS ..... 32
3.5 VULNERABILITY ASSESSMENT AND MAPPING ..... 33
3.6 RISK ASSESSMENT FOR INFRASTRUCTURE ..... 34
3.7 ADAPTATION STRATEGY AND ACTION PLANNING ..... 35

**4 SENSITIVITY ANALYSIS** ..... **36**

4.1 CLIMATE SENSITIVITY ..... 36

4.1.1 Existing Climate Setting ..... 36
4.1.2 Projected Climate Profiles ..... 38
4.2 Projected Hazard Sensitivity ..... 39
4.2.1 St. Thomas ..... 40
4.2.2 St. Croix ..... 41
4.2.3 St. John ..... 43
4.3 Socioeconomic Setting and its Sensitivity ..... 46
4.3.1 St. Thomas ..... 46
4.3.2 St. John ..... 48
4.3.3 St. Croix ..... 50
4.4 Sensitivity of the Tourism Sector ..... 54
4.4.1 Assets ..... 54
4.4.2 Threats ..... 56
4.5 Sensitivity of the Agricultural Sector ..... 58
4.5.1 Assets ..... 58
4.5.2 Threats ..... 60
4.6 Sensitivity of Critical Infrastructure ..... 61
4.6.1 Assets ..... 61
4.6.2 Threats ..... 64
4.7 Summary Sensitivity Analysis ..... 68
**5 ADAPTIVE CAPACITY ANALYSIS ..... 74**
5.1 Review of Policy and Legislation ..... 74
5.1.1 Legal Context ..... 74
5.1.2 USVI Policy ..... 75
5.1.3 Climate Change ..... 76
5.1.4 Wetlands ..... 77
5.1.5 Legislation ..... 77
5.2 Overview of Key Institutions Relating to Climate Change ..... 89
5.2.2 Policy Legislative and Institutional Gaps ..... 93
5.3 Institutional Capacity Issues ..... 94
5.3.1 Agriculture ..... 94
5.3.2 Tourism ..... 94
5.3.3 Critical Infrastructure ..... 95
5.4 Private Sector ..... 95
5.5 Civil Society ..... 95
5.6 Summary Adaptive Capacity ..... 97

**6 VULNERABILITY ASSESSMENT ..... 107**

6.1 SOCIOECONOMIC IMPACT ..... 107
6.1.1 St. Thomas ..... 107
6.1.2 St. Croix ..... 110
6.2 CRITICAL INFRASTRUCTURE ..... 115
6.2.1 St. Thomas ..... 119
6.2.2 St. Croix ..... 124
6.2.3 St. John ..... 127
6.3 TOURISM ..... 130
6.4 AGRICULTURE ..... 136
6.5 SUMMARY VULNERABILITY ..... 139

**7 RECOMMENDED PLANNING AREAS ..... 147**

7.1 SOCIOECONOMIC ..... 147
7.2 POLICY AND LEGAL ..... 147
7.3 TOURISM ..... 147
7.4 AGRICULTURE ..... 148
7.5 CRITICAL INFRASTRUCTURE ..... 148
7.6 OTHER ..... 149

**8 PRELIMINARY TERRITORIAL ADAPTATION STRATEGY AND ACTION PLAN ..... 151**

8.1 INTRODUCTION ..... 151
8.2 STRATEGIC OBJECTIVES AND OUTCOMES ..... 151
8.2.1 Planning Area 1: Socio- economic Setting ..... 152
8.2.2 Planning Area 2: Policy Legal and Institutional ..... 156
8.2.3 Planning Area 3: Tourism ..... 158
8.2.4 Planning Area 4: Agriculture ..... 162
8.2.5 Planning Area 5: Critical Infrastructure ..... 165
8.2.6 Planning Area 6: Institutional Capacity ..... 171
8.3 IMPLEMENTATION OF THE STRATEGY ..... 174
8.4 MONITORING AND EVALUATION ..... 174

**9 REFERENCES ..... 175**

**APPENDICES ..... 183**

APPENDIX I ..... 183
APPENDIX II ..... 185

# List of Figures

Figure 2.1: St Thomas: Topography and Settlement ..... 14
Figure 2.2: St. John: Topography and Settlement ..... 14
Figure 2.3: St. Croix: Topography and Settlement ..... 15
Figure 2.4: Observed globally averaged combined land and ocean surface temperature anomaly 1850 – 2012 (IPCC, 2013) ..... 16
Figure 2.5: Change in Sea Surface Temperatures since 1901 (Environmental Protection Agency, 2016). 18
Figure 2.6: The shoreline at Cinnamon Bay in St. John experiencing erosion (Pendleton, 2004) ..... 18
Figure 2.7: Direct and Total Contribution of Travel and Tourism to GDP (World Travel and Tourism Council, 2017) ..... 20
Figure 2.8: Total Number of Visitors and Cruise Passengers to USVI (1990-2015) (Bureau of Economic Research, 2016) ..... 20
Figure 2.9: Bleached Colonies of Boulder Star Coral ..... 21
Figure 2.10: Market Value of Agricultural Products Sold: 2007 and 2002 (United States Department of Agriculture, National Agricultural Statistics Service, 2009) ..... 23
Figure 3.1: Community Consultation in St. Thomas ..... 28
Figure 3.2: Community Consultation in St. Croix ..... 28
Figure 4.1: FEMA Flood Zones for St Thomas ..... 40
Figure 4.2: Flooding due to sea-level rise on St Thomas ..... 40
Figure 4.3: Difference in Flood Depths for a 100-year 72-hour storm event for year 2100 using the baseline intensity and the projected 30% increase. The aerial shows the topography and difference of computed depths of water ..... 41
Figure 4.4: FEMA Flood Zones for St Croix ..... 42
Figure 4.5: Flooding due to sea-level rise on St Croix ..... 42
Figure 4.6: Difference in Flood Depths for a 100-year 72-hour storm event for year 2100 using the baseline intensity and the projected 30% increase. The aerial shows the topography and difference of computed depths of water ..... 43
Figure 4.7: Coastal Geomorphology of Virgin Islands National Park (Pendleton et al., 2004) ..... 44
*Figure 4.8: FEMA Flood Zones for St John* ..... 45
Figure 4.9: Flooding due to sea-level rise on St John ..... 45
Figure 4.10: St. Thomas - Population Distribution ..... 46
Figure 4.11: Hospital Severely Damaged from Hurricane Irma (Hilary Swift for the New York Times) . 47
Figure 4.12: Annas Rest, with the damaged Tutu Hi-Rise apartments toward rear of the photo in St. Thomas. (James Gardner of the St. Croix Source, September 15, 2017) ..... 47
Figure 4.13: Ravaged houses in St. Thomas (Erika P. Rodriguez for The New York Times, September 11, 2017) ..... 48
Figure 4.14: Damaged houses in St. Thomas (Erika P. Rodriguez for The New York Times, September 11, 2017) ..... 48
Figure 4.15: St. John - Population Distribution ..... 49
Figure 4.16: Hurricane Irma leaves debris and destruction in its wake on St. John, part of the U.S. Virgin Islands (Anthony Faiola / The Washington Post, 2017) ..... 50
Figure 4.17: A Damaged Vehicle sits on Top of Debris from the Destroyed Chateau Bordeaux Restaurant after Hurricane Irma in St. John, U.S. Virgin Islands, (Jessica Rinaldi/Bloomberg News Sept. 12, 2017) 50
Figure 4.18: St. Croix - Population Distribution ..... 51
Figure 4.19: A man stands outside a destroyed home in this aerial photo from a Marine Corps MV-22 Osprey surveying the aftermath from Hurricane Maria in St. Croix, U.S. Virgin Islands, last Thursday. (REUTERS/Jonathan Drake) ..... 52
Figure 4.20: Damaged Infrastructure and Flooding in St. Croix Following Hurricane Maria ..... 53
Figure 4.21: Shipping containers strewn around the main port are seen from a Marine Corps MV-22

Osprey surveying damage from Hurricane Maria in St. Croix, U.S. Virgin Islands, last Thursday. (REUTERS/Jonathan Drake) ..... 54
Figure 4.22: Tourism Assets in St. Thomas ..... 55
Figure 4.23: Tourism Assets in St. John ..... 55
Figure 4.24: Tourism Assets in St. Croix ..... 56
Figure 4.25: The Caneel Bay Resort on St. John was heavily damaged (Hilary Swift for The New York Times) ..... 58
Figure 4.26: Agricultural Assets in St. Croix ..... 59
Figure 4.27 Critical facilities ..... 62
Figure 4.28 Project modeling domain including the aerial of St. Thomas and the location of critical facilities (A higher resolution map is provided in appendix A02.MODEL_DOMAiN.pdf) ..... 63
Figure 4.29: Model domain is highlighted with read line. (A higher resolution map is provided in appendix A04.MODEL_DOMAiN.pdf) ..... 64
Figure 4.30: La Grange watershed footprint in St Croix. This is an area of concern that floods repeatedly during strong rain storm events. ..... 65
Figure 4.31: During high tide events, seawater can impede proper drainage of urban centers. Stormwater drain in Charlotte Amalie (left); closeup of wave travelling upstream in drain at low tide (right). ..... 66
Figure 4.32: Solar panels that provided a small percentage of power for St. Thomas were destroyed (Hilary Swift for The New York Times) ..... 66
Figure 4.33: Sprauve School Annex after Irma finished tearing it apart in St John. (Amy Roberts, St. Thomas Source, September 9, 2017) ..... 67
Figure 6.1: St. Thomas 100 Year Flood Impact Zones 2017 – Population ..... 108
Figure 6.2: St. Thomas 100 Year Flood Impact Zones 2100 – Population ..... 109
Figure 6.3: St. Thomas 500 Year Flood Impact Zone 2017 - Population ..... 109
Figure 6.4: St. Thomas 500 Year Flood Impact Zone 2100 - Population ..... 110
Figure 6.5: St. Croix 100 Year Flood Impact Zone 2017 – Population ..... 112
Figure 6.6: St. Croix 100 Year Flood Impact Zone 2100 - Population ..... 113
Figure 6.7: St. Croix 500 Year Flood Impact Zone - Population ..... 114
Figure 6.8: St. Croix 500 Year Flood Impact Zone 2100 – Population ..... 115
Figure 6.9: Critical facilities impacted by different types of storm-induced flooding ..... 116
Figure 6.10: Structures impacted by different types of storm-induced flooding ..... 116
Figure 6.11: Percent of roads impacted by different types of storm-induced flooding ..... 116
Figure 6.12: Land area lost to sea level rise inundation in the USVI ..... 117
Figure 6.13: Critical facilities impacted by sea level rise ..... 118
Figure 6.14: Structures impacted by sea level ..... 118
Figure 6.15: Percent of roads impacted by sea level rise ..... 119
Figure 6.16: Ranked critical facilities in St Thomas ..... 120
Figure 6.17: Flood Depth Analysis of 100-year 72-hour storm event for year 2100. The aerial shows the topography and computed depth of water (Appendix A13.MAP_STT_2100_0100_HD.pdf provides a higher resolution map) ..... 121
Figure 6.18: Flood Depth Analysis of 500-year 72-hour storm event for year 2100. The aerial shows the topography and computed depth of water and areas of concern where flood depth greater than 2 ft is observed (Appendix A14.MAP_STT_2065_0500_HD.pdf provides a higher resolution map). ..... 121
Figure 6.19 Ranked critical facilities in St Croix ..... 124
Figure 6.20 Flood Depth Analysis of 100-year 72-hour storm event for year 2100. The aerial shows the topography and computed depth of water (Appendix A13.MAP_STT_2100_0100_HD.pdf provides a higher resolution map) ..... 125
Figure 6.21: Flood Depth Analysis of 500-year 72-hour storm event for year 2100. The aerial shows the topography and computed depth of water (Appendix A14.MAP_STT_2065_0500_HD.pdf provides a higher resolution map). ..... 126
Figure 6.22: Ranked critical facilities in St John ..... 128

Figure 6.23: St. Thomas 100 Year Flood Impact Zones 2100 – Tourism Sector ..... 130
Figure 6.24: St. Thomas 500 Year Flood Impact Zone 2100 - Tourism ..... 131
Figure 6.25: St. Croix 100 Year Flood Impact Zone 2100 – Tourism ..... 132
Figure 6.26: St. Croix 500 Year Flood Impact Zone 2100 – Tourism ..... 133
Figure 6.27: St. Croix 500 Year Flood Impact Zone 2100 – Agriculture ..... 137

# List of Tables

Table 2.1: Legislation Governing the Agriculture and Tourism Sectors ..... 24
Table 3.1: Reporting Template for the Summary Results of the Sensitivity Analysis ..... 30
Table 3.2: Reporting Template for the Summary Results of the Adaptive Capacity Analysis ..... 33
Table 3.3: Reporting Template for the Summary Results of the Vulnerability Analysis ..... 34
Table 3.4: Ranking of Critical Infrastructure ..... 35
Table 4.1: Description for Assessing Sensitivity ..... 36
Table 4.2: Summary Sensitivity Analysis ..... 68
Table 5.1: Description for Adaptative Capacity ..... 74
Table 5.2: Summary Adaptive Capacity Assessment ..... 97
Table 6.1: Description for Vulnerability Analysis ..... 107
Table 6.2: St. Thomas' Critical Facilities Inundated under the 100yr and 500 Year Flood Return Period ..... 122
Table 6.3: St. Croix's Critical Facilities Inundated under the 100 year and 500 year Flood Return Periods ..... 126
Table 6.4: Tourism Facilities Inundated under the 100 and 500 Year Flood Impact Zone - 2100 ..... 133
Table 6.5: Summary Vulnerability Analysis ..... 139
Table 8.1: Objectives, Activities, Indicative Costs and Responsible Agencies for Planning Area 1 – Socio-Economic ..... 153
Table 8.2: Objectives, Activities, Indicative Costs and Responsible Agencies for Planning Area 2 – Policy and Legal ..... 157
Table 8.3: Objectives, Activities, Indicative Costs and Responsible Agencies for Planning Area 3 – Tourism ..... 159
Table 8.4: Objectives, Activities, Indicative Costs and Responsible Agencies for Planning Area 4 – Agriculture ..... 163
Table 8.5: Objectives, Activities, Indicative Costs and Responsible Agencies for Planning Area 5 – Critical Infrastructure ..... 166
Table 8.6: Objectives, Activities, Indicative Costs and Responsible Agencies for Planning Area 6 – Other ..... 172

# List of Acronyms

| | |
|---|---|
| CAPRA | Central America Probabilistic Risk Assessment |
| CCCCC | Caribbean Community Climate Change Centre |
| CEO | Chief Executive Officer |
| CIMH | Caribbean Institute for Meteorology and Hydrology |
| CWWA | Caribbean Water and Wastewater Association |
| CMSP | Coastal Marine Spatial Planning |
| CROP | Caribbean Regional Ocean Partnership |
| CTO | Caribbean Tourism Organization |
| DEH | Division of Environmental Health |
| DPNR | Department of Planning and Natural Resources |
| ECLAC | Economic Commission for Latin America and the Caribbean |
| EDB | Economic Development Bank |
| EPA | Environmental Protection Agency |
| FEMA | Federal Emergency Management Agency |
| GCMs | Global Climate Models |
| GDP | Gross Domestic Product |
| HAZUS | Hazards United States |
| IPCC | Intergovernmental Panel on Climate Change |
| IPPC | International Plant Protection Convention |
| MW | MegaWatt |
| NAPPO | North American Plant Protection Organization |
| NEPA | National Environmental Policy Act |
| NGO | Non-Governmental Organization |
| NOAA | National Oceanic and Atmospheric Administration |

| | |
|---|---|
| OIE | World Organization for Animal Health |
| RCMs | Regional Climate Models |
| RECC | Review of the Economics of Climate Change |
| SBDA | Small Business Development Agency |
| SLR | Sea Level Rise |
| STARS | Sustainable Tourism through Arts-based Revenue Stream |
| UNDP | United Nations Development Program |
| UNFCCCC | United Nations Framework Convention on Climate Change |
| US | United States |
| USA | United States of America |
| USGS | United States Geological Survey |
| USVI | United States Virgin Islands |
| UVI | University of the Virgin Islands |
| UWI | University of the West Indies |
| VICCC | Virgin Islands Climate Change Council |
| VITEMA | U.S. Virgin Islands Territorial Emergency Management Agency |
| VIWAPA | Virgin Islands Water and Power Authority |
| WAPA | Water and Power Company |
| WPC | Water Pollution Control |
| WTO | World Trade Organization |

# 1 Introduction

## 1.1 Purpose

This Draft Final Vulnerability and Risk Assessment Report represents the eleventh deliverable for the project: ***Climate Change Adaptation Planning Assessment and Implementation*** in the US Virgin Islands. The Report presents the final results of the vulnerability and risk assessment completed for the territory along with a preliminary Territorial Adaptation Strategy and Action Plan (TASAP) which meets the project objectives as stipulated in Section 1.2.1 below.

## 1.2 The Project Objective and Rationale

### 1.2.1 Project Objective

The goal of the overall project is to assist the U.S. Territories of the Virgin Islands to develop a framework with the capacity to 1) assemble and make use of a comprehensive base of information related to climate change vulnerability and risk associated with several sectors of society; 2) establish relationships among territorial agencies, Federal partners, NGOs, and University partners to prioritize adaptation and mitigation plans and actions, maximize use of resources, promote economic development and human well-being and reduce risks associated with climate change; and 3) develop a robust multi-sector climate adaptation strategy.

The specific objectives of the project, which form the key tasks are to:

a) Identify existing vulnerabilities of the key economic sectors and infrastructure
b) Identify gaps in information and capacity
c) Identify risks of climate change to the territories' infrastructure assets, resources and long-term goals
d) Identify specific climate adaptation actions that feasibly and realistically can address the needs of the US Virgin Islands
e) Promote inter-agency collaboration

Final project deliverables are a Territorial Adaptation Strategy and Action Plan with specific reference to addressing issues associated with the legal framework, the socioeconomic setting, the agriculture sector, the tourism sector and key infrastructure.

### 1.2.2 Project Rationale

The natural hazard history of the USVI demonstrates the vulnerability of the Territory to the effects of climate-triggered events. The projected changes of most concern are rising temperatures, changing rainfall patterns, stronger hurricanes and rising sea level. The Territory's coastal zone is particularly at risk to the effects of storm surge and rising sea level because of the concentration of hotels, businesses, critical infrastructure, and residential development.

The Review of the Economics of Climate Change (RECC/ECLACC) assessment of the economic impact of Climate Change on the coastal and marine sector of The Virgin Islands up to 2050 conservatively estimates an impact ranging from 68% to 286% of 2008 GDP under a relatively high carbon emissions scenario, and an impact ranging from 30% to 189% of 2008 GDP under a relatively low carbon emissions

scenario (CCCCC, 2011). This equates to cumulative losses to 2050 ranging from $671 million to $2.8 billion and from $301 million to $1.8 billion by 2050 respectively. Cost impacts to the other sectors affected are yet to be determined for The Virgin Islands, but regional studies anticipate high costs as well. In addition, there is the cost incurred from disaster events which are expected to intensify with Climate Change.

Given the level of concern regarding, vulnerability and risks associated with climate change in the Territories, Governor Kenneth Mapp in October 2015 signed Executive Order No. 474-2015: Preparing the Virgin Islands of the United States for Adapting to the Impacts of Climate Change. The order calls for all agencies of the territorial government to 1) assess vulnerabilities and risks to their operations and mission that are associated with climate change, 2) develop agency specific adaptation plans and report annually on progress, 3) develop decision support systems for climate change adaptation, and 4) establish the Virgin Islands Climate Change Council.

The execution of this project specifically meets the requirements of the Executive Order and will establish processes and implement vulnerability and risk assessments in support of the production of a climate change adaptation strategy for the U.S. Virgin Islands (USVI).

# 2 Contextual Setting

## 2.1 The United States Virgin Islands Territory

The U.S. Virgin Islands, situated east of Puerto Rico and north of the Lesser Antilles in the Caribbean, is an archipelago comprising three main and several smaller islands. The islands cover an area of 1,910 $km^2$, with 346 $km^2$ of land and the remaining 1564 $km^2$ of territorial seas. St. Croix, St. Thomas, and St. John are the three main islands in descending order of size: St Croix 64 km south of St John and St Thomas covers an area of 217.5 $km^2$; St Thomas which houses the capital town Charlotte Amalie is 24 $km^2$, and St. John the smallest is 20 $km^2$.

### 2.1.1 St. Thomas

St. Thomas is characterized by rugged topography with extensive steep rocky and irregular shoreline segments, sandy beaches and embayments. Forest cover is extensive with both subtropical moist and dry forest, and there are several protected areas. Social and economic infrastructure is concentrated in the coastal zone.

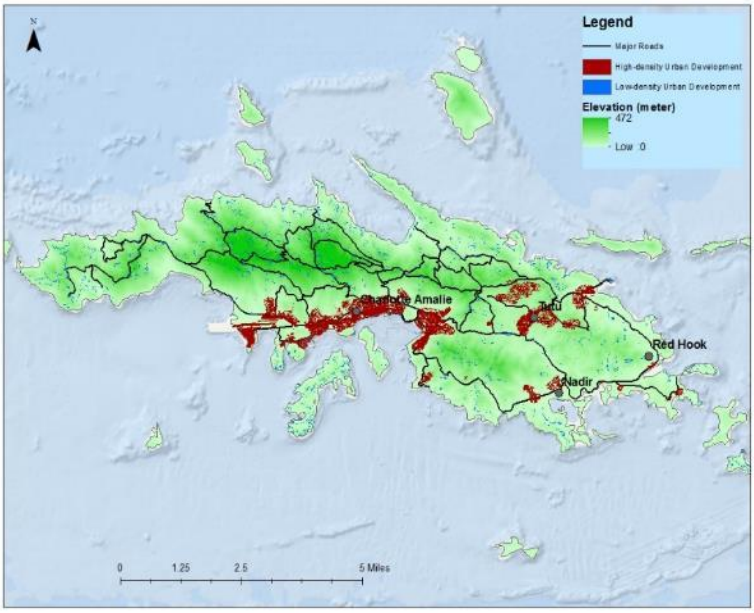



*Figure 2.1: St Thomas: Topography and Settlement*

### 2.1.2 St. John

St. John, the smallest of the US Virgin Islands, is irregularly shaped covering about 48 km2). It is characterized by steep slopes and more than 80 percent of the island is covered by slopes in excess of 30 percent. (CH2M Hill, 1979) (Figure 2.2). Bedrock is well exposed in outcrops and cliffs along the irregular shoreline, in some of the water courses (locally called guts), along some ridge crests, and in road cuts. Cliffs are commonly interrupted by deep cuts caused by the erosion of nearly vertical dikes. In places, cliffs drop into deep water.

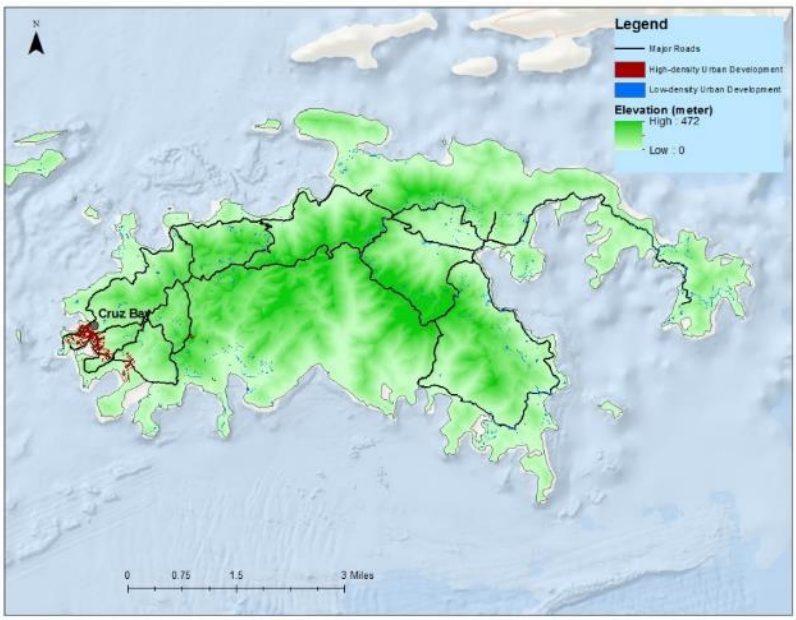



*Figure 2.2: St. John: Topography and Settlement*

All U.S. Virgin Islands have a high percent of young and undeveloped forests; however, St. John has a higher percentage of mature forests then St. Croix and St. Thomas. The National Park Service manages half of the land as the Virgin Islands National Park.

### 2.1.3 St. Croix

St. Croix roughly 40 miles south of St. Thomas and about 100 miles south-southeast of San Juan, Puerto Rico, is the largest of the three main islands, with a flatter terrain with a slope of less than 10 percent. St. Croix is 22 miles from east to west and 6 miles at the widest point, covering a total land area of 53,480 acres (84 square miles) (Figure 2.3). St. Croix is composed of both volcanic rock and limestone of former coral reefs, unlike the other two main islands that are composed of mainly volcanic rock. While dense tropical vegetation can be found in some locations, cactus and thorn bush typifying drier conditions is more common. There are 64 miles of coastal plains in the southwest, steep cliffs in the northwest, an extensive salt pond-sand beach at the southwest point, and beaches in the shallow embayment. St. Croix also has barrier coral reefs and algal ridges which create protection. An example of a recreational resource on the coastal zone would be Davis Beach on St. Croix.

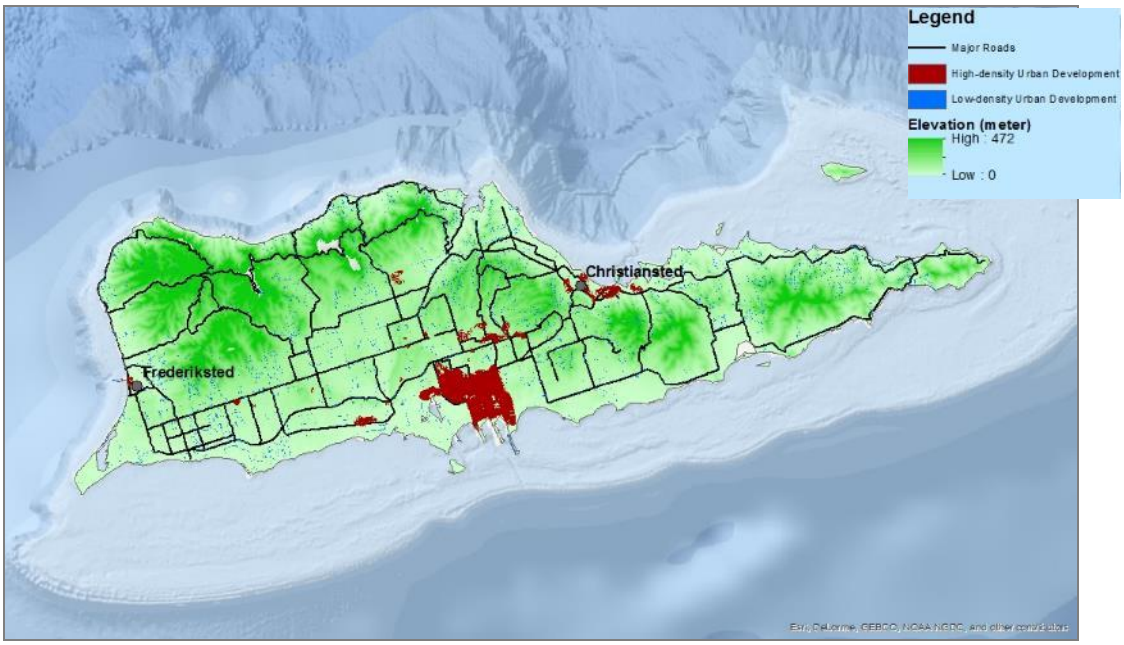



*Figure 2.3: St. Croix: Topography and Settlement*

In St. Croix the existing marine and coastal protected areas are Buck Island Reef National Monument, Christiansted Waterfront Area of Particular Concern, East End Area of Particular Concern, Frederiksted Waterfront Area of Particular Concern, Great Pond and Great Pond Bay Area of Particular Concern and Area of Preservation and Restoration, St. Croix Mutton Snapper Spawning Area, Salt River Bay Area of Particular Concern and Area of Preservation and Restoration, Salt River Marine and Wildlife Sanctuary, Salt River National Historic Park and Ecological Preserve, Sandy Point Area of Particular Concern, South Shore Industrial Area of Particular Concern, Southgate Pond/Chenay Bay Area of Particular Concern and Area of Preservation and Restoration, and St. Croix Coral Reef System Area of Particular Concern and Area of Preservation and Restoration (Gardner, 2002).

## 2.2 Climate Change and Climate Change Issues

### 2.2.1 Global Setting

There has been warming of the climate system, and since the 1950s, many of the observed changes are unprecedented. Empirical evidence has shown that, globabally, the atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased (IPCC, 2013). The IPCC (2013) also presents other evidence which shows that:

- Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850 (see Figure 2.1). Global surface temperature change for the end of the 21st century is likely to exceed 1.5°C relative to 1850 to 1900 for all Representative Concentration Pathways (RCP) scenarios except the lowest one (RCP2.6). Warming will continue to exhibit inter annual-to-decadal variability and will not be regionally uniform.

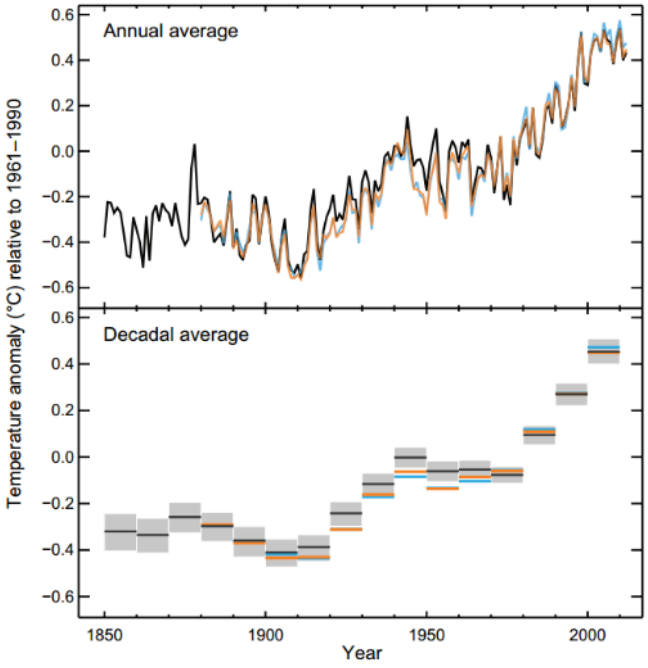



*Figure 2.4: Observed globally averaged combined land and ocean surface temperature anomaly 1850 – 2012 (IPCC, 2013)*

- Changes in the global water cycle in response to the warming over the 21st century will not be uniform. The contrast in precipitation between wet and dry regions and between wet and dry seasons will increase, although there may be regional exceptions.
- Changes in many extreme weather and climate events have been observed since about 1950. In general there are more land regions where the number of heavy precipitation events has increased than where it has decreased. The frequency or intensity of heavy precipitation events has generally increased in North America and Europe.
- The rate of sea level rise since the mid-19th century has been larger than the mean rate during the previous two millennia (high confidence). Over the period 1901 to 2010, global mean sea level rose by 0.19 m [0.17 to 0.21].

### 2.2.2 Regional Setting

Based on the IPCC Fifth Assessment Report (2013), projections of temperature rise in the Caribbean basin range between 0.7°C to 2.4°C by the end of the 21st century. Similarly Global climate models (GCMs) project changes in annual precipitation varying from –29% to +14% with a median value of -5%. Studies using regional climate models (RCMs) suggest higher temperatures changes (up to 3.5°C) for the Caribbean region and slightly more severe drying, which is not regionally uniform (Karmalkar et al. 2013; Campbell et al. 2010). Climatic changes are projected to include reduced length of rainy seasons, increased lengths of dry seasons, increased occurrence of 'very hot' days and nights and decreased occurrence of 'very cool' days and nights, increased and more intense extreme events (both flooding and drought events), increased in the intensity of hurricanes, and higher sea levels. In small island states the impact of climate change will therefore be felt from ridge to reef.

The Caribbean is expected to be among the earliest and most impacted by climate change over the course of this century (Pulwarty et al. 2010; Simpson et al. 2009, Mora et al. 2013). The current trends and predictions point to a state of increasing future vulnerability for the Caribbean. The vulnerability and sensitivity of the majority of Caribbean states to the effects of global climate change is largely seen as a function of their relatively small geographic size, high coastal population densities, poorly developed infrastructure, limited natural and human resource base, open economies, and location in regions highly prone to extreme weather events such as hurricanes and droughts (Gamble et al. 2010; Mimura et al. 2007; Nurse et al. 2001; Nurse and Moore 2005; Pelling and Uitto 2001). Therefore, the impacts will vary across islands, sectors and different socio-demographic groups.

### 2.2.3 Local Setting

#### *2.2.3.1 Temperature*

Increasing temperatures, no different than the global and regional scenario, has been impacting the USVI for several years. Increasing temperatures negatively impact all the key productive sectors. It results in increase emergency usage for cooling and impacts negatively on agricultural productivity. It may also result in increasing issues with respect to mosquito breeding, which can pose a public health issue.

#### *2.2.3.2 Precipitation*

Environmental Protection Agency (2016) has indicated that the total rainfall is likely to continue to decrease, especially during spring and summer. Warmer temperatures also increase evapo-transpiration leading to drier soils. This is significant for the agriculture sector, this is further discussed in Section 2.4.2. Residents also rely extensively on rainwater harvesting, which could lead to a higher pressure on existing desalination plants for water security.

#### *2.2.3.3 Extreme Events*

Tropical storms and hurricanes have become more intense during the past 20 years (EPA, 2016). This can result in the shutdown of the Territory as experienced during 2017 hurricane season. Critical infrastructure such as road were blocked and, electricity was not available due to downed poles and other damaged equipment. Residential homes and all the major sectors experienced significant losses. These hurricanes provided several concrete examples of vulnerabilities which are referenced throughout this report (for example Section 4).

*2.2.3.4 Changing Oceans – Ocean Acidification*

Sea surface temperatures have warmed by at least 2º since 1901 (Figure 2.5). USVI had its first experience of coral bleaching in 2005 as a result of sustained warm sea surface temperatures. Coral bleaching occurs because of the loss of algae which causes corals to turn white. Section 2.4.1 elaborates on how this has impacted the tourism sector.

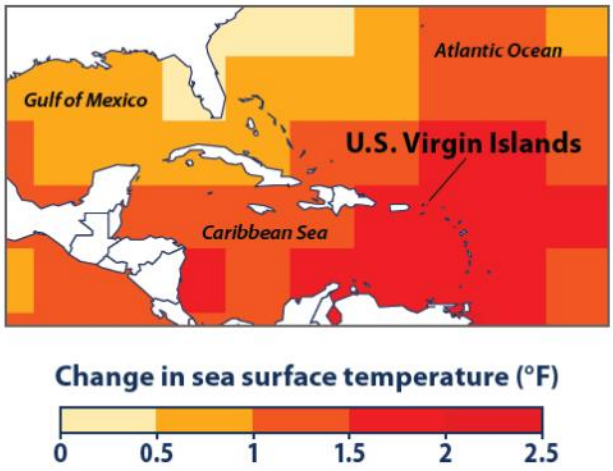



*Figure 2.5: Change in Sea Surface Temperatures since 1901 (Environmental Protection Agency, 2016)*

Increasing acidity can also damage corals. Ocean acidity has increased by about 25 percent in the past three centuries, and it is likely to increase another 40 to 50 percent by 2100 (EPA, 2016). Warming and acidification could harm marine ecosystems and economic activities that depend on them.

*2.2.3.5 Sea Level Rise and Coastal Resources*

Sea level has been rising by about an inch every ten years (EPA, 2016). A coastal vulnerability assessment to sea-level rise was conducted of Virgin Islands National Park (VIIS) in St. John. It shows that some areas in St. John have very high vulnerability to sea level rise and coastal erosion. Cinnamon Bay is one such area shown in Figure 2.6 below.

*Figure 2.6: The shoreline at Cinnamon Bay in St. John experiencing erosion (Pendleton, 2004)*

## 2.3 Socioeconomic Setting

The total population for the USVI is 104,170 (July 2014 est.) (CIA World Factbook, 2014). The country has a growth rate -0.56 (2014 est.) showing a decreasing population (ibid). Prior to 2010, St. Croix had

the largest population of all the islands. This has now been surpassed by St. Thomas due to the deteriorating economic conditions that led to the loss of job opportunities (Sygma PCS, 2015). USVI population continues to decrease as persons seek opportunities elsewhere.

Unemployment was at a high of 13 percent in 2014. Approximately 25.1% of the population ages 25 and older did not graduate from high school as at 2012(CIA World Factbook, 2014; Sygma PCS, 2015).

Poverty rates declined 10 percentage points between 2000 and 2010 and between 2010 and 2012 (Sygma PCS, 2015) there was a further slight decrease of 0.8%. As at 2012, the poverty rate for the USVI was 15%, with St. Croix holding the largest proportion of this, followed by St. Thomas and then St John.

Settlements in the USVI are located on hilly terrain as well as in the coastal areas. The social and economic settings of the country are significantly intertwined. Rainfall variability is a key concern as many residents are dependent on rainwater harvesting to supply their households; extreme events can bring devastation similar to Hurricane Marilyn in 1995; and coastal erosion and sea level rise can negatively impacts houses located in coastal areas. Section 2.4 below presents a summary of the economic setting.

## 2.4 Economic Sectors

The USVI's economy declined between 2008 and 2015 after which there has been a slight positive uptick. Estimates of GDP indicate that real GDP—GDP adjusted to remove price changes—increased 0.2 percent in 2015 (Bureau of Economic Analysis, 2016).

The Government of the USVI has experienced significant financial challenges over the years and despite some growth, the country continues to experience distress as it relates to financial liquidity and budgetary obligations. In fiscal year 2017, the estimated budget deficit is $110 million (Bureau of Economic Analysis, 2017). If the Government is unable to meet its financial obligations, it is likely to layoff public sector employees. This would reduce both governmental and consumer spending within the overall economy (ibid).

The economic growth at the end of 2015 reflected increases in exports of services and consumer spending. The growth in exports of services, which consists primarily of spending by tourists, reflected increases in air arrivals and hotel revenues. This shows the importance of the tourism sector to the national economy and as such the building of sector resilience from climate change impacts is crucial. Further discussion on tourism is given in Section 2.4.1 below.

The agriculture sector has experienced many struggles over the years, and these have led to food security challenges. Ninety nine per cent (99%) of food consumed in the USVI is imported, which makes the country highly dependent and susceptible to external and global shocks (Personal Communication: Commissioner of Agriculture). The building of the agriculture sector and the encouragement of its growth in the face of climate change is a challenging consideration for food security and for the economy as a whole. Section 2.4.2 elaborates on the agriculture sector.

### 2.4.1 Tourism

Tourism is the main economic earner in the USVI especially since the close of the HOVENSA oil refinery. In 2016, the total contribution of Travel & Tourism was USD1,415.10 million, 31.8% of GDP ((World Travel and Tourism Council, 2017) (Figure 2.7).

Approximately 43,186 civilians are employed to the tourism sector, 54 % of these persons are accounted for from St. Thomas and St. John and 46% from St. Croix (Bureau of Economic Research, 2016).

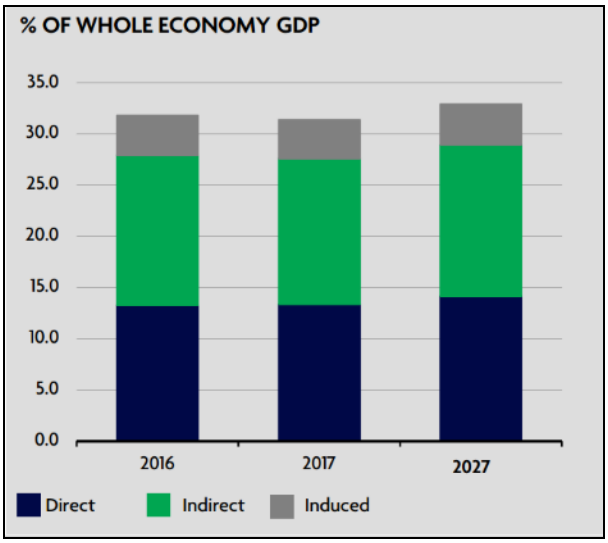



*Figure 2.7: Direct and Total Contribution of Travel and Tourism to GDP (World Travel and Tourism Council, 2017)*

The trend in visitor and cruise ship arrivals is illustrated in Figure 2.8 below. Between the years 2014 and 2015 a distinct reduction in arrivals was noted. This has been thought to be partly as a result of the threat that the Zika virus posed to visitors (Personal Communication: Commissioner of Tourism).

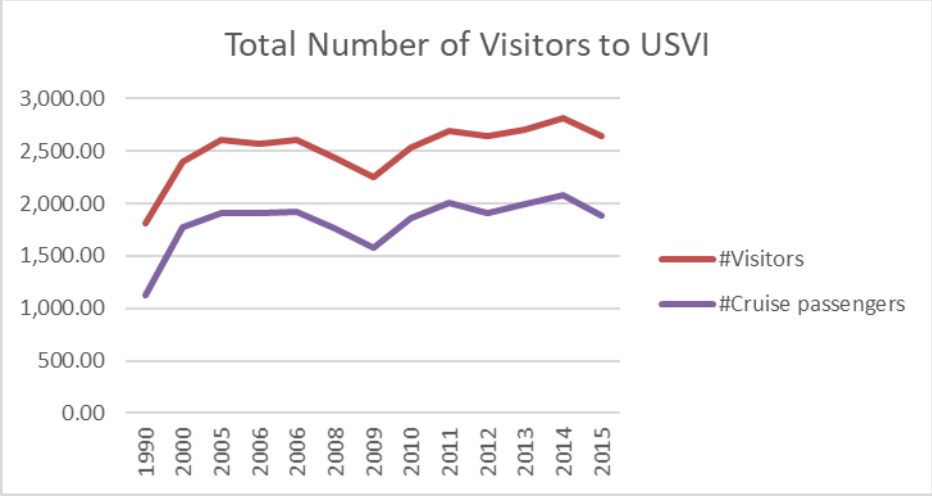



*Figure 2.8: Total Number of Visitors and Cruise Passengers to USVI (1990-2015) (Bureau of Economic Research, 2016)*

The different islands have different types of attractors, which, together create an attractive place for tourists. St. Thomas is hilly and holds the capital, Charlotte Amalie. It is the base of tourism and center of

commerce, trade, finance, and government. Its strategic location along the Anegada Passage is a key advantage for berthing ships bound for the Panama Canal and its natural deep-water harbor make it suitable for tourism and trade (Sygma PCS, 2015).

St. John is hilly and two-thirds of the island is a national park. It is an ideal location for land and marine based eco-tourism activities due to its unspoiled scenery and pristine beaches. St. John is famous for luxurious homes, villas, and hotels for high-end vacationers (Sygma PCS, 2015).

St. Croix is the largest of the three islands with mixed terrain of flat lands and hillsides. The island's economy is predominantly-manufacturing with a historic dependence on oil production, and to a lesser extent, traditional agriculture and tourism (Sygma PCS, 2015). St. Croix also is home to the territory's research and development activity through the University of the Virgin Islands research and technology park (ibid).

Extreme natural events bring the threat of beach erosion to the coastline of the US Virgin Island territories. Negative impacts have been visible particularly after the passage of tropical storms and hurricane events.

As atmospheric temperature increases so does sea surface temperature. Global climate change, for example, impacts coral reefs directly as warmer waters are leading to more frequent and more severe mass bleaching events. The USVI in 2005 experienced significant coral bleaching triggered by the 2004-2505 El Nino event, which resulted in prolonged exposure of the coral to above normal water temperatures (Smith et al., 2011). The year 2010 started warmer than 2005 and experts predicted another mass bleaching event; however, Hurricane Earl passed the USVI on August 2010 and sea surface temperatures dropped rapidly due to tropical storm cooling, averting more significant bleaching and mortality (ibid).

*Figure 2.9: Bleached Colonies of Boulder Star Coral Montastraea annularis at Flat Cay, October 2005 (Source: Smith et al., 2011)*

During the 2005 event, about 60% of shallow corals in water less than 25m depth were approximately 60% bleached to stark white. This led to unprecedented levels of white disease and severely affected the foundational reef building boulder star coral (Montastraea annularis spp. complex), leading to an approximate 50% loss of coral cover (Smith et al., 2011). Boulder star corals are responsible for much of the habitat creation. These impacts have negative impacts on the tourism sector (snorkeling, beach creation) and on fisheries, which supply the needs for many restaurants.

Since the 2005 event, USVI has instituted a Reef Resilience Plan to combat these issues. A key part of this plan includes: identifying Resilient Reefs; bleach watching, instituting an early warning system; community volunteer training and bleaching assessment and monitoring.

Warming temperatures have also had negative impacts on health. There were prior challenges in the country with mosquitoes carrying dengue and the chikungunya virus. However, increasing temperatures have exacerbated breeding of mosquitoes contributing to the spread of the Zika virus. This has had significant long term losses in the tourism industry. In 2015, there was a US$0.25 million reduction in the wedding and honeymoon aspect of tourism due to cancellations as a result of the Zika Virus (Personal communications: Commissioner of Tourism). The wedding and honeymoon market contributes approximately US$30 million to the economy on an annual basis and with brides either pregnant or planning to be, the risks were high for infants born with Microcephaly (Personal communications: Commissioner of Tourism).

### 2.4.2 Agriculture

The 2007 agriculture census reports a total of 219 farms[1] on a total of 2379.96 hectares (5,881 acres) of land. St. Croix accounted for 73% of the total farms, while St. Thomas and St. John shared the remaining 27%.

Figure 2.10 illustrated the market value of agricultural products sold in 2007 and 2002. The data shows that horticultural plant sales have had the greatest value on the market and has increased since 2002. There has been a significant reduction in cattle rearing.

[1] Farm Definition: All places from which $500 or more of agricultural products were produced and sold, or normally would have been sold, during the calendar year 2007. (USVI Agriculture Census 2007)

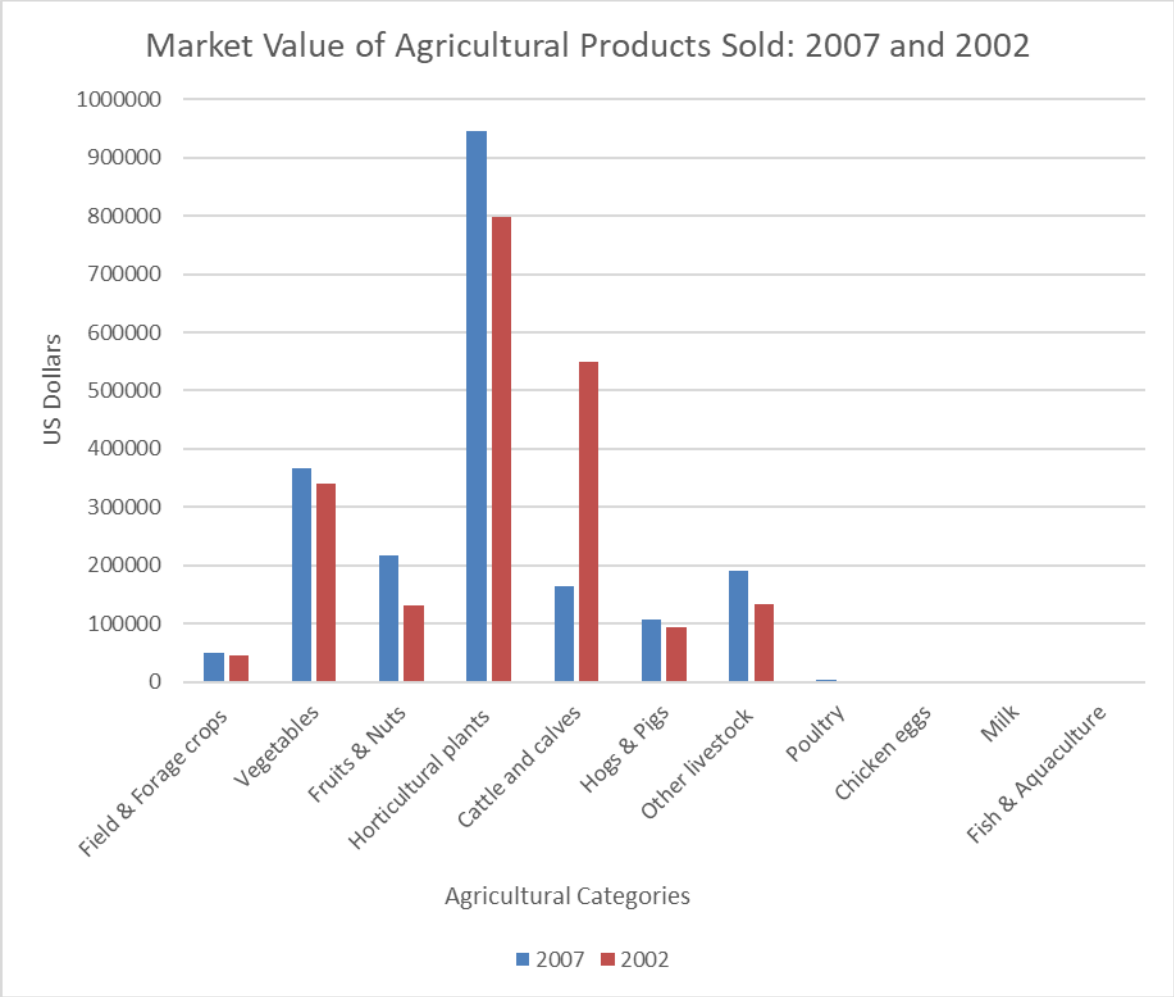



*Figure 2.10: Market Value of Agricultural Products Sold: 2007 and 2002 (United States Department of Agriculture, National Agricultural Statistics Service, 2009)*

There were no 2007 Reports for chicken, eggs, fish and aquaculture and milk. In 2002 60% of farms were irrigated, while in 2007 this figure was reduced to 45%. Most persons irrigate with water stored in wells or cisterns, some by public utility supply or other means; and a few use water from ponds. Agriculture in USVI is largely rainfall dependent (Personal Communication: Commissioner of Agriculture). Because of this dependence, agriculture is exposed to climate change impacts, in particular changes in the pattern of temperature, rainfall, humidity and extreme events.

The agricultural sector is plagued with challenges associated with water availability, storage and distribution. The ability to irrigate in a sustainable manner throughout the year would prove very beneficial for the sector.

Disease outbreaks are another challenge experienced by the agriculture sector in the USVI. The internal technical capacity to manage and control and prevent diseases is limited. Recently there was a downy mildew outbreak which stunted the cucumber production altogether and the ability to restart after such

losses was difficult. Limited staffing also impacts the ability to deal with entomology issues (Personal Communication: Commissioner of Agriculture).

As shown in the above data, agricultural production largely takes place on the island of St. Croix. Currently, St. Croix is experiencing contamination of aquifer due to salt water intrusion. This is a challenge for freshwater supply. So far they are able to pump freshwater from wells but do not anticipate that with the onset of climate change this will be the same in the short and medium future (Personal Communication: Commissioner of Agriculture). Between November 2014 and October 2015, St. Croix experienced no precipitation leading to a disaster for the agricultural sector and Federal Assistance had to be sought. With the unpredictability of key meteorological variables, there are and will continue to be challenges within the sector.

There is no funding for breeding more adaptable plant and animal varieties for the changing environment. It is clear that research and development is urgently needed to combat the issues faced by USVI.

Other issues facing the agriculture sector include the need to develop the infrastructure for marketing produce. Only a small 1% of produce is grown locally and marketed. Development is needed for post-harvest handling and marketing in order to compete with imported products.

## 2.5 Policy Legal and Institutional Setting

The USVI is governed by a plethora of legislation but this policy and legislative review will focus on the two key economic sectors which have been elaborated above.

The agricultural and tourism sectors are governed by many laws, these are listed in Table 2.1 below.

*Table 2.1: Legislation Governing the Agriculture and Tourism Sectors*

| **Agriculture Sector** | **Tourism Sector** |
|---|---|
| • Animal Health<br>  ○ Animal Disease Traceability<br>  ○ Export Requirements<br>  ○ Animals<br>  ○ Products<br>• Animal Welfare<br>  ○ The Animal Welfare Act and Regulations<br>  ○ Animal Care Policy Manual<br>  ○ The Horse Protection Act<br>  ○ Horse Protection Act Regulations<br>  ○ Horse Protection Operating Plan<br>• Biotechnology<br>  ○ Title 7, Part 340: Introduction of Organisms and Products Altered or Produced Through Genetic Engineering which are Plant Pests or which there is a reason to believe are Plant Pests<br>  ○ Biotechnology Environmental | • Economic Development Bank (EDB) Laws<br>• Small Business Development Agency (SBDA) Laws<br>• Economic Development Commission Laws<br>• Tax Increment Financing<br>• Enterprise Zone Commission Law<br>• VIEDA Laws<br>• Hotel Development Act<br>• Economic Development Commission<br>• Sustainable Tourism through Arts-based Revenue Stream Production (STARS)<br>• Youth Recreational Incentives Act |

| Agriculture Sector | Tourism Sector |
| --- | --- |
| Documents for Permits and Petitions<br>• Emergency Response and Preparedness<br>o ESF11-- Emergency Support Function #11 (All-Hazards Response)<br>o APHIS Emergency Mobilization Guide<br>o APHIS Health and Safety Plan<br>o National Response Framework<br>o National Incident Management System<br>• International Standards<br>o World Trade Organization (WTO)<br>o World Organization for Animal Health (OIE)<br>o International Plant Protection Convention (IPPC)<br>o North American Plant Protection Organization (NAPPO)<br>• Environment<br>o National Environmental Policy Act of 1969 (NEPA)<br>o Title 7 PART 372—APHIS' National Environmental Policy Act Implementing Procedure<br>o NEPA Title 1<br>o NEPA Title 2<br>o Wildlife Damage Management - National Environmental Policy Act (NEPA) Documents<br>• Plant Protection<br>o Plant Protection Act, as amended<br>o Lacey Act, as amended<br>o Title III, Federal Seed Act<br>o Honeybee Act<br>• Title II, Subtitle B, of the Agricultural Bioterrorism Protection Act of 2002 | |

This legal framework for the two sectors will be examined in relation to the prevailing climate change issues and needs.

# 3 Methodology

The project is mandated to undertake the 6 major tasks outlined below.

1) Sensitivity Analysis
2) Hazard Assessment
3) Adaptive Capacity Analysis
4) Vulnerability Analysis
5) Risk Assessment for Infrastructure
6) Adaptation Strategy and Action Planning

A literature review was first conducted to determine the vulnerability assessment approach for the project; the results of the literature review are presented in Section 3.1 below. The approach used to complete the various tasks are presented in Sections 3.2 to 3.7.

## 3.1 Assessment of Selected Approaches to Vulnerability Assessment

Several vulnerability and risk assessment methodologies were reviewed to help inform determination of an approach easily applicable to this study. Examples of those reviewed are listed in Appendix I. After reviewing these methods it was determined that a mixed approach would be most suitable for this project, merging aspects of the NOAA-CCCCC *Vulnerability and Capacity Assessment Methodology* (2008) the *Preparing for Climate Change: A Guidebook for Local, Regional and State Governments* (2007), the *IDB's Climate Change Data and Risk Assessment Methodologies for the Caribbean* (2016) as well as NOAA's *Adapting to Climate Change: A Planning Guide for State Coastal Managers* (2010). Each of these approaches has distinctive elements that were considered best practice applications for the USVI application.

Identification of the climatic phenomena that have impacts for a specified location, and the identification of the assets that are exposed to these impacts form a key part of the sensitivity analysis elaborated in the preferred methodology below. NOAA's method in *Adapting to Climate Change: A Planning Guide for State Coastal Managers* puts climate modelling as a step after the consideration of adaptive capacities. However, this approach was not embraced since the project team thought it best to develop a climate profile of the USVI which includes the use of climate modelling data as an early part of the sensitivity analysis so that it can inform both the hazard modelling and this assessment. This, it is felt, lends for a more thorough vulnerability assessment.

Aspects of the risk-based vulnerability assessment methodology presented in UNDP Adaptation Policy Framework (2001); *Being Prepared for Climate Change;* and *A Workbook for Developing Risk Based Adaptation Plans* (2014) have been incorporated into the methodology presented in Sections 3.2 to 3.7 below.

The methodology presented in *Climate Adaptation: Risk, Uncertainty and Decision Making* (2003) was not incorporated since it is not applicable to the conduct of a vulnerability assessment but serves solely for the conduct of a climate risk analysis, which is not the objective of this project.

In the development of the adaptation strategies, elements of the UNFCCC's *Guidelines for the preparation of NAPAs* were incorporated into the methodology. In particular elements that speak to the following are prioritised: the characteristics of the adaptation strategies and activities will be easy to

understand, are action-oriented, country-driven, and will be organized clearly outlining the priorities for urgent and immediate adaptation activities as identified by stakeholders. Elements of the criteria for selecting priority activities have also been incorporated. Aspects of *EPA Climate Ready Water Utilities Toolkit* (2014) and *Climate Change: Mastering the Public Health Role* (2011) were also incorporated in the methodology for the development of the strategic action plan for climate change adaptation.

Sections 3.2 to 3.7 below detail the methodology that was used in execution of this project.

## 3.2 Sensitivity Analysis

Sensitivity is the degree to which a system will be affected by, or be responsive to, climate stimuli (Smith et al. 2001). The first step in the sensitivity analysis was to determine the exposure of the sectors and infrastructure to climate induced hazards. To understand what could be affected, it was first necessary to identify the climate risk and the vulnerable areas. This process includes collecting data on the physical environment, reviewing historical events in Territory, and modeling data for potential future events.

### 3.2.1 Climate Sensitivity/Risk

The sensitivity analysis involved determining the sensitivity of the identified sectors to climate change. The climate profile of the USVI were compiled through examining historical trends, analyzing global and regional climate model output and using statistical downscaling (where data are available) to generate projections. Statistical Downscaling and Analysis of scenarios for medium and long-term periods have been attempted for the Territory in the past, but because of the lack of long-term station data it has not been possible to have island-specific climate projections for the territory to help inform potential risk. However, this was the case for many islands around the world and there were multiple options available to create climate scenarios for planning purposes. For this project, use was being made of existing climate information from the USGS Climate Science Center, the University of the West Indies and Caribbean Community Climate Change Centre, the NOAA Regional Climate Services office, the Caribbean Landscape Conservation Cooperative, the USDA Caribbean Climate Sub Hub and others to develop suitable future climate scenarios.

The future climate scenarios would allow for:

1. Identifying climate change issues and threats through projections
2. Identifying vulnerability of the sectors and potential impacts
3. Assessing potential socio-economic impact

Ultimately this information informed planning for the identified sectors.

### 3.2.2 Sector Sensitivity

As part of the Assessments, stakeholder consultations were conducted with the key stakeholders identified. This was done in an effort to understand the current state of the sectors. Stakeholder consultations took the form of targeted interviews (face to face meetings and conference calls) focus groups, community meetings and surveys (print and electronic). To date, several site visits were conducted and meetings were held as outlined below:

Two community meetings were held with farmers and other community members to garner their perspective on and evidence of climate change in their respective communities as well as on their respective livelihoods. Stakeholders were encouraged to identify needs as well. One meeting was held in St. Thomas on June 8, 2017 at 5:30pm and the other was held in St. Croix on June 12, 2017 at 5:30pm (Figure 3.1; Figure 3.2).

*Figure 3.1: Community Consultation in St. Thomas*

*Figure 3.2: Community Consultation in St. Croix*

Ad hoc meetings were also held in the field with fisher folk and divers from the following areas:

- Frenchtown – St. Thomas
- Hull Bay – St. Thomas
- Coki Bay – St. Thomas
- Benner Bay – St. Thomas
- Fort Mylner Fish Stalls – St. Thomas
- Altona Lagoon – St. Croix

The following organizations were also consulted:

- Water and Power Authority

    - Chief Operating Officer Electric System Clinton Hedrington, Jr.
    - Director of Transmission & Distribution Group – Neil Vanterpool
- Department of Public Works
    - Commissioner Gustav James
    - Assistant Commissioner Dennis Brown
    - Chief Planner Keya Canail
    - Shelton Shulterbrandt
- Bureau of Economic Research
    - Director Bernadette Melendez
    - Senior Policy Analyst Donnie Dorsett
- Department of Agriculture
    - Commissioner Carlos Robles
    - Deputy Commissioner Errol Chichester
- Department of Tourism
    - Commissioner Beverly Nicholson Doty
    - Director of Office Operations Tanya Duran
- Department of Planning & Natural Resources
    - Commissioner Dawn Henry
    - Director of Coastal Zone Jean Pierre Oriol
- Virgin Islands Territorial Emergency Management Agency
    - Director/ Homeland Security Advisor Mona Barnes
    - Deputy Director Planning and Preparedness Todd Patton
    - Fusion Center Director Wayne Bryan
- Virgin Islands Housing Authority
    - Director of Modernization and Development Karl Knight
- Lisa Hamilton - Hotel and Tourism Association
- Frank Comito – CEO Caribbean Hotel and Tourism Association (CHTA)
- Valerie Peters – Coral World
- Richard Dumae – Bolongo Bay Beach Resort

A few indicative stressors on the sectors were identified below, but these are by no means exhaustive:

1. Tourism- beach erosion, impacts of sea level rise, overdevelopment near beaches, loss of mangroves and wetlands, water pollution, and overfishing
2. Agriculture- changes in precipitation patterns and droughts, rising temperatures, water quality, disease, land use changes, increasing population, and pests
3. Infrastructure- flooding, non-resilient construction material, wind
4. Socioeconomic – population, settlement, climate sensitive economic centres

The data collected answered the following questions:

- How exposed is the sector to the impacts of climate change?
- Is the sector subject to existing stress?
- Does the sector have limiting factors that may be affected by climate change?
- What is the “impact threshold” associated with the sector?

Table 3.1 below shows a sample template for presenting the summary results of the sensitivity analysis.

*Table 3.1: Reporting Template for the Summary Results of the Sensitivity Analysis*

| **Current and Expected Stresses to Systems in the sector** | **Projected climate change impacts to systems in the sector** | | **SENSITIVITY ANALYSIS** | | |
|---|---|---|---|---|---|
| | | **How known climate conditions currently affect systems in the sector** | **Projected Impact of changes to systems in the sector *(without any action)*** | **Projected change in stresses to systems *(without any action)*** | **Degree of sensitivity of the sector** |
| | | | | | |
| | | | | | |

## 3.3 Hazard Modelling

The hazard assessment takes some of the outputs from the climate assessment conducted and integrates that data into traditional hazard models. The hazard models were run using future conditions from the climate models. There were different types of hazard assessment approaches and tools; however, they usually involve a mapping component. The objective of the hazard assessment was to understand where the hazard could occur and identify probable characteristics.

For a detailed climate change risk assessment, the probabilistic approach is recommended. This is a risk-based map developed using a probabilistic analysis. These maps are typically developed using historical hazard information to identify an event and assign likelihood to that event occurring in the future.

It is important, where possible, to use downscaled data for input into the models so that impacts projects will be at the correct tempo-spatial scale and as representative as possible. Also, the longest time series was used, as this produced a better representation of extreme events. For example, 200 years of data provided a better indication of what a 1 in 500-year event would look like compared to 30 years of data.

The scope of Hazard Modeling included two hydrodynamic models, one for St. Thomas and one for St Croix. The main effort during this reporting period was data assembly, review, verification and development of model input files. The models use MIKE FLOOD software from DHI (https://www.dhigroup.com/). MIKE FLOOD includes 2D hydrodynamic model for modeling coastal areas and inland flood zones and MIKE 11 1D hydrodynamic model for modeling of 1D linear infrastructure components (roads, pipes, culverts bridges and open channels).

During the reporting period of February 2017 to December 2017, best available data were obtained from various sources (USGS, NOAA, NPS). Data were reviewed and transformed as needed to convert to model input files (known as dfs0, dfs1 and dfs2 files, which were also proprietary for this software). The model input files were converted from GIS data rasters, shapefiles and time series data.

During this reporting period all data needed for the model were assembled and the two hydrodynamic models are in development and testing. All critical input files were obtained and the summary below provides a list of available data, and a list of data which were desirable for potential model improvements.

- **Model Domain Extents** - were prepared for input in MIKE 21. Two domain files were developed.
- **Aerials -** were obtained from available USGS sources. The rasters have a resolution of 1 ft or greater and are of sufficient quality, however, for future purposes it is desirable to obtain rasters with resolution 0.25ft which are becoming the standard and are most likely available. Furthermore, it is desirable to obtain pre- and post-Irma and post-Maria aerials which can be used as part of the analysis.
- **Bathymetry -** was obtained from available NOAA sources. The bathymetry is with resolution of 30 ft, which is considered sufficient for MIKE FLOOD, however, it is desirable to obtain high resolution LIDAR which can provide the shore line depths up to 20 ft and can be combined with the current model bathymetry. Two dfs2 model files were developed for St. Thomas and for St Croix.
- **Inland Topography -** was obtained from available USGS sources with resolution of 30 feet and was and converted to model input files (dfs2). It is desirable to obtain recent LIDAR data which will be used for providing an improved topography and in addition can be used to determine the elevation of various linear civil infrastructure such as roads.
- **Computational mesh** - 2 types of computational mesh were developed: a square gridded mesh with resolutions of 100, 20 and 10 feet and a Flexible mesh. Initial tests showed that square mesh with 10 ft resolution will be adequate for this domain.
- **Simulation length** - A 10 day simulation period will be used for model calibration and for analysis of stormwater events.
- **Calibration events -** The time series of rainfall during recent hurricane and storm events was obtained for the entire available period (1985-present) and currently is being analyzed to determine calibration storm events which have highest daily cumulative rainfall. Additionally, all recent hurricane events are being analyzed to determine the combination of high rainfall and high storm surge which cause the greatest stress on the civil infrastructure, including flooding and erosion.
- **Soils** - The soil data files were downloaded from GeoCAS and USDA.
- **Land Use Map** - was made available from GeoCAS. The data will provide the fraction of impervious areas which will be used for model input to determine the infiltration and runoff distribution inland.
- **Hydrography data (streams) -** were obtained from USGS sources, in addition, the topography of St Croix's model was analyzed to determine potential streams and was compared to the hydrography for verification.
- **Roadways** - Available transportation network was obtained as GIS shape file and will be used to determine the road infrastructure.
- **General data (adm boundaries, etc)** - General reference GIS data were obtained from USGS and will be used to provide geographic and administrative references.
- **Rainfall Boundary for Calibration** - Historical rainfall for calibration obtained from NOAA and UWI Climate Studies Group.

- **Rainfall Boundary for Simulation Events** - The rainfall events which will be used for simulations of extreme events were from NOAA, Rainfall Atlas and V14.
- **Evapotranspiration for Calibration** - This dataset was considered non-critical and can be applied on a later stage as model refinement.
- **Evapotranspiration for Simulation Events** - This dataset is considered non-critical and can be applied on a later stage as model refinement.
- **Critical Public and Civil Infrastructure and Facilities** – Data will be reviewed to determine the need for including critical facilities. The data can be entered in the model at a later stage when simulation events are used to determine impacts.
- **Storm Surge Boundary for Calibration** - this is a critical dataset which is required to be entered in the model. For initial model development storm surge estimates were used which were available from Florida Department of Transportation. These boundary conditions were updated during calibration and verification by obtaining data from VITEMA or from the Department of Transportation.
- **Tidal boundaries** - were obtained from NOAA's using the first harmonics. Data for amplitude and period were used to develop typical time series which can be used as model boundaries. Additionally, data from VITEMA and GeoCAS Portal were analyzed to determine the best source.
- **Bridges** are critical infrastructure which were estimated from aerials.
- **Major Storm Infrastructure (Culverts and Canals)** - Initially, the major stormwater infrastructure were estimated from aerials.
- **Canal Cross sections -** Initially, the major stormwater infrastructure was estimated from aerials. During model development additional features were implemented as data becomes available.

## 3.4 Adaptive Capacity Analysis

Adaptive capacity refers to the potential or capability of a system to adjust to climate change, including climate variability and extremes. This includes the capability to moderate potential damages, to take advantage of opportunities, or to cope with consequences (Smit and Pilifosova, 2001). To understand a sector's ability to adapt to climate change, it is first necessary to determine the institutional resources and ability to absorb shocks.

All the policies, legislation and regulations related to the three key economic sectors and infrastructure are being reviewed. It is important to understand the current institutional and legislative framework within the USVI that governs and relates to the identified sectors. Based on the projected climate variability and change patterns, the institutions will have to position themselves to adapt to the needs that will be generated by these potential impacts. Relevant policies, plans and legislation that guide these institutions have to be reviewed in order to identify gaps, and to realign them to address the situation.

Generally, systems that have a high adaptive capacity are better able to deal with climate change impacts. The stakeholders identified are also being consulted in order to identify gaps and needs for the sectors (institutional framework, physical infrastructure, human and financial resources). As stated above, stakeholder consultations took place via face to face targeted interviews and community meetings during the period June 6 to 14. Following this period follow-up meetings were held via telephone and

telecommunications applications (including Skype and Go to Meeting). Screen sharing was facilitated in some of the meetings to help build consensus toward a common goal for each sector.

A thorough review was conducted of all the ministries and other relevant agencies and organizations that are involved in research, regulations, provision or enforcement within the sectors. The key issues related to climate change were included as part of this review, which summarily, has the following categories:

- Uses, ownership and management of sector infrastructure and resources
- Policies specific to or related to the sector and climate change adaptation
- Legislation and regulations governing or related to the sector
- Institutional arrangements governing the sector

The question guiding this process was: "To what extent are the systems associated with the sectors able to accommodate changes in climate at minimum disruption or cost?"

In conducting the adaptive capacity analysis, several other considerations were factored in. These were investigated by a series of other specific questions:

- Are the systems associated with the sectors already able to accommodate changes in climate?
- Conversely, are there barriers to a system's ability to accommodate changes in climate?
- Are the systems associated with this planning area already stressed in ways that will limit their ability to accommodate changes in climate?
- Is the rate of projected climate change likely to be faster than the adaptability of the systems in this planning area?
- Are there efforts already underway to address impacts of climate change related to systems in this planning area?

This provided a qualitative summary of how adaptable the systems in the sectors were to the projected regional impacts of climate change. The template showing how this is presented was given in Table 3.2.

*Table 3.2: Reporting Template for the Summary Results of the Adaptive Capacity Analysis*

| **Current and Expected Stresses to Systems in the sector** | **Projected impact of changes to systems in the sector (without preparedness action)** | **ADAPTIVE CAPACITY** | |
|---|---|---|---|
| | | **Ability of the systems in the sector to accommodate projected impacts with minimum disruption or costs** | **Adaptive Capacity of the sector** |
| | | | |
| | | | |

## 3.5 Vulnerability Assessment and Mapping

This combined the findings about sensitivity and adaptability to determine how and where the sector is vulnerable to climate change. The vulnerability assessment can be quantitative (numbers and percentages) or qualitative (high, medium, low) in nature. The vulnerability assessment is not

static: existing vulnerabilities that are identified in this assessment may change, and new ones emerge in the future. This could be as a result of:

1. Changes in the frequency, intensity, duration, and/or extent of specific climate events;
2. The emergence of new threats, such as the introduction of a new invasive species or disease into the community;
3. New information on how climate change may affect specific systems in planning areas within communities;
4. Implementation of preparedness actions;
5. Changes in the population size, economy, preferences, or other factors that can influence a community's vulnerability to climate change.

Table 3.3 below shows a sample template for presenting the summary results of the overall vulnerability analysis.

*Table 3.3: Reporting Template for the Summary Results of the Vulnerability Analysis*

| **Current and Expected Stresses to Systems in the sector** | **Projected climate change impacts to systems in the sector** | **VULNERABILITY ASSESSMENT** | | |
|---|---|---|---|---|
| | | **Degree of sensitivity of the sector** | **Adaptive Capacity of the sector** | **Vulnerability of systems in the sector** |
| | | | | |
| | | | | |

The Technical Team Lead was responsible for reviewing all the input compiled by the Research Analyst. All the raw data gathered was properly managed by a Data Manager with expertise in GIS. The data and information produced/generated by the project will be archived and stored in a dedicated database.

## 3.6 Risk Assessment for Infrastructure

A detailed risk assessment produced more granular information concerning project structural design, support for cost-benefit analysis, siting information, and economic loss estimates. However, these detailed risk assessments can be costly and take a longer time to complete. Before a risk assessment can proceed, the assets must be defined in detail. Other quantifiable characteristics must also be compiled. The risk assessment was informed by the hazard assessment completed in Section 3.3 above then a consequence assessment.

The risk to infrastructure was estimated by ranking different types of structures according to their exposure to two different types of hazards: 1) storm induced flooding, and 2) sea-level rise. Exposure of different structures to each type of hazard was ranked from 1 to 4, where 1 is minimal exposure, and 4 maximum exposure (Table 3.4). Final ranking was computed as the geometric mean of the individual ranks.

*Table 3.4: Ranking of Critical Infrastructure*

| | **Rank 1** | **Rank 2** | **Rank 3** | **Rank 4** |
|---|---|---|---|---|
| Storm Flood Hazard | Outside FEMA Zones | Inside FEMA Zone A and AO | Inside FEMA Zone AE | Inside FEMA Zone VE |
| Sea-Level Rise (SLR) | Not Impacted by SLR | Impacted by less than 5' of SLR | Impacted by less than 3' of SLR | Impacted by less than 2' of SLR |

For storm related flooding, structures outside of FEMA flood zones received a rank of 1; structures in A and AO zones, which are subject to flooding during rain storms, received a rank of 2; structures in AE zone, which are subject to flooding during rain storms and by wave action, received a rank of 3; and regions in VE zones, which are subject to flooding by storm surge and wave action, received a rank of 4.

USACE (2014) and Hall et al. (2016) indicated that sea-level rise was likely to be between 1.5 and 2' by 2050, and around or above 5' by 2100. Structures that flooded by less than 2' of sea-level rise received a rank of 4, less than 3' a rank of 3, less than 5' a rank of 2, and structures that are not impacted by sea-level rise received a rank of 1.

Consequence assessment focuses on the characteristics of the people, environment, and infrastructure exposed to the hazard and determines an impact. The output of the hazard assessment focused on storm surge depths and coastal flood depths, which can be used to calculate losses in terms of direct and indirect economic losses, population at risk, and environmental habitat impacts (Tetra Tech, Inc, 2014).

To convert the hazard assessment information into a loss estimate, a fragility curve also known as a damage function or a damage curve is used. The specific outputs of the hazard assessment are related to a mean damage ratio (the damage sustained divided by the total value of the structure). There are several types of tools that can be used to support this more detailed risk assessment; Central America Probabilistic Risk Assessment (CAPRA) and HAZards U.S. (HAZUS).

## 3.7 Adaptation Strategy and Action Planning

The future climate scenarios and results of the above assessments was used to identify, assess and prioritize adaptation measures. This step was key as it developed a framework for how the territory will address climate change in the near- short- and long- term. These were integrated into the Territory's climate change adaptation strategy and plan. Rather than simply allowing the adaptation plan to be a compilation of risk assessments and adaptation measures of individual institutions, the VICCC will seek to lay out a territory-wide strategy that "mainstreams climate change", identifies necessary policy measures and funding opportunities, and sets the path forward for the long-term.

Details from the event and the results from response and recovery efforts and lessons learnt from the Hurricanes Irma and Maria events of 2017 were also gathered to fully inform the climate change adaptation strategy and action plan. The strategy and action plan will be finalized at the end of the project once all phases of the project have been completed and national stakeholder consultations have taken place.

# 4 Sensitivity Analysis

As mentioned in Section 3.2 this section, among other things, discusses:

- the known climate conditions resulting in stresses on the sectors of relevance for this project;
- how present climate conditions affect the sectors;
- how climate change projections will impact on the sectors.

This sensitivity analysis was the first step in the vulnerability analysis. Table 4.1 below shows the criteria used in assessing sensitivity.

*Table 4.1: Description for Assessing Sensitivity*

| Sensitivity | Description |
|---|---|
| High | • Currently faced with existing climate stresses<br>• Expected to be significantly affected by projected climate change impacts (without preparedness action) |
| Medium | • Currently faced with few existing climate stresses<br>• Expected to be moderately affected by projected climate change impacts (without preparedness action) |
| Low | • Currently faced with little to no existing climate stresses<br>• Expected to not be affected by projected climate change impacts (without preparedness action) |

## 4.1 Climate Sensitivity

### 4.1.1 Existing Climate Setting

The existing climate of the USVI and the trends being experienced over time is summarized below for temperature, rainfall, sea level and hurricanes. This has been taken from the United States Virgin Islands: Historical Trends and Future Climate Changes (CSGM, 2018).

**Temperature**

- The mean temperature climatology for the USVI mirrors the Caribbean pattern whereby it is characterized by cooler temperatures in the beginning of the year (January- February) with a gradual increase to a single in peak in summer (June-September). Thereafter, there is a decline in temperature towards the end of the year.
- The temperature range over the year is generally small (~3-4$^0$C) with mean temperatures peaking near 30$^0$C.
- The Caribbean's mean temperature has followed global mean surface temperature trends. Similarly, so has the USVI, with an increase of 0.18$^o$C/decade.
- The daily temperature range has decreased slightly.
- There has also been a slight increase in the number of warm nights and a slightly smaller numerical decrease in the number of cool nights.

**Rainfall**

- USVI has a bimodal pattern of precipitation which mirrors that of the Caribbean. There is an early wet season peak in May followed by a mid-summer drought in June-July and a progressive climb to a late wet season that peaks in November. The driest part of the year is from January to March.
- Mean rainfall totals are fairly low, with maximum value of ~140 mm per month at the height of the late rainy season.
- Rainfall during the rainy season is primarily due to easterly waves or their derivatives (tropical depressions, storms and hurricanes).
- In early months of the dry season rain can also be a result of North American frontal systems.
- Significant year-to-year variability is observed due to the influence of phenomenon like the El Niño Southern Oscillation (ENSO).
- There appears to be an increase in the intensity of rainfall events.
- The trend in the number of consecutive dry days (CDD) shows a decrease for 1986-2010. Very wet days are also decreasing.

**Hurricanes**

- The hurricane season in the North Atlantic spans June to November.
- The North Atlantic has seen an increase in tropical cyclone activity since 1995 with a distinct increase in the number of intense (category 4 and 5) storms.
- The USVI falls within the most likely track for storms during August and September and in the likely track for hurricanes during October.
- 22 hurricanes have passed within 200km of St. Thomas & St. John, and 23 within the same radius of St. Croix, since 1950. Of these storms, approximately 8-10 were classified as "catastrophic" (category 4 and above) at closest approach.
- The severity of the systems and overall damage caused by the 2017 hurricanes was unprecedented and are considered historic.

**Sea Levels**

- Caribbean Sea level changes are near the global mean.
- A regional rate of increase of 1.8 ± 0.1 mm/year between 1950 and 2009 has been observed.
- In more recent years, the region has seen larger increases in sea levels due to the influence of warmer El Niños.
- There is evidence of a higher rate of increase in later years: up to 2.5 ± 0.1 mm/year between 1993 and 2010.
- U.S. Virgin Islands Territory has experienced sea level rise of between 1.86 ± 0.5mm/year and 2.07 ± 0.69 mm/year between 1975 and 2016.

#### *4.1.1.1 Overview of Hurricanes Irma and Maria*

The USVI experienced two extreme hurricane events, 12 days apart in September 2017: Hurricanes Irma and Maria. A review of these events and the USVI experience are presented in Sections 5.2 to 5.5. This review is instructive, in that it serves to inform the vulnerabilities of the key economic sectors and

infrastructure and identify gaps in information and capacity. The first two objectives of this project as listed in Section 1.2.1 speak to those issues.

Hurricane Irma has been ranked among the strongest hurricanes to have ever hit the Caribbean. It pummeled the north-eastern Leeward Islands where it first made landfall on the island of Barbuda. On the 6th of September 2017 Hurricane Irma hit St. Thomas with maximum sustained winds of 185 mph (295km/h) (National Hurricane Centre, 2017). This event left a trail of destruction in several parts of the Caribbean including the USVI.

Following Hurricane Irma, the plans for recovery in St. Thomas and St. John included using St. Croix as a base. However, two weeks after the strike of Hurricane Irma, Hurricane Maria entered the region. Following Hurricane Maria's landfall on Dominica as a category 5 storm on Monday September 18, 2017, it sustained its strength whilst passing St. Croix on Tuesday September 19, 2017 and Wednesday September 20, 2017 with maximum sustained winds of 175 mph. Wind gusts to 114 mph (183 km/h) were reported in the western portion of the island. (National Hurricane Center, September 19, 2017 at 10:00pm and at 11:00pm). Of all the USVI, St. Croix experienced the brunt of Hurricane Maria. The USVI experienced multi-island, multi-event within two weeks.

### 4.1.2 Projected Climate Profiles

Future climate projections for temperature, rainfall, sea levels and hurricanes in the USVI are summarized below.

**Temperature**

- Irrespective of the scenario used, the minimum, maximum and mean temperatures show an increase through the end of the century.
- GCMs suggest that the range of increase in mean annual temperatures will be 0.46°–0.55°C by the 2020s; 0.83°-1.43°C by the 2050s and 0.80-2.89°C for 2081-2100 relative to 1986-2005.
- Projected changes for minimum annual temperature are 0.45°-0.55°C by the 2020s, 0.83°-1.44°C by the 2050s, and 0.81°-2.91°C by the end of century relative to 1986-2005, with similar increases in maximum annual temperatures.

**Rainfall**

- The GCMs suggest that a drying regime will onset very early in the century (by the 2020s) and intensify through century's end.
- Projections for the mid - 2020s are for 3% to 2% less rainfall than the annual mean. The 2050s are up to 12% drier, while by the end of the century the country as a whole may be up to 25% drier for the most severe RCP (RCP8.5).
- Drying will be in both the wet season and dry season i.e., all year round.
- The available RCM run projects that St. Thomas and St. John will experience slight increases in annual precipitation (5-16%) by mid-century while eastern St. Croix will experience a slight decrease (8-17%).
- The RCM also suggests slight increase in days with average precipitation above 1 – 4 inches for St. Thomas and St. John by mid-century.

**Hurricanes**

- There is expected to be no change or slight decrease in the frequency of hurricanes.
- There is expected to be a shift toward stronger storms by the end of the century as measured by maximum wind speed increases of +2 to +11%.
- There is expected to be a +20% to +30% increase in rainfall rates for the model hurricane's inner core, with a smaller increase (~10%) at radii of 200 km or larger.
- There is expected to be an 80% increase in the frequency of Saffir-Simpson category 4 and 5 Atlantic hurricanes over the next 80 years using the A1B scenario.
- There is expected to be a potential northward shift in future hurricane tracks.

**Sea Levels**

- The Fifth Assessment Report of the IPCC does not provide projections for the Caribbean separate from that for the global mean.
- The combined range for projected global mean sea level rise over all scenarios (RCPs) spans 0.26 to 0.82 m by 2100 relative to 1986-2005 levels.
- Models suggest the U.S. Virgin Islands may experience up to 1.00 m by the end of the century.
- It is suggested that gravitational and geophysical factors will lead to the region experiencing a greater rise in sea levels than most global areas. In fact, sea level rise over the northern Caribbean may exceed the global average by 25% by end of century.
- Other recent studies suggest an upper limit for the Caribbean of up to 1.5 m under RCP8.5 by end of century.

## 4.2 Projected Hazard Sensitivity

The focus of the hazard modelling was on coastal and inland flooding specifically focusing on Charlotte-Amalie, St. Thomas and Fredriksted, St. Croix. These areas of focus were selected as they have the highest concentration of critical infrastructure. The models were applied to investigate changes in drainage patterns, flood depths and potential erosion concerns in the light of climate change.

The hazard modeling study included:

- Determining the flooding extent for design return periods 10, 25, 50, 100, and 500 yr. with Sea Level Rise (SLR) scenarios
- Assessing flooding duration for each event
- Determining the impacts of SLR on infrastructure
- Determining the impact of Climate Change (mainly increased Rainfall intensity) on drainage patterns

Rising sea levels are likely to impact low lying areas by increasing the water table causing additional challenges to the drainage infrastructure. Higher groundwater tables reduce the total storage capacity of the soils, which is likely to cause increased surface runoff and flooding for equivalent storms. The performance of stormwater units, such as exfiltration trenches and drainage wells is similarly reduced, which additionally results in increased runoff. Furthermore, the potential increase in the number of

category 4 and 5 events bringing heavy stormwater, is likely to cause additional impacts by increasing the frequency of flooding.

### 4.2.1 St. Thomas

**Storm and Sea-Level Rise Induced Flooding**

FEMA Flood zones and regions inundated by different sea-level rise values for St Thomas are presented in Figure 4.1 and Figure 4.2, respectively. Regions most at risk on St Thomas are Charlotte Amalie and its surroundings, the Bovoni area, and the Smith Bay area, as well as Megan's Bay.

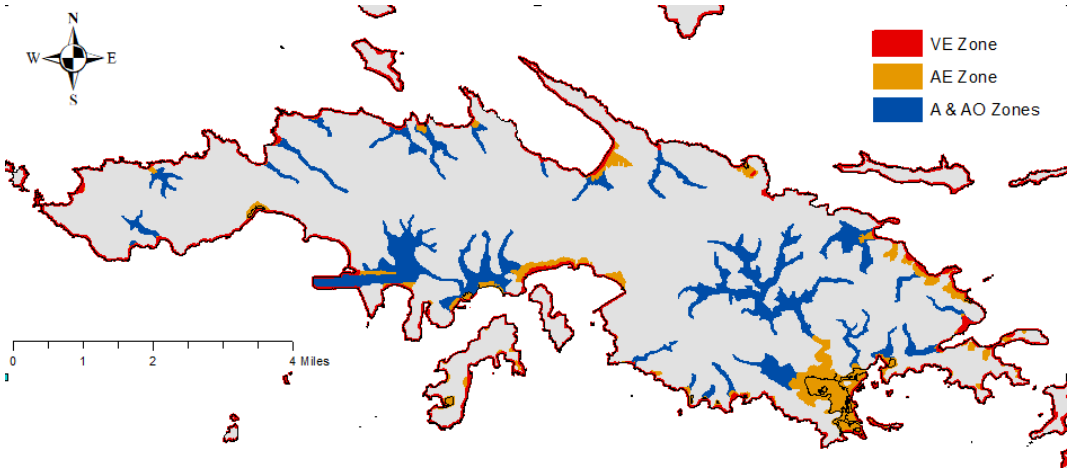



*Figure 4.1: FEMA Flood Zones for St Thomas*

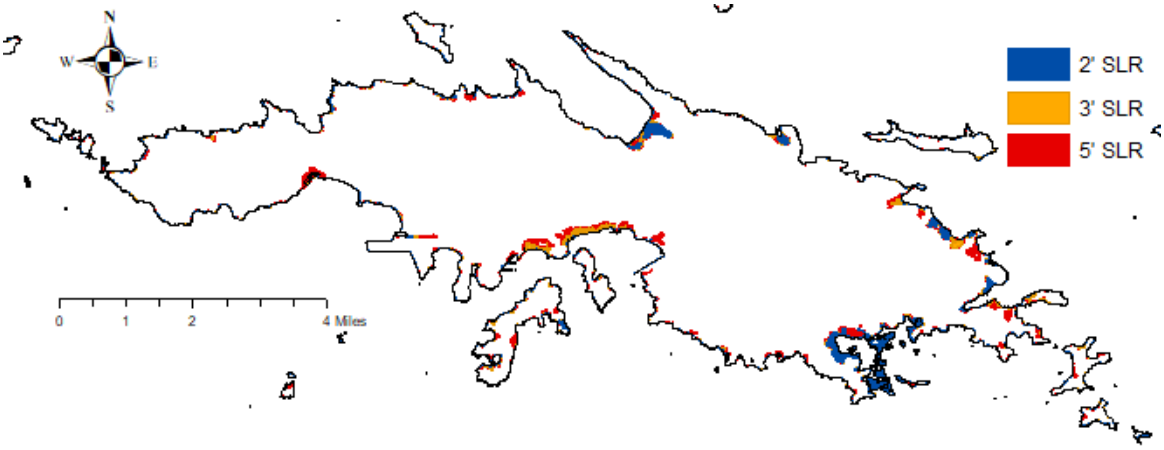



*Figure 4.2: Flooding due to sea-level rise on St Thomas*

The model of Charlotte Amalie focuses on coastal and inland inundation. The results demonstrate that for the different time periods, 2017, 2035, 2065 and 2100 there are negligible differences in the simulations, which indicates that rise in sea level, even though noteworthy, is, by itself and in comparison to other

potential climate threats, not expected to be of significant concern in the near term. However, coastal areas lower than 8- ft elevation are prone to coastal flooding.

**Flooding from higher rainfall intensity**

The analysis shows that higher rainfall intensity results in increased flooding extent and flood depth when compared to the baseline intensity (2017). Up to 3 feet greater flooding depths can be experienced for the areas highlighted with red on Figure 4.3.

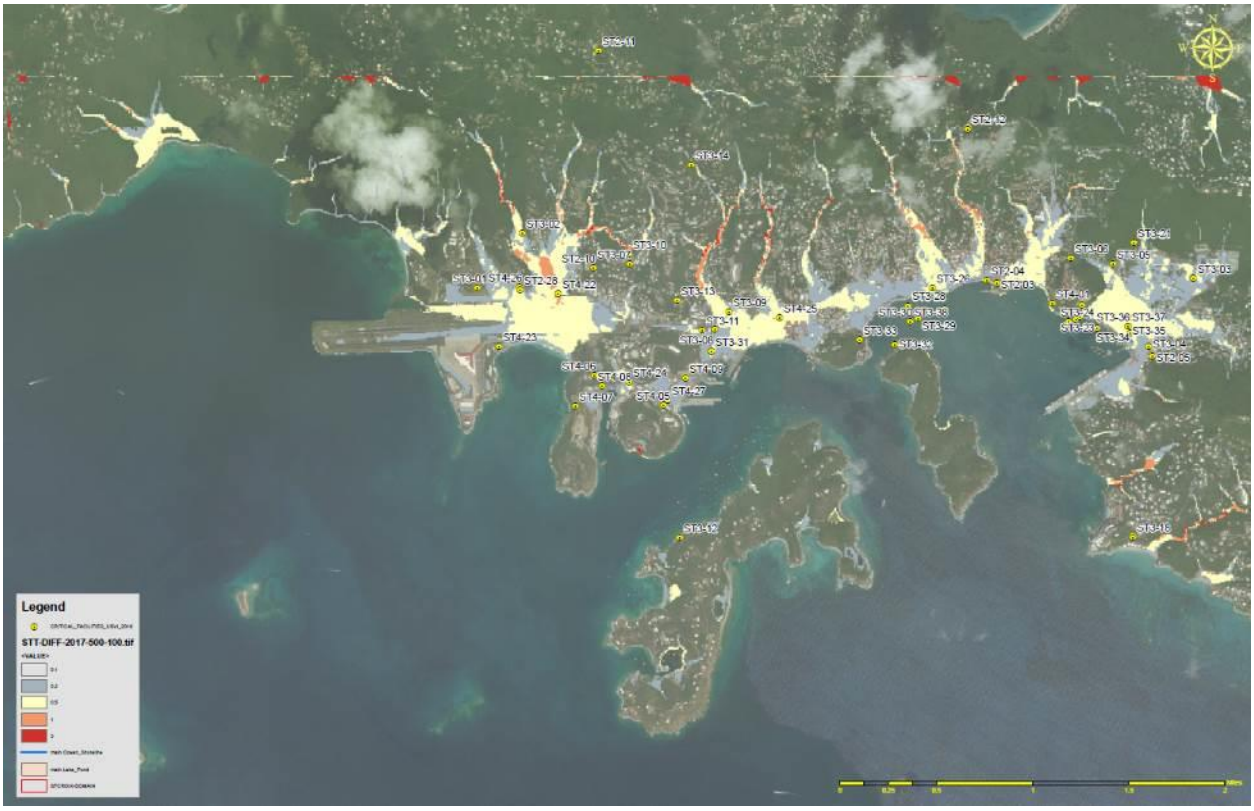



*Figure 4.3: Difference in Flood Depths for a 100-year 72-hour storm event for year 2100 using the baseline intensity and the projected 30% increase. The aerial shows the topography and difference of computed depths of water*

### 4.2.2 St. Croix

**Storm and Sea-Level Rise Induced Flooding**

FEMA Flood zones and regions inundated by different sea-level rise values for St Croix are presented in Figure 4.4 and Figure 4.5, respectively. Most of the south coast is prone to flooding, including Sandy Point, but most populated regions at risk on St Croix are Limetree Bay area, as well as Christiansted and Fredericksted.

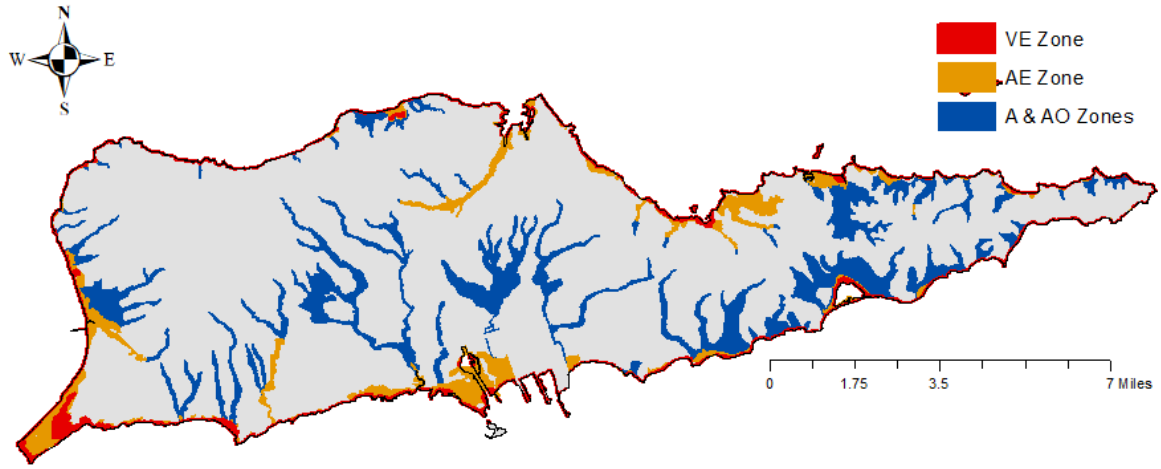



*Figure 4.4: FEMA Flood Zones for St Croix*

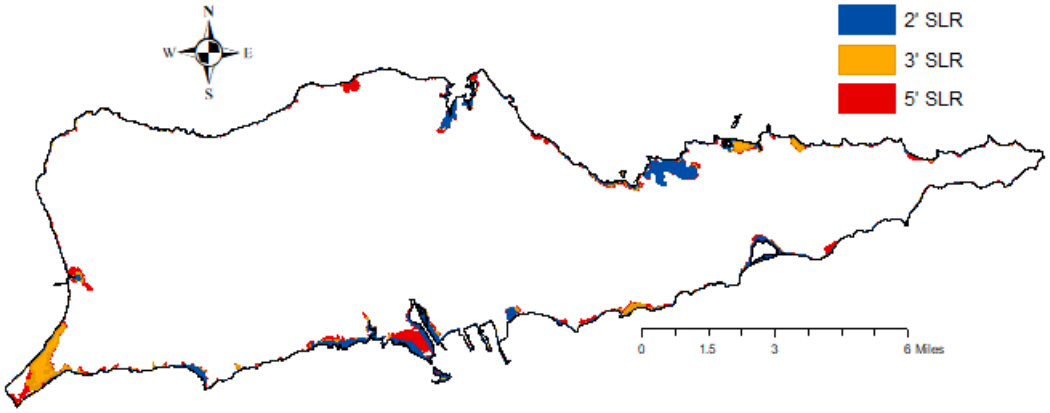



*Figure 4.5: Flooding due to sea-level rise on St Croix*

The model of Frederiksted is focused on inland hydrology and inundation. It demonstrates that the coastal -fluvial interface is along La Grange Road from northwest to southeast. The simulations for the different time periods, 2017, 2035, 2065 and 2100 show similarities in flood depth patterns and insignificant differences for inland flooding indicating the relative rise in sea level is not expected to be the primary concern for climate change in near term period.

**Flooding from higher rainfall intensity**

The analysis shows that higher rainfall intensity results in increased flooding extent and flood depth when compared to the baseline intensity (2017). Up to 3 feet greater flooding depths can be experienced for the areas highlighted with red on Figure 4.6.


*Figure 4.6: Difference in Flood Depths for a 100-year 72-hour storm event for year 2100 using the baseline intensity and the projected 30% increase. The aerial shows the topography and difference of computed depths of water*

### 4.2.3 St. John

**Overall Vulnerability**

St. John was analyzed on a conceptual level, because as indicated in the methodology no hazard modelling was done for that island. The coastal and marine communities of the St. John Island are susceptible to the effects of climate change including increasing hazardous coastal conditions and loss of marine, coastal and island resources. Climate change is anticipated to add to the stresses of the coastal environment by altering temperature and precipitation patterns, increasing the likelihood of extreme precipitation events, and accelerating rates of sea level rise. Man-made infrastructure may have vulnerabilities to SLR that depends on the natural characteristics of a coastal area and climate. The frequency and severity of various impacts that are acceptable to human stakeholders are relevant to vulnerability.

Pendleton et al., 2004 demonstrates that extended length of the coastal line including inland coastal areas will be impacted by elevated levels of SLR (Figure 4.7).

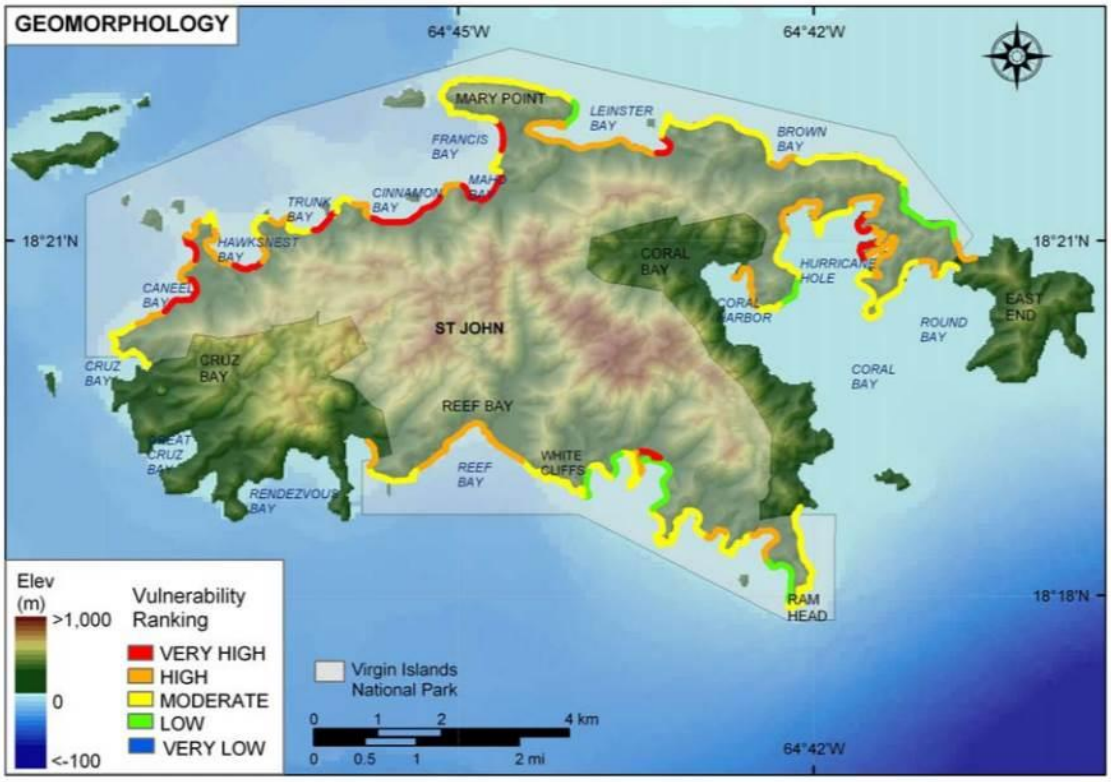



*Figure 4.7: Coastal Geomorphology of Virgin Islands National Park (Pendleton et al., 2004)*

The study was focused mostly on the impacts to the National Park and classified the vulnerability of the island in several categories:

- Very high vulnerability geomorphology is mostly sand beaches or mangrove wetlands.
- High vulnerability geomorphology includes gravel or cobble-sized beaches or cliff-backed beaches.
- Moderate vulnerability geomorphology consists of alluvium or fringing reefs fronting low cliffs.
- Low vulnerability geomorphology includes medium cliffs and rock headlands.

The main issues relevant to St. John Island included examination and analysis of: (i) how vulnerable the existing infrastructure facilities are to SLR, (ii) what are the critical thresholds of coastal evolution past, (iii) which infrastructure is unacceptably impacted, (iv) whether the infrastructure is adaptable to become more resilient to SLR, and (v) if the infrastructure fails, what might be the impacts on the protected area.

Conceptual analysis was conducted for St. John to define infrastructure vulnerability related to:

- **Navigation** - Relative SLR will result in morphology responses within and adjacent to navigation projects that may affect feature stability as well as project performance. SLR has the potential to modify the coastal processes affecting navigation channel stability and disposal site depressiveness.
- **Coastal Storm Damage Reduction** Coastal landscapes vary in their degree of vulnerability to SLR. Cross-shore and along shore morphological evolution will together define how a system responds.

- **Flood Damage Reduction** As sea levels change, hydraulic gradients will be impacted, affecting sediment transport in rivers. Modifications of coastal and riverine landforms and coastal marshes by increased forcing can result in increased risk of flood intensity and frequency.

### Storm and Sea-Level Rise Induced Flooding

FEMA Flood zones and regions inundated by different sea-level rise values for St John are presented in Figure 4.8 and Figure 4.9, respectively. Most of the island coast is at risk from flooding by storm or sea-level rise. Regions most at risk on St John are the south-west coast of the island, from Cruz Bay to Coral Bay.

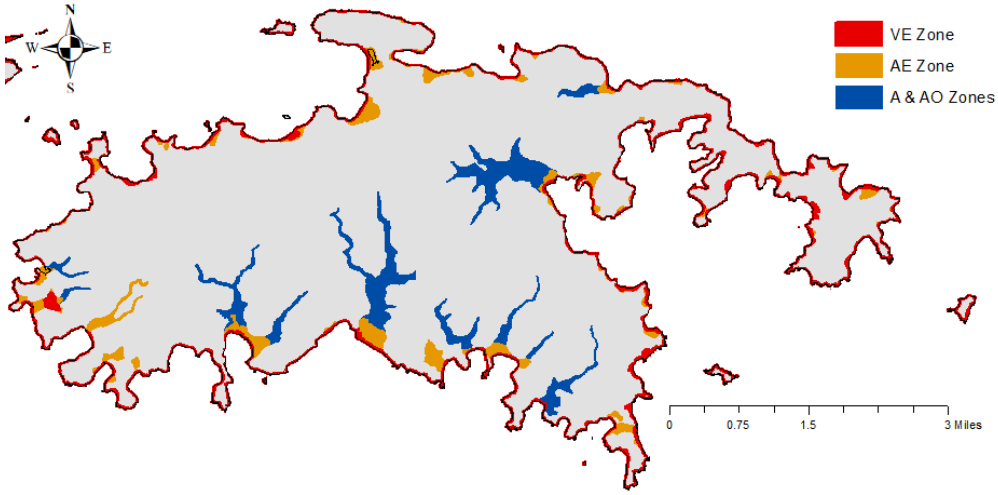



*Figure 4.8: FEMA Flood Zones for St John*

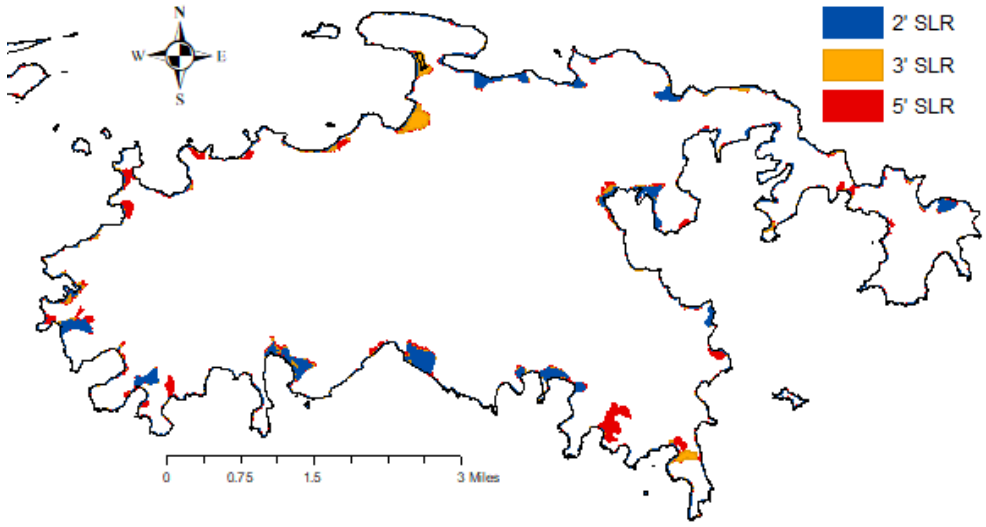



*Figure 4.9: Flooding due to sea-level rise on St John*

## 4.3 Socioeconomic Setting and its Sensitivity

The U.S. Virgin Islands has a total population of 106,827 as of August 17, 2017, with a crude birth rate of 12.838 births/thousands and a crude death rate of 8.107 deaths/thousands (World Population). Population growth is currently negative at -0.5% per year. (U.S. Bureau of Labor Statistics 2017). The average hourly wage for workers in the U.S. Virgin Islands is $23.86, and there is a slow job growth (Bureau of Labor Statistics 2017).

### 4.3.1 St. Thomas

The island is known for its rich culture, lush vegetation and turquoise waters, all of which are important resources for the thriving tourism industry. The 2010 census indicates that the population for St. Thomas is 51,452, of which 24,522 are males and 26,930 are females. The number of households is 21,462 with an average household size of 2.39. Approximately 70% of St. Thomas is zoned for low density residential uses (R-1 and R-2), and agriculture and industry each have less than 5% of area zoned for those purposes (US Virgin Islands Census 2010). (Figure 4.10). The second most densely populated area is in the hilly area of Tutu (Figure 4.10).

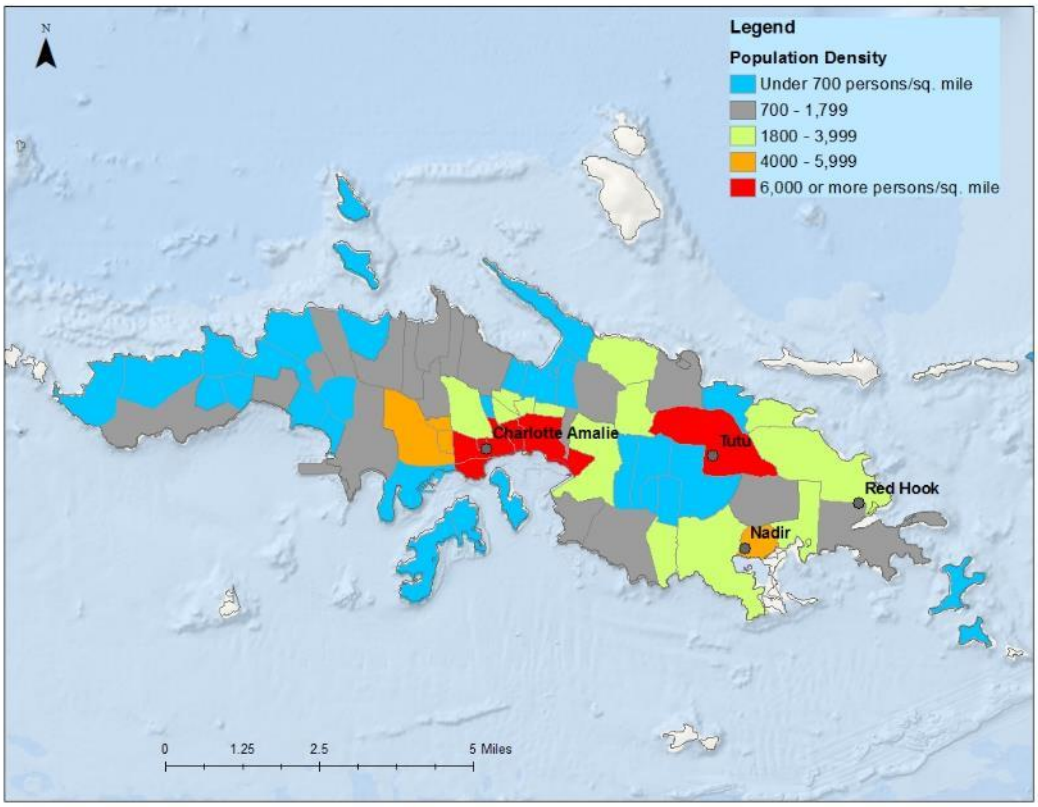



*Figure 4.10: St. Thomas - Population Distribution*

There are 2,322 people with a disability and of those people 1,233 of them are unemployed (US Virgin Islands Census 2010).

The county's social and economic life is vulnerable to current climate-triggered events. Droughts and floods have been reported and the impact of a major hurricane in 2017 has been mentioned above. Irma

destroyed thousands of homes, schools and public buildings and damaged the only hospital on the Island. The Estate Tutu Apartments was severely damaged, and its residents had to be moved to other locations (St. Croix Source, September 15, 2017).

*Figure 4.11: Hospital Severely Damaged from Hurricane Irma (Hilary Swift for the New York Times)*

Governor Kenneth Mapp reported in the St. Croix Source (September 15, 2017) that he went to the Tutu Housing community on one of his recent tours and of approximately 285 families living there, about 160 were living in shelters.

"It was really heartbreaking to see," Mapp said. The walls were blown out "like matchboxes," and one of the territory's four confirmed storm fatalities was a woman resident of Tutu. (Governor Kenneth Mapp interview by the St. Croix Source reported on September 15, 2017).

*Figure 4.12: Annas Rest, with the damaged Tutu Hi-Rise apartments toward rear of the photo in St. Thomas. (James Gardner of the St. Croix Source, September 15, 2017)*

*Figure 4.13: Ravaged houses in St. Thomas (Erika P. Rodriguez for The New York Times, September 11, 2017)*

*Figure 4.14: Damaged houses in St. Thomas (Erika P. Rodriguez for The New York Times, September 11, 2017)*

### 4.3.2 St. John

St. John has been famous for its remarkable cover of lush vegetation, numerous bays, very steep slopes, and rubbly guts. More than one-half of the island area has been declared a National Park and very little development is allowed in that area. The population is 4170, out of which 2040 are males and 2128 are female. Most of the residents reside in the Cruz Bay settlement (Figure 4.15). There are 167 individuals with a disability and 61 of those people are unemployed (US Virgin Islands Census 2010). The number of households in St. John is 1894, and the average household size is 2.03.

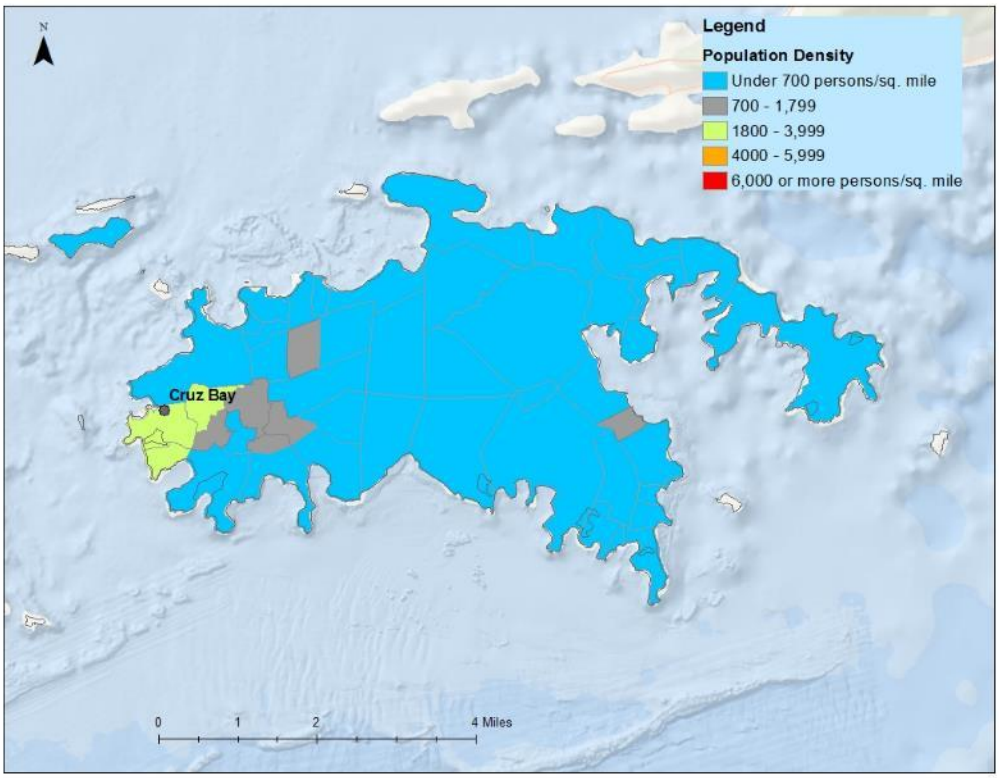



*Figure 4.15: St. John - Population Distribution*

Hurricane Irma revealed the vulnerability of the island. Vegetation was decimated, and St. John suffered a similar fate as St. Thomas wherein “pieces of cars and boats were dangling on dead power lines” (USA Today, September 17, 2017).

"While there were some homes that survived - some lost just roofs - there are homes that are totally obliterated right down to the foundation," reported David Mapp, Executive Director of the Virgin Islands Port Authority (USA Today, September 17, 2017).

*Figure 4.16: Hurricane Irma leaves debris and destruction in its wake on St. John, part of the U.S. Virgin Islands (Anthony Faiola / The Washington Post, 2017)*

*Figure 4.17: A Damaged Vehicle sits on Top of Debris from the Destroyed Chateau Bordeaux Restaurant after Hurricane Irma in St. John, U.S. Virgin Islands, (Jessica Rinaldi/Bloomberg News Sept. 12, 2017)*

### 4.3.3 St. Croix

The population of St. Croix is 50,601, of which 24,206 are males and 26,395 are females (US Virgin Islands Census 2010). There are 2,664 individuals with a disability and of those individuals there are 1,492 that are unemployed (US Virgin Islands Census 2010). There are 8,253 people on St. Croix that are unemployed and 13,613 individuals whose income in 2009 were under the poverty level (ibid). The manufacturing sector experienced growth over several years with oil refining, alumina processing, watch assembly, textiles and rum production. Since 2012, the sector declined considerably after the closure of the two large industrial operations - Hess Oil and Martin Marietta Alumina.

The number of households in St. Croix is 19, 765 with an average household size of 2.46 (US Virgin Islands Census 2010). Low density residential districts account for 54% of the land area, 7% for medium density residential areas, almost 25% for zoned agricultural, and around 1% for business and commercial. The waterfront districts account for about 2% and the coastline accommodates mainly low density residential zones with large public, industrial and agricultural districts along the south shore. Christiansted has the greatest population density (Figure 4.18).

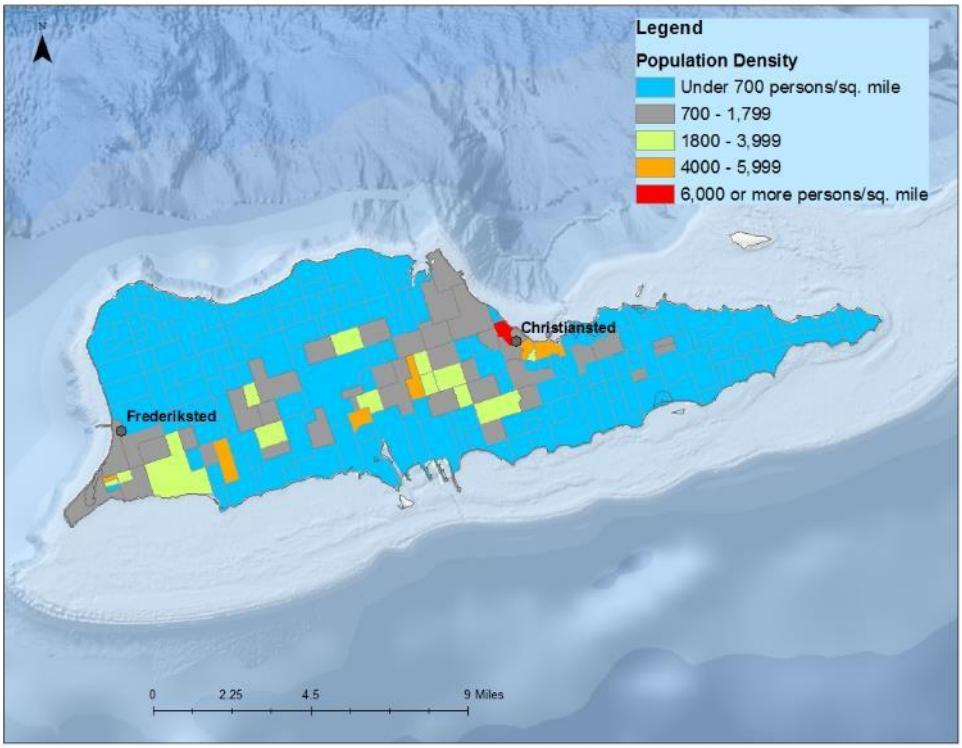



*Figure 4.18: St. Croix - Population Distribution*

2017 proved disastrous for St Croix as it did for the other islands. Spared the brunt of Hurricane Irma, St Croix suffered major loss and damage from the subsequent Hurricane Maria which was particularly hard on the western end. Residents remained trapped in their homes days after the event (Fox News, September 25, 2017). Inadequate clean water, blocked roads due to downed trees, a lack of electricity and telecommunication services were significant challenges. Approximately 70 percent of the buildings were damaged (ibid) and the airport lost the control tower leaving that critical facility inaccessible.

Sections of the eastern parts of St. Croix were spared the worst.

Figure 4.19 to Figure 4.21 below show some impacts of Hurricane Maria on St. Croix.

*Figure 4.19: A man stands outside a destroyed home in this aerial photo from a Marine Corps MV-22 Osprey surveying the aftermath from Hurricane Maria in St. Croix, U.S. Virgin Islands, last Thursday. (REUTERS/Jonathan Drake)*

*Figure 4.20: Damaged Infrastructure and Flooding in St. Croix Following Hurricane Maria*


*Figure 4.21: Shipping containers strewn around the main port are seen from a Marine Corps MV-22 Osprey surveying damage from Hurricane Maria in St. Croix, U.S. Virgin Islands, last Thursday. (REUTERS/Jonathan Drake)*

Following the strike of Maria, 1,200 U.S. National Guardsmen spent days helping to rescue residents that were trapped. Some 800 Guardsmen were from the USVI many of whom also lost their own homes and were living in tents and helping others (Fox News, September 25, 2017). Another 1,500 were deployed and slept onboard a cruise ship that Federal Emergency Management Agency (FEMA) contracted to give them shelter (ibid).

## 4.4 Sensitivity of the Tourism Sector

Tourism is the major economic sector for the USVI, with accommodation and food contributing 13% to the country's GDP in 2014 (Bureau of Economic Analysis, 2016).

The World Travel and Tourism Council indicated that the direct contribution of Travel & Tourism to GDP was forecast to rise by 3.0% pa, from 2015-2025.

### 4.4.1 Assets

The USVI's natural environment is a critical part of the tourism product: this includes the weather, the scenic beauty of the hillsides, the beaches and marine life just to emphasize a few. There is also the built infrastructure, which includes: hotels and other accommodation, restaurants, shopping facilities, attractions, heritage and cultural assets, the cruise ship pier and other marinas.

St. Thomas is the main U.S. Virgin Island in the tourism industry (Figure 4.22). Starting in the 1950s, tourism has been raised as an economic option for the islands (Weaver 2006, cited by (Oswalt, 2004)). There were fewer than 50,000 visitors each year in the 1950s (Rogozinski 2000), however, now tourism accounts for 80 percent of gross domestic product, with the islands hosting more than 2 million visitors each year (Central Intelligence Agency 2007). St. Thomas' large cruise ship docking facilities and duty-free shopping attract the lion's share of visitors to the U.S. Virgin Islands each year.

.

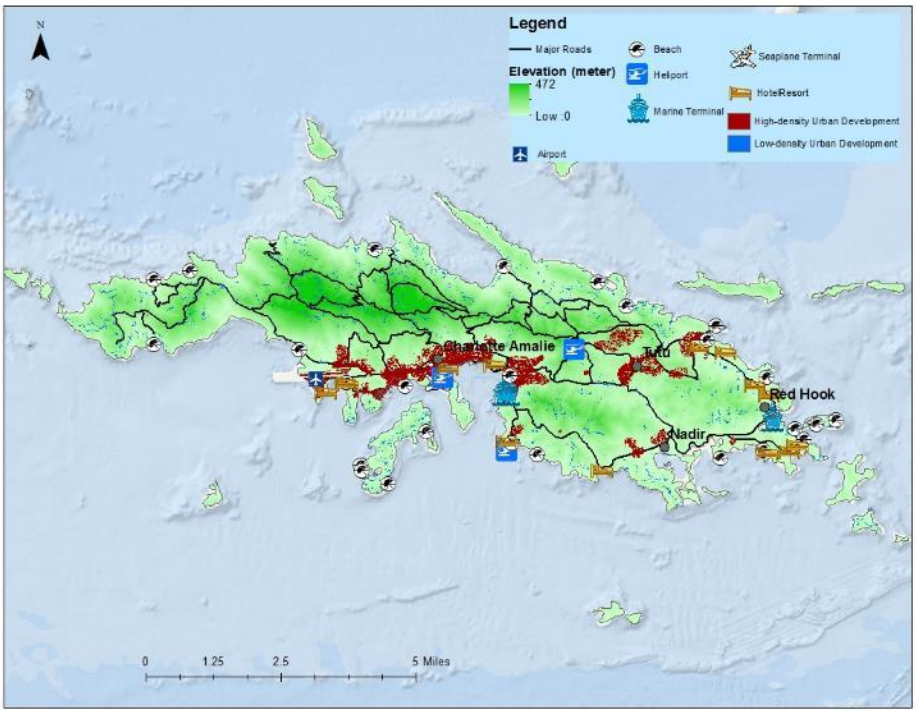



*Figure 4.22: Tourism Assets in St. Thomas*

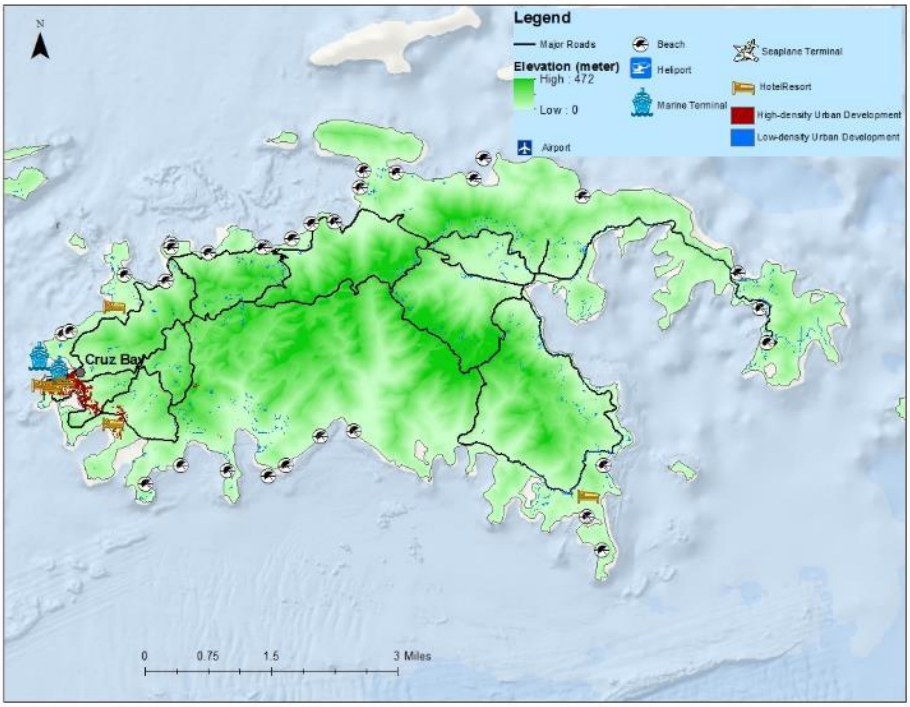



*Figure 4.23: Tourism Assets in St. John*

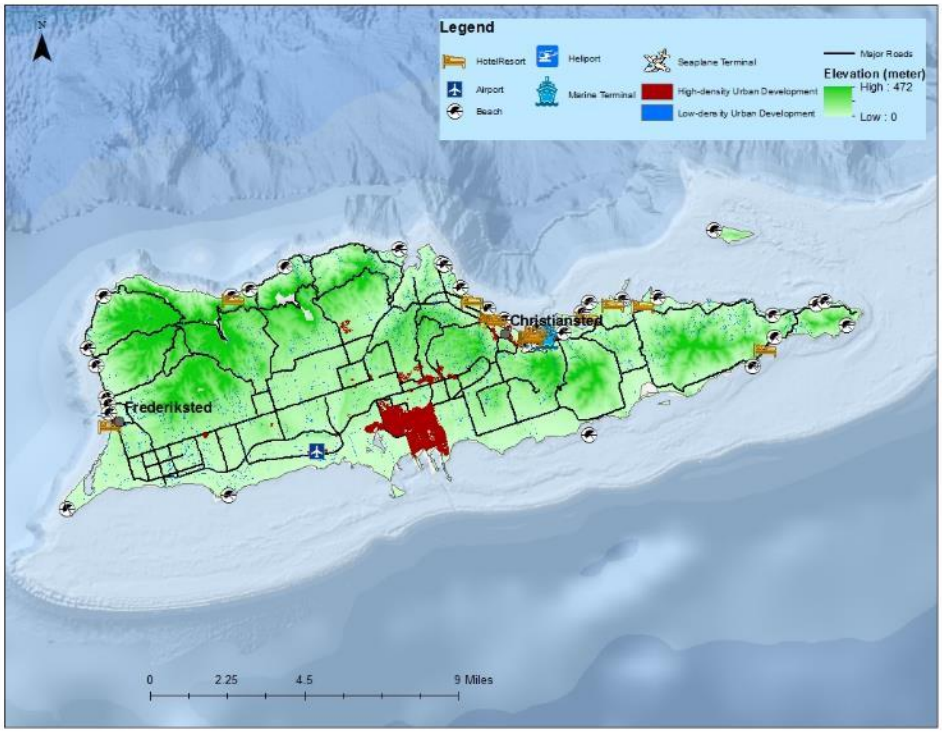



*Figure 4.24: Tourism Assets in St. Croix*

### 4.4.2 Threats

The main climate related concerns expressed through stakeholder consultations and literature reviews include:

1. Heat waves and tourists opting not to come off cruise ships.
2. Coral bleaching and the impacts that this can have on tours and fish resources.
3. Outbreak of the Zika Virus and losses in the wedding market. During 2015, when the spread of the virus peaked, repellant bands and information were provided to visitors at airports and information was made available at all ports of entry.
4. Coastal erosion of beaches is a threat to the main asset for the tourism sector. This has been particularly evident at Bolongo Bay, St. Thomas.
5. Sargassum is a major problem on the beaches. This has been significant on the west end and significant at Fortuna Bay, St. Thomas. Anecdotal evidence from hoteliers' indicate that this has on different occasions led to a reduction in visitors, as guests cancel reservations or opt not to book when they learn of the issues with sargassum on the beaches
6. Coastal flooding from tidal or storm surges is a threat for two main historical towns: Charlotte Amalie in St. Thomas and Frederiksted in St. Croix.
7. There are also concerns for surges or riptides and the risk of drowning for beach goers.
8. Poor watershed management (e.g. absence of a land management plan, lack of zoning, as well as overdevelopment near beaches). Links between land use decisions, water quality and development in vulnerable areas already evident. Segments of the population and important infrastructure are at increasing risk. Watershed management or lack thereof all links back to what is seen on the coastline in terms of environmental. E.g. not having sufficient room for wetlands

to migrate inland to keep up with sea level rise will result in greater negative impacts on these crucially important coastal ecosystems.

Other issues that aggravate the impacts of climate change, and that are also of concern to persons within the sector are indicated below:

- Diving and sailing are widely marketed but divers have been complaining, especially in St. Croix, about overfishing. There are dive concerns because of the geographic location of St. Croix and how fishing and over-fishing in particular impact the dive experience.
- In an attempt to diversify the tourism product, the Department of Agriculture and the Department of Tourism currently have a joint initiative to build the brand "Made in the Virgin Islands". This is dependent on the USDA's definition of how much of the ingredients are sourced in the territory. Agriculture is a struggling industry in the USVI and it is very vulnerable to climate change.

Hurricane Irma in 2017 did not just threaten but devastated the tourism sector in St. Thomas and St. John. Reports have indicated significant losses. Hotels have been damaged and getting those back up and functional to accommodate visitors will take some time (USA Today, September 7, 2017).

The three Marriott hotels on St. Thomas: The Frenchman's Reef & Morning Star Marriott Beach Resort, Marriott's Frenchman's Cove, and The Ritz-Carlton were able to have their guests evacuated to Puerto Rico following Hurricane Irma as the International hotel chain sent a ferry to transport these tourists. It was, however, unfortunate that as Beverly Nicholson-Doty, Commissioner for the US Virgin Islands Department of Tourism, reported to Business Insider (September 13, 2017) dock security did not allow people whose names did not appear on the passenger manifest to board. They had to follow legal protocol and so guests from other hotels were not evacuated at that time.

Following this several cruise lines sent ships to shuttle evacuees to Miami and Puerto Rico. Tourism Commissioner further indicated that everyone was doing their part to ease the burden on travelers and the people of St. John and St. Thomas (CBS2 September 1, 2017). Many hotels and airlines offered refunds and waived cancellation fees for several travelers. Airlines like Jet Blue and Delta flew "mercy flights" to rescue the sick and elderly trapped in Irma's wake. At that time, Commissioner Nicholson-Doty encouraged tourists to discover St. Croix, the only U.S. Virgin Island that was spared the worst from Irma.

The tourism sector in St. John, similar to St. Thomas also experienced significant damage. The two largest resorts will not be able to open until sometime in 2018; owners of the restaurants and bars now damaged will struggle; and residents who are suddenly without jobs are leaving en masse for the mainland (New York Times, September 27, 2017). Figure 4.25 shows the devastation of the Caneel Bay Resort on St. John.

*Figure 4.25: The Caneel Bay Resort on St. John was heavily damaged (Hilary Swift for The New York Times)*

## 4.5 Sensitivity of the Agricultural Sector

The agriculture sector can be broadly divided into livestock and crop farming. The assets exposed and the sensitivity of these assets to existing threats posed by climate change are elaborated below.

### 4.5.1 Assets

The 2007 agriculture census reports[2] a total of 219 farms[3] on a total of 2379.96 hectares (5,881 acres) of land. St. Croix accounted for 73% of the total farms (160 farms 5,574 acres in total), while St. Thomas and St. John shared the remaining 27% (Figure 4.26).

[2] The most recent figures available

[3] Farm Definition: All places from which $500 or more of agricultural products were produced and sold, or normally would have been sold, during the calendar year 2007. (USVI Agriculture Census 2007)

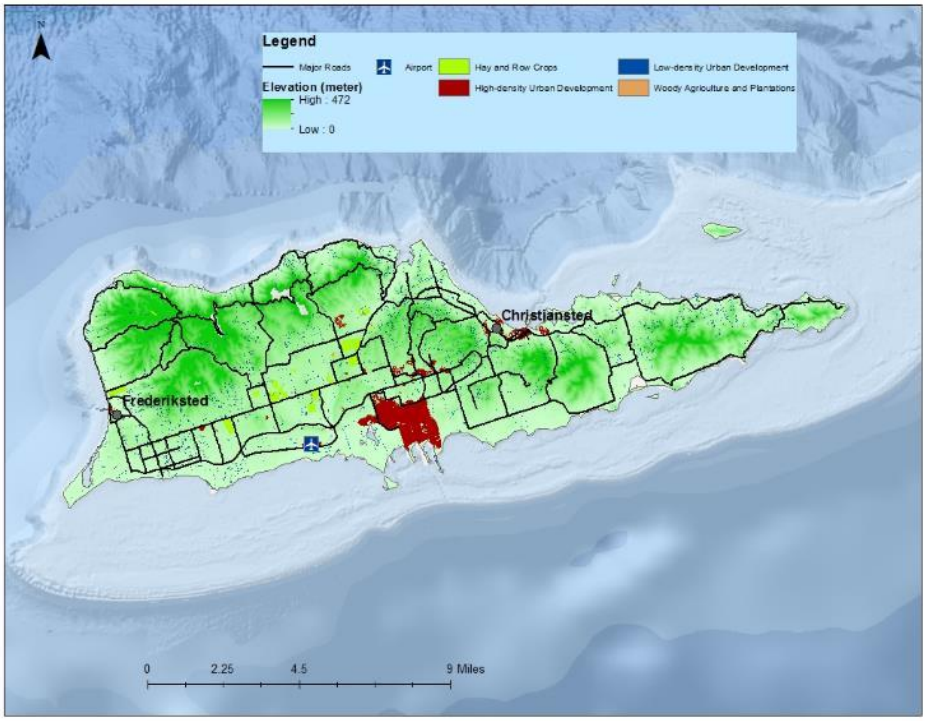



*Figure 4.26: Agricultural Assets in St. Croix*

There is approximately 85% of land on St. Croix that is suitable for farming. These farmers mainly fall in the age group of 65 and over, with the majority of them having their farm for over 10 years. Crops such as tomatoes, peppers, eggplant, okra, cucumbers, avocado, banana, coconut, breadfruit, grapefruit, mangoes, papaya, limes and lemons are grown on over 30 farms.

There is an agricultural experiment station on the St. Croix campus of the University of the Virgin Islands (UVI). They conduct research on livestock (and livestock products): sheep, cows, and beef; fish and crops including, vegetables, root crops, and forages. Water scarcity has prompted new research initiatives to improve water management, including the use of microprocessor technology to monitor and control irrigation of crops. Some plants reported on in the 2016 report included sorrel and Vahl's Boxwood, which is an endangered tree only found at four sites on the island. According to the 2016 report produced by the UVI St. Croix, small farmers tend to farm in low-external-input conditions, because of the limited access to other resources that conventional agriculture systems use to maximize crop yields. Due to lack of resources and affordable services these small farmers experience high pests issues and low soil fertility (Godfrey, 2016).

With respect to livestock, cattle, pigs, goats and sheep are the main livestock assets in the territory. The Senepol Cattle Breed was developed in St. Croix for its dorsal structure and its ability to manage heat stress. The breed has done very well and has also been exported to other countries. Over the years there has been a reduction in cattle production (Personal Communication). There are some chicken farmers but a significant amount of chicken is imported.

Vegetables are the main crop commodity, which is largely for domestic purposes. Primary crops are cucumbers. These are easy to sell locally because it is a favored by the customer. Other prevalent crops

include: tomatoes, pumpkin, eggplant and squash for tourism. These have tended to replace the cultivation of root crops which once dominated agricultural production.

The Department of Agriculture has land earmarked for farming and they have been requesting the submission of business plans. The intention is to grant applicants land-lease free of cost.

### 4.5.2 Threats

The agriculture sector being primarily open-field with small holdings, is very exposed and sensitive to climate. Droughts are particularly deleterious to production, as experienced in 2015. This was the worst drought experienced with 12 months of no rainfall, leading to devastating impacts. Farmers were not prepared in many ways. Water availability was a particular problem as storage was inadequate for irrigation and feed. Many animals died as there was no stored forage to meet the need. Culling of animals and sale of meat was also not done leading to significant loss in income and loss of animals. Pastures were totally destroyed from overgrazing and the financial resources were not available to purchase feed. This forced the Department of Agriculture to seek bag feed and hay from Puerto Rico.

Additionally, extended drought periods result in challenges with mites and aphids-lace bugs. During extended rainy periods Lepidoptera (worms) such as army worms, pin worms, etc. have been a significant challenge for many crops. Diamond bugs have also been a plague in cabbage production. In more recent times (the past 6-8 years), other challenges have arisen. For example, the cultivation of cucumber has been highly affected by downy mildew. This has the potential to wipe out an entire crop and efforts are being made to address this.

The sector's vulnerability is also affected by the "human factor" as much of the advice and best practices shared in training by both the Department of Agriculture and the UVI are not followed. Farmers are reluctant to change and prefer to continue with old inefficient practices.

Among specific adverse human behavior and practices that are aggravating the stress already posed by climate change are the following:

- Very few farmers < 5% see farming as business. Livestock farmers tend to treat animals more as pets, than commodities and over grow them without adequate food.
- Few persons farm as a livelihood so the time devoted is limited.
- Overgrazing pastures is allowed.
- Over stocking pastures more than the recommended rate of 1000 lbs. of livestock per 5 acres.
- Disproportionately small number of people engaged in farming.
- There is a lack of data collection for the sector as persons are reluctant to give their information on production and income.

The agricultural sector is also very vulnerable to hurricane conditions of heavy rainfall and high winds. Following Hurricane Irma and Maria in September 2017, the sector was devastated. Agriculture Commissioner Carlos Robles reported to the V.I. Senate Committee on Economic Development and Agriculture that immediately after Hurricane Irma and Hurricane Maria, the USVI had to rely on food imports for all of its food (Buchanan, 2018). He explained that one key project that was killed when the food crops were devastated was the Farm to School Initiative. This program was aimed at introducing more locally grown fresh fruits and vegetables into territory schools and other institutions.

“Robles told the committee that prior to the hurricane, at least 10 farmers on St. Croix were engaged in the Farm to School Initiative. School menus were set, crops were selected, and planting, harvesting, and delivery schedules were established” (Buchanan, 2018). “Thousands of pounds of locally grown fruits and vegetables were scheduled to be delivered to the Department of Education’s School Food Authority beginning in late September or early October 2017”. Commissioner Roble reported that 21 acres or more of vegetables were lost in the storms. He also reported for:

- St. Thomas – flooding in the administrative building;
- St. John – the Coral Bay office, greenhouse and adjacent buildings sustained damages;
- St. Croix – the expanded irrigation system in the Community Gardens and the LaReine Vegetable Market were damaged.

Commissioner Robles also indicated that the Agriculture Department has no disaster funds and they are relying on institutions such as the USDA to provide support.

## 4.6 Sensitivity of Critical Infrastructure

The United Nations International Strategy for Disaster Reduction (UNISDR) redefined critical infrastructure in 2017 as: “the physical structures, facilities, networks and other assets which provide services that are essential to the social and economic functioning of a community or society”.

As guided by this international definition this project examines critical lifelines (i.e. key roads, bridges), utilities, drainage, schools, hospitals, police stations, fire stations and shelters. Figure 4.27 to Figure 4.29 below illustrate the location of these key assets in all three islands.

### 4.6.1 Assets

Critical facilities are here ports and airports, power station, wastewater facilities, government buildings, police stations, fire stations and other public safety buildings. Also included are public housing, houses of worship and schools. Those facilities are mostly located along the coast, in larger population centers such as Charlotte Amalie, Cruz Bay, Smith Bay, Red Hook, Fredericksted, and Christiansted (Figure 4.27), which makes them susceptible to the combined impacts of coastal flooding and riverine flooding.

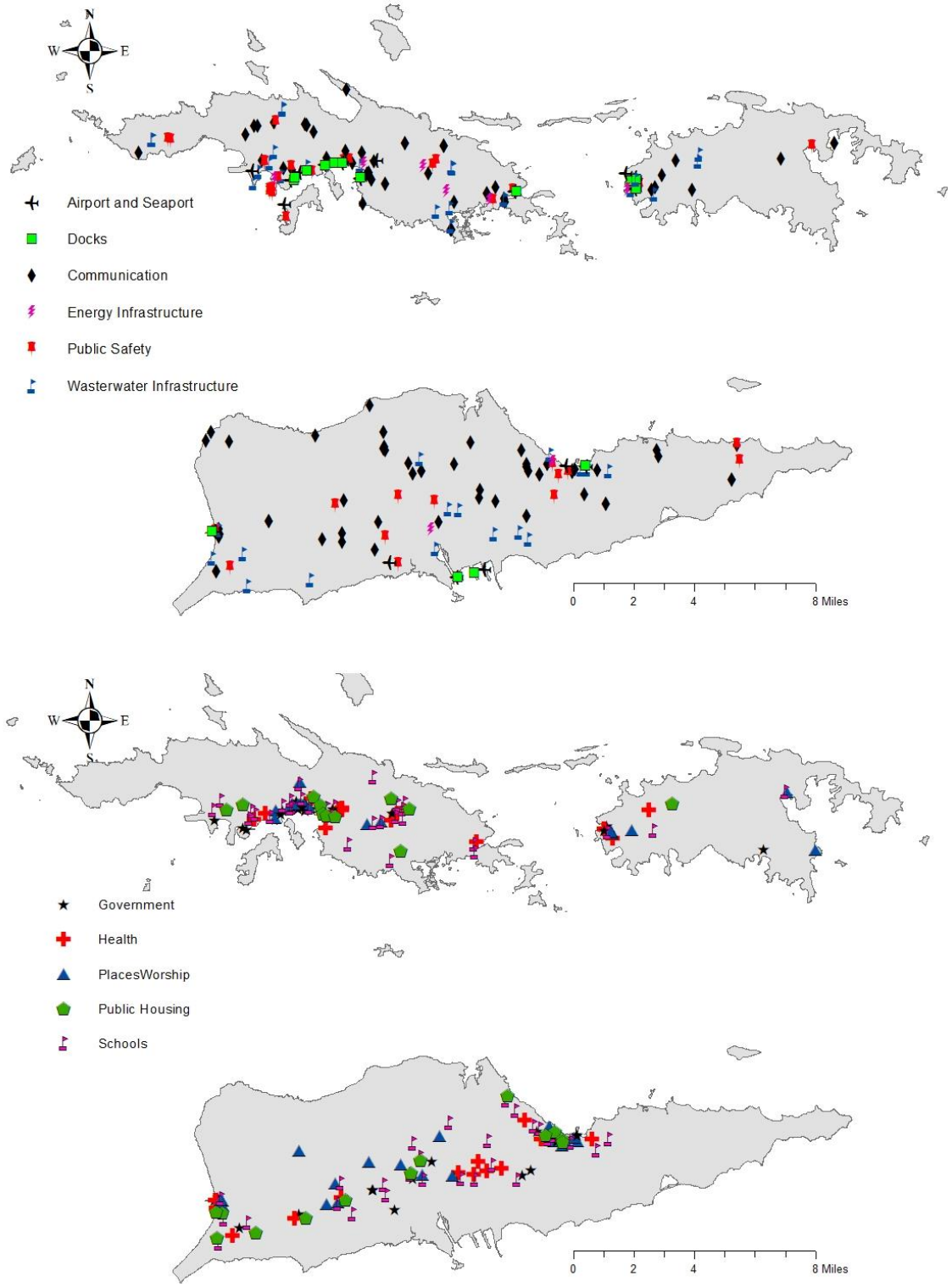



*Figure 4.27 Critical facilities*

Based on the project research, key critical infrastructure for the USVI are concentrated in Charlotte Amalie in St. Thomas and Frederiksted in St. Croix. **Error! Reference source not found.** and show the list of these facilities on St. Thomas and St. Croix respectively. These critical facilities are already exposed to varying climatic conditions and are vulnerable to heavy rainfall, high winds and storm surge hazards that come with extreme events. Several key infrastructure were completely devastated in Hurricane Irma in 2017.

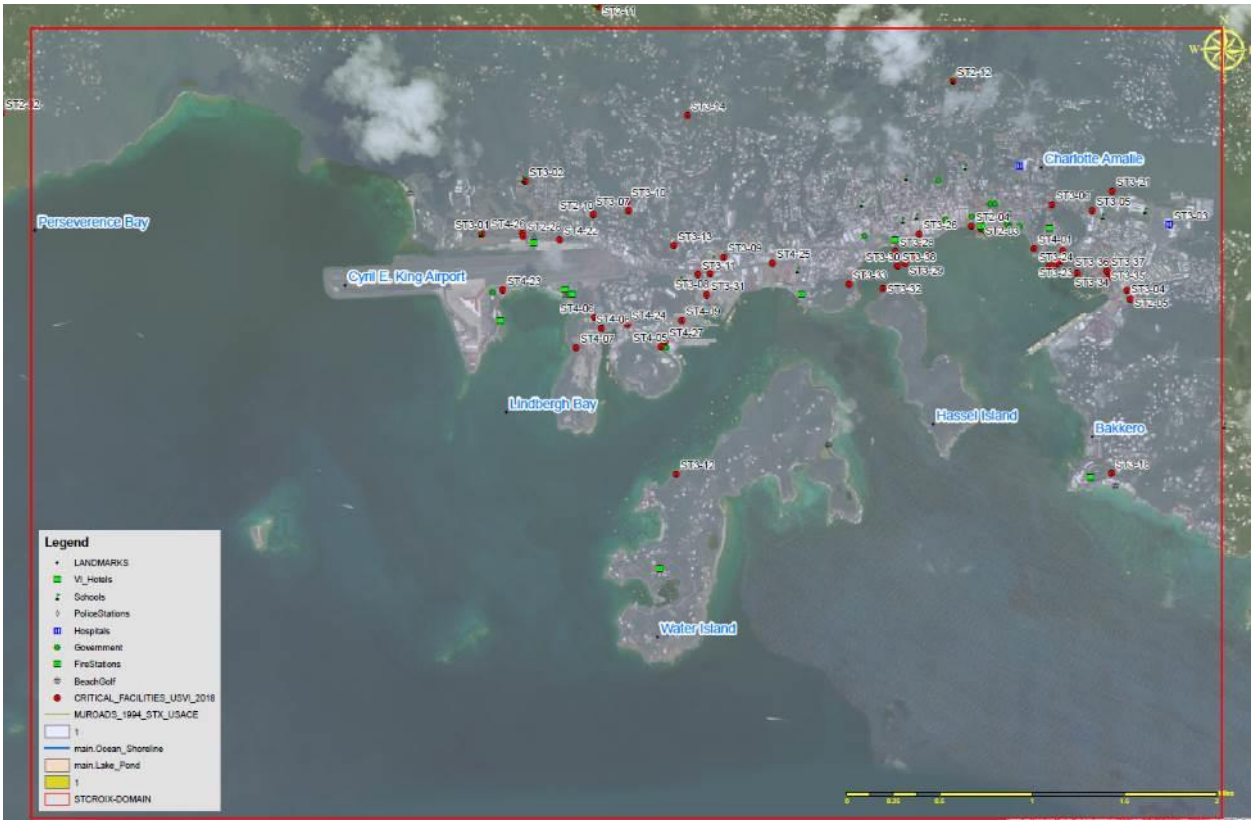



*Figure 4.28 Project modeling domain including the aerial of St. Thomas and the location of critical facilities (A higher resolution map is provided in appendix A02.MODEL_DOMAiN.pdf)*


*Figure 4.29: Model domain is highlighted with read line. (A higher resolution map is provided in appendix A04.MODEL_DOMAiN.pdf)*

### 4.6.2 Threats

The two geophysical threats investigated herein are inundation due to storms and to sea-level rise. These threats are compounded by other factors such as maintenance. Consultations held in 2017 with two key agencies responsible for several critical infrastructure – the Water and Power Authority (WAPA) and the Department of Public Works indicated confidence in their infrastructure as well as weaknesses in particular areas.

For instance, WAPA indicated that Virgin Islanders get their water in two different ways: direct distribution from WAPA through its pipelines to approximately 13,000 customers in Charlotte Amalie (St. Thomas), Christiansted and Frederiksted (St. Croix) and Cruz Bay (St. John) as well as certain subdivisions; or from cisterns attached to individual buildings or houses. Residents with cisterns also occasionally buy water from private water trucks. WAPA produces water from desalination plants located on each island. WAPA also provides electricity to residents via the operation of 7 generating units on St. Thomas and 6 on St. Croix. In addition, WAPA is operating a 20 MW solar farm on St. Thomas, and 10 MW farm on St Croix. Plans for establishing a wind farm are also underway in St Croix. These smaller energy generation plants, which can be remotely controlled to some extent, are indicative of WAPA's desire to decentralize electricity generation to increase the robustness and reliability of its operation.

Discussion with WAPA representatives prior to Hurricanes Irma and Maria indicated that all their facilities are built to resist the impacts of wind, rain and coastal storms. Most pipelines and distribution

lines are buried, substations are waterproof and can be turned offline when and if necessary. Finally, WAPA also indicated that they were in the process of revamping all their emergency plans.

With respect to droughts, the culture of rain water harvesting at the household level is an excellent adaptive drought measure for the population. However, the lack of water supply to the agriculture sector is a major disadvantage as discussed in Section 4.5 above. With respect to electricity supply, the destructive experience of Hurricanes Irma and Maria revealed the vulnerability of the infrastructure to hurricane events despite initial statements made by WAPA. Section 4.6.2.1 below elaborates on this.

Discussions with the Department of Public Works indicated that most roads in the territory fail because of a lack of maintenance. They indicated that transportation infrastructure in USVI is vulnerable to flooding. Rainfall intensities averaging approximately 1" (25mm) per hour is considered normal, but greater intensity rain events, such as those that occurred in 2005 and 2010, can result in loss of life and road washouts. One of the main watersheds of concern is the La Grange watershed in St Croix, which floods parts of Frederiksted (Figure 4.30). The canal at the intersection of Bovoni and Mariendahl Roads, in St Thomas, is also a concern, but this is being currently remediated by the re-construction of the intersection. Roads do flood during hurricanes, but danger to life is minimal as most people stay indoors during those events.

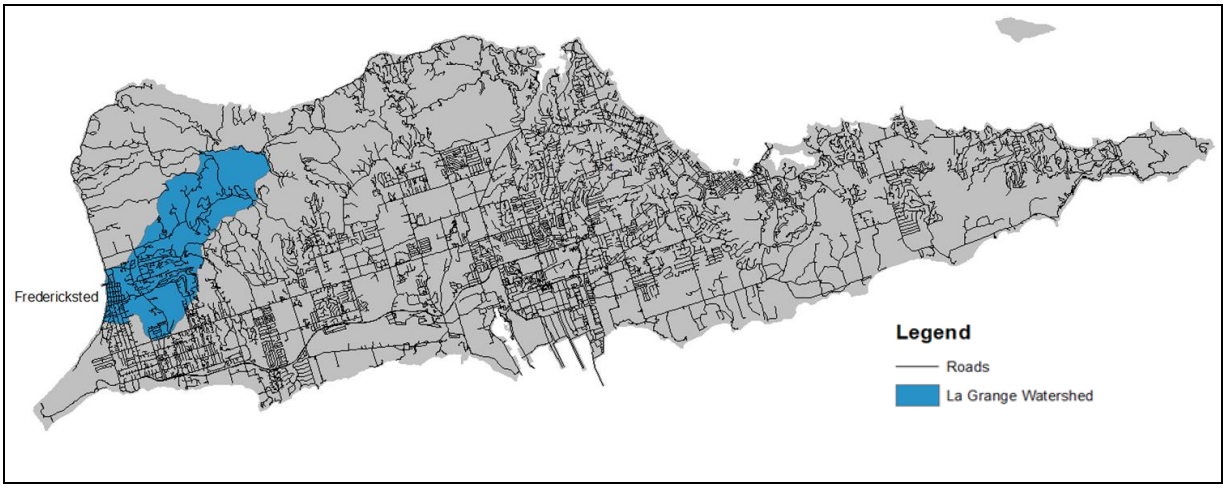



*Figure 4.30: La Grange watershed footprint in St Croix. This is an area of concern that floods repeatedly during strong rain storm events.*

Sections 4.6.2.1 to 4.6.2.3 below illustrate the devastating effect that Hurricanes Irma and Maria had on critical infrastructure in all three main islands.

The transportation and built infrastructure are also vulnerable to the impacts of sea-level rise (SLR). Most of the storm water outlets are below Mean-Sea Level, and seawater intrusion in the drainage infrastructure, especially during the highest tides, prevents proper drainage and creates backflow and flooding issues upland (Figure 4.31). In addition, as mentioned above a lot of public and private buildings are built along the coast, and thus are at increased risk of flooding during high tide events.

*Figure 4.31: During high tide events, seawater can impede proper drainage of urban centers. Stormwater drain in Charlotte Amalie (left); closeup of wave travelling upstream in drain at low tide (right).*

#### *4.6.2.1 St. Thomas*

In the aftermath of the hurricanes of 2017, electricity was cut off by the downed poles and damaged lines. Governor Kenneth Mapp reported to Fox News (September 25, 2017) that they hope to have the electricity back by December 2017. It is estimated that $200 million would be needed to rebuild the electrical grid, most of which was built above ground (ibid). Telecommunications also suffered similar damage.

Figure 4.32 below shows the destruction to the solar park on St. Thomas following Hurricane Irma.

*Figure 4.32: Solar panels that provided a small percentage of power for St. Thomas were destroyed (Hilary Swift for The New York Times)*

Rep. Stacey Plaskett, the delegate from the Virgin Islands, reported to Fox News that following Hurricane Irma the hospital, airport, and the fire station are "lost." At least three people were reported dead in the U.S. Virgin Islands (Fox News September 9, 2017).

#### *4.6.2.2 St John*

During the hurricanes, the 20 square mile island was cut off from the world as they were without power, landlines and cellular service. The streets of Cruz Bay, the largest town of this island of roughly 5,000, were a bizarre tableau of broken businesses and boats on sidewalks. Within a few days of this devastation lawlessness broke out as there was no means of getting in touch with law enforcement officials (The Washington Post, September 28, 2017).

*Figure 4.33: Sprauve School Annex after Irma finished tearing it apart in St John. (Amy Roberts, St. Thomas Source, September 9, 2017)*

#### *4.6.2.3 St. Croix*

Although St. Croix was spared the worst of hurricane Irma, Hurricane Maria either completely mangled or badly damaged almost every utility pole from east to west (The Virgin Islands Consortium, 2017). Most customers on St. Croix lost power due to Hurricane Maria. Additionally, the St. Croix's thoroughfares were impassible from uprooted trees and broken limbs.

By the 27$^{th}$ of September reports were made that limited restoration was being made to critical facilities as priority and some communities in particular: downtown Christiansted, and Frederiksted from the Midland substation to the Paul E. Joseph Stadium. Portions of two additional feeders on St. Croix were then energized (US Department of Energy, 2017). These feeders were in addition to the electrical service being provided to the Luis Hospital and the Rohlsen Airport. Customers on sections of Feeder 1A, which serves the downtown Christiansted area and Feeder 8B which originates at the Midland substation and runs to the west end of the island up to the Frederiksted ball park were the first areas to have their power restored.

## 4.7 Summary Sensitivity Analysis

*Table 4.2: Summary Sensitivity Analysis*

| Current Stresses | Projected Stresses from Climate Change | Likely Impacts | Projected change in stresses to systems *(without adaptation measures)* | Degree of sensitivity |
|---|---|---|---|---|
| **SOCIOECONOMIC** | | | | |
| Increase in temperatures 0.18$^{o}$C per decade | Increase in mean annual temperatures 0.80$^{o}$ to 2.89$^{o}$C | Increased need for cooling can put pressure on energy demands.<br><br>Heat stress especially for the vulnerable population (e.g. those aged and ill). | Could be aggravated | Moderate |
| Low annual rainfall with high inter-annual variability | Drying trend will be in both the wet and dry season (all year round) | Greater pressure on WAPA to supply potable water. This may increase the need for more desalination plants or more storage. | Could be aggravated | Moderate |
| Annual exposure to hurricanes and tropical storms | Increase in the frequency of category 4 and 5 hurricanes.<br><br>Increase in rainfall rates during hurricanes and storms. | Developed areas may be prone to flooding and wind damage, especially those located near drainage pathways and in low-lying coastal areas.<br><br>This would result in significant damage to property and life.<br><br>Repeated losses negatively impact livelihood and the amount of resources available to persons and can lead to poverty for vulnerable groups (e.g. those with disability or the aged).<br><br>Risk of flood related illnesses such as water-borne diseases, and proliferation of vectors such as mosquitoes.<br><br>Productivity within the local population may be affected. | Likely to increase | High |
| **AGRICULTURE** | | | | |
| Increase in temperatures | Increase in mean annual | Increase in evapotranspiration thus | Likely to be | High |

| Current Stresses | Projected Stresses from Climate Change | Likely Impacts | Projected change in stresses to systems *(without adaptation measures)* | Degree of sensitivity |
|---|---|---|---|---|
| 0.18$^{o}$C per decade | temperatures 0.80$^{o}$ to 2.89$^{o}$C | increasing the demand for water.<br><br>Increased evaporation combined with drier conditions and poor farming practices will result in reduced yield. | aggravated | |
| Heavy dependence on rainwater<br><br>Few persons have access to well water or other sources<br><br>No supply of water from WAPA<br><br>Poor livestock farming techniques | Decease in precipitation for the western end of St. Croix. Projected decrease in precipitation by mid-century in St. Croix.<br><br>Drying trend will be in both the wet and dry season (all year round) | More frequent drought events will result in reduced crop yield.<br><br>Reduction in available freshwater supply for crops and livestock.<br><br>Dependence on rainfed agriculture is unsustainable in the long term.<br><br>Inadequate water supply to support livestock farming. This issue with poor livestock farming practices such as the lack of culling, overstocking and overgrazing when necessary will result in death of animals and loss of revenue.<br><br>Invasive pests such as mites and aphids-lace bugs that result during extended droughts.<br><br>Loss of crops and livestock. | Likely to be aggravated | High |
| Damage from heavy rainfall/storm events<br><br>Poor farming practices<br><br>Flooding and damage to farms such as in St. Croix due to high rainfall | Increase in the frequency of category 4 and 5 hurricanes.<br><br>Increase in rainfall rates during hurricanes and storms. | Loss of crops, reduction in crop yield, loss of livestock.<br><br>Landslide and soil erosion due to heavy rains may lead result in moderate damage to crops due to debris flow and a loss of fertile top soil.<br><br>Clearing of hillside vegetation for farming especially on slopes can lead to increased surface runoff and lower the groundwater recharge capacity of the area.<br><br>Flooding of low lying areas in St. | Likely to be aggravated | High |

| Current Stresses | Projected Stresses from Climate Change | Likely Impacts | Projected change in stresses to systems *(without adaptation measures)* | Degree of sensitivity |
|---|---|---|---|---|
| | | Croix due to high intensity rainfall events.<br><br>Invasive pests such as Lepidoptera (worms) that result during extended rainy.<br><br>Damage to infrastructure such as offices and irrigation systems. | | |
| **TOURISM** | | | | |
| Increase in temperatures 0.18$^{o}$C per decade | Increase in mean annual temperatures 0.80$^{o}$ to 2.89$^{o}$C<br><br>Sea surface temperatures also expected to continue increasing over the century. | Increased need for cooling can put pressure on energy demands.<br><br>Enhanced stress on people, water resources, cooling systems and energy resources.<br><br>Warmer temperatures also cause negative impacts on ecological resources such as corals which are sensitive to temperature shifts<br><br>As temperatures continue to increase, it is likely that continued problem with sargassum lining the beaches of the coastline.<br><br>Increases in the frequency of warm days and warm nights can lead to heat waves which stress residents, visitors and workers (especially those working outdoors) alike. | Problems caused by warmer temperatures likely to worsen | High |
| Coastal erosion in some areas of the coastline | Increase in USVI sea levels up to 1m by the end of the century. | This can result in coastal erosion in some coastal areas and thus loss of beaches. Megan's Beach in St. Thomas, Frederiksted in St. Croix, Cruz Bay in St. John have low lying areas which will likely experience flooding from rising sea levels.<br><br>Rise in sea level between 1.86 +/- 0.5mm and 2.07 +/- 0.69 mm/yr | Could get worse | High |

| Current Stresses | Projected Stresses from Climate Change | Likely Impacts | Projected change in stresses to systems *(without adaptation measures)* | Degree of sensitivity |
|---|---|---|---|---|
| | | contributes to erosion of natural coastal assets. Increasing storm surge impacts.<br><br>Increasing negative impact on tourism due to erosion of the coastal resources which form the foundation of the industry. Could also impact cultural and historical resources. | | |
| Overall trend of increase in rainfall observed seen from 1977-2015, now shifting to more of a downward trend in rainfall. | Drying trend will be in both the wet and dry season (all year round)<br><br>Drought conditions anticipated to increase over time (going from 3% less in mean by 2020 and up to 25% less by end of century). Drying expected to be evident in both wet and dry seasons. | Observed and anticipated changes in rainfall patterns could have a cascade effect and ultimately impact planning for tourism activities, visitorship, the visitor experience and marketing efforts.<br><br>Increased pressure on water resources and water supply likely. If water supply stresses emerge they will negatively impact tourism since it is a heavy water use industry.<br><br>Water supply could become problematic in future as drought conditions heighten. Can partially be managed with better public education and enhanced industry practices to support and practice water conservation. Situation could worsen if number of visitors to region increases. | Anticipated changes in rainfall and temperature patterns likely to become more and more evident as we move to end of century. | Moderate |
| Extreme weather and Flooding from tropical cyclone events | Increase in the frequency of category 4 and 5 hurricanes.<br><br>Increase in rainfall rates during hurricanes and storms. | Damage to coastal tourism facilities such as hotels, restaurants, beaches, shops, craft market due to inland and coastal flooding associated with high intensity rainfall events.<br><br>Reduction in visitor arrivals due to recurring damages from storm | Likely to be aggravated | High |

| Current Stresses | Projected Stresses from Climate Change | Likely Impacts | Projected change in stresses to systems *(without adaptation measures)* | Degree of sensitivity |
|---|---|---|---|---|
| | | events. | | |
| Outbreak of vector borne diseases (Zika Virus) | More periods of short duration intense rainfall, which can cause ponding<br><br>Increase in mean annual temperatures 0.80$^{o}$ to 2.89$^{o}$C | The mosquitoes which carry viruses breed in water that settles around homes, schools, churches, workplaces and playgrounds.<br><br>Nearby wetlands are grounds for mosquito breeding.<br><br>Temperature increase may also exacerbate the incidence of vector borne diseases such as, chikungunya.<br><br>Reduction in visitor arrivals especially for wedding market.<br><br>Flash floods may also lead to loss of life. | Likely to be aggravated (Repellant bands and information provided to visitors at all ports) | Moderate |
| Mounting negative stresses on coastal resources important to tourism | Increase in greenhouse gas (carbon dioxide) emissions globally is projected to exacerbate ocean acidification. Sea level rise contributes to erosion and loss of coastal habitat. | Ocean acidification and coral bleaching events already being observed in USVI, as well as loss of coastal ecosystems such as mangroves and wetlands. Water pollution and overfishing also occurring. While not direct climate change impacts further stress coastal resources being impacted by climate change thereby making them less resilient.<br><br>Reduced resilience of coastal resources and ecosystems due to combined stresses. Negative shifts in ecosystem health and function. Because the tourism sector is integrally linked to natural resources, any impact may produce a negative feedback on the USVI's tourism product. | Likely to be aggravated | Moderate |
| Poor watershed management (e.g. | Anticipated climate change impacts | Links between land use decisions, water quality and development in | Likely to be aggravated | High |

| Current Stresses | Projected Stresses from Climate Change | Likely Impacts | Projected change in stresses to systems *(without adaptation measures)* | Degree of sensitivity |
|---|---|---|---|---|
| absence of a land management plan, lack of zoning, as well as overdevelopment near beaches). | such as erosion, loss of habitat, and more intense storms will be exacerbated where there is poor watershed management. | vulnerable areas already evident.<br><br>Haphazard/poorly planned development decreases beauty and allure of the region and threatens health of natural resources. Difficult to stem negative spin-off effects of poor watershed management- both environmental and economic implications.<br><br>Segments of the population and important infrastructure are at increasing risk. Watershed management or lack thereof may reduce the ability of some habitats to adapt. | | |
| **CRITICAL INFRASTRUCTURE** | | | | |
| Damage to road network due to coastal and inland flooding | Increase in the frequency of category 4 and 5 hurricanes.<br><br>Increase in rainfall rates during hurricanes and storms. | Blocked and flooded roads hinder the movement of vehicular traffic and pedestrians.<br><br>More intense rainfall events likely. Likelihood of more intense storms coupled with accelerated sea level rise can result in increased storm surge and flooding of low-lying coastal areas. Climate models looking at chance of 100 and 500yr flood events (2017, 2035, 2065 and 2100) do not show widespread flooding everywhere. However, they do reveal that certain areas as well as important transportation infrastructure (airport) are at high risk from significant flooding events. | Likely to be aggravated | High |
| Damage to utility infrastructure | Increase in the frequency of category 4 and 5 | Potential damage to electrical grid infrastructure (electric poles, solar farms, ..) | Likely to be aggravated | Moderate |

| Current Stresses | Projected Stresses from Climate Change | Likely Impacts | Projected change in stresses to systems *(without adaptation measures)* | Degree of sensitivity |
|---|---|---|---|---|
| Sea levels rise impacting coastal infrastructure | Increase in USVI sea levels up to 1m by the end of the century. | Seawater intrusion in the drainage infrastructure, especially during the highest tides, prevents proper drainage and creates backflow and flooding issues upland. | Likely to be aggravated | Moderate |

# 5 Adaptive Capacity Analysis

The adaptive capacity analysis is the second step in conducting the vulnerability assessment. This analysis describes the ability of the USVI to accommodate changes in climate with minimum disruption or minimum additional cost (Climate Impacts Group, King County, Washington, and ICLEI-Local Governments for Sustainability, 2007).

Generally, systems that have high adaptive capacity are better able to deal with climate change impacts. The adaptive capacity focuses on the institutions as well as the community. Table 5.1 shows the descriptive criteria used in the adaptive capacity analysis.

*Table 5.1: Description for Adaptative Capacity*

| Adaptive Capacity | Description |
|---|---|
| High | • Low sensitivity to climate<br>• Can fully accommodate the projected climate change impacts with minimum disruption or costs |
| Medium | • Low to medium sensitivity to climate<br>• Can partially accommodate the projected climate change impacts with minimum disruption or costs |
| Low | • Medium to High sensitivity to climate<br>• Cannot accommodate the projected climate change impacts with minimum disruption or costs |

## 5.1 Review of Policy and Legislation

### 5.1.1 Legal Context

The United States Virgin Islands (USVI) is an organized, unincorporated territory of the United States with policy relations between the Virgin Islands and the United States under the jurisdiction of the Office of Insular Affairs, U.S. Department of the Interior. There are numerous sources of law governing the Virgin Islands including the Organic Act of 1954, which is considered the Constitution for the Virgin Islands; applicable provisions of the United States Constitution; federal laws operating in the Virgin Islands; local law; and United States common law as adopted by the American Law Institute Restatements. There is no long-standing or deeply ingrained indigenous, traditional law.

The Organic Act of 1954 is the constitution of the Virgin Islands. The Organic Act includes a revised version of the "Bill of Rights" and charters the government of the territory establishing separate executive, legislative and judicial branches as part of a central government. In 1976, Congress authorized the Virgin Islands to adopt its own constitution, although Congress retained the authority to approve the constitution before it went into effect. At this time, the USVI has written a number of Constitutions, but none have passed a country-wide vote.

The United States Constitution has been incorporated to a degree into the Revised Organic Act of 1954. However, Virgin Islands residents, even though they are United States citizens, do not receive the full protection of the U.S. Constitution. The doctrine of territorial incorporation states that "natural rights" such as the right not to be deprived of property without just compensation are protected, but "artificial rights," such as the right to a grand jury, must be provided for by Congress.

In addition to the U.S. Constitution, other federal laws operating in USVI have the power to preempt local regulations which conflict with these federal laws. Generally, the laws of general application to the several states are also applicable to the territories, but it is often not quite so straightforward. The most clearly applicable laws are those in which Congress specifically mentions applicability to the Virgin Islands or the United States territories generally. Some federal environmental laws that apply in USVI include the Endangered Species Act, Clean Water Act, Clean Air Act, and National Environmental Policy Act (NEPA). The Federal Land Policy and Management Act (FLPMA) does not apply because there is no applicable federal land in the USVI and the Wilderness Act does not apply because the islands are not large enough to support a Wilderness Area under the Act.

Congress has the power to pass laws affecting USVI, or even change their constitution, but Virgin Islands public opinion discourages this. The islanders elect a nonvoting representative to the U.S. Congress, but they cannot vote in presidential elections. USVI does not have much influence on United States politics and generally does not appreciate it when Congress makes laws affecting the USVI without its input.

The USVI legislature has primary legal authority over regulations locally affecting the Virgin Islands as well as the power to raise local taxes. However, local regulations cannot conflict with the Revised Organic Act, other federal laws that are applicable to USVI, or impede an existing treaty of the United States. Finally, common law, as expressed in the American Law Institute Restatements, is considered authoritative. The USVI courts must follow the Restatements absent local law to the contrary.

### 5.1.2 USVI Policy

In 2010, President Barack Obama issued an Executive Order that established the first-ever national ocean policy, created a National Ocean Council composed of cabinet-level officials, and directed federal agencies to implement coastal and marine spatial planning (CMSP) consistent with the Final Recommendations of the Interagency Ocean Policy Task Force.

In response to this order, the Caribbean Regional Ocean Partnership (CROP) was formed in 2012 and is led by the U.S. Virgin Islands Department of Planning and Natural Resources and the Puerto Rico Department of Natural and Environmental Resources.

The CROP establishes mechanisms to improve regional collaboration on ocean management in order to reduce user conflicts, improve cohesive regional planning, and support healthy communities and

ecosystems for present and future generations. The CROP also plans to address cumulative effects from anthropogenic activities to ensure the protection, integrity, maintenance, resilience, and restoration of coastal and ocean Caribbean ecosystems, while promoting multiple uses.

Main objectives of the CROP are:

- Strengthening regional ocean governance mechanisms to improve understanding of coastal and ocean ecosystems;
- Defining local and marine use objectives;
- Addressing fragmented planning and management of societal uses of coastal ocean lands and waters;
- Facilitating the effective management of ocean and coastal resources across jurisdictional boundaries by improving communications, aligning priorities, and enhancing resources sharing;
- Promoting collaboration among governments, communities, NGOs, and the private sector of the participating jurisdictions in order to facilitate sustainable marine and coastal uses;
- Coordinating with existing regional organizations;
- Providing an enhanced voice and point of access with Federal agencies regarding ocean and coastal issues;
- Support efforts to harmonize policy, legal, and institutional frameworks among the participating Caribbean jurisdictions including neighboring jurisdictions;
- Enlisting and seeking the assistance of non-governmental organizations to provide facilitation and project management services in order to effectively fulfill the intent of this partnership.

The CROP will continue identifying marine management priorities that require a coordinated regional response. In order to reduce user conflicts and support healthy communities and ecosystems for present and future generations, the CROP will foster cooperation and increased collaboration between stakeholders. We will work to implement an effective CMSP program in PR and the USVI and promote multiple ocean uses based on sound science and the best available information in the wider Caribbean.

### 5.1.3 Climate Change

Executive Order Bi, 474-2015 was signed on the 15th day of October 2015 by Governor Mapp to prepare the U.S. Virgin Islands for adapting to the impacts of climate change.

Governor Kenneth Mapp signed an executive order that provides for the launch of a territorial climate change initiative and is intended to facilitate cooperation between the territory, the federal government, the private sector and civil society.

“The impacts of climate change are adversely affecting ecosystems, communities, economies, and public health across the Nation, with the United States Virgin Islands experiencing excessively high temperatures, increasingly severe droughts, and increasing intensity of downpours,” Mapp said. “Communities that already face economic or health-related challenges will experience higher levels of disruption from climate change impacts given that the United States Virgin Islands, like most small islands, are particularly vulnerable”; and thus concluding that “With fragile ecosystems, limited freshwater resources, a small population and economy, the ability of the Territory to absorb shocks from storms and other natural disasters is constrained.”

Part of the order includes the creation of the US Virgin Islands Climate Change Council, which acts as a coordinating mechanism Agency overseeing Adaptation Plans that not only address risk reduction but also integrate climate change adaptation considerations into future project and program design and implementation.

### 5.1.4 Wetlands

The absence of policies and guidelines for wetlands management inhibit the development or integration of relevant programs. The 2009 Section 309 Assessment for the USVI Coastal Zone management Program states that policies to increase protections for wetlands were approved by the Coastal Zone Management Commission in 2006, but now needs to be promulgated and adopted as rules and regulations within the coastal zone management program. Similarly, there is no institutional arrangement that supports information sharing and collaborative programming, both necessary to ensure the development of synergies between the various programs.

### 5.1.5 Legislation

#### *5.1.5.1 USVI Coastal Zone Management Act*

Key Definitions

“Coastal dependent development or use” means any development or use which requires a site on, or adjacent to, the sea to be able to function effectively.

“Coastal Land and Water Use Plan” means the comprehensive plan for the development of the first tier of the coastal zone which is intended to serve as a policy guide for decision-making relative to development activities within this tier.

“Coastal zone” means all land and water areas of the Territory of the United States Virgin Islands extending to the outer limits of the territorial sea, specified on the maps identified in section 908, subsection (a) of this chapter, and is composed of two parts, a first tier and a second tier.

“Coastal Zone Management Program” means the program prepared by the Virgin Islands Planning Office for the management of the Coastal Zone of the Virgin Islands and submitted by the Governor of the United States Virgin Islands to the U.S. Department of Commerce pursuant to section 306, subsection (c), paragraph 4 of the Federal Coastal Zone Management Act of 1972 (P.L. 92-583).

“Commission” means the Coastal Zone Management Commission as created by section 904 of this chapter.

“First tier” means that area extending landward from the outer limit of the territorial sea, including all offshore islands and cays, to distances inland as specified in the maps incorporated by reference in section 908, subsection (a) of this chapter.

“Major coastal zone permit” means a permit required for development within the coastal zone, which development is not "minor development" as defined in section 910, subsection (c) of this chapter.

“Minor coastal zone permit” means the permit required for development defined in section 910, subsection (c) of this chapter.

“Second tier” means the interior portions of the Islands of St. Thomas, St. John and St. Croix, including all watersheds and adjacent land areas not included in the first tier.

“Shorelines” means the area along the coastline of the United States Virgin Islands from the seaward line of low tide, running inland a distance of fifty feet, or to the extreme seaward boundary of natural vegetation which spreads continuously inland, or to a natural barrier, whichever is the shortest distance. Whenever the shore is extended into the sea by or as a result of filling, dredging or other man-made alteration activities, the landward boundary of the shorelines shall remain at the line previously established.

Basic Rationale for the Act

The following constitute the main rationale for the Act:

(1) the protection of the natural and scenic resources of the coastal zone is of vital concern to present and future residents of the United States Virgin Islands;

(2) to promote the public safety, health and welfare, and to protect public and private property, wildlife, ocean resources and the natural environment, it is necessary to preserve the ecological balance of the coastal zone, and to prevent its deterioration and destruction;

(3) improper development of the coastal zone and its resources has resulted in land use conflicts, erosion, sediment deposition, increased flooding, gut and drainage fillings, decline in productivity of the marine environment, pollution and other adverse environmental effects in and to the lands and waters of the coastal zone, and has adversely affected the beneficial uses of the coastal zone by the people of the United States Virgin Islands;

(4) the present system of regulatory controls in the United States Virgin Islands affecting the coastal zone consists of fragmented or overlapping laws and regulations which are not properly coordinated and which when taken together do not constitute a comprehensive or adequate response to the needs of the people of the United States Virgin Islands to protect, and to effect the best use of, the resources of the coastal zone;

(5) there exists no comprehensive program for the overall management, conservation and development of the resources of the coastal zone, for the prevention of encroachment on natural areas in the coastal zone by urbanized developments and for the avoidance of irreversible commitments of coastal zone resources which provide short-terms benefits at the cost of adverse effects on the long-term productivity and amenity of the coastal zone environment.

(6) protect, maintain, preserve and, where feasible, enhance and restore, the overall quality of the environment in the coastal zone, the natural and man-made resources therein, and the scenic and historic resources of the coastal zone for the benefit of residents of and visitors of the United States Virgin Islands;

(7) promote economic development and growth in the coastal zone and consider the need for development of greater than territorial concern by managing: (1) the impacts of human activity

and (2) the use and development of renewable and nonrenewable resources so as to maintain and enhance the long-term productivity of the coastal environment;

(8) promote and provide affordable and diverse public recreational opportunities in the coastal zone for all residents of the United States Virgin Islands through acquisition, development and restoration of areas consistent with sound resource conservation principles;

(9) maintain or increase coastal water quality through control of erosion, sedimentation, runoff, siltation and sewage discharge;

Specific Policies Applicable to the first tier of the Coastal Zone

Development policies in the first tier are as follows:

(1) to guide new development to the maximum extent feasible into locations with, contiguous with, or in close proximity to existing developed sites and into areas with adequate public services and to allow well-planned, self-sufficient development in other suitable areas where it will have no significant adverse effects, individually or cumulative, on coastal zone resources;

(2) to give highest priority to water dependent uses, particularly in those areas suitable for commercial uses including resort hotels and related facilities, industrial uses including port and marine facilities, and recreation; to give secondary priority to those uses that are water-related or have special siting needs; and to discourage uses which are neither water-dependent, water-related nor have special siting needs in areas suitable for the highest and secondary priority uses;

(3) to assure that new or expanded public capital improvement projects will be designed to accommodate those needs generated by development or uses permitted consistent with the Coastal Land and Water Use Plan and provisions of this chapter;

(4) to assure that all new subdivisions, in addition to the other requirements contained in this chapter and in the Virgin Islands Zoning and Subdivision Law, are physically suitable for the proposed sites and are designed and improved so as to avoid causing environmental damage or problems of public health;

(5) to encourage waterfront redevelopment and renewal in developed harbors in order to preserve and improve physical and visual access to the waterfront from residential neighborhoods and commercial downtown areas;

(6) to assure that development will be cited and designed to protect views to and along the sea and scenic coastal areas, to minimize the alteration of natural land forms, and to be visually compatible with the character of surrounding areas;

(7) to encourage fishing and carefully monitor mariculture and, to the maximum extent feasible, to protect local fishing activities from encroachment by non-related development;

(8) to assure that dredging or filling of submerged lands is clearly in the public interest; and to ensure that such proposals are consistent with specific marine environment policies contained in this chapter. To these ends, the diking, filling or dredging of coastal waters, salt ponds, lagoons,

marshes or estuaries may be permitted in accordance with other applicable provisions of this chapter only where there are no feasible, less environmentally-damaging alternatives and, where feasible, mitigation measures have been provided to minimize adverse environmental effects, and in any event shall be limited to the following: (i) maintenance dredging required for existing navigational channels, vessel berthing and mooring areas; (ii) incidental public service purposes, including but not limited to the burying of cables and pipes, the inspection of piers and the maintenance of existing intake and out-fall lines; (iii) new or expanded port, oil, gas and water transportation, and coastal dependent industrial uses, including commercial fishing facilities, cruise ship facilities, and boating facilities and marinas; (iv) except as restricted by federal law, mineral extraction, including sand, provided that such extraction shall be prohibited in significant natural areas; and (v) restoration purposes;

(9) to the extent feasible, discourage further growth and development in flood-prone areas and assure that development in these areas is so designed as to minimize risks to life and property;

(10) to comply with all other applicable laws, rules, regulations, standards and criteria of public agencies.

Environmental policies in the first tier shall be as follows:

(1) to conserve significant natural areas for their contributions to marine productivity and value as habitats for endangered species and other wildlife;

(2) to protect complexes of marine resource systems of unique productivity, including reefs, marine meadows, salt ponds, mangroves and other natural systems, and assure that activities in or adjacent to such complexes are designed and carried out so as to minimize adverse effects on marine productivity, habitat value, storm buffering capabilities, and water quality of the entire complex;

(3) to consider use impacts on marine life and adjacent and related coastal environment;

(4) to assure that siting criteria, performance standards, and activity regulations are stringently enforced and upgraded to reflect advances in related technology and knowledge of adverse effects on marine productivity and public health;

(5) to assure that existing water quality standards for all point source discharge activities are stringently enforced and that the standards are continually upgraded to achieve the highest possible conformance with federally-promulgated water quality criteria;

(6) to preserve and protect the environments of offshore islands and cays;

(7) to accommodate offshore sand and gravel mining needs in areas and in ways that will not adversely affect marine resources and navigation. To this end, sand, rock, mineral, marine growth and coral (including black coral), natural materials, or other natural products of the sea, excepting fish and wildlife, shall not be taken from the shorelines without first obtaining a coastal zone permit, and no permit shall be granted unless it is established that such materials or products are not otherwise obtainable at reasonable cost, and that the removal of such materials or products

will not significantly alter the physical characteristics of the area or adjacent areas on an immediate or long-term basis; or unless the Commission has determined that a surplus of such materials or products exists at specifically designated locations;

(8) to assure the dredging and disposal of dredged material will cause minimal adverse effects to marine and wildlife habitats and water circulation;

(9) to assure that development in areas adjacent to environmentally-sensitive habitat areas, especially those of endangered species, significant natural areas, and parks and recreations areas, is sited and designed to prevent impacts which would significantly degrade such areas;

(10) to assure all of the foregoing, development must be designed so that adverse impacts on marine productivity, habitat value, storm buffering capabilities and water quality are minimized to the greatest feasible extent by careful integration of construction with the site. Significant erosion, sediment transport, land settlement or environmental degradation of the site shall be identified in the environmental assessment report prepared for or used in the review of the development, or described in any other study, report, test results or comparable documents.

Amenity policies in the first tier are the following:

(1) to protect and, where feasible or appropriate, enhance and increase public coastal recreational uses, areas and facilities;

(2) to protect and enhance the characteristics of those coastal areas which are most valued by the public as amenities and which are scarce, or would be significantly altered in character by development, or which would cause significant environmental degradation if developed;

(3) to preserve agricultural land uses in the coastal zone by encouraging either maintenance of such present agricultural use or use as open-space areas;

(4) to incorporate visual concern into the early stages of the planning and design of facilities proposed by siting in the coastal zone and, to the extent feasible, maintain or expand visual access to the coastline and coastal waters;

(5) to foster, protect, improve, and ensure optimum access to, and recreational opportunities at, the shoreline for all the people consistent with public rights, constitutionally protected rights of private property owners, and the need to protect natural resources from overuse;

(6) to ensure that development will not interfere with the public's right of access to the sea where acquired through customary use, legislative authorization or dedication, including without limitation the use of beaches to the landward extent of the shoreline;

(7) to require, in the discretion of the appropriate Committee of the Commission, that public access from the nearest public roadway to the shoreline be dedicated in land subdivisions or in new development projects requiring a major coastal zone permit. Factors to be considered in requiring such dedication of public access include (i) whether it is consistent with public safety or protection of fragile coastal zone resources; (ii) whether adequate public access exists nearby; (iii) whether existing or proposed uses or development would be adversely affected; (iv)

consideration of the type of shoreline and its appropriate potential recreational, educational, and scientific uses; and (v) the likelihood of trespass on private property resulting from such access and availability of reasonable means for avoiding such trespass. Dedicated access-ways shall not be required to be open to public use until a public agency or private association agrees to accept responsibility for providing off-street parking areas and for maintenance and liability of the accessway, shoreline and beach areas. Nothing in this subsection shall be construed as restricting existing public access nor shall it excuse the performance of duties and responsibilities of public agencies as provided by law to acquire or provide public access to the shoreline. This provision shall not be construed as requiring free use of private facilities on land adjoining any beach or shoreline but only as requiring access to the beach or shoreline to the general public as a condition precedent to the grant of a coastal zone permit.

*Coastal Zone permits*

The Coastal Zone Management Act provides in respect of applications for coastal zone permits:

(1) Any person wishing to perform or undertake any development in the first tier of the coastal zone, except as provided in subsection (b) of this section, shall obtain a coastal zone permit in addition to obtaining any other permit required by law from any public agency prior to performing or undertaking any development.

(2) A permit shall be granted for a development if the appropriate Committee of the Commission or the Commissioner, whichever is applicable, finds that (A) the development is consistent with the basic goals, policies and standards provided in sections 903 and 906 of this chapter; and (B) the development as finally proposed incorporates to the maximum extent feasible mitigation measures to substantially lessen or eliminate any and all adverse environmental impacts of the development; otherwise the permit application shall be denied. The applicant shall have the burden of proof to demonstrate compliance with these requirements; and (C) the applicant has presented certification from the Bureau of Internal Revenue and Department of Finance that the applicant has filed and paid all taxes, penalties and interest and from the Office of the Lieutenant Governor that the applicant has filed its required annual report or has satisfactorily made agreement to pay the taxes or file the required reports.

(3) Any coastal zone permit that is issued shall be subject to terms and conditions imposed by the appropriate Committee of the Commission or the Commissioner, whichever is applicable, in order to ensure that such development will be in accordance with the provisions of this chapter. To this end, any of the development provisions in section 299 of Title 29, chapter 3, of this Code may be made more or less restrictive by the appropriate Committee of the Commission in the case of a major coastal zone permit and more restrictive by the Commissioner in the case of a minor coastal zone permit.

(4) In connection with any land subdivision or major coastal zone permit issued for development adjacent to the shoreline, the appropriate Committee of the Commission may require the dedication of an easement or a fee interest in land for reasonable public access from public highways to the sea.

Standards for major and minor coastal zone permits

A major coastal zone permit shall be issued by the appropriate Committee of the Commission for all approved applications for development except:

(1) a development which is to be conducted completely or substantially seaward of the line of mean high tide and is designated by the appropriate Committee of the Commission pursuant to subsection (e), paragraph (5) of this section; or

(2) a development which is to be conducted completely landward of the line of mean high tide and satisfies one of the following criteria:

(A) the development consists of a subdivision, or the construction of one or two single family residences or a duplex on any parcel of record on the effective date of this chapter; or

(B) the development consists entirely of improvements to an existing structure, which improvements cost the developer less than fifty-two thousand dollars ($52,000); or

(C) the development consists of one or more structures valued in their entirety at less than seventy-five thousand dollars ($75,000); or

(D) the development consists of any other development, except the extraction of minerals, valued at less than sixty-six thousand dollars ($66,000); or

(E) the development consists of the extraction of minerals valued at less than seventeen thousand dollars ($17,000), in which case a minor coastal zone permit shall be issued by the Commissioner; provided, however, that if the Commissioner, upon reviewing any minor permit application submitted pursuant to subsection (d), paragraph (3) of this section, determines that the proposed activity is likely to have significant adverse environmental consequences he shall, upon giving notice to the applicant, forward such application to the appropriate Committee of the Commission for review as a major coastal zone permit.

The Coastal Zone Management Act also stipulates that permits are required in the following circumstances:

(1) No person shall develop or occupy the trust lands or other submerged or filled lands of the United States Virgin Islands without securing a coastal zone permit which includes, in addition to the elements of a section 910 permit, a permit or lease for the development or occupancy of the trust lands or other submerged or filled lands.

(2) The provisions of this section shall be in addition to all other requirements of this chapter and shall apply to all applications for, and issuance of, permits for development or occupancy of the trust lands or other submerged or filled lands, and for modifications or renewals of permits or leases for such development or occupancy issued prior to the effective date of this chapter.

*5.1.5.2 Virgin Islands Native Aquatic Species Act*

The Virgin Islands Native Aquatic Species Protection Act was enacted to establish, maintain, and support by appropriations to the Department of Planning and Natural Resources (DPNR), efforts to develop strategies to protect Virgin Islands native aquatic species through control of invasive species and other methods, thus benefitting our aquatic ecosystem and our economy. (c) Definition. “Invasive Species”, as

similarly defined in Executive Order 13112, means an alien species or species complex whose introduction does or is likely to have an adverse impact in the Virgin Islands.

#### *5.1.5.3 Title 12, Chapter 2: Protection of Indigenous, Endangered, and Threatened Fish, Wildlife and Plants*

The VI Endangered and Indigenous Species Act protects native species of flora and fauna from injury, death, and harassment. It also specifically prohibits the cutting, pruning, removal and disturbance to mangroves, as well as no net loss of wetlands, without express written permission from the Commissioner. Mangroves are also protected under Title 12, chapter 21 in assurance that activities in or adjacent marine resources of unique productivity are designed and carried out so as to minimize adverse effects on marine productivity, habitat value, storm buffering capabilities, and water quality of the entire complex.

#### *5.1.5.4 Title 12, Chapter 3: Trees and Vegetation Adjacent to Watercourses*

This Act prohibits the cutting or injury of any tree or vegetation within 30 feet of the center of any natural watercourse or 25 feet from the edge, whichever is greater, without written permission from the Commissioner.

#### *5.1.5.5 Title 12, Chapter 13: Environmental Protection*

This Act establishes an environmental protection program to prevent improper development of land and harmful environmental changes in order to prevent watershed conditions leading to erosion and sediment deposition on lower lying lands and in tidal waters, increased flooding, gut drainage filling and alteration, pollution and other harmful environmental changes to such a degree that fish, marine life, and recreational and other private and public uses of land and waters are being adversely affected.

#### *5.1.5.6 Title 19, Virgin Islands Rules and Regulations*

Part VI: Regulatory Provisions concerning Public Health

Chapter 56: Solid and Hazardous Waste Regulations

Chapter 56 provides for a comprehensive framework for the management of waste. The Regulations cover prohibited acts (Section 1560-2), storage of waste (section 1560-100); Collection and Disposal of Waste (section 1560-200), Transportation of Waste, Responsibilities and Duties (Section 1560-204), Permit for the Approval of Public or Private Disposal Sites (section 1560-300); Hazardous Waste (section 1560-301.20); Run-on – Run off Control Systems (section 1560-301.26); Compliance: Violations (section 1560-304); Location Restrictions for flood plains (section 1560-311); Location Restrictions for Wetlands (section 1560-312); Location Restrictions for Fault Areas )section 1560-313); Location Restriction for Unstable Areas (section 1560-315); Hazardous Wastes (section 1560-500); Ground Water Sampling and Analysis (section 1560-813).

#### *5.1.5.7 Title 7, Chapter 3: Soil Conservation*

The Soil Conservation Act allows for the conservation of soil and water resources in order to prevent erosion and sedimentation.

#### *5.1.5.8 Territorial Pollution Control Act*

Under the provisions of the Territorial Pollution Control Act of 1972 (Title 12, Chapter 7, VI Code), the Virgin Islands Water Pollution Control Program is mandated to conserve, protect, preserve, and improve

the quality of water for public use, and for the propagation of wildlife, fish, and aquatic life in the Virgin Islands. The role of this program is to facilitate the preservation and where necessary, make improvements to water quality conditions so as to ensure that water quality standards are met; to monitor health; and to ensure that permitted discharges to waters of the VI meet effluent limitations. The DPNR/DEP is charged with the task of implementing and enforcing these provisions (DEP 2002).

*5.1.5.9 Indigenous and Endangered Species Act*

The USVI Indigenous and Endangered Species Act of 1990 aims to "protect, conserve, and manage indigenous fish, wildlife, and plants, and endangered or threatened species for the ultimate benefit of all Virgin Islanders, now and in the future." In 1991, following the creation of the Act, the USVI Division of Fish and Wildlife compiled a list of Endangered Plants and Animals of the USVI. While this list has been useful for proper development planning in the territory, it must be periodically revised and updated to reflect the changing realities of the environment. The USVI protected flora and fauna can be found by visiting the Division of Fish and Wildlife webpage www.vifishandwildlife.com or http://ecos.fws.gov/tess_public//pub/ stateListing.jsp?status= listed&state=VI.

*5.1.5.10Virgin Islands Development Code*[4]

The regulations of the Development Code apply to all development, public or private, within the Territory of the U.S. Virgin Islands unless otherwise expressly stated.

The objective of this development code is to establish regulations, standards, and procedures for the development of land, water, buildings, and structures in the U.S. Virgin Islands.

The purposes of the Development Code include the following:

- Promote the public health, safety, morals, or general welfare of the Territory and its present and future residents;
- Protect agricultural resources;
- Conserve and manage natural resources, both living and non-living, and the mineral resource base;
- Protect ecosystems, including natural areas, features, and functions;
- Support the protection and preservation of the historic and cultural resources of the Territory for future generations, including prehistoric and historic archaeological sites, submerged sites, cemeteries, sacred sites, historic buildings and structures, properties listed on the Virgin Islands Register of Historic Buildings, Sites, and Places, and areas of cultural significance for the Territory.
- Ensure coordination with development in Historic and Architectural Control districts;
- Minimize conflicts among the uses of land, water, buildings, and structures and limit or prohibit their improper use;
- Ensure a balanced distribution of residential and nonresidential uses, buildings, and structures by regulating and limiting lot occupancy, residential density, and nonresidential intensity;
- Promote the construction of affordable housing;

[4] U.S. Virgin Islands Development Code – Pre-Adoption Draft (June 9, 2014)

- Protect the amenities of the U.S. Virgin Islands that make the Territory attractive to tourists or for tourism;
- Encourage economic development that is consistent with the amenities and natural environment of the U.S. Virgin Islands;
- Promote efficiency, economy, and coordination among territorial departments and divisions in the development process; and
- Implement the Territorial Comprehensive Plan at such time as the plan is adopted by the Legislature.

*5.1.5.11Uniform Conservation Easement Act*

Under the Uniform Conservation Easement Act, "conservation easement" means a non-possessory interest of a holder in real property imposing limitations or affirmative obligations the purposes of which include retraining or protecting natural, scenic, or open-space values of real property, assuring its availability for agricultural, forest, recreational or open-space use, protecting natural resources, maintaining or enhancing air or water quality, or preserving the historical, architectural, archaeological or cultural aspects of real property.

Under the Uniform Conservation Easements Act at §604 a conservation easement may be created, conveyed or recorded, assigned released, modified, terminated or otherwise altered or affected in the same manner as other easements.

A conservation easement is a legally enforceable land preservation agreement between a landowner and a government agency or a qualified land protection organization for the purposes of conservation of the land. A conservation easement restricts real estate development, commercial and industrial uses, and certain other activities on a property to a mutually agreed upon level. However, the property remains the private property of the landowner.

The primary purpose of a conservation easement is to protect land from certain forms of development or use. Lands which are generally subjected to conservation easements include agricultural land, timber resources, and/or other valuable natural resources such as wildlife habitat, clean water, clean air, or scenic open space.

Nearly all states have enacted laws specifically authorizing the creation of conservation easements as valid interests in land. These laws are generally modeled after the Uniform Conservation Easement Act adopted by the National Conference of Commissioners on Uniform State Laws in 1981. States that have adopted the Uniform Conservation Easement Act include Alabama, Alaska, Arizona, Arkansas, Delaware, District of Columbia, Idaho, Indiana, Kansas, Kentucky, Maine, Minnesota, Mississippi, Nevada, New Mexico, Oregon, South Carolina, South Dakota, Texas, Virginia, West Virginia, Wisconsin and Wyoming.

The term "Conservation easement" means a nonpossessory interest of a holder in real property imposing restrictions and obligations on real property in order to protect natural resources, maintaining or enhancing air or water quality, or preserving the historical, architectural, archaeological, or cultural aspects of real property. The holder of a conservation easement may be a governmental body or a charitable corporation, charitable association, or charitable trust. The easement may also be enforced by an assignee of the holder of the easement.

A unique feature of the Uniform Conservation Easement Act is the "third-party enforcement right." Accordingly, an easement may empower an entity other than an immediate holder to enforce its terms. However, the possessor of the third-party enforcement right must be a governmental body or a charitable corporation, association, or trust.

A conservation easement can be of an unlimited duration. The restrictions and obligations attached to the real property move along with the land when there is a transfer of ownership. The terms of the easement can be modified or terminated. Similarly, an easement will be valid even though it is not appurtenant, and imposes a negative burden. No privity of contract, or effect on a dominant estate, is required. However, the easements may be created only for purposes which are intended to serve the public interest. The easement cannot restrain prior rights of the owners of the real property unless the owners have consent to it. It also has to be noted that courts have the power to modify or terminate a conservation easement.

An action to enforce, modify or terminate a conservation easement may be brought by an owner of the real property, a holder of the easement, a person having a third-party right of enforcement or a person authorized by any law.

The Uniform Conservation Easement Act enables durable restrictions and affirmative obligations to real property to protect natural and historical resources. The Uniform Conservation Easement Act provides a simple, limited way to end impediments to the use of easements under the common law. The Act permits the acquisition of easements as limited easements in land with the minimum disturbance of other interests and uses.

The Uniform Conservation Easements Act situations where the owner of property seeks to transfer an easement by way of gift, sale or other conveyance. Thus the Act promotes the non-compulsory, voluntary solutions to land use problem.

*5.1.5.12Water Legislation*

Virgin Islands law gives Department of Planning and Natural Resources (DPNR), over which the Commissioner presides, expansive authority over the water within the Territory's boundaries. The Legislature enacted the WRCA in 1965 "in recognition of its sovereign duty to conserve and control its water resources for the benefit of the inhabitants of the United States Virgin Islands" and in order to remedy "an emergency condition [that] exists with respect to the availability of surface and underground water in the United States Virgin Islands." 12 V.I.C §§ 151, 152 (d). The WRCA authorizes the DPNR to perform "comprehensive planning and regulation" of the Territory's waters in order to ensure a supply of water for competing uses now and in the future. Id. at § 151. As noted previously, the WRCA declares that all waters within the Virgin Islands, including ground waters, belong to the people of the Virgin Islands. Id. The statute allows the DPNR to regulate large withdrawals of ground water by issuing permits. See id. at §§ 153-155. Under the WRCA, DPNR must approve the drilling of new wells. See id. at §158, The statute prohibits wasteful uses of water and establishes penalties, including imprisonment, for violations of the statute or implementing regulations promulgated by DPNR. Id. at §§ 162, 164.

In 1976, the Virgin Islands enacted the Water Pollution Control Act ("WPCA"), 12 V.I.C. §§ 181-98. The WPCA states that it is the government's policy, among other things, "to provide that no waste be discharged into any waters of the United States Virgin Islands without first receiving the necessary

treatment or other corrective action to protect the legitimate beneficial uses of such waters; [and] to provide for the prevention, abatement and control of new or existing water pollution." Id. at § 181. Among other provisions, the WPCA authorizes DPNR to promulgate water quality standards and "to issue, modify, or revoke orders prohibiting or abating discharges of wastes or pollution into the waters" of the Virgin Islands. Id. at § 184. Like the WRCA, the WPCA applies to ground water. See Id. at §182.

*5.1.5.13Legislation Regarding Wetland activities*

Development within or near wetlands is regulated by several Federal statutory prohibitions and incentives that are intended to slow wetland losses. Some of the more important of these are contained in the 1899 Rivers and Harbors Act; the 1972 Clean Water Act and amendments; the 1985 Food Security Act; the 1990 Food, Agriculture, Conservation, and Trade Act; the 1986 Emergency Wetlands Resources Act; and the 1972 Coastal Zone Management Act. In the following description of wetland-related Federal legislation, regulations that apply to States also apply to the U.S. Virgin Islands.

Section 10 of the Rivers and Harbors Act gives the U.S. Army Corps of Engineers (Corps) authority to regulate certain activities in navigable waters. Regulated activities include diking deepening, filling, excavating, and placing of structures. The related section 404 of the Clean Water Act is the most often-used Federal legislation protecting wetlands. Under section 404 provisions, the Corps issues permits regulating the discharge of dredged or fill material into wetlands. Permits are subject to review and possible veto by the U.S. Environmental Protection Agency, and the FWS has review and advisory roles. Section 401 of the Clean Water Act grants to States and eligible Indian Tribes the authority to approve, apply conditions to, or deny section 404 permit applications based on a proposed activity's probable effects on the water quality of a wetland.

Most farming, ranching, and silviculture activities are not subject to section 404 regulation, but the "Swampbuster" provision of the 1985 Food Security Act and amendments in the 1990 Food, Agriculture, Conservation, and Trade Act discourage (through financial disincentives) the draining, filling, or other alteration of wetlands for agricultural use. The law allows exemptions from penalties in some cases, especially if the farmer agrees to restore the altered wetland or other wetlands that have been converted to agricultural use. The Wetlands Reserve Program of the 1990 Food, Agriculture, Conservation, and Trade Act authorized the Federal Government to purchase conservation easements from landowners who agree to protect or restore wetlands. The Consolidated Farm Service Agency (formerly the Agricultural Stabilization and Conservation Service) administers the Swampbuster provisions and Wetlands Reserve Program. The Natural Resources Conservation Service (formerly the Soil Conservation Service) determines compliance with Swampbuster provisions and assists farmers in the identification of wetlands and in the development of wetland protection, restoration, or creation plans.

The 1986 Emergency Wetlands Resources Act and the 1972 Coastal Zone Management Act and amendments encourage wetland protection through funding incentives. The Emergency Wetlands Resources Act requires States to address wetland protection in their Statewide Comprehensive Outdoor Recreation Plans to qualify for Federal funding for State recreational land; the National Park Service (NPS) provides guidance in developing the wetland component of their plans. Coastal States that adopt coastal-zone management programs and plans approved by the National Oceanic and Atmospheric Administration are eligible for Federal funding and technical assistance through the Coastal Zone Management Act.

Under the provisions of the Federal and Local Water Pollution Control Act, the US Virgin Islands Water Pollution Control (WPC) and Water Quality Management (WQM) Programs are mandated to conserve, protect, preserve, and improve the quality of water for public use, and the propagation of wildlife, fish and aquatic life for the USVI. To ensure the preservation of water quality WQM projects monitor compliance with the Water Quality Standards as set forth in the US Virgin Islands Environmental Laws and Regulations.

The Government of the Virgin Islands is presently enhancing and strengthening its territorial Water Pollution Control Act and revising its Water Quality Standards. The triennial review will be completed when the revised Water Quality Standards are adopted in the later part of FY2018. This ongoing process builds upon previous 305(b) and 303(d) reporting periods.

## 5.2 Overview of Key Institutions Relating to Climate Change

#### *5.2.1.1 Virgin Islands Department of Planning and Natural Resources*

In Virgin Islands, the U.S. Virgin Islands Department of Planning and Natural Resources ("DPNR") was established in 1987 under the Government Reorganization and Consolidation Act. The DPNR serves as the agency responsible for the administration and enforcement of all laws pertaining to the preservation and conservation of fish and wildlife, trees and vegetation, coastal zones, cultural and historical resources, water resources, and air, water and oil pollution. It is also responsible for oversight and compliance of land survey, land subdivision, development and building permits, earth change permits, zoning administration, boat registration, and mooring and anchoring of vessels within territorial waters. Simultaneously, the DPNR formulates long-range comprehensive and functional development plans for the human, economic and physical resources of the territory.

The DPNR is mandated to promote, implement, support, maintain and coordinate library and information services and museums, and preserve items of historical significance in the archives of the Virgin Islands. The DPNR is further obligated to formulate functional development plans for the territory's human, economic and physical resources.

The Commissioner of Planning and Natural Resources ("Commissioner") acts as the head of the DPNR. The Commissioner is appointed by the Governor with the advice and consent of the legislature. The Commissioner holds office during the continuance in office of the governor by whom s/he is appointed and until his successor is appointed and qualified, unless sooner removed by the Governor. The DPNR is administered under the supervision and direction of the Commissioner. The Governor organizes the DPNR to provide the most efficient, cost-effective and coordinated delivery of services and programs within its jurisdiction[i].

The DPNR has 11 primary operating divisions, each with its own unique set of administrative and regulatory mandates. Some of its divisions are:

- The Division of Business and Administrative Services – It has oversight responsibility for all fiscal matters pertaining to budgeting, personnel and payroll and for revenue collection involving general, federal and other special funds for all divisions within the DPNR;
- The Division of Capital and Development Planning – It plans for facilitating the improvement of neighborhood and community services and facilities, especially those for the benefit of low-to-

moderate income persons and disaffected segments of the U.S.Virgin Islands population (such as the elderly, the disabled and the homeless, as well as victims of domestic violence);

- The Division of Environmental Enforcement – It serves as the law enforcement arm of the Department of Planning & Natural Resources. Its primary function is to enforce all laws applicable to the protection, preservation and conservation of the natural resources and overall environment of the U.S. Virgin Islands;

- The Division of Fish and Wildlife (DFW)- It is charged with monitoring, assessing and implementing public awareness and other activities that help to enhance and safeguard fish and wildlife resources in the USVI.

The DPNR provides comprehensive long-range planning services for all territorial departments and agencies. Pursuant to 3 V.I.C. § 401, the DPNR also fosters, promotes and undertakes programs and projects for the conservation and development of the natural resources of the U.S. Virgin Islands. It also conducts surveys, and maintains real and personal property appropriate to the goal of promoting the fullest public appreciation of the archaeological, architectural, cultural and historical heritage of the people of the U.S. Virgin Islands.

In addition, the DPNR erects and maintains historic signs or markers within the right-of-way of any territorial roadway or highway or any other property under its jurisdiction and control under such conditions or limitations as may be appropriate.

The Department of Planning and Natural Resources is the principal agency requiring permit application for construction activities in the coastal zone, where wetlands usually form. This responsibility was granted to the Department by the Coastal Zone Management Act passed in 1978. In addition to evaluating permit requests, the Department comments on Federal permit applications to ensure consistency with the Coastal Zone Management Plan. When wetland losses are unavoidable, the Department requires mitigation actions to ameliorate anticipated losses. The Department also monitors wetlands to ensure that unpermitted activities are not taking place and that authorized activities are in full compliance with permit requirements. The Territorial Legislature adopted the Indigenous and Endangered Species Act of 1990, in which section 104(e) establishes a policy of "no net loss of wetlands" to the maximum extent possible.

**Fish and Wildlife Restoration Trust Fund**

The Fish and Wildlife Restoration Trust Fund (“the Trust”) is established in the Treasury of the Government of the Virgin Islands as a separate and distinct fund held by the Commissioner of Finance in trust for the benefit Department of Planning and Natural Resources, Division of Fish and Wildlife, to fund fish restoration and management projects pursuant to section 81c. Trust funds may not be comingled with monies in the General Fund and may be used only for the purposes specified in subsection (d). (b) The Commissioner of Finance shall administer the Trust as trustee and shall disburse funds.

*5.2.1.2 Endangered Species Preservation Commission*

The Endangered Species Preservation Commission is established within the Department of Planning and Natural Resources. The Commission comprises of the Commissioner of Planning and Natural Resources, who shall be a non-voting member, ex officio, the other members are: (1) the Director of the Division of Fish and Wildlife, (2) the Chief of the Bureau of Environmental Education, (3) the Chief of the Bureau of

Fisheries, (4) the Chief of the Bureau of Wildlife, and (5) the Chief of Environmental Enforcement of the Department of Planning and Natural Resources, (6) the Director of the Division of Fish and Wildlife, (7) the Chief of the Bureau of Environmental Education.

*5.2.1.3 Virgin Islands Climate Change Council*

The Virgin Islands Climate Change Council was established by Executive Order no. 476-2015. The Council is chaired by the Office of the Governor General and includes the following members:

(i) Department of Planning and Natural Resources;
(ii) Virgin Islands Department of Health;
(iii) Virgin Islands Territorial Emergency Management Agency;
(iv) University of the Virgin Islands;
(v) Foundation for Development Planning, Inc.;
(vi) U.S. Virgin Islands Hotel & Tourism Association;
(vii) Virgin Islands Department of Education;
(viii) Virgin Islands Department of Public Works;
(ix) Virgin Islands Water & Power Authority;
(x) Virgin Islands Department of Agriculture;
(xi) Virgin Islands Department of Justice;
(xii) Virgin Islands Port Authority;
(xiii) The Nature Conservancy;
(xiv) Virgin Islands Conservation Society;
(xv) St. Thomas-St. John Chamber of Commerce;
(xvi) St. Croix Chamber of Commerce;
(xvii) Virgin Islands Bureau of Economic Research;
(xviii) St. Croix Foundation
(xix) Community Foundation of the Virgin Islands;
(xx) Virgin Islands Public Television;
(xxi) Virgin Islands Economic Development Authority;
(xxii) St. John Community Foundation;
(xxiii) Virgin Islands Inter-Faith Coalition;
(xxiv) Virgin Islands Department of Tourism;
(xxv) American Red Cross of the Virgin Islands;
(xxvi) AARP Virgin Islands; and
(xxvii) United Way of the U.S. Virgin Islands, Inc.

The Office of the Governor provides administrative support and additional resources for the operations of the Council.

The Council is established to facilitate the development of a cohesive framework and strategy to prepare for climate change impacts on the territory. The Council also functions as a coordinating mechanism for public sector institutions as well as working with Federal and local agencies, academic and research institutions and private and non-profit sectors.

#### *5.2.1.4 Division of Environmental Health*

The Division of Environmental Health (DEH) provides primary prevention through a combination of surveillance education, enforcement, and assessment programs designed to identify, prevent and abate the environmental conditions that adversely impact human health. The DEH enhances quality of life by protecting public health and safeguarding environmental quality, educating the public to increase environmental awareness, and implementing and enforcing Virgin Islands and federal environmental public health laws.

DEH protects and improves public health by preventing, minimizing and eliminating exposure to biological, chemical or physical hazards through a variety of regulatory activities, including permitting and inspecting businesses and public facilities. Environmental Health Inspectors also investigate reports of public health and safety menaces anywhere in the community including residential, commercial and industrial areas.

#### *5.2.1.5 Virgin Islands Water and Power Authority*

The Virgin Islands Water and Power Authority (VIWAPA) has responsibility for clean and reliable drinking water.

Regulations under the US Environmental Protection Act and the Virgin Islands Department of Planning and Natural Resources set the guidelines and standards to which the VIWAPA strictly address VIWAPA countries to monitor drinking water produced through continuous testing.

#### *5.2.1.6 VITEMA*

Local institutional strength is important for climate change adaptation in USVI, as indeed it does elsewhere. The territory's ability to adapt to the effect of changing parameters of climate depends on the ability of the leading government agencies, the business sector and civil society to respond appropriately.

VITEMA's principal mission as a first response coordinator tasked with saving lives and property throughout the territory, is accomplished through planning, coordinating, training and exercise (VITEMA, 2011). The agency aims to prepare territorial organizations to respond, recover from, and mitigate against all hazards. The agency does this through the authority derived from V. I. Code, Title 23, the VITEMA Act (5233) of 1986 and the Emergency Management Act of 2009 and carries out their role using the Territorial Operational Emergency Management Plan and the Territorial Hazard Mitigation Plan.

VITEMA has a very good relationship with both the Government and the private sector. Each agency of the Government is required to build its resilience, and VITEMA plays a key role in assisting with this process. It is essential therefore that this vulnerability assessment and adaption planning project collaborate with the expertise and database available through VITEMA.

VITEMA has setup a Fusion Centre, which conducts intelligence analysis for territory through linkages with key agencies. The Federal Emergency Management Agency (FEMA) works very closely in developing maps as well as in hazard preparedness and response activities.

VITEMA has made attempts to incorporate climate change within their plans and activities. With the establishment of the Climate Change Council under the Chairmanship of former Senator Shawn Malone more strides will be made and as such the working relationship during the execution of this current project is vital.

VITEMA has expressed its focus on the coastal zone because all the critical facilities are located in coastal areas. There are also concerns for St. John because it is considered highly vulnerable by virtue of its isolation from St. Thomas. That island has the smallest population, and there are no alternative ports outside of Cruz Bay for docking should an emergency arise. Additionally, there is no hospital on the island of St. John, which is a cause for concern.

Other concerns raised by VITEMA related to limited sea floor depth. Cruise ships come into the harbor in St. Thomas but their hull and keel are less than three meters from the sea floor. This means that there is little buffer space in the harbor for large ships. This poses a challenge in the case of certain hazards, as emergency ships may be hindered from entering in the harbor.

### 5.2.2 Policy Legislative and Institutional Gaps

The absence of policies and guidelines for wetlands management inhibit the development or integration of relevant programs. The 2009 Section 309 Assessment for the USVI Coastal Zone management Program states that policies to increase protections for wetlands were approved by the Coastal Zone Management Commission in 2006, but now needs to be promulgated and adopted as rules and regulations within the coastal zone management program. Similarly, there is no institutional arrangement that supports information sharing and collaborative programming, both necessary to ensure the development of synergies between the various programs.

The major issues and priorities currently relevant to wetlands are:

Need for an Integrated Policy Framework – There are several laws relevant to the management of wetlands, and those laws are administered by different agencies. Though the programs managed by the various agencies are usually in line with national priorities, there is a need to establish a mechanism for integration of the wetlands-related policies and programs of the public agencies in the U.S. Virgin Islands, including the involvement of non-governmental organizations.

(a) Existence of Significant Threats – There are significant threats to wetlands and associated resources from natural and man-made sources. The man-made threats are primarily from land use activities (e.g. changed drainage, sediment from construction activities, filling of wetlands, disposal of solid waste and effluents), but also from illegal practices (e.g. solid waste disposal). These threats reduce the benefits provided by wetlands. While threat reduction is a priority of the management agencies, success of management interventions require changes in attitudes and practices of individuals and institutions in the community.

(b) Need for Improved Storm Water Management – Due to the topography of the islands, most development activities (including residential development) involves the channeling of surface runoff from rainfall events. Poor storm-water management practices result in damage to wetlands, social infrastructure (e.g. roads), and private property. Individuals and companies undertaking developments must therefore use best practices in the design of storm-water management systems.

(c) Need for Improved Information Management – There is no structured program for research and monitoring of wetland resources. As such, data collection is sporadic, ad hoc, and not necessarily linked to institutional mandates or programs. Data and information is consistently lost.

Additionally, databases compiled by Federal agencies are not utilized by USVI regulatory agencies for management decision making.

## 5.3 Institutional Capacity Issues

As described in 5.2.1.3 above, the USVI Climate Change Council was established through Executive Order no. 476-2015 to facilitate development of a cohesive framework and strategy to prepare for climate change impacts on the territory. It was intended to serve a coordinating function for public sector institutions, Federal and local agencies, academic and research institutions and private and non-profit sectors. However, it has been indicated (*personal communication)* that limited funding allocation and the absence of a Coordinator have stymied the operation of the Council. A Coordinator was appointed in 2018 and it is expected that the Council will be more fully operational going forward.

Of further consideration is the need for disaster risk management planning for the various Departments of Government. Some Departments (e.g. WAPA) have indicated that they have emergency plans but some require updating. VITEMA is the lead agency for emergency response at the national level but recovery planning in advance is not well thought out.

Sections 5.3.1 to 5.3.2 presents institutional capacity challenges for the key sectors.

### 5.3.1 Agriculture

The greatest issue with the agriculture sector as indicated from stakeholder consultants is the attitude and mindset of the local farmers. Very few farmers < 5% see farming as a business.

Whilst there are human resource limitations at the Department of Agriculture, to address this challenge, partnerships have been made with the UVI to execute training and capacity building workshops for farmers to learn and adopt best practices for a sustainable agricultural sector. However, many farmers are resistant to change.

Also, despite that fact that there are financial resource challenges within the Department of Agriculture, the government has instituted a number of beneficial programs to incentivize agriculture for local farmers. For example:

1. Department of Agriculture has land which they provide to farmers once they make the request and submit a business plan.
2. There is funding for well construction under an Equipment program wherein there is 95% reimbursement of expenditure under the USDA Natural Resource Conservation Service.
3. In the past the Department of Agriculture provided assistance to persons to create earthen ponds for water storage. However, they didn't not have the financial resources to sustain this assistance.

Regrettably, many persons have taken the land and not used it for production, and there are several persons who do not take up the financing for well construction.

### 5.3.2 Tourism

The Department of Tourism has no regulatory authority for tourism; instead their mandate according to the VI Code is to develop and promote tourism in the Virgin Islands. The department actively promotes the country's assets as sun, sand, and sea, but they have recently been delving into showcasing some uniqueness and diversity in activities. The Department understands that the sector is heavily dependent on

the natural resources of the country but in terms of regulation, this is the purview of the Department of Natural Resources (DPNR).

As it pertains to standards DPNR and the Department of Health are responsible for setting the standards and regulations for tourism enterprises to operate. The role of DPNR with respect to protection and enforcement was already elaborated in Section 5.2 above. Discussions with DPNR indicated some limitations in available resources, especially related to adequacy of enforcement officers.

The Department of Health sets the standards for public health that hotels, restaurants and other facilities follow and to address arising issues such the Zika virus challenge that arose in 2014. Additionally, the Department of Consumer and Licensing sets property standards that enterprises are expected to follow.

Climate change and tourism has not previously been looked at collectively, but agencies of Government that help regulate the sector would be a key part of the framework in getting the sector climate change resilient.

### 5.3.3 Critical Infrastructure

Consultations with the Water and Power Authority revealed a few existing capacity challenges. There are challenges in the Transmission / Distribution (T&D) network for water. They have indicated that major refurbishment was necessary but financial resources constrained that upgrade. It was then estimated that it would cost over US$200million to replace the pipes across the island.

Department of Public Works has also indicated in consultations the lack of maintenance for several roadways and bridges due to inadequate financial resources.

With respect to emergency services, entities such as the Hospital, Clinics, Fire Station and Police Station are all plagued with financial, human and technical resource challenges which limit their operations.

With respect to shelters, these are mainly schools which VITEMA has assessed to determine their adequacy to function as shelters. VITEMA, through Shelter Manager are also responsible for ensuring that relief supplies are provided to persons at these locations as needed. VITEMA is equipped with modern resources managed under their Fusion Center to function and communicate (through established partnerships) with all the key players i.e. the various emergency services as well as the various Departments of the Government to respond in an event. VITEMA operates in an event as guided by their Territorial Operational Emergency Management Plan.

## 5.4 Private Sector

Business continuity planning is not done within many private sector organizations. This limits the ability of private sector to handle speedy and efficient recovery following major events. Stakeholder consultations have revealed that off-site resources and business continuity is only being pushed for a few organizations such as Tropical Shipping, which is located at the port. They have moved some aspects of their business offsite, including documents etc. as part of their business continuity plan.

## 5.5 Civil Society

It is important for the general public to be properly educated about climate change and the potential impacts that it poses for them as individuals, their communities and on the Territory as a whole. Several Departments of Governments that have been interviewed shared the sentiment that greater public

awareness on the issues is needed. Stakeholder consultations reveal that the human factor can play a major role in vulnerability and can be a hindrance to successful adaptability.

## 5.6 Summary Adaptive Capacity

*Table 5.2: Summary Adaptive Capacity Assessment*

| **Current Stresses** | **Projected Stresses from Climate Change** | **Projected Impact of Changes to the Systems *(without adaptation or risk reduction measures)*** | **ADAPTIVE CAPACITY ANALYSIS** | |
|---|---|---|---|---|
| | | | **Ability of the Systems to Accommodate Projected Impacts with Minimum Disruption or Costs** | **Adaptive Capacity** |
| **SOCIOECONOMIC** | | | | |
| Increase in temperatures 0.18$^{o}$C per decade | Increase in mean annual temperatures 0.80$^{o}$ to 2.89$^{o}$C | Increased need for cooling can put pressure on energy demands.<br><br>Heat stress especially for the vulnerable population (e.g. those aged). | Diversified energy supply (solar) but still very dependent on imported oil.<br><br>Country reliance on WAPA for power. | Moderate |
| Low annual rainfall with high inter-annual variability | Drying trend will be in both the wet and dry season (all year round) | Greater pressure on WAPA to supply potable water. This may increase the need for more desalination plants or more storage. | Existing challenges with respect to lack of maintenance for transmission and distribution system can hinder adaptability.<br><br>Rainwater harvesting and storage culture at the household level is an adaptive measure. | Moderate |
| Annual exposure to hurricanes and tropical storms | 80% increase in the frequency of category 4 and 5 hurricanes over the next 80 years.<br><br>Shift in stronger storms by end of century<br><br>20 to >30% increase in rainfall rates for model hurricane's inner core. | Residential and commercial areas may be prone to flooding and wind damage. Especially those located near drainage pathways and in low-lying coastal areas.<br><br>This would result in significant damage to property and life.<br><br>Repeated losses negatively impact livelihood and the amount of resources available to persons and | DPNR lack of enforcement officers to ensure developments following guidelines is a limitation.<br><br>Public Works lack of financial resources to maintain key infrastructure can impact residences and commerce.<br><br>Policy to increase protection of wetlands (which act as natural flood mitigation measure) that were approved by the CZM commission in 2006 is not promulgated and | Low to Moderate |

| Current Stresses | Projected Stresses from Climate Change | Projected Impact of Changes to the Systems *(without adaptation or risk reduction measures)* | ADAPTIVE CAPACITY ANALYSIS | |
|---|---|---|---|---|
| | | | **Ability of the Systems to Accommodate Projected Impacts with Minimum Disruption or Costs** | **Adaptive Capacity** |
| | | can lead to poverty for vulnerable groups (e.g. those with disability or the aged).<br><br>Risk of flood related illnesses such as water-borne diseases, and proliferation of vectors such as mosquitoes.<br><br>Productivity within the local population may be affected. | adopted as rules and regulations to be followed.<br><br>Lack of business continuity planning for the private sector.<br><br>Lack of public awareness on climate change. | |
| **AGRICULTURE** | | | | |
| Increase in temperatures 0.18$^{o}$C per decade | Increase in mean annual temperatures 0.80$^{o}$ to 2.89$^{o}$C | Increase in evapotranspiration thus increasing the demand for water.<br><br>Increased evaporation combined with drier conditions and poor farming practices will result in reduced yield. | Poor farming techniques adopted by farmers are a major challenge. | Low |
| Heavy dependence on rainwater<br><br>Few persons have access to well water or other sources<br><br>No supply of water from WAPA | Decease in precipitation for the western end of St. Croix. Projected decrease in precipitation by mid-century in St. Croix.<br><br>Drying trend will be in both the wet and dry season (all year round) | More frequent drought events will result in reduced crop yield.<br><br>Reduction in available freshwater supply for crops and livestock.<br><br>Dependence on rainfed agriculture is unsustainable in the long term.<br><br>Inadequate water supply to support | No supply of water to agricultural sector is a hinderance.<br><br>Many persons cannot afford to upfront the offer for well construction though offered by the government. | Low |

| Current Stresses | Projected Stresses from Climate Change | Projected Impact of Changes to the Systems *(without adaptation or risk reduction measures)* | ADAPTIVE CAPACITY ANALYSIS | |
|---|---|---|---|---|
| | | | **Ability of the Systems to Accommodate Projected Impacts with Minimum Disruption or Costs** | **Adaptive Capacity** |
| Poor livestock farming techniques | | livestock farming. This issue with poor livestock farming practices such as the lack of culling, overstocking and overgrazing when necessary will result in death of animals and loss of revenue.<br><br>Invasive pests such as mites and aphids-lace bugs that result during extended droughts.<br><br>Loss of crops and livestock. | No more government support for construction for water storage ponds.<br><br>Despite training from the Dept of Agriculture and UVI, poor farming techniques adopted by farmers are still a major challenge. | |
| Damage from heavy rainfall/storm events<br><br>Poor farming practices<br><br>Flooding and damage to farms such as in St. Croix due to high rainfall | 80% increase in the frequency of category 4 and 5 hurricanes over the next 80 years.<br><br>Shift in stronger storms by end of century<br><br>20 to >30% increase in rainfall rates for model hurricane's inner core. | Loss of crops, reduction in crop yield, loss of livestock.<br><br>Landslide and soil erosion due to heavy rains may lead result in moderate damage to crops due to debris flow and a loss of fertile top soil.<br><br>Clearing of hillside vegetation for farming especially on slopes can lead to increased surface runoff and lower the groundwater recharge capacity of the area.<br><br>Flooding of low lying areas in St. Croix due to high intensity rainfall | Poor farming techniques adopted by farmers are a major challenge.<br><br>No disaster risk planning at the Government level. | Low |

| Current Stresses | Projected Stresses from Climate Change | Projected Impact of Changes to the Systems *(without adaptation or risk reduction measures)* | ADAPTIVE CAPACITY ANALYSIS | |
|---|---|---|---|---|
| | | | **Ability of the Systems to Accommodate Projected Impacts with Minimum Disruption or Costs** | **Adaptive Capacity** |
| | | events.<br><br>Invasive pests such as Lepidoptera (worms) that result during extended rainy.<br><br>Damage to infrastructure such as offices and irrigation systems. | | |
| **TOURISM** | | | | |
| Increase in temperatures 0.18$^{o}$C per decade | Increase in mean annual temperatures 0.80$^{o}$ to 2.89$^{o}$C<br><br>Sea surface temperatures also expected to continue increasing over the century. | Increased need for cooling can put pressure on energy demands.<br><br>Enhanced stress on people, water resources, cooling systems and energy resources. Warmer summers, warmer winters – less comfortable.<br><br>Reduction in cruise tourists interacting on island due to high temperatures.<br><br>Warmer temperatures also cause negative impacts on ecological resources such as corals which are sensitive to temperature shifts<br><br>As temperatures continue to increase, it is likely that continued problem with sargassum lining the beaches of | Diversified energy supply (solar) but still very dependent on imported oil.<br><br>Country reliance on WAPA for power.<br><br>Can develop heat stress decision calendars – what to do and when. Capacity exists now to better educate visitors and residents on how to deal with heat waves and better manage cooling and energy demands.<br><br>Not much can be done with respect to temperature changes that have already been locked into the climate realm from past emissions. However, can continue to take measures to reduce greenhouse gas emissions which are contributing to global warming and rising temperatures.<br><br>Given what is currently known from science | Moderate |

| Current Stresses | Projected Stresses from Climate Change | Projected Impact of Changes to the Systems *(without adaptation or risk reduction measures)* | ADAPTIVE CAPACITY ANALYSIS | |
|---|---|---|---|---|
| | | | **Ability of the Systems to Accommodate Projected Impacts with Minimum Disruption or Costs** | **Adaptive Capacity** |
| | | the coastline.<br><br>Increases in the frequency of warm days and warm nights can lead to heat waves which stress residents, visitors and workers (especially those working outdoors) alike. | not much can be done by the USVI to directly control Sargassum distribution. However, there are opportunities to better coordinate locally and pool resources to deal with Sargassum removal. Currently being done on just a small scale (by "We Do" through NOAA grant) but could/should be scaled up. Additional resources will be needed to support this from private and public sources and also to address PR issues. | |
| Coastal erosion in some areas of the coastline (e.g. Bolongo Bay) | Increase in USVI sea levels up to 1m by the end of the century. | This can result in coastal erosion in some coastal areas and thus loss of beaches. Charlotte Amalie in St. Thomas, Frederiksted in St. Croix, Cruz Bay in St. John have low lying areas which will likely experience flooding from rising sea levels.<br><br>Rise in sea level between 1.86 +/- 0.5mm and 2.07 +/- 0.69 mm/yr contributes to erosion of natural coastal assets. Increasing storm surge impacts.<br><br>Increasing negative impact on tourism due to erosion of the coastal resources which form the foundation of the industry. Could also impact | Department of Public Works has limited financial resources to maintain coastal infrastructure.<br><br>Coastal adaptation possible but will be challenging because of powerful and intensifying erosion potential from storms and sea level rise. There is potential to utilize both nature-based and engineering approaches to help increase coastal resilience. However, these techniques will be costly. Planning and coastal management decisions can begin taking into account erosion and shoreline change possibilities more intentionally and directly as it relates to siting important infrastructure and activities. Will depend on creating a mechanism for managers, policymakers, property owners and technical experts to work together to identify locally | Moderate |

| Current Stresses | Projected Stresses from Climate Change | Projected Impact of Changes to the Systems *(without adaptation or risk reduction measures)* | ADAPTIVE CAPACITY ANALYSIS | |
|---|---|---|---|---|
| | | | **Ability of the Systems to Accommodate Projected Impacts with Minimum Disruption or Costs** | **Adaptive Capacity** |
| | | cultural and historical resources. | effective strategies and develop an integrated shoreline management plan. Technical experts available to help inform planning. | |
| Overall trend of increase in rainfall observed seen from 1977-2015, now shifting to more of a downward trend in rainfall. | Drying trend will be in both the wet and dry season (all year round)<br><br>Drought conditions anticipated to increase over time (going from 3% less in mean by 2020 and up to 25% less by end of century). Drying expected to be evident in both wet and dry seasons. | Observed and anticipated changes in rainfall patterns could have a cascade effect and ultimately impact planning for tourism activities, visitorship, the visitor experience and marketing efforts.<br><br>Increased pressure on water resources and water supply likely. If water supply stresses emerge they will negatively impact tourism since it is a heavy water use industry.<br><br>Water supply could become problematic in future as drought conditions heighten. Can partially be managed with better public education and enhanced industry practices to support and practice water conservation. Situation could worsen if number of visitors to region increases. | No Business continuity planning<br><br>Lack of enforcement by DPNR.<br><br>Because changing weather patterns will influence all aspects of the tourism sector it will be difficult to accommodate these impacts with minimum disruption or costs. Some will be more easily addressed compared to others. Costs will vary. Starts with building a collective adaptation mindset among industry leaders and across all tiers of society that looks at both short and long-term needs. This process is beginning.<br><br>Can enhance water conservation practices and public/visitor education. Incorporate planning for water supply into tourism business models and practices. | Moderate |
| Extreme weather and Flooding from tropical | 80% increase in the frequency of category 4 and 5 hurricanes over the next | Damage to coastal tourism facilities such as hotels, restaurants, beaches, shops, craft market due to inland and | Can improve stormwater management and drainage to deal with stormwater flows. Can integrate climate change considerations into | Moderate |

| Current Stresses | Projected Stresses from Climate Change | Projected Impact of Changes to the Systems *(without adaptation or risk reduction measures)* | ADAPTIVE CAPACITY ANALYSIS | |
|---|---|---|---|---|
| | | | **Ability of the Systems to Accommodate Projected Impacts with Minimum Disruption or Costs** | **Adaptive Capacity** |
| cyclone events | 80 years.<br><br>20 to >30% increase in rainfall rates for model hurricane's inner core.<br><br>Shift in stronger storms by end of century. | coastal flooding associated with high intensity rainfall events.<br><br>Coral bleaching due to high intensity hurricane events would negatively impact diving as a tourism attraction. This may result in the slow recovery of reef systems due to frequency of impact. Can negatively impact fish breeding as well.<br><br>Reduction in visitor arrivals due to recurring damages from storm events. | disaster planning. Develop storm disaster plans for hotels etc.<br><br>Use hurricane season education as a platform to link messages to population and visitors. | |
| Outbreak of vector borne diseases (Zika Virus) | More periods of short duration intense rainfall, which can cause ponding<br><br>Increase in mean annual temperatures 0.80$^{o}$ to 2.89$^{o}$C | The mosquitoes which carry viruses breed in water that settles around homes, schools, churches, workplaces and playgrounds.<br><br>Nearby wetlands are grounds for mosquito breeding.<br><br>Temperature increase may also exacerbate the incidence of vector borne diseases such as, chikungunya.<br><br>Reduction in visitor arrivals especially for wedding market.<br><br>Flash floods may also lead to loss of | While not much can be done to stop change in range and distribution of vector agents, can enhance public education on what can be done to limit breeding areas for mosquitoes as well as share other public safety guidance. Develop public health plans that take these changing scenarios into account. | Moderate |

| Current Stresses | Projected Stresses from Climate Change | Projected Impact of Changes to the Systems *(without adaptation or risk reduction measures)* | ADAPTIVE CAPACITY ANALYSIS | |
|---|---|---|---|---|
| | | | **Ability of the Systems to Accommodate Projected Impacts with Minimum Disruption or Costs** | **Adaptive Capacity** |
| | | life. | | |
| Mounting negative stresses on coastal resources important to tourism | Increase in greenhouse gas (carbon dioxide) emissions globally is projected to exacerbate ocean acidification. Sea level rise contributes to erosion and loss of coastal habitat. | Ocean acidification and coral bleaching events already being observed in USVI, as well as loss of coastal ecosystems such as mangroves and wetlands. Water pollution and overfishing also occurring. While not direct climate change impacts further stress coastal resources being impacted by climate change thereby making them less resilient.<br><br>Reduced resilience of coastal resources and ecosystems due to combined stresses. Negative shifts in ecosystem health and function. Because the tourism sector is integrally linked to natural resources, any impact will produce a negative feedback on the USVI's tourism product. | Capacity exists to ramp up public education on these stressors and what can be done to address each.<br><br>Capacity exists to harness technical expertise within, government and UVI to collaborate and develop climate adaptation plans. Capacity also exists to collaborate with key stakeholders from the tourism industry to develop practical plans (leverage support). Opportunities exist to link to existing efforts of the CHTA and the CTO on disaster management, hurricane preparedness, Sargassum response, enhancing energy efficiency, cleaning up water quality, etc. Capacity to strengthen and form new partnerships as greater coordination for long term planning will be essential. Will be time and resource heavy. | Moderate |
| Poor watershed management (e.g. absence of a land management plan, lack of zoning, as well as overdevelopment near | Anticipated climate change impacts such as erosion, loss of habitat, and more intense storms will be exacerbated where there is poor watershed | Links between land use decisions, water quality and development in vulnerable areas already evident.<br><br>Haphazard/poorly planned development decreases beauty and | Capacity exists to bring resource managers, policymakers, government officials together to develop a land management plan to address overdevelopment and improve watershed development. Will however be a costly and lengthy process. Need to strengthen capacity | Moderate |

| Current Stresses | Projected Stresses from Climate Change | Projected Impact of Changes to the Systems *(without adaptation or risk reduction measures)* | ADAPTIVE CAPACITY ANALYSIS | |
|---|---|---|---|---|
| | | | **Ability of the Systems to Accommodate Projected Impacts with Minimum Disruption or Costs** | **Adaptive Capacity** |
| beaches). | management. | allure of the region and threatens health of natural resources. Difficult to stem negative spin-off effects of poor watershed management- both environmental and economic implications.<br><br>Segments of the population and important infrastructure are at increasing risk. Watershed management or lack thereof all links back to what is seen on the coastline in terms of environmental. E.g. not having sufficient room for wetlands to migrate inland to keep up with sea level rise will result in greater negative impacts on these crucially important coastal ecosystems. | for this kind of integrated planning. | |
| **CRITICAL INFRASTRUCTURE** | | | | |
| Damage to transportation infrastructure including the road network due to coastal and inland flooding | 80% increase in the frequency of category 4 and 5 hurricanes over the next 80 years.<br><br>20 to >30% increase in rainfall rates for model hurricane's inner core. | Blocked and flooded roads hinder the movement of vehicular traffic and pedestrians.<br><br>Enhanced likelihood of flooding of airport and transportation assets from climate change impacts and significant flooding events. | Limited financial resources at Department of Public Works for maintenance is a challenge.<br><br>Capacity exists to develop an adaptation plan for airport and other key transportation assets. Identify opportunities to bolster resilience of the airport and better deal with stormwater flows. | Moderate |

| **Current Stresses** | **Projected Stresses from Climate Change** | **Projected Impact of Changes to the Systems *(without adaptation or risk reduction measures)*** | **ADAPTIVE CAPACITY ANALYSIS** | |
|---|---|---|---|---|
| | | | **Ability of the Systems to Accommodate Projected Impacts with Minimum Disruption or Costs** | **Adaptive Capacity** |
| Damage to utility infrastructure | 80% increase in the frequency of category 4 and 5 hurricanes over the next 80 years.<br><br>Shift in stronger storms by end of century. | Downed electricity communication poles due to high winds from storms.<br><br>Loss of solar panels located on slopes from high winds. | Any limitations within WAPA such as limited human resources and financial resources can slow the recovery process. | Moderate |
| Sea levels rise impacting coastal infrastructure | Increase in USVI sea levels up to 1m by the end of the century. | Storm water outlets are below Mean-Sea Level, and seawater intrusion in the drainage infrastructure, especially during the highest tides, prevents proper drainage and creates backflow and flooding issues upland. | Limited financial resources within Department of Public Works to make adjustments to storm water outlets. | Low |

# 6 Vulnerability Assessment

The final step in the vulnerability assessment process is to combine the findings of the sensitivity analysis and the adaptability to determine how and where is vulnerable to climate change. It is important to note that the vulnerability assessment does not remain static, as it can improve or worsen with time. Changes can occur within the USVI e.g. implementation of preparedness activities, and new threats may emerge. These can all influence a country's vulnerability. Table 6.1 describes the criteria used to assess vulnerability.

*Table 6.1: Description for Vulnerability Analysis*

| Vulnerable | Description |
|---|---|
| High | • Highly Sensitive to Climate<br>• Low Adaptive Capacity to deal with projected climate change impacts |
| Medium | • Moderately Sensitive to Climate<br>• Moderate Adaptive Capacity to deal with projected climate change impacts |
| Low | • Low Sensitivity to Climate<br>• High Adaptive Capacity to deal with projected climate change impacts |

## 6.1 Socioeconomic Impact

### 6.1.1 St. Thomas

Flood maps in Figure 6.1 to Figure 6.2 show a combination of inland and coastal flooding associated with 100year and 500year storm events. The main town of Charlotte Amalie is inundated in all four projected years 2017, 2035, 2065 and 2100, but the variations are insignificant. As such, only 2017 and 2100 are presented below. Based on the areas impacted 100 and 500 year inundated zone a total of 27,235 persons would be affected. This area is the most densely populated on the island of St. Thomas. As highlighted in the vulnerability maps below and expressed in the hazard assessment above (Section 4.2), the island is most impacted by inland flooding, wherein storm water during rainy events are carried by the many guts traversing the landscape. These guts do not have the capacity to contain the high water levels and as such they overflow their banks. The narrow flat coastal areas are flooded because the flow of storm water to the sea is blocked by increased sea levels and high tide.

This coastal area of Charlotte Amalie hosts the main business centre for the island including several financial institutions, retail and commerce businesses, hotels, bars, restaurants, market, craft market, historical buildings and museum, schools, churches, all the key public-sector buildings including the various departments of the Government, marinas, the sea plane port, the main international airport and the Cruise Ship Pier. These areas are all vulnerable to flooding.

Several residential communities in and around the town, particularly those houses and apartment complexes located along the guts are also vulnerable to flooding. The following areas are inundated in the 100 and 500 year storm event:

- Estate Kings Quarter
- Estate Contant
- Estate Demarara
- Estate Thomas
- Estate Lindbergh Bay
- Estate Solberg
- Estate Frenchman Bay
- Estate Fortuna

- Estate Queens Quarter
- Estate St. Joseph and Rosendal
- Estate Honduras
- Estate Lerkenlund
- Estate Dorothea
- Estate Bakkero
- Estate Lower John Dunko
- Estate Annas Fancy
- Estate Bonne Resolution
- Estate Lilliendal and Marienhoj
- Estate Upper John Dunko
- Estate Agnes Fancy
- Estate Bonne Esperance
- Estate Pearl
- Estate Hospital Ground
- Estate Santa Maria
- Estate Elizabeth
- Estate Mafolie
- Estate Western Water Island
- Estate Nisky
- Estate Ross
- Estate Misgunst
- Estate Fortuna Hill
- Estate Crown and Hawk
- Estate Canaan and Sherpenjewel
- Estate Zufriedenheit
- Estate Eastern Water Island
- Estate Hassel Island
- Estate Perseverance
- Estate John Brewers Bay
- Estate Adelphi

For the he population being impacted, their ability to return to work would be delayed and their personal property, lives and family negatively impacted. It therefore means that recovery following an event is much slower due to hinderances experienced by the labour force as they prioritize their recovery efforts.

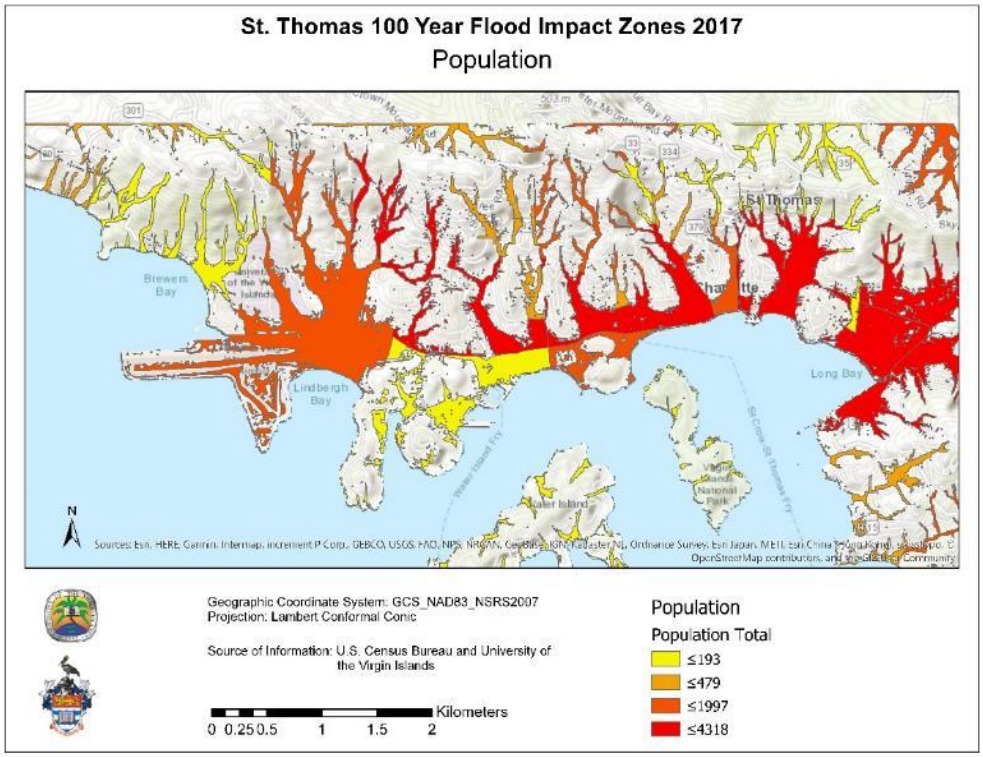



*Figure 6.1: St. Thomas 100 Year Flood Impact Zones 2017 – Population*

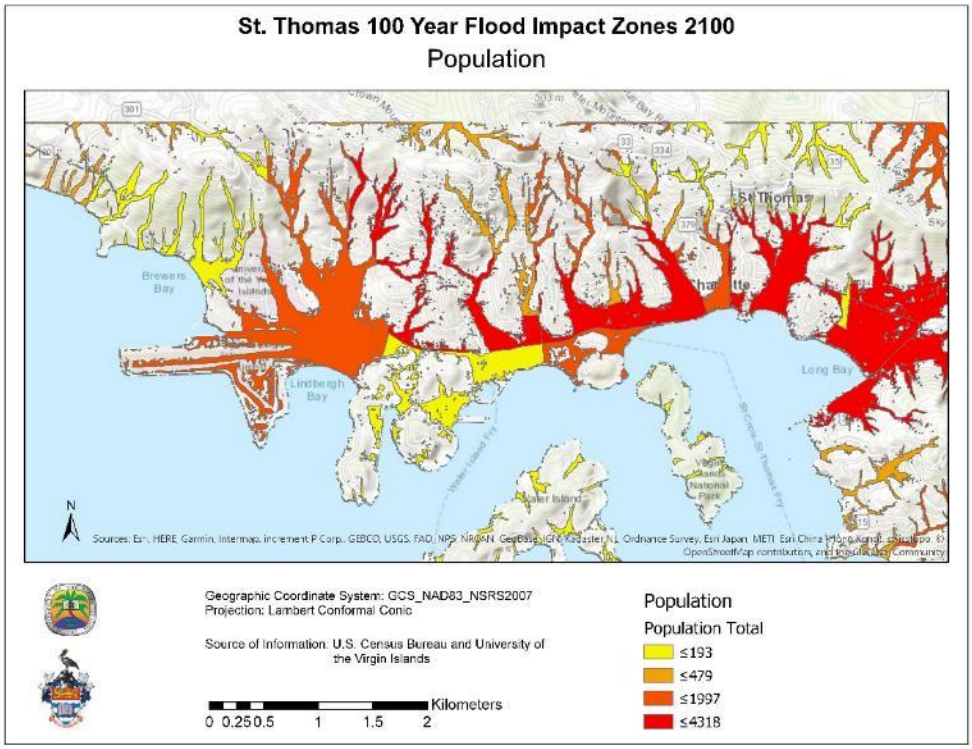



*Figure 6.2: St. Thomas 100 Year Flood Impact Zones 2100 – Population*

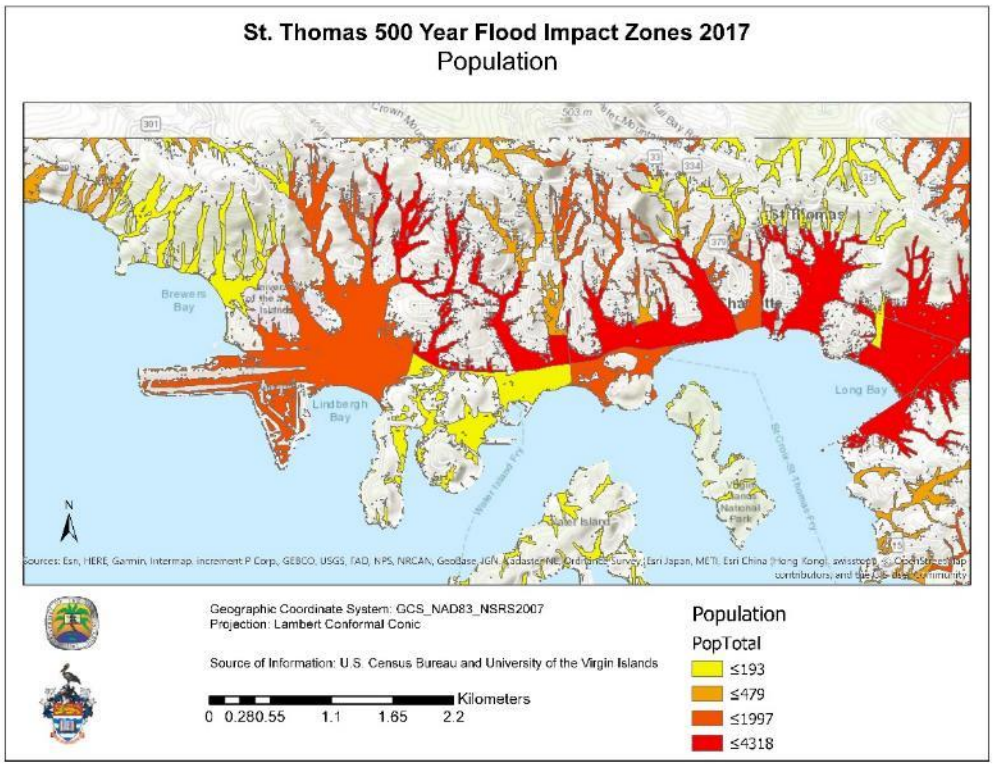



*Figure 6.3: St. Thomas 500 Year Flood Impact Zone 2017 - Population*

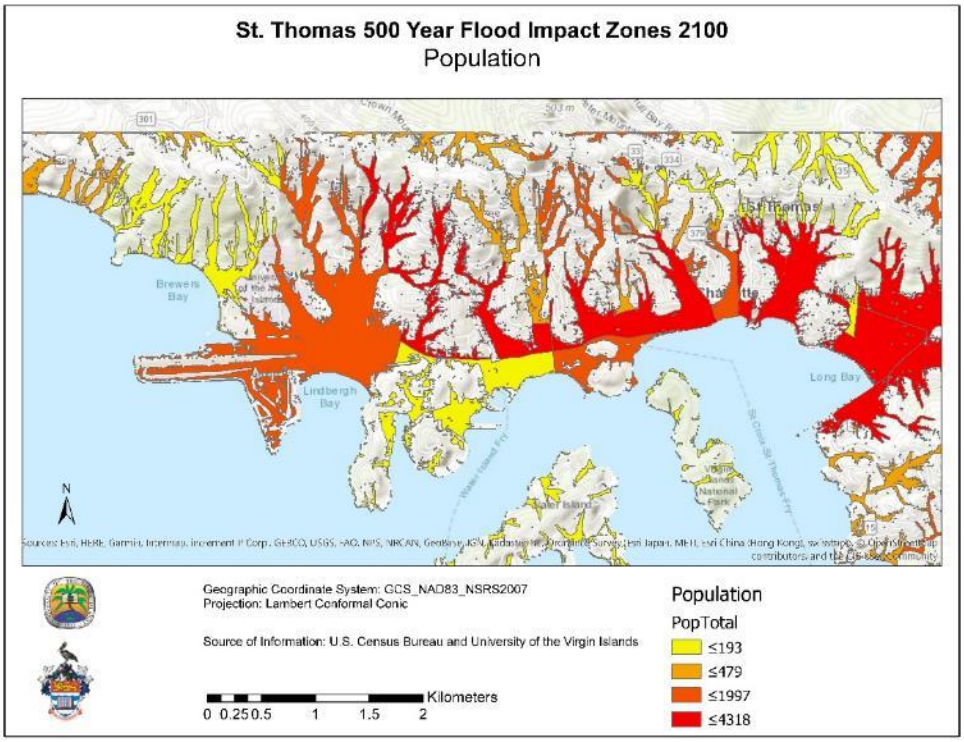



*Figure 6.4: St. Thomas 500 Year Flood Impact Zone 2100 - Population*

### 6.1.2 St. Croix

Figure 6.5 to Figure 6.8 show a combination of inland and coastal flooding associated with 100year and 500year storm events in St. Croix. The main town of Frederiksted is inundated in all four projected years 2017, 2035, 2065 and 2100 but the variations are insignificant. As such, only 2017 and 2100 are presented below. Based on the areas impacted in the 100 and 500 year inundated zone a total of 16,465 persons would be affected. Populated areas impacted are as follows:

- Estate Whim
- Estate Williams Delight
- Estate Two Brothers
- Estate Mount Pleasant West
- Estate St. George
- Estate Hannahs Rest
- Estate Grove Place
- Estate La Grange
- Estate Concordia West
- Estate Enfield Green
- Estate Wheel of Fortune
- Estate Carlton 2
- Estate Plessen 2
- Estate Paradise
- Estate Stony Ground
- Estate Whites Bay 1
- Estate Diamond West
- Estate Cane
- Estate White Lady
- Estate Carlton 1 North
- Estate Prosperity West
- Estate Frederikshaab
- Estate Little La Grange
- Estate Sprat Hall
- Estate Montpellier West
- Estate Carlton 1 South
- Estate Mountain
- Estate Northside
- Estate Hope West
- Estate Cain Carlton
- Estate Brooks Hill
- Estate St. Georges Hill
- Estate Orange Grove West
- Estate Hogensborg

- Estate Mount Victory
- Estate Plessen 1
- Estate Cane Valley
- Estate Mount Washington and Washington Hill
- Estate Hams Bay
- Estate Spring Garden
- Estate Waldberggaard
- Estate Annaly
- Estate Jolly Hill
- Estate North Hall
- Estate Nicholas
- Estate Becks Grove
- Estate Oxford
- Estate William
- Estate Pleasant Valley West
- Estate Two Friends

This coastal area of Frederiksted hosts some of the main business centres for the island of St. Croix including: several financial institutions, retail and commerce businesses, hotels, cruise ship port, bars, restaurants, market, craft market, historical buildings, schools, churches, all the key public-sector buildings and marinas.

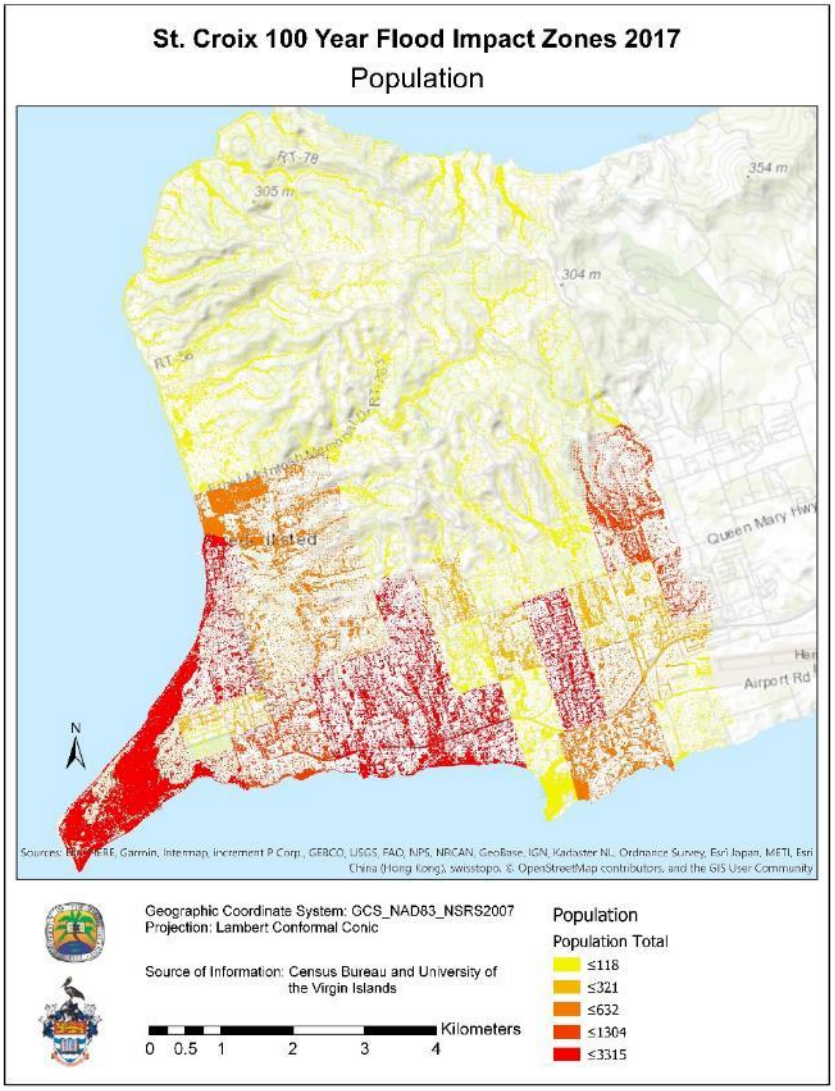



*Figure 6.5: St. Croix 100 Year Flood Impact Zone 2017 – Population*

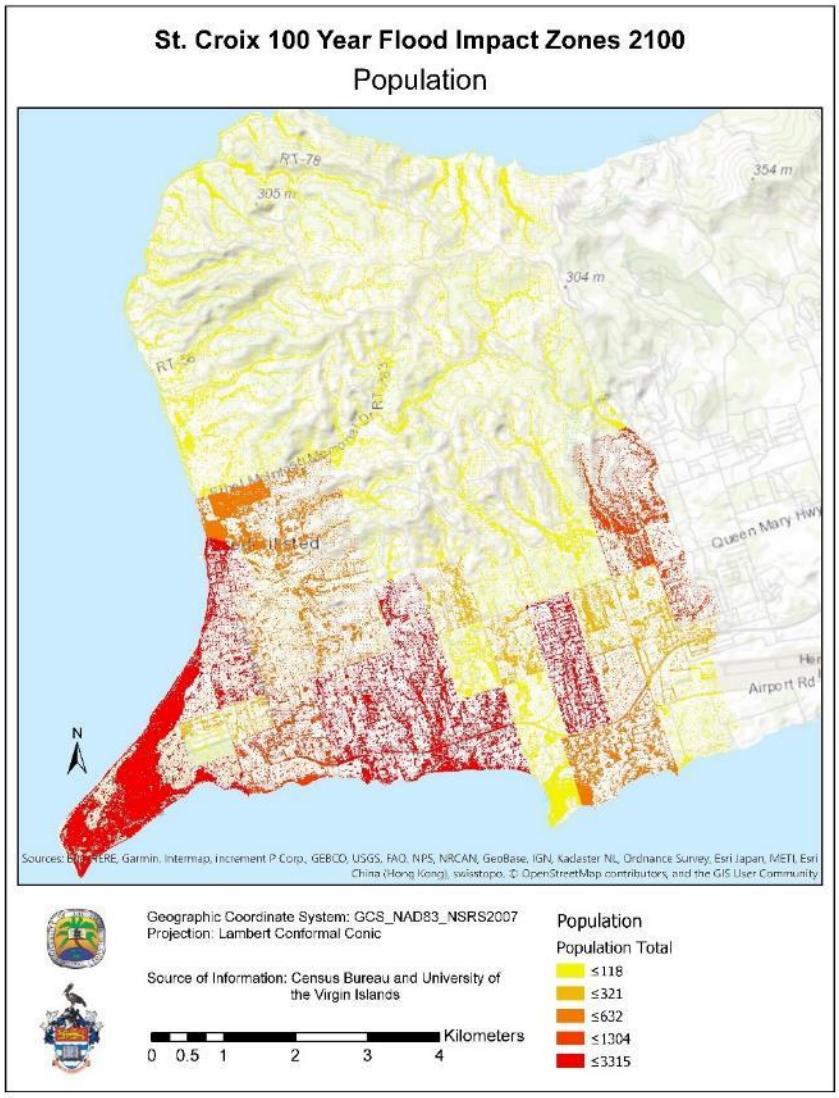



*Figure 6.6: St. Croix 100 Year Flood Impact Zone 2100 - Population*

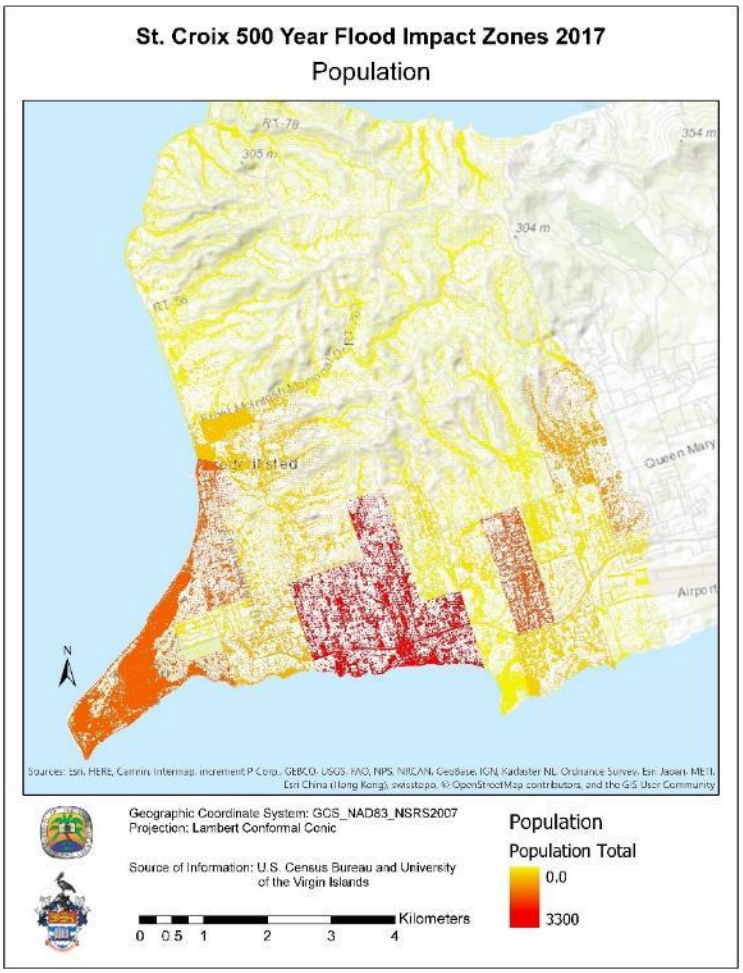



*Figure 6.7: St. Croix 500 Year Flood Impact Zone - Population*

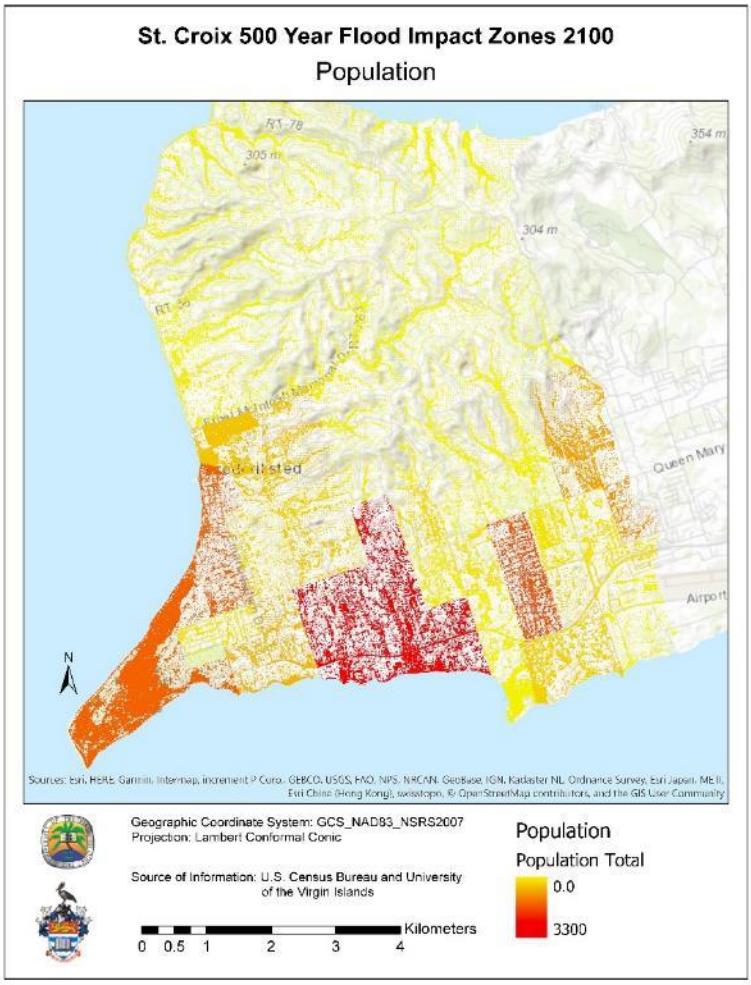



*Figure 6.8: St. Croix 500 Year Flood Impact Zone 2100 – Population*

## 6.2 Critical Infrastructure

Several critical facilities are at risk during storms now and in the future because they are located in or near hazard zones. Under current conditions, 141 critical facilities (Figure 6.9, 74 on St Thomas, 48 on St Croix, and 19 on St John), and 48 out of 147 miles of underground electric lines are located in flood zones. Of the critical infrastructure impacted, 113 structures (64 on St Thomas, 33 on St Croix, and 16 on St John) and 46 miles of underground electric lines are vulnerable to riverine flooding (rain storms), and 98 structures (49 on St Thomas, 33 on St Croix, and 16 on St John) and 33 miles of underground electric lines are vulnerable to coastal flooding (storm surge and swells). Similarly, 6,999 structures are located in flood zones (Figure 6.10, 4,178 on St Croix, 2,534 on St Thomas, and 287 on St John), 6,696 of which are vulnerable to riverine flooding (4,018 on St Croix, 2,447 on St Thomas, and 231 on St John), and 2,188 are vulnerable to coastal flooding (1,142 on St Croix, 800 on St Thomas, and 246 on St John). Finally, storms can inundate a significant amount of roads, complicating rescue operations and evacuations (Figure 6.11). Most of these roads are located in urban centers, and often lead to critical facilities, such as the landfills on St Thomas and St Croix. The majority of the vulnerable roads are in St Croix, where nearly 40% of them are prone to riverine flooding, and 20% to coastal flooding. On St Thomas and St

John, around 25% of the roads are vulnerable to riverine flooding, and less than 15% to coastal flooding. These numbers demonstrate the need for a robust drainage infrastructure in the Territory.

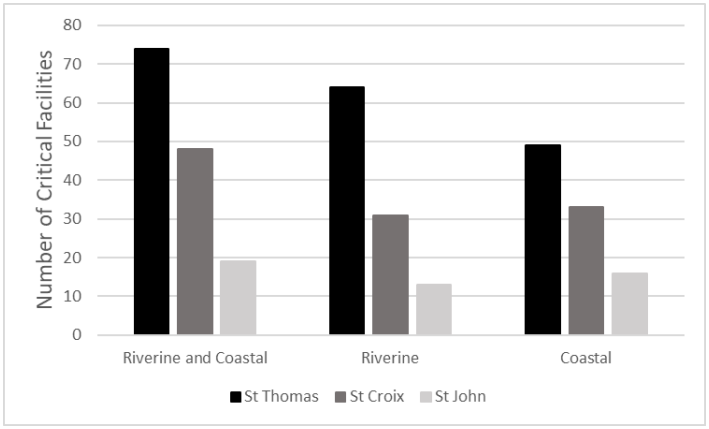



*Figure 6.9: Critical facilities impacted by different types of storm-induced flooding*

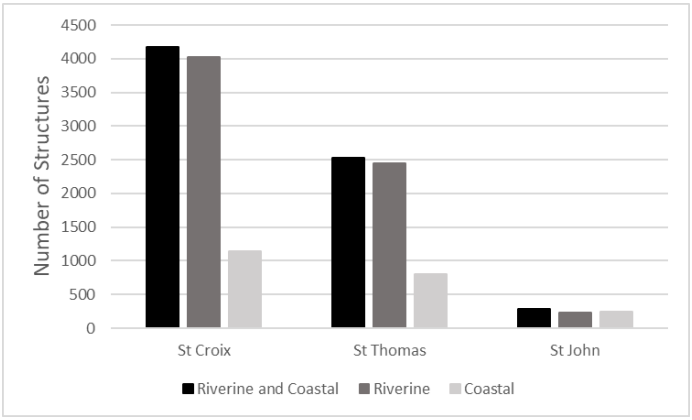



*Figure 6.10: Structures impacted by different types of storm-induced flooding*

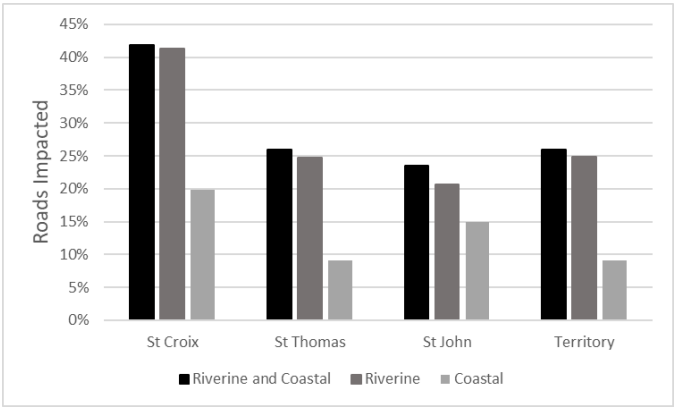



*Figure 6.11: Percent of roads impacted by different types of storm-induced flooding*

In addition to storms, the continued rise in sea level in the USVI will cause inundation and coastal erosion on all three islands, leading to thousands of acres of land lost (see Section 4.2; Figure 6.12). In particular, this might have consequences for tourism for popular places like Megans Bay or Smith Bay on St. Thomas, or Sandy Point on St. Croix, and Maho Bay on St. John.

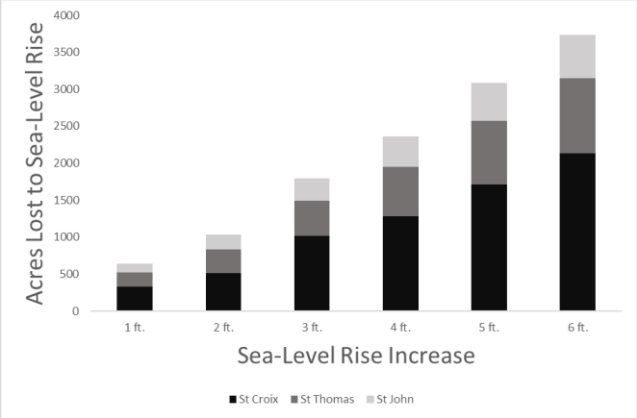



*Figure 6.12: Land area lost to sea level rise inundation in the USVI*

The built environment will also suffer consequences, as Charlotte Amalie, Red Hook, Bovoni, Coral Bay, Christiansted, Salt-River area and Limetree Bay area will experience significant flooding (see Section 4.2; Figure 6.13) In particular, if as predicted by the Army Corps of Engineers, sea level rises by approximately 1ft on both islands by 2050, nearly 16 critical facilities (4 on St. Thomas, 3 on St. Croix, and 9 on St. John) such as government buildings, schools, police and fire stations, airport, power plants, wastewater treatment facilities, etc., and 12 out of 147 miles of underground electric lines, will experience flooding due to rising seas. In addition to critical facilities, 106 structures (public and private buildings and houses) will experience flooding (56 on St. Thomas, 29 on St. Croix, and 21 on St. John). Fortunately, few coastal roads will experience flooding, and most of them are isolated. By 2100, a predicted 4 ft increase will cause 54 critical facilities (23 on St. Thomas, 14 on St. Croix, and 15 on St. John), 23 miles of underground electric lines, and 748 structures (375 on St. Thomas, 238 on St. Croix, and 135 on St. John) to be impacted. In addition, 4% of the roads in the territory (most of them on St. John) will be impacted; most of them are in urban centers on all islands, and near popular tourist destinations.

If the rate of increase accelerates, and extreme predictions come true, 2 ft of sea level rise in 2050 will cause 23 critical facilities (Figure 6.13), 7 on St. Thomas, 5 on St. Croix, and 11 on St. John), 13 miles of underground electric lines, and 199 structures (Figure 6.14; 92 on St. Thomas, 67 on St. Croix, and 40 on St. John) to experience flooding in the territory. Fortunately, few roads will be impacted (Figure 6.15). However, a 6 ft increase by the end of the century will impact 67 facilities (37 on St. Thomas, 14 on St. Croix, and 16 on St. John), 31 miles of underground electric lines and 1,395 structures (555 on St. Thomas, 344 on St. Croix, and 190 on St. John), and more than 8% of Territory roads (Figure 6.15), most of them in urban centers, leading to airports, or specifically on St. John, that might be impacted. The most

impacted facilities will be government buildings, wastewater facilities, and seaports. Fire and police stations, heliports, communication facilities, post offices, historical building, schools, public housing facilities, water and power facilities, and healthcare facilities will also be impacted.

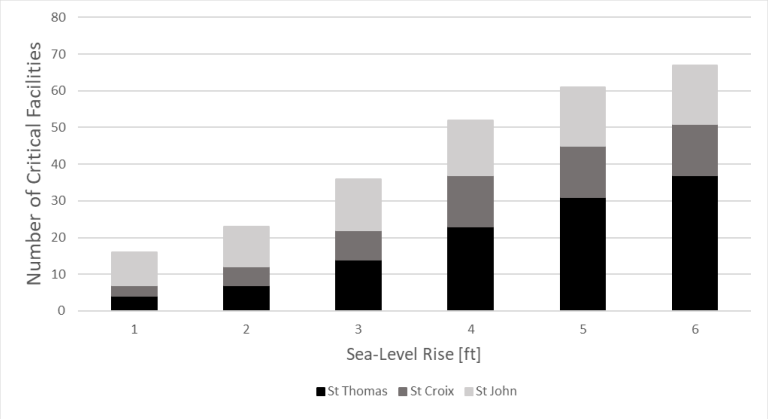



*Figure 6.13: Critical facilities impacted by sea level rise*

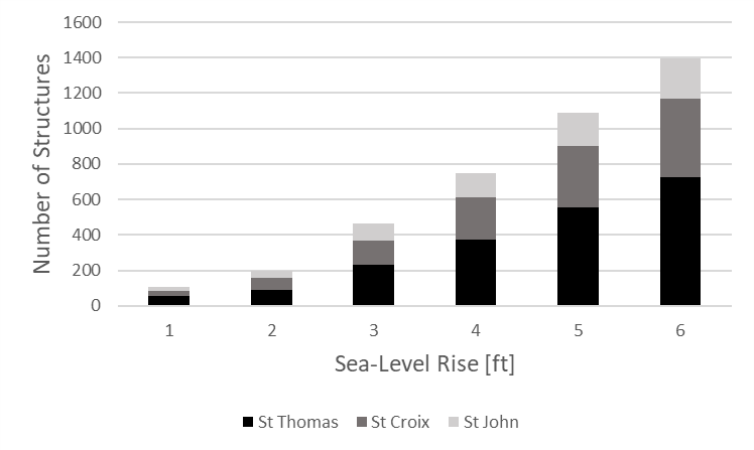



*Figure 6.14: Structures impacted by sea level*

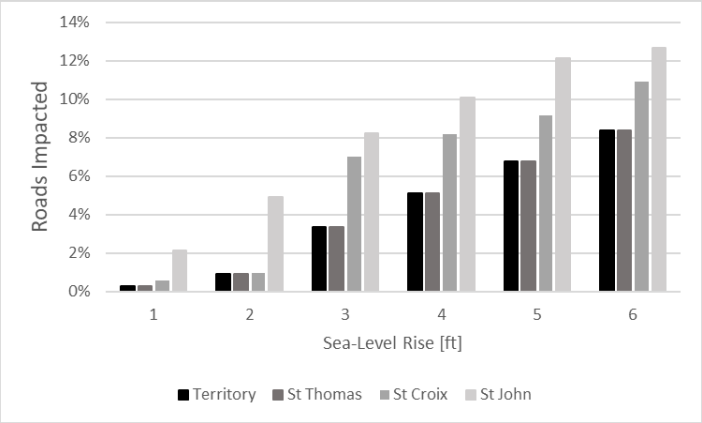



*Figure 6.15: Percent of roads impacted by sea level rise*

In addition to impacts to tourist attractions and the built environment, sea level rise might cause potential problems for drainage, as outfalls could become submerged. And as mentioned above, the rise in sea level will also likely increase the inland extent of inundation of other coastal hazards, such as storm surge, swell-induced inundation, or even tsunami inundation.

Below are more details on the impacts of storms on existing critical infrastructure, in 2100.

### 6.2.1 St. Thomas

The most exposed critical facilities in St Thomas are located on the coast, exposed to the impacts of sea-level rise and coastal flooding during storms (Figure 6.16). The most impacted facilities are the ports, seaports, but wastewater treatment facilities in Charlotte Amalie, Bovoni and Red Hook areas are also vulnerable. Other government buildings, most of them in Charlotte Amalie are also vulnerable to the impacts of sea-level rise, storm surge and riverine flooding. The most exposed buildings are the Justice Center, the Frenchtown Post-Office, the Tourist Office, the Visitor's Bureau, the Fire Department Headquarters, or the Justice Department. Also, the Millin Homes public housing complex is particularly vulnerable, mostly because it is subject to riverine flooding, but also because amplified storm surge under a sea-level rise scenario, along with numerous Place of worship (e.g., Morovian Church) and schools (e.g. Ulla Muller, Wesleyan Academy). Most of these facilities are impacted by storm-induced flooding, or potential enhanced flooding under sea-level rise conditions; flooding from sea-level rise only starts to occur when sea-level rises by 3', which would happen in the 2070's. Detailed results of critical facility ranking are presented in Appendix II.

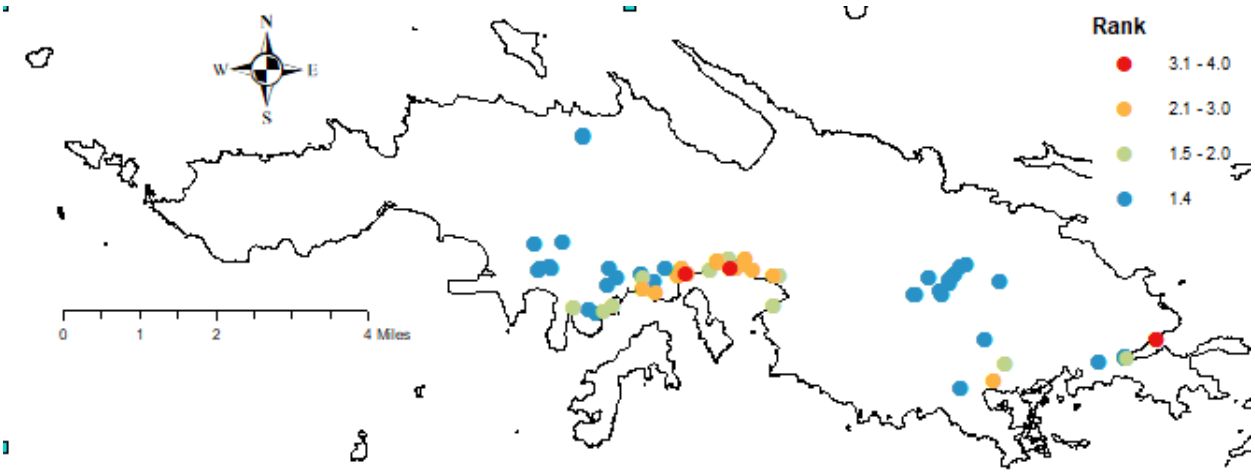



*Figure 6.16: Ranked critical facilities in St Thomas*

Figure 6.17 and Figure 6.18 show the vulnerability of critical infrastructure within the 100 year and 500 year flood inundation zone for the projected year 2100. It is clear that there are several facilities within the county's capital that are vulnerable to the flood hazard. This becomes a critical factor as the ability of these facilities to function during this hazard becomes challenged as emergency functions needed in the response phase of a disaster can either be totally unavailable, unreliable or delayed. This has implications for saving lives and properties.


*Figure 6.17: Flood Depth Analysis of 100-year 72-hour storm event for year 2100. The aerial shows the topography and computed depth of water (Appendix A13.MAP_STT_2100_0100_HD.pdf provides a higher resolution map)*


*Figure 6.18: Flood Depth Analysis of 500-year 72-hour storm event for year 2100. The aerial shows the topography and computed depth of water and areas of concern where flood depth greater than 2 ft is observed (Appendix A14.MAP_STT_2065_0500_HD.pdf provides a higher resolution map).*

Table 6.2 presents the list of critical infrastructure that are inundated in all the scenarios and the flood depths for the 100 year and 500 year period. Emergency services such as the fire station, the police station, the country's main hospital, several key government offices, schools which act as shelters, utilities such as one of the electricity substations and several wastewater treatment plants have been identified.

*Table 6.2: St. Thomas' Critical Facilities Inundated under the 100yr and 500 Year Flood Return Period*

| Description | Type | 100 Y* | 500 Y* |
|---|---|---|---|
| Home Port Dock | Airport And Seaport | 6.00 | 6.00 |
| The Edward Wilmoth Blyden Iv Marine Terminal | Airport And Seaport | 6.00 | 6.00 |
| The Crown Bay Cargo Port | Airport And Seaport | 5.00 | 5.00 |
| Police Station/Dpnr | Public Safety | 4.28 | 4.46 |
| Jane E. Tuitt | School | 1.94 | 2.46 |
| Gladys Abraham | School | 1.40 | 1.86 |
| Alexander A. Farelley Justice Center | Government Services | 1.28 | 1.59 |
| Michael Kirwan Terrace | Public Housing | 1.10 | 1.58 |
| Memorial Moravian Church | Place of worship | 1.32 | 1.55 |
| Bournefield Pump Station | Wastewater | 1.12 | 1.52 |
| Ulla Muller | School | 1.14 | 1.49 |
| Lucinda A. Millin Homes | Public Housing | 1.15 | 1.48 |
| Fiber Access Point (Fap) | Communication | 1.27 | 1.47 |
| Saint Thomas Reformed Church | Place of worship | 1.10 | 1.45 |
| Healthy Living Pharmacy | Public Health | 1.05 | 1.38 |
| Long Bay Pump Station | Wastewater | 0.97 | 1.29 |
| Leonard Dober | School | 0.93 | 1.28 |
| Donald Francois Sub | Energy | 0.95 | 1.26 |
| Paul M. Pearson Garden | Public Housing | 0.89 | 1.23 |
| The Medicine Shoppe Pharmacy | Public Health | 0.78 | 0.99 |
| Lockhart | School | 0.76 | 0.99 |
| Cancryn Pump Station | Wastewater | 0.72 | 0.97 |
| Christ Church Methodist Church | Place of worship | 0.67 | 0.95 |
| Cell Sites | Communication | 0.70 | 0.87 |
| Oswald E. Harris Court | Public Housing | 0.58 | 0.83 |
| Federal Building | Government Services | 0.55 | 0.81 |
| Aircraft Rescue And Firefighter Services | Public Safety | 0.58 | 0.77 |
| Territorial Virgin Island Government Visitors Bureau | Government Services | 0.48 | 0.75 |
| Subbase (Pw Yard) Pump Station | Wastewater | 0.53 | 0.73 |
| Drug Farm Pharmacy | Public Health | 0.46 | 0.68 |

| Description | Type | 100 Y* | 500 Y* |
|---|---|---|---|
| Saint Thomas Community Based Outpatient Clinic | Public Health | 0.46 | 0.68 |
| Virgin Islands Tourist Office | Government Services | 0.41 | 0.66 |
| Doctor's Choice Pharmacy | Public Health | 0.43 | 0.65 |
| Stt Hospital Heliport | Airport And Seaport | 0.33 | 0.64 |
| Fire Department Headquarters | Public Safety | 0.46 | 0.56 |
| Fiber Access Point (Fap) | Communication | 0.40 | 0.54 |
| Special Operations | Public Safety | 0.42 | 0.54 |
| Justice Department | Government Services | 0.39 | 0.54 |
| All Saints | School | 0.20 | 0.53 |
| Fiber Access Point (Fap) | Communication | 0.16 | 0.49 |
| Emancipation Gardens Post Office | Government Services | 0.37 | 0.45 |
| H.H. Bergs Homes/ Bergs Additi | Public Housing | 0.34 | 0.44 |
| Morovian Town Church (Historical) | Place of worship | 0.28 | 0.42 |
| Roy Lester Schneider Regional Medical Center | Public Health | 0.25 | 0.40 |
| Nana Gut Pump Station | Wastewater | 0.25 | 0.38 |
| Frenchtown Post Office | Government Services | 0.18 | 0.34 |
| Eoc Stt | Public Safety | 0.27 | 0.32 |
| Sugar Estate Post Office | Government Services | 0.18 | 0.31 |
| Kmart | Public Health | 0.18 | 0.28 |
| Harley Power Plant/Sub | Energy | 0.18 | 0.23 |
| Doctor's Choice Sub Base | Public Health | 0.14 | 0.23 |
| Charlotte Amalie High School | School | 0.17 | 0.23 |
| Fiber Access Point (Fap) | Communication | 0.17 | 0.23 |
| Beth Ha-Haim | Place of worship | 0.16 | 0.23 |
| Drug Farm Pharmacy | Public Health | 0.14 | 0.22 |
| St. Peter & Paul | School | 0.19 | 0.21 |
| Office Of Management And Budget | Government Services | 0.15 | 0.21 |
| Charlotte Amalie Seaplane Base | Airport And Seaport | 0.13 | 0.21 |
| Wapa Administration Office Building | Government Services | 0.15 | 0.21 |
| Tradewinds Pharmacy | Public Health | 0.14 | 0.20 |
| Vi Legislature Facility | Government Services | 0.13 | 0.19 |
| Evelyn Marcelli | School | 0.15 | 0.19 |
| The Knolls At Contant | Public Housing | 0.13 | 0.17 |
| Airport Pump Station | Wastewater | 0.12 | 0.16 |
| Addelita Cancryn | School | 0.00 | 0.16 |
| Property And Procurement | Government Services | 0.11 | 0.14 |
| Capitol Building | Government Services | 0.00 | 0.13 |
| Knud Hansen Memorial Hospital | Public Health | 0.00 | 0.13 |

| Description | Type | 100 Y* | 500 Y* |
|---|---|---|---|
| Cell Sites | Communication | 0.00 | 0.12 |
| Virgin Islands Fire Department Water Island Fire Station | Public Safety | 0.00 | 0.12 |
| Cyril E King Airport | Airport And Seaport | 0.00 | 0.11 |
| Pollyberg Gardens | Public Housing | 0.00 | 0.10 |

**Flood depths for each critical facility in the 100 year and 500 year return period in feet.*

Wastewater treatment systems that cannot function due to loss of electricity/back-up power supplies or damage to the system itself contribute to a cross-cutting environmental issue as untreated sewage can be released in coastal waters resulting in the pollution of beaches and coral reefs. This can result in algal growth on coral reef systems and a negative health factor for beach users.

### 6.2.2 St. Croix

Similar to St Thomas, the most exposed facilities are located on the coast, in populated areas of Christiansted and Fredericksted (Figure 6.19). As expected, docks and wastewater treatment facilities and equipment are at risk. But the Senate Building and other government buildings in Fredericksted and Christiansted are also at risk, as well as pharmacies and clinic. These buildings are at risk because they are susceptible to coastal flooding, riverine flooding, and tidal flooding. Most of these facilities are impacted by storm-induced flooding, or potential enhanced flooding under sea-level rise conditions; flooding from sea-level rise only starts to occur when sea-level rises by 3', which would happen in the 2070's. A listing of the ranked critical facilities vulnerable is provided in Appendix II.

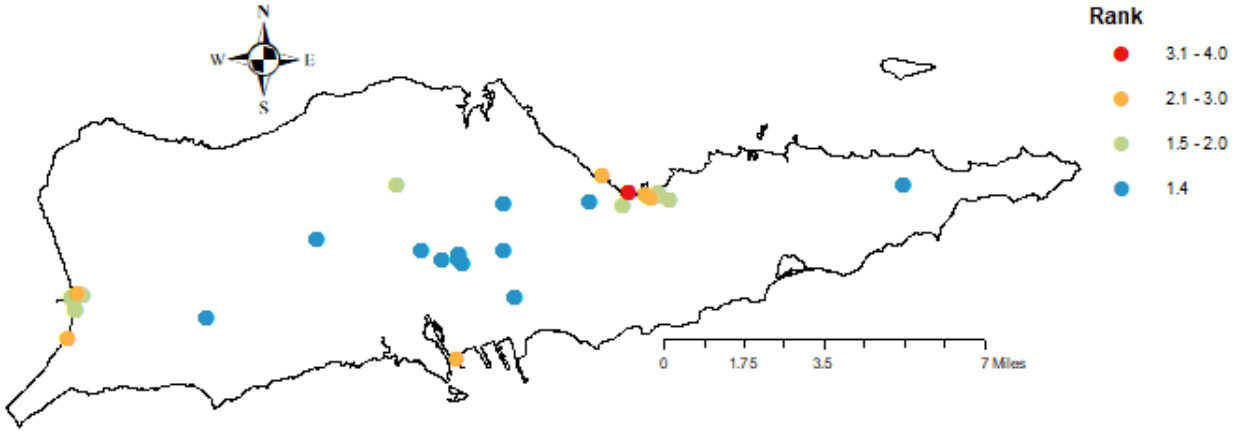



*Figure 6.19 Ranked critical facilities in St Croix*

Figure 6.20 and Figure 6.21 show the vulnerability of critical infrastructure in the 100 year and 500 year flood events for projected flood risk in 2100. Similar to St. Thomas, Fredericksted is the main town in St. Croix hosting a lot of critical infrastructure. Several facilities were located in the flood inundation zone, which impacts the abilities of these facilities to function during such conditions.

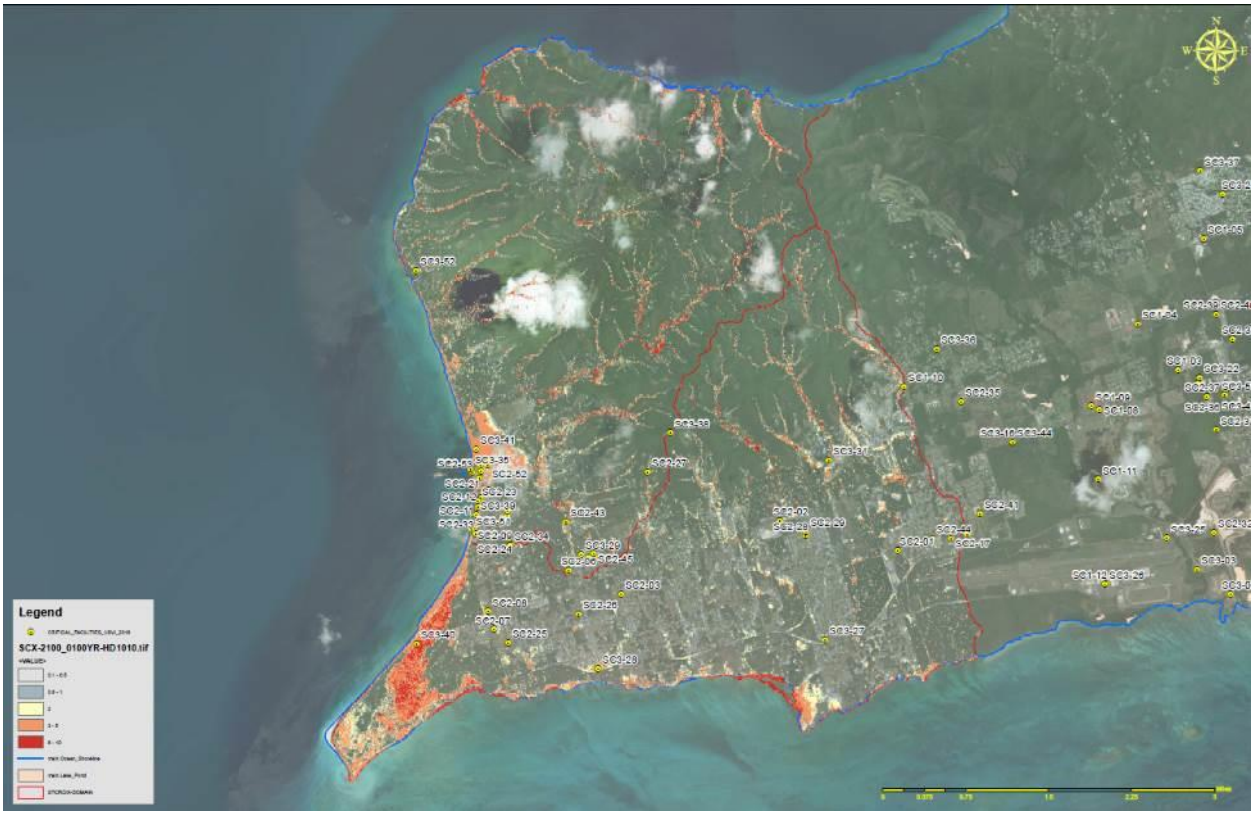



*Figure 6.20 Flood Depth Analysis of 100-year 72-hour storm event for year 2100. The aerial shows the topography and computed depth of water (Appendix A13.MAP_STT_2100_0100_HD.pdf provides a higher resolution map)*

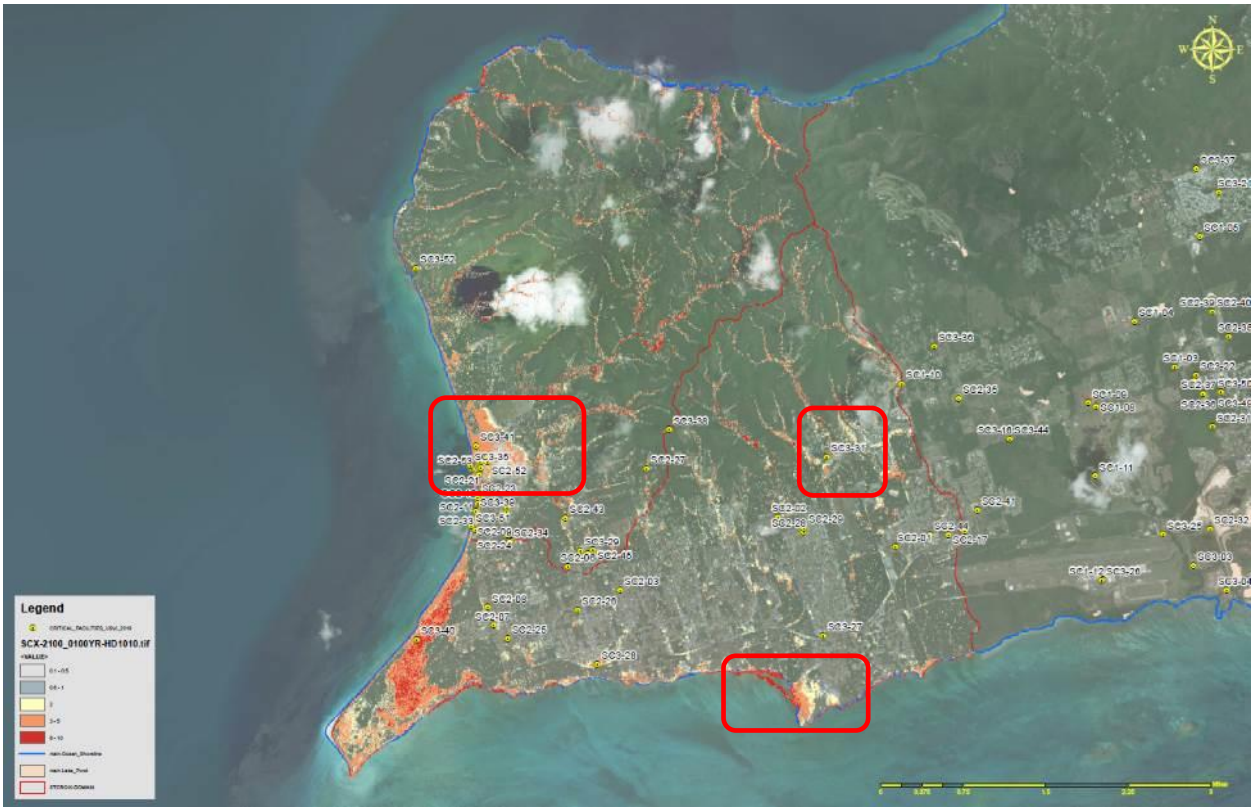



*Figure 6.21: Flood Depth Analysis of 500-year 72-hour storm event for year 2100. The aerial shows the topography and computed depth of water (Appendix A14.MAP_STT_2065_0500_HD.pdf provides a higher resolution map).*

Table 6.3 which follows shows the list of critical infrastructure that are inundated in all the scenarios and the flood depths for the 100 year and 500 year period.

*Table 6.3: St. Croix's Critical Facilities Inundated under the 100 year and 500 year Flood Return Periods*

| Description | Type | 100 Y* | 500 Y* |
|---|---|---|---|
| Cable | Communication | 4.04 | 5.07 |
| Concordia Pump Station | Wastewater | 4.08 | 4.45 |
| Fiber Access Point (Fap) | Communication | 4.07 | 4.11 |
| Senate Building | Government Services | 4.00 | 4.05 |
| Bay Road Pump Station | Wastewater | 3.71 | 3.77 |
| Campo Rico Pump Station | Wastewater | 3.33 | 3.72 |
| Ann E. Abramson Marine Facility | Airport and Seaport | 2.75 | 2.79 |
| Central Office | Communication | 2.39 | 2.54 |
| Old Frederiksted Public Library | Government Services | 2.33 | 2.44 |
| Christian's Pharmacy | Public Health | 2.29 | 2.36 |
| Cell Sites | Communication | 1.86 | 2.22 |
| Internet Service Providers (Isp) | Communication | 1.86 | 2.22 |
| Virgin Islands Energy Office | Government Services | 1.56 | 1.58 |
| Zion Church | Place of worship | 0.89 | 1.44 |

| Description | Type | 100 Y* | 500 Y* |
|---|---|---|---|
| Wilbur H. Francis - Bike Unit - Sub-Station | Public Safety | 1.29 | 1.33 |
| Marley Homes/Marley Homes Addi | Public Housing | 1.02 | 1.17 |
| Walter I.M. Hodge Pavilion | Public Housing | 0.60 | 0.87 |
| Saint Josephs Church | Place of worship | 0.44 | 0.57 |
| William's Delight Villas | Public Housing | 0.28 | 0.52 |
| Athalie Mcfarlane Petersen Public Library | Government Services | 0.48 | 0.51 |
| Whim Gardens | Public Housing | 0.22 | 0.36 |
| St. Joseph's High School | School | 0.28 | 0.34 |
| Williams Delight Pump Station | Wastewater | 0.10 | 0.30 |
| Arthur A. Richards Jr. High | School | 0.17 | 0.23 |
| Holy Trinity Lutheran Church | Place of worship | 0.12 | 0.16 |
| Claude O. Markoe School | School | 0.00 | 0.15 |
| Internet Service Providers (Isp) | Communication | 0.11 | 0.14 |
| Cell Sites | Communication | 0.11 | 0.14 |

**Flood depths for each critical facility in the 100 year and 500 year return period in feet.*

### 6.2.3 St. John

Critical infrastructure in St John are exposed to coastal flooding during storms and due to sea-level rise. As a consequence, most of the vulnerable critical infrastructure is located on the coast, in the highly populated areas of Cruz Bay and Coral Bay (Figure 6.22). The most vulnerable facilities are the docks and seaport terminals, but also the wastewater treatment facilities and pumps located in Cruz Bay and Coral Bay, the national park headquarter and the post office in Cruz Bay, and other government buildings (see Appendix II for a list of critical infrastructure impacted in St John). Most of these facilities are impacted by storm-induced flooding, or potential enhanced flooding under sea-level rise conditions; flooding from sea-level rise only starts to occur when sea-level rises by 3', which would happen in the 2070's.

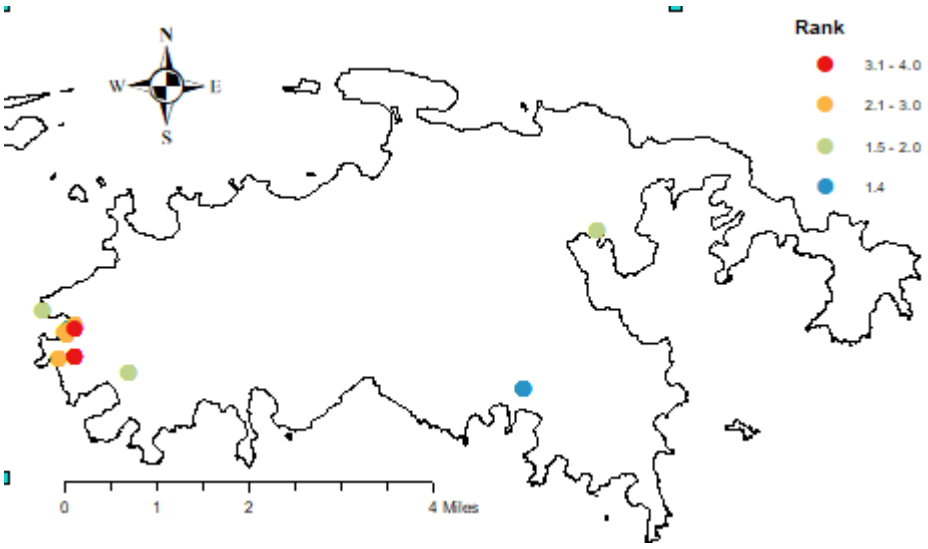


*Figure 6.22: Ranked critical facilities in St John*

- **Increased intensity of rainfall**
    - Extreme flooding can lead to loss of communication including radar and radio equipment
    - Capacity overload of the drainage infrastructure system may lead to flooding and consequently erosion of roads, foundation and cause pollution
    - Disruption of the road network and access to the port
- **Heatwaves impacts**
    - Higher risk of structure failures
    - Higher rates of deterioration of infrastructure
    - Energy consumption impacts
- **Increased intensity of storms**
    - Inaccessibility of models of transport affecting supply and distribution
    - Disruption of port operations and logistics
- **Increased intensity of storm surge**
    - Increased wave action at waterfront structures
    - Beach erosion
- **High speed winds**
    - Damage to navigation and communication equipment
    - Increased delays in processing vessels
    - Damage to infrastructure, including roads and buildings

Addressing port potential issues requires building adaptive capacity to address future climate change involves developing the organizational ability to respond effectively to climate change challenges. This includes data collection and monitoring and research, skill development and awareness raising. Implementation of adaptation actions includes

- **Technological** – requires investment in technology to expand and extend the ability of equipment to operate under extreme climate conditions. Reducing power demands and automation of logistics can provide better capacity for Climate Change challenges
- **Engineering change** – Future procurement of assets which would be more resilient to increased wind loads, heat waves, stormwater system improvements, increased hydrologic monitoring and reporting, incremental elevation of seawalls, roadway improvements.
- **Design and maintenance** – Introducing elements of redundancy, include Climate Change is included in design specifications
- **Planning** – Planning requires broad collaboration and partnership with other agencies.

**Coastal Storm Damage Reduction**

Sea-level rise will increase the exposure of coastal infrastructure to storm surge and high speed winds. Reducing storm damage requires analysis of:

- How vulnerable is existing infrastructure to SLR?
- What are the critical thresholds of coastal evolution past which infrastructure is unacceptably impacted?
- What are thresholds and tipping points for human response to SLR?
- How will SLR affect the loading or behavior of the engineered shore protection measures?
- If the infrastructure fails, what might be the impacts on the protected area?

For critical project areas the exposure and vulnerability to SLR will be analyzed using the simulation events and will include:

- How will SLR affect other coastal forces, such as storm surges or storm waves?
- Will changes to the local mean sea level change the frequency or severity of flooding?
- What are the dominant forces and are they impacted by SLR?
- What are the expected human responses?
- How might riverine, estuarine, or barrier island processes change?

**Flood Damage Reduction**

Some of the key questions related to Flood Damage Reduction (FDR) include:

- Changes in hydrologic boundary conditions governing the performance and operation of FDR infrastructure
- Measures which are recommended at an FDR project to adapt to SLR impact coastal storm damage reduction, ecosystem restoration, navigation, or other projects nearby
- The temporal scale or magnitude of change of rainfall runoff or fluvial geomorphological processes which will begin to impact basic FDR design considerations
- Regional differences which exist on the three islands and the potential of addressing using the same methods.

## 6.3 Tourism

The tourism sector is a major income earner for the USVI. Flood vulnerability maps (Figure 6.23 to Figure 6.26) as developed from the hazard modelling results illustrates the various tourism facilities impacted within the inundation zone for both the 100 year and 500 year return period as projected for 2100. Table 6.4 presents the list of facilities recorded for St. Thomas and St. Croix identified in the inundated zone.

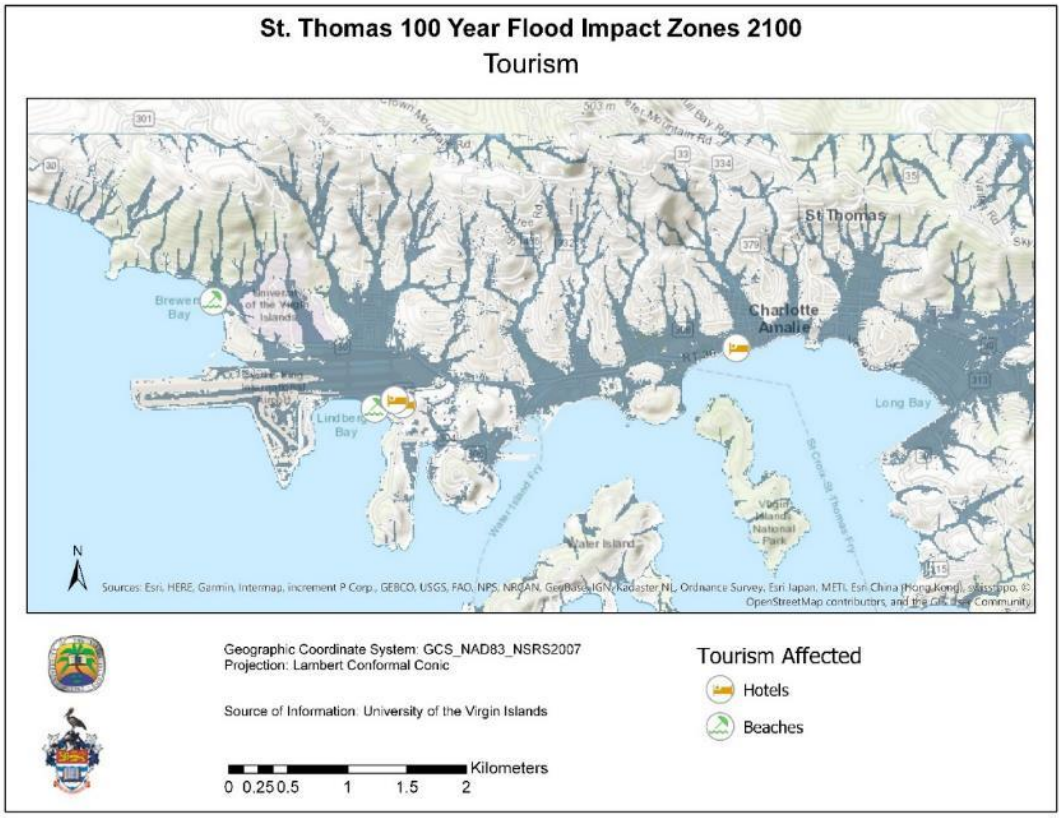



*Figure 6.23: St. Thomas 100 Year Flood Impact Zones 2100 – Tourism Sector*

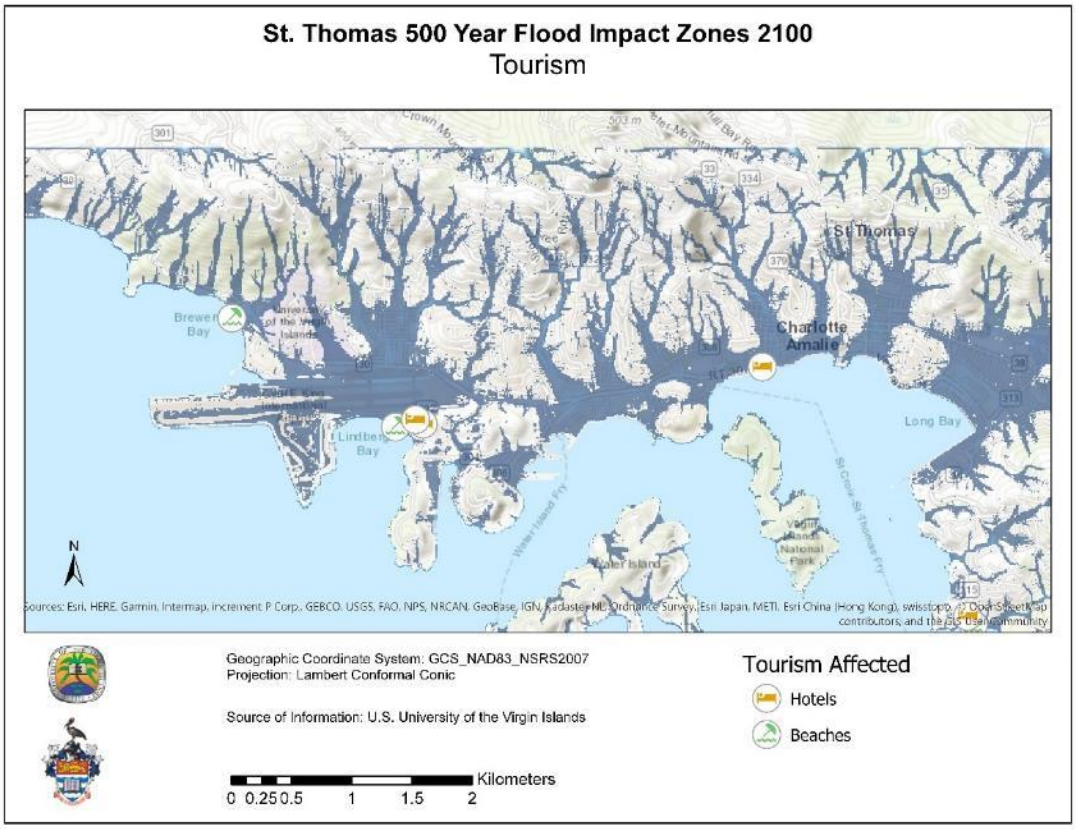



*Figure 6.24: St. Thomas 500 Year Flood Impact Zone 2100 - Tourism*

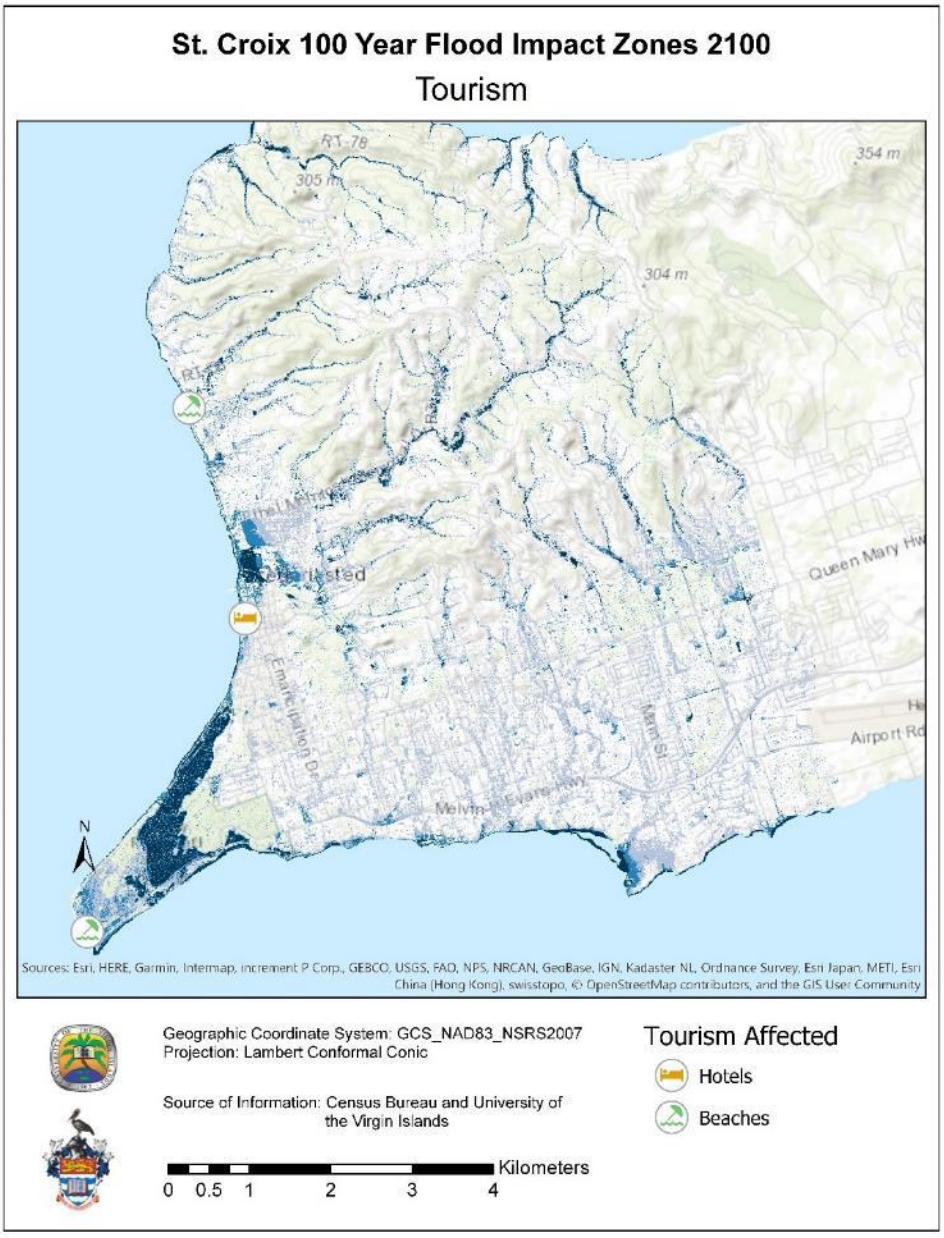



*Figure 6.25: St. Croix 100 Year Flood Impact Zone 2100 – Tourism*

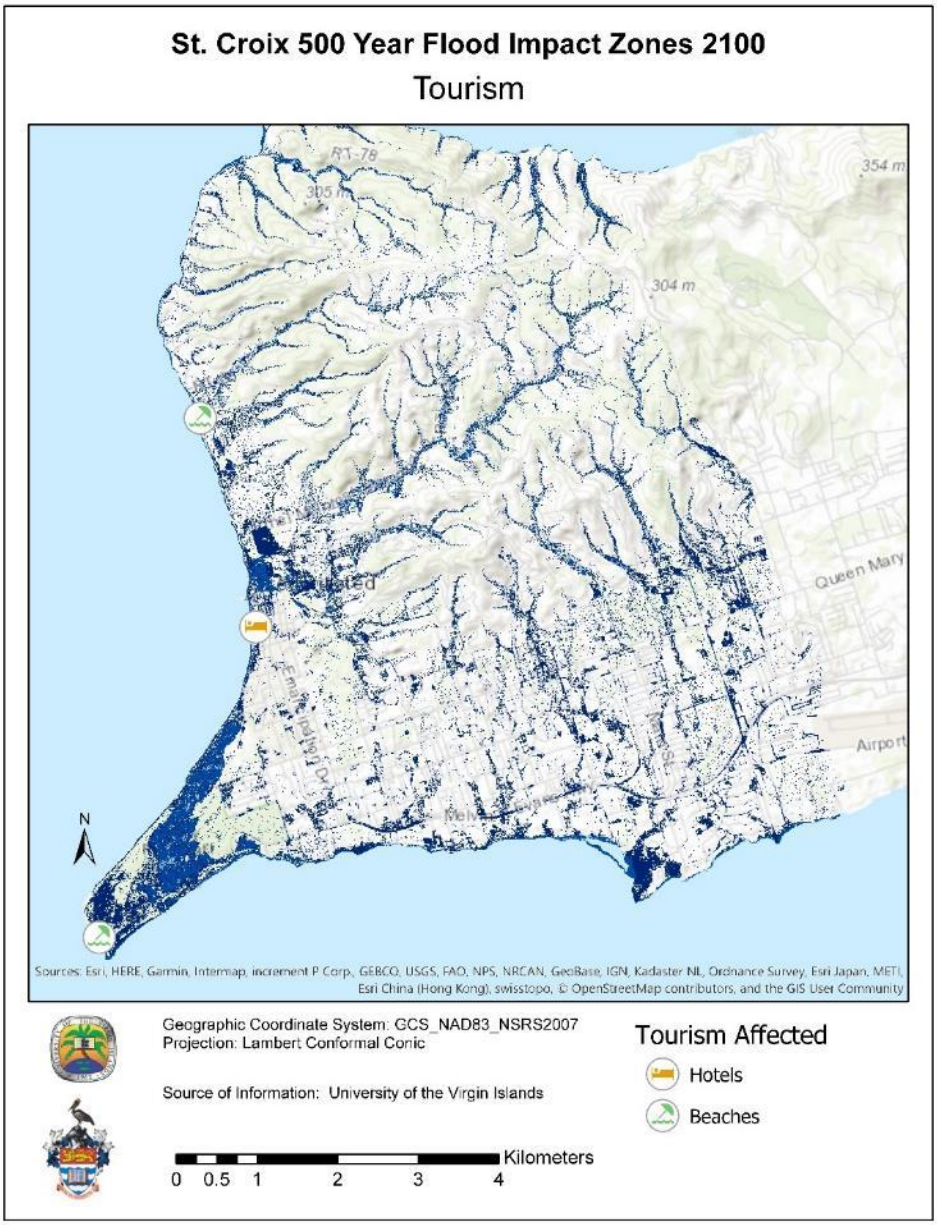



*Figure 6.26: St. Croix 500 Year Flood Impact Zone 2100 – Tourism*

*Table 6.4: Tourism Facilities Inundated under the 100 and 500 Year Flood Impact Zone - 2100*

| Name | Class | Island |
|---|---|---|
| **Tourism Facilities Inundated under the 100 Year Flood Impact Zone - 2100** | | |
| Emerald Beach Resort | Resorts and Hotels | St. Thomas |
| Windward Passage | Resorts and Hotels | St. Thomas |
| The Island Beachcomber Hotel | Resorts and Hotels | St. Thomas |
| Brewers Bay Beach | Beaches | St. Thomas |

| Name | Class | Island |
|---|---|---|
| Lindberg Beach | Beaches | St. Thomas |
| Rainbow Beach | Beach | St. Croix |
| Sandy Point Beach | Beach | St. Croix |
| The Frederiksted Hotel | Resorts and Hotels | St. Croix |
| **Tourism Facilities Inundated under the 500 Year Flood Impact Zone - 2100** | | |
| Emerald Beach Resort | Resorts and Hotels | St. Thomas |
| Windward Passage | Resorts and Hotels | St. Thomas |
| The Island Beachcomber Hotel | Resorts and Hotels | St. Thomas |
| Frenchman's Reef & Morning Star | Resorts and Hotels | St. Thomas |
| Morningstar Bch | Beaches | St. Thomas |
| Brewers Bay Beach | Beaches | St. Thomas |
| Lindberg Beach | Beaches | St. Thomas |
| Rainbow Beach | Beach | St. Croix |
| Sandy Point Beach | Beach | St. Croix |
| The Frederiksted | Hotel Resorts & Hotels | St. Croix |

There are several implications arising from the fact that several tourism facilities are vulnerable to flooding. The first is the reduction of visitor arrivals which in turn reduces revenue, which negatively impacts the economy.

In addition, with respect to the observed increase in frequency and duration of hurricanes since 1995, climate change projections indicate stronger more intense storms with increasing wind speeds over time. This change in storm intensity is expected to be one of the primary manifestations of climate change impacts on the USVI. No significant change or perhaps even slight decreases are anticipated for hurricane frequency but there is an expected increase in frequency of major hurricanes, i.e. Category 4 & 5.

USVI is on a very vulnerable path with respect to hurricane tracks. Powerful storms such as the recent (2017) Irma and Maria have exposed vulnerabilities of the territory to winds, storm surge and rainfall induced flooding. These storms caused widespread damage unlike that experienced previously. Both events wreaked havoc on people, natural resources and all aspects of societal operations. There is a heavy recovery burden from the 2017 hurricane season exacerbated by storms occurring within two weeks of each other.

This has posed a negative impact on tourism due to interruptions to travel, damage to tourism infrastructure and natural resources, and potential interruptions to delivery of food, water, and medicines, which are integral to business operations. There is also a negative impact on visitor experience as well as the potential to attract new visitors or keep existing ones.

The concentration of some important tourism infrastructure in low lying coastal areas and some located in floodplain has increased the vulnerability of the sector. This factor has increased the likelihood of flooding impacts from storms and sea level rise. Table 6.4 shows examples of beaches and hotels at high risk.

Flooding impacts are already being observed and was demonstrated in Irma and Maria hurricane experiences. As storms are likely to intensify in the future, increased damage to important infrastructure and popular tourist areas in at risk areas can be anticipated. Development occurring at higher elevations are less vulnerable to sea level rise but may be exposed to damage and loss from high winds.

Several residential developments are also concentrated in low lying areas. Significant flood events will therefore not just impact infrastructure but also residents/workers who serve in the tourism sector.

The vulnerability of critical infrastructure such as ports and roadways also has negative implications for the tourism sector. Flooding of coastal areas impacts key transportation assets. The projection for more intense storms, more rainfall within storms and accelerated sea level rise can result in increased storm surge and flooding of low-lying coastal areas. The model results as illustrated in Figure 6.23 to Figure 6.26 do not show widespread flooding everywhere but reveal that certain areas as well as important transportation infrastructure such as the Cyril E. King International Airport are at high risk from significant flooding events.

Intense storms, such as the recent Irma and Maria, highlighted the sensitivity of certain areas to flooding, caused airport closure which negatively impacted national and community operations and reduced transportation options for residents and tourists.

**Increases in temperatures** over time as projected by climate change modelling will also impact the tourism sector in a negative manner. Key impacts include:

- **Heat wave** can cause heat stress and increase the need for cooling.
- **Vector-borne diseases** causes a public health threat – Associated shifts in temperature and rainfall patterns affect vector life cycles and range of occurrence, increasing the threat of mosquito-borne diseases such as the dengue, malaria, chikungunya (Chik-V), and Zika Virus. The Caribbean Region and the USVI have already experienced impact from Chik-V and Zika outbreaks in recent years. This lead to a reduction in visitors due to fear of getting the disease. Impacts were felt in the wedding industry in particular, given warnings issued to women of child-bearing age. More problems with outbreaks and management of vector-borne diseases on the ground and in tourism public relations and marketing are likely to continue based on climate projections.
- **Sargassum** in the coastal area – Increase in distribution of species such as Sargassum seaweed in the coastal zone. This increase is believed by scientists to result from increasing ocean temperature coupled with increased nutrient levels. Proliferation in the Sargasso Sea and movement has led to increases in the amount of sargassum reaching coastal areas in the USVI and washing up on beaches (AccuWeather, 2018). This has forced the closure of several coastal areas due to dense mats interrupting tourism activities and remaining for extended periods of time. This problem deters tourists from visiting. Further, the decomposing algae has an unpleasant smell and is labor intensive and costly to clean-up. Available resources are limited for clean-up. This problem is expected to recur as ocean temperatures rise.

**Ocean acidification**

Ocean acidification is also a negative effect of climate change that impacts the tourism sector. The increase in greenhouse gases (e.g. carbon dioxide) emissions globally is projected to exacerbate ocean acidification. This coupled with sea level rise which contributes to erosion and loss of coastal habitat has negative implications for the coastal and marine ecosystem. Ocean acidification and coral bleaching events are already being observed in USVI, as well as loss of coastal ecosystems such as mangroves and wetlands. Water pollution and overfishing, which are also occurring, while not direct climate change impacts, further stress coastal resources being impacted by climate change, thereby making them less resilient.

Since tourism is heavily depended on the natural ecosystems as its main assets, reduced resilience of coastal resources and ecosystems due to combined stresses may produce a negative feedback on the USVI's tourism product.

## 6.4 Agriculture

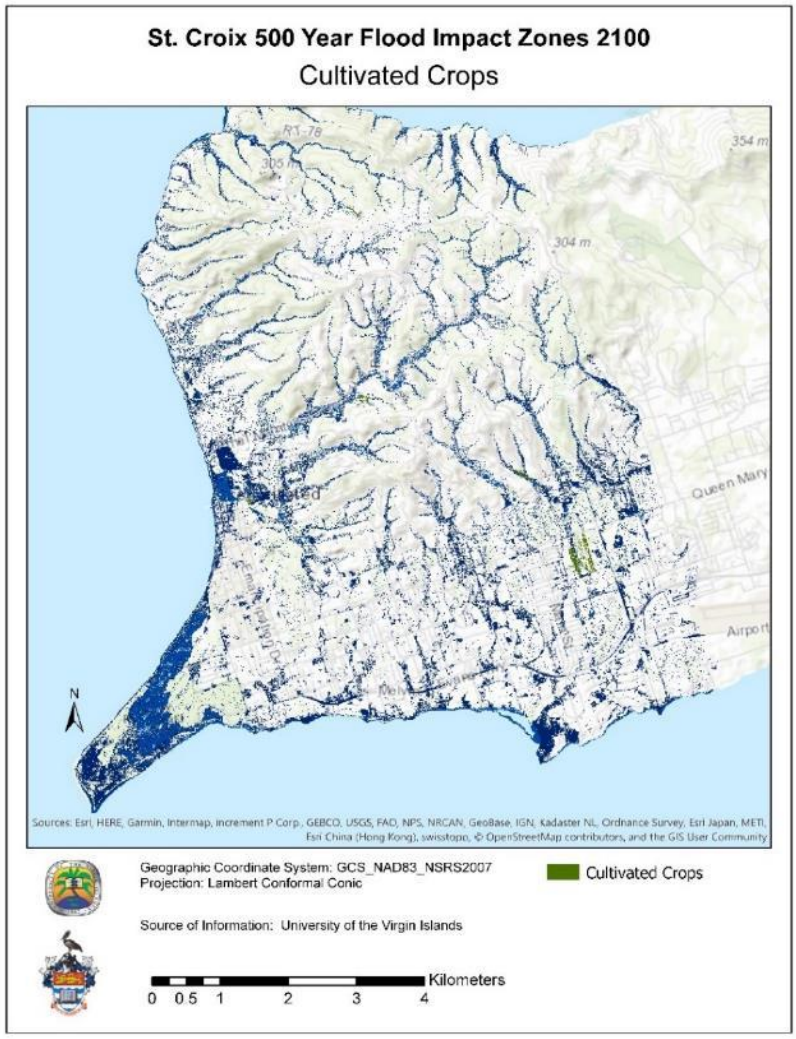
Agricultural areas on St. Thomas are located in the north and west of the island and are therefore not included in the Charlotte Amalie hazard modelling exercise. However, the following climatic factors are of concern to the sector:

- Increase in mean annual temperatures 0.80º to 2.89ºC
- Decease in precipitation for the western end of St. Croix. Projected decrease in precipitation by mid-century in St. Croix.
- Drying trend will be in both the wet and dry season (all year round)
- 80% increase in the frequency of category 4 and 5 hurricanes over the next 80 years.
- Shift in stronger storms by end of century
- 20 to >30% increase in rainfall rates for model hurricane's inner core.

These trends coupled with poor farming practices will be detrimental to the future of the agriculture sector. Already, there are few farmers located on the island of St. Thomas, the level of vulnerability may even result in fewer farmers persisting within the sector.

Figure 6.27 below illustrates the 500 year flood inundation zone for St. Croix's agricultural areas located in the hazard modeling study area. The hazard modeling result for the 100 year return period is similar and as such only one map is presented below. The general flat nature of St. Croix shows that both crop farms and agricultural farms are impacted by flooding during storm events. With the prediction that more rainfall in high intensity storms can be expected flood attenuation measures need to be implemented. Storm events also come with high wind damage which can result in loss of both crops and livestock.

With respect to droughts and increasing temperatures, water supply becomes a major issue for most farmers as they are not supplied by the public body WAPA and only few persons have access to well-water. Over the years there have been devastating losses in revenue from extended drought conditions. The climate change projections show continued warming and reduction of rainfall during both the wet and dry seasons, this drying trend is particularly marked for the western parts of St. Croix. This means that if the government and farmers are serious about maintaining a sustainable agricultural industry appropriate adaptation measures need to be designed and implemented to support a sustainable supply of water, and water conserving farming practices such as mulching would need to be the new norm.




sd

*Figure 6.27: St. Croix 500 Year Flood Impact Zone 2100 – Agriculture*

One of the main barriers to the success of the agricultural sector as reported by both government and community stakeholders is the mindset of farmers in the USVI. As much as it is a declining sector that persons are moving away from, the majority that remain do not treat it as a business and are resistant to employing best practices despite training sessions offered by both the Department of Agriculture and the UVI. This human factor hinders the sector from adapting to climate change making it vulnerable to all the impacts of climate change.

With the onset of climate change there are also crosscutting environmental issues which can arise as a result. In particular, poor agricultural practices on hillside farms in St. Thomas coupled with drought conditions can result in significant siltation and debris flow to coastal waters when the rainy season starts. This can negatively impact coral reefs smothering them and preventing the appropriate light penetration for them to survive. This can further impact the fishing industry as spawning is hindered. Another issue is that fertilizer and pesticides that are washed down become a major pollutant to coastal areas resulting in algal growth on reef systems.

In addition to vulnerability from climate change, the sector is also vulnerable to competition from food imports. With the country importing over 90% of the food consumed in the territory, this not only poses a significant threat to the economic livelihoods of local farmers, but also renders the country vulnerable to global food price shocks that could have an adverse negative impact on national food security.

## 6.5 Summary Vulnerability

*Table 6.5: Summary Vulnerability Analysis*

| Current Stresses | Projected Stresses from Climate Change | Projected Impact of Changes to the Systems *(without adaptation measures)* | VULNERABILITY ASSESSMENT | | |
|---|---|---|---|---|---|
| | | | **Degree of sensitivity** | **Adaptive Capacity** | **Vulnerability of systems** |
| **SOCIOECONOMIC** | | | | | |
| Increase in temperatures 0.18ºC per decade | Increase in mean annual temperatures 0.80º to 2.89ºC | Increased need for cooling can put pressure on energy demands.<br><br>Heat stress especially for the vulnerable population (e.g. those aged). | Moderate | Moderate | Moderate |
| Low annual rainfall with high inter-annual variability | Drying trend will be in both the wet and dry season (all year round) | Greater pressure on WAPA to supply potable water. This may increase the need for more desalination plants or more storage. | Moderate | Moderate | Moderate |
| Annual exposure to hurricanes and tropical storms | 80% increase in the frequency of category 4 and 5 hurricanes over the next 80 years.<br>Shift in stronger storms by end of century<br>20 to >30% increase in rainfall rates for model hurricane's inner core. | Residential and commercial areas may be prone to flooding and wind damage. Especially those located near drainage pathways and in low-lying coastal areas.<br><br>This would result in significant damage to property and life.<br><br>Repeated losses negatively impact livelihood and the amount of resources available to persons and can lead to poverty for vulnerable groups (e.g. those with disability or the aged).<br><br>Risk of flood related illnesses such as water-borne diseases, and proliferation of vectors such as mosquitoes. | High | Low to Moderate | High |

| Current Stresses | Projected Stresses from Climate Change | Projected Impact of Changes to the Systems *(without adaptation measures)* | VULNERABILITY ASSESSMENT | | |
|---|---|---|---|---|---|
| | | | **Degree of sensitivity** | **Adaptive Capacity** | **Vulnerability of systems** |
| | | Productivity within the local population may be affected. | | | |
| **AGRICULTURE** | | | | | |
| Increase in temperatures 0.18°C per decade | Increase in mean annual temperatures 0.80° to 2.89°C | Increase in evapotranspiration thus increasing the demand for water.<br>Increased evaporation combined with drier conditions and poor farming practices will result in reduced yield. | High | Low | High |
| Heavy dependence on rainwater<br>Few persons have access to well water or other sources<br>No supply of water from WAPA<br>Poor livestock farming techniques | Decease in precipitation for the western end of St. Croix. Projected decrease in precipitation by mid-century in St. Croix.<br>Drying trend will be in both the wet and dry season (all year round) | More frequent drought events will result in reduced crop yield.<br><br>Reduction in available freshwater supply for crops and livestock.<br>Dependence on rainfed agriculture is unsustainable in the long term.<br><br>Inadequate water supply to support livestock farming. This issue with poor livestock farming practices such as the lack of culling, overstocking and overgrazing when necessary will result in death of animals and loss of revenue.<br><br>Invasive pests such as mites and aphids-lace bugs that result during extended droughts.<br><br>Loss of crops and livestock. | High | Low | High |
| Damage from heavy rainfall/storm events<br>Poor farming practices<br><br>Flooding and damage | 80% increase in the frequency of category 4 and 5 hurricanes over the next 80 years.<br>Shift in stronger storms by end of century | Loss of crops, reduction in crop yield, loss of livestock.<br>Landslide and soil erosion due to heavy rains may lead result in moderate damage to crops due to debris flow and a loss of fertile top | High | Low | High |

| Current Stresses | Projected Stresses from Climate Change | Projected Impact of Changes to the Systems *(without adaptation measures)* | VULNERABILITY ASSESSMENT | | |
|---|---|---|---|---|---|
| | | | **Degree of sensitivity** | **Adaptive Capacity** | **Vulnerability of systems** |
| to farms such as in St. Croix due to high rainfall | 20 to >30% increase in rainfall rates for model hurricane's inner core. | soil.<br>Clearing of hillside vegetation for farming especially on slopes can lead to increased surface runoff and lower the groundwater recharge capacity of the area.<br>Flooding of low lying areas in St. Croix due to high intensity rainfall events.<br>Invasive pests such as Lepidoptera (worms) that result during extended rainy.<br>Damage to infrastructure such as offices and irrigation systems. | | | |
| **TOURISM** | | | | | |
| Increase in temperatures 0.18ºC per decade | Increase in mean annual temperatures 0.80º to 2.89ºC<br><br>Sea surface temperatures also expected to continue increasing over the century. | Increased need for cooling can put pressure on energy demands.<br><br>Enhanced stress on people, water resources, cooling systems and energy resources. Warmer summers, warmer winters – less comfortable.<br><br>Reduction in cruise tourists interacting on island due to high temperatures.<br><br>Warmer temperatures also cause negative impacts on ecological resources such as corals which are sensitive to temperature shifts<br><br>As temperatures continue to increase, it is likely that continued problem with sargassum lining the beaches of the coastline. | High | Moderate | Moderate |

| Current Stresses | Projected Stresses from Climate Change | Projected Impact of Changes to the Systems *(without adaptation measures)* | VULNERABILITY ASSESSMENT | | |
|---|---|---|---|---|---|
| | | | **Degree of sensitivity** | **Adaptive Capacity** | **Vulnerability of systems** |
| | | Increases in the frequency of warm days and warm nights can lead to heat waves which stress residents, visitors and workers (especially those working outdoors) alike. | | | |
| Coastal erosion in some areas of the coastline (e.g. Bolongo Bay) | Increase in USVI sea levels up to 1m by the end of the century. | This can result in coastal erosion in some coastal areas and thus loss of beaches. Charlotte Amalie in St. Thomas, Frederiksted in St. Croix, Cruz Bay in St. John have low lying areas which will likely experience flooding from rising sea levels.<br><br>Rise in sea level between 1.86 +/- 0.5mm and 2.07 +/- 0.69 mm/yr contributes to erosion of natural coastal assets. Increasing storm surge impacts.<br><br>Increasing negative impact on tourism due to erosion of the coastal resources which form the foundation of the industry. Could also impact cultural and historical resources. | High | Moderate | High |
| Overall trend of increase in rainfall observed seen from 1977-2015, now shifting to more of a downward trend in rainfall. | Drying trend will be in both the wet and dry season (all year round)<br><br>Drought conditions anticipated to increase over time (going from 3% less in mean by 2020 and up to 25% less by end of century). Drying expected to be evident in both wet | Observed and anticipated changes in rainfall patterns could have a cascade effect and ultimately impact planning for tourism activities, visitorship, the visitor experience and marketing efforts.<br><br>Increased pressure on water resources and water supply likely. If water supply stresses emerge they will negatively impact tourism since it is a | Moderate | Moderate | Moderate |

| Current Stresses | Projected Stresses from Climate Change | Projected Impact of Changes to the Systems *(without adaptation measures)* | VULNERABILITY ASSESSMENT | | |
|---|---|---|---|---|---|
| | | | **Degree of sensitivity** | **Adaptive Capacity** | **Vulnerability of systems** |
| | and dry seasons. | heavy water use industry.<br><br>Water supply could become problematic in future as drought conditions heighten. Can partially be managed with better public education and enhanced industry practices to support and practice water conservation. Situation could worsen if number of visitors to region increases. | | | |
| Extreme weather and Flooding from tropical cyclone events | 80% increase in the frequency of category 4 and 5 hurricanes over the next 80 years.<br><br>20 to >30% increase in rainfall rates for model hurricane's inner core.<br>Shift in stronger storms by end of century. | Damage to coastal tourism facilities such as hotels, restaurants, beaches, shops, craft market due to inland and coastal flooding associated with high intensity rainfall events.<br><br>Coral bleaching due to high intensity hurricane events would negatively impact diving as a tourism attraction. This may result in the slow recovery of reef systems due to frequency of impact. Can negatively impact fish breeding as well.<br><br>Reduction in visitor arrivals due to recurring damages from storm events. | High | Moderate | High |
| Outbreak of vector borne diseases (Zika Virus) | More periods of short duration intense rainfall, which can cause ponding<br>Increase in mean annual temperatures $0.80^{o}$ to $2.89^{o}C$ | The mosquitoes which carry viruses breed in water that settles around homes, schools, churches, workplaces and playgrounds.<br><br>Nearby wetlands are grounds for mosquito breeding.<br><br>Temperature increase may also | Moderate | Moderate | Moderate |

| Current Stresses | Projected Stresses from Climate Change | Projected Impact of Changes to the Systems *(without adaptation measures)* | VULNERABILITY ASSESSMENT | | |
|---|---|---|---|---|---|
| | | | **Degree of sensitivity** | **Adaptive Capacity** | **Vulnerability of systems** |
| | | exacerbate the incidence of vector borne diseases such as, chikungunya.<br>Reduction in visitor arrivals especially for wedding market.<br>Flash floods may also lead to loss of life. | | | |
| Mounting negative stresses on coastal resources important to tourism | Increase in greenhouse gas (carbon dioxide) emissions globally is projected to exacerbate ocean acidification. Sea level rise contributes to erosion and loss of coastal habitat. | Ocean acidification and coral bleaching events already being observed in USVI, as well as loss of coastal ecosystems such as mangroves and wetlands. Water pollution and overfishing also occurring. While not direct climate change impacts further stress coastal resources being impacted by climate change thereby making them less resilient.<br><br>Reduced resilience of coastal resources and ecosystems due to combined stresses. Negative shifts in ecosystem health and function. Because the tourism sector is integrally linked to natural resources, any impact will produce a negative feedback on the USVI's tourism product. | Moderate | Moderate | Moderate |
| Poor watershed management (e.g. absence of a land management plan, lack of zoning, as well as overdevelopment near beaches). | Anticipated climate change impacts such as erosion, loss of habitat, and more intense storms will be exacerbated where there is poor watershed management. | Links between land use decisions, water quality and development in vulnerable areas already evident.<br><br>Haphazard/poorly planned development decreases beauty and allure of the region and threatens health of natural resources. Difficult to stem negative spin-off effects of poor watershed management- both | High | Moderate | Moderate |

| Current Stresses | Projected Stresses from Climate Change | Projected Impact of Changes to the Systems *(without adaptation measures)* | VULNERABILITY ASSESSMENT | | |
|---|---|---|---|---|---|
| | | | **Degree of sensitivity** | **Adaptive Capacity** | **Vulnerability of systems** |
| | | environmental and economic implications.<br><br>Segments of the population and important infrastructure are at increasing risk. Watershed management or lack thereof all links back to what is seen on the coastline in terms of environmental. E.g. not having sufficient room for wetlands to migrate inland to keep up with sea level rise will result in greater negative impacts on these crucially important coastal ecosystems. | | | |
| **CRITICAL INFRASTRUCTURE** | | | | | |
| Damage to road network due to coastal and inland flooding | 80% increase in the frequency of category 4 and 5 hurricanes over the next 80 years.<br><br>20 to >30% increase in rainfall rates for model hurricane's inner core. | Blocked and flooded roads hinder the movement of vehicular traffic and pedestrians.<br><br>More intense rainfall events likely. Likelihood of more intense storms coupled with accelerated sea level rise can result in increased storm surge and flooding of low-lying coastal areas. Climate models looking at chance of 100 and 500yr flood events (2017, 2035, 2065 and 2100) do not show widespread flooding everywhere. However, they do reveal that certain areas as well as important transportation infrastructure (airport) are at high risk from significant flooding events. | Moderate | Moderate | Moderate |
| Damage to utility infrastructure | 80% increase in the frequency of category 4 and 5 hurricanes over the | Downed electricity communication poles due to high winds from storms. | Moderate | Moderate | Moderate |

| Current Stresses | Projected Stresses from Climate Change | Projected Impact of Changes to the Systems *(without adaptation measures)* | VULNERABILITY ASSESSMENT | | |
|---|---|---|---|---|---|
| | | | **Degree of sensitivity** | **Adaptive Capacity** | **Vulnerability of systems** |
| | next 80 years.<br>Shift in stronger storms by end of century. | Loss of solar panels located on slopes from high winds. | | | |
| Sea levels rise impacting coastal infrastructure | Increase in USVI sea levels up to 1m by the end of the century. | Storm water outlets are below Mean-Sea Level, and seawater intrusion in the drainage infrastructure, especially during the highest tides, prevents proper drainage and creates backflow and flooding issues upland. | Moderate | Low | Moderate |

# 7 Recommended Planning Areas

Sections 7.1 to 7.5 below propose several preliminary recommendations as next steps. These will be incorporated and expanded on in the Adaption Plan, which will be drafted with stakeholder input for this project.

## 7.1 Socioeconomic

Public awareness program about climate change should be developed nationally and executed to raise awareness on the issues affecting the country, highlighting what individuals, communities, government and business enterprise can do to adapt. Awareness should include education of the private sector including owners of significant real estate persons and high-level decision makers such as Senators so that there is political understanding and buy-in with respect to the issues with which the Territory has to contend. This should help to undergird the process of change among all key stakeholders toward building climate resilience within the USVI.

Employment of more enforcement officer within the DPNR to ensure residential and commercial developments are following guidelines.

DPNR through partnerships should undertake a tree reforestation program for those degraded hillsides and other key areas.

Current planning should consider potential climate change impacts in future development so that initiatives such as the subsidizing housing in the coastal zone/100-yr flood plain are avoided.

## 7.2 Policy and Legal

Further to the policy and legislative review, the following are proposed to improve the policy and legal framework governing climate change in the USVI.

- In order to improve decision making in the development planning and development control processes, the environmental management agencies need to develop an overall data management strategy. That strategy should ensure compatibility of data collection regimes and data management systems, as well as establishment of data sharing mechanisms. The civil society institutions engaged should also be brought into the information management process.
- Changes in parameters of climate are expected to result in inundation of some coastal areas as well as negative impact on social infrastructure and some major resources (e.g. aquifers). A comprehensive monitoring program should be established to support informed resource management decision making, particularly for critical or fragile ecosystems.
- Greater public awareness of the importance and value of natural resources and of the impact of climate change.
- Adoption of the Territorial Comprehensive Plan
- Implementation of the Territorial Comprehensive Plan after it has been adopted.

## 7.3 Tourism

Business and operational continuity planning is recommended for both the private sector and government entities so as to facilitate the recovery process following a catastrophic or less dislocating extreme event. In light of climate change there should be greater public awareness within the sector. The Hotel and

Tourism Association should be involved in this initiative given their reach. Awareness programs should focus on potential damage and economic losses so as to support the economic viability and sustainability of the respective plants.

Employment of more enforcement officers within the DPNR to ensure developments are following guidelines.

Flood and coastal protection strategies as presented in Section 7.5 below will help protect the tourism infrastructure.

Considerations can be made for the relocation of very vulnerable properties and people but this will cause major disruptions and can be costly. Since there is an annual and growing likelihood of major storms, storm impacts might occur faster than the timescale of adaptability of these systems.

With respect to the issue with Sargassum, not much can be done by the USVI to directly control Sargassum distribution. However, there are opportunities to better coordinate locally and pool resources to deal with Sargassum removal. Initiatives such as "We Do" through a NOAA grant could be scaled up to adapt to the recurring issue. Additional resources from private and public entities will be needed to support management of removal and also to address public relations issues.

## 7.4 Agriculture

Professional behavior modification interventions should be explored to help improve the attitude of farmers to building resilient agricultural practices.

A think tank for brainstorming possible incentives should be held to encourage persons to invest in the sector.

Considerations should be made for investment in sustainable water supply for the agricultural sector.

## 7.5 Critical Infrastructure

Based on the results of the vulnerability assessment, there are a number of concerns for critical infrastructure in Charlotte Amalie and Fredericksted, the two largest population and commercial concentrations in the territory. Some proposed adaptation measures include:

1. **Stormwater master planning** - should take into account the following aspects and specific measures:

    a. Develop an inventory of existing stormwater drainage structures and features in a GIS Format, which includes update of all infrastructure changes.
    b. Increase the connectivity of the stormwater components which will provided better distribution of drainage water and better utilization of the stormwater infrastructure
    c. Develop a program for gradual implementation of Green Infrastructure within the public and the private realms.
    d. Implement Green Infrastructure Components where possible to reduce the load of the current stormwater system by increasing the storage, the channeling and the infiltration.

e. Analysis of the potential impacts on the stormwater components which are directly coupled to the groundwater table elevations (exfiltration trenches and drainage wells for fat areas), and the sea level (outfalls).
f. Provide an update of existing stormwater models or develop new models by incorporating all infrastructure components.
g. Revise the boundary conditions which are used in the current model and provide analysis for two periods: Near Future (0.5-1.0 ft sea level rise) and Long Term Analysis (1.0-5.0 ft sea level rise). Conduct simulations and optimize the performance of the corresponding infrastructure components.
h. Develop preliminary conceptual schematics with planning-level cost estimates for the high priority areas that will be included in the stormwater Capital Improvement Plans.
i. Meet requirements set forth in the National Pollutant Discharge Elimination System (NPDES) permit.
j. Retrofitting Civil Infrastructure by adding detention areas on site, improving conveyances without increasing stormwater runoff.
k. Reduce Impervious areas to preserve natural hydrologic cycle

2. **Accurate mapping and surveys -** Update mapping using new LiDAR elevation surveys, complemented by detailed surveys of individual at risk facilities to determine vulnerabilities and determine most cost-effective strategies, and action time frames.

3. **Consider *no regret* actions** - cost-effective and simple improvements, such as flood-proofing, which can be made during upgrading and routine maintenance.

4. **Explore possible changes in Land Use, Design, Site Selection and Building Standards -** consider amendments to existing land use and zoning laws, regulations and building codes to account for expected climate change impacts when designing and constructing new infrastructure, repairing and upgrading existing infrastructure and evaluating sites suitable for infrastructure development.

5. **Give priority to measures that have clear, robust and long-term benefits –** such as those that address known risks and vulnerabilities; and promote public health, safety, security and well-being.

## 7.6 Other

It is recommended that the Territory collect additional data to better understand climate risks. In particular, more data is required to understand the wave climate, beach behavior, soil characteristics, land use, and hydrology.

It is recommended that the representation on the Climate Change Council include expertise that can help the government to implement measures required to build resilience. It is anticipated that outputs from this project will be taken into consideration by the Council for appropriate action.

Disaster risk management planning for the public sector is key to building resilience to climate change. Departments need to implement a process toward developing disaster risk management and operational continuity plans.

It is anticipated that the data and maps produced under this project will be utilized by key agencies such as VITEMA, DPNR, WAPA and Public Works in climate resilience planning activities. It is also recommended that the Territory's government should introduce and use drought monitoring products and early warning systems, such as those developed by the University of the Virgin Islands, or the Caribbean Institute for Meteorology and Hydrology (CIMH). These products would be useful to inform planning activities for all sectors. Further, building the capacity of the National Weather Service in USVI to integrate with Caribbean initiatives, or to develop new capabilities to target threats specific to the USVI (as opposed to mainland USA) would be a benefit to the Territory.

It is further recommended that the government of the USVI should participate in regional initiatives driven by entities such as the Caribbean Community Climate Change Centre (CCCCCs), Caribbean Tourism Organization (CTO), CIMH, and Caribbean Water and Wastewater Association (CWWA). These entities run various programs aimed at building resilience of the Caribbean countries and sectors. This will allow the USVI to align itself more with the Small Island Developing States of the Caribbean that share common characteristics.

# 8 Territorial Adaptation Strategy and Action Plan

## 8.1 Introduction

This Territorial Adaptation Strategy and Action Plan (TASAP) was developed to further ***Project Objective 3*** that is '*to develop a robust multi-sector climate adaptation strategy*'. This TASAP is designed for the main islands of the US Virgin Islands – St. Thomas, St. Croix, and St. John to prepare them to meet the challenges of climate change in the specific Planning Areas of Socio-economic, Policy and Legal, Critical Infrastructure, Tourism, Agriculture and Other.

Adaptation has been defined as "*the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects*" (IPCC, 2014). It involves anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the damage they can cause, or taking advantage of opportunities that may arise. Well planned, early adaptation action has been shown to save money and lives. Adaptation measures could include: improving consistent supply of water for agriculture; upgrading building codes to handle future climate conditions and extreme weather events; climate resilient physical infrastructure; developing drought-tolerant crops; developing management plan for Sargassum; investment in climate-smart technology such as solar energy, or rainwater harvesting which could be used to store the excess storm water runoff and can be used during periods of drought when supply systems are dwindling.

Adaptation strategies are needed at all levels of administration: at the local, national, regional, and international level. However, adaptation activities tend to be local – district, regional or national – issues rather than international (Paavola and Adger, 2005). This is because communities possess different vulnerabilities and adaptive capabilities, they tend to be impacted differently, thereby exhibiting different adaptation needs.

This strategic action plan is designed to guide implementation of, and track progress toward climate change goals and targets in St. Thomas, St. Croix, and St. John. The strategy covers the period 2019-2024 and focuses on the six recommended planning areas. This plan will be further validated in a workshop in January 2019.

It is important to note that since the beginning of this project in 2017 some significant events have altered the land, livelihood and economy in the USVI, and have underscored the imperative for climate change adaptation in the Territory. Further, revelations in the IPCC 1.5◦ Global Warming Report released in October 2018 have heightened the urgency to deal with climate risk.

## 8.2 Strategic Objectives and Outcomes

Several adaptation strategies have been identified for the USVI. These are based on findings from the Vulnerability and Risk Assessment studies under this UVI-UWI project; past studies assessing the existing sectors in the Territory; the recently released FEMA reports and USVI Hurricane Recovery and Resilience Force (2018); the IPCC Fifth Assessment Report and the recently released IPCC Special Report on Global Warming of 1.5◦. The TASAP also incorporates stakeholder perspectives and suggestions as recorded during stakeholder interviews. Planning areas have been identified and

recommended based on the results of the Vulnerability and Adaptive Capacity Assessment, and stipulations of the Terms of Reference:

1. Socio-Economic
2. Policy, Legal and Institutional
3. Tourism
4. Agriculture
5. Critical Infrastructure

Overall, the focus of the Adaptation Strategy is to improve the capacity for local institutions to play a role in building resilience and reducing vulnerability to climate change; improve collaboration among islands and agencies to minimize loss and damage and to facilitate optimal recovery following an extreme event. The objectives, activities and further details of each of these planning areas are examined in more detail below.

One cross-cutting theme throughout all the Planning Areas is the need to implement a targeted national public awareness program which will include the importance of natural resources to climate resilience within the USVI. Awareness programs should focus on potential damage and economic losses to the economic viability and sustainability of the respective entities. This objective can be completed in the Short to Medium term and will involve:

- Identifying target audiences, including Private Sector (e.g. owners of real estate) and High-level Decision-makers (e.g. senators)
- Engaging with key stakeholders in each sector (e.g. hoteliers with a wide reach) to identify key messages e.g. Potential Impacts of Climate Change, Utility Efficiency Program, Waste Reduction Programs
- Developing awareness campaign specific to target audience – including channel, activities, message
- Implementing the program

### 8.2.1 Planning Area 1: Socio- economic Setting

The socioeconomic sector in USVI is currently considered to be 'moderately' to 'highly' vulnerable to climate change, with stressors in the form of increased temperatures, decreasing annual rainfall, higher inter-annual rainfall variability, and increased annual exposure to hurricanes and tropical storms. Without adaptation these could lead to increased energy consumption, heat stress, unavailability of potable water, flood damage and associated indirect impacts such as post-disaster illnesses, loss of productivity, etc.

**Output:**

By the end of this strategic planning period, it is expected that the following will be achieved:

- Territorial Awareness Campaign on risk reduction associated with climate change
- Updated development guidelines and building codes for housing and supporting infrastructure
- Business continuity planning for private sector and government agencies
- Goals for improved use of resources
- Enhanced facilities for vulnerable communities in the event of a disaster

*Table 8.1: Objectives, Activities, Indicative Costs and Responsible Agencies for Planning Area 1 – Socio-Economic*

| OBJECTIVE | ACTIVITIES | TIMELINE | INDICATIVE COST (US$) | RESPONSIBLE AGENCIES |
|---|---|---|---|---|
| To improve capacity of developments to reduce damage and loss from climate risk | Review of existing development guidelines to identify gaps and needs, considering regional guidelines and predicted impacts of climate change | Short term | 50,000 | Lead: USVI DPNR<br><br>Partner: Virgin Islands Territorial Emergency Management Agency, Foundation for Environmental Planning |
| | Identify planning guidelines for future developments e.g. the subsidizing housing in the coastal zone/100-yr flood plain are avoided. | Short term | 30,000 | |
| | Update and amend guidelines with climate change considerations, paying particular attention to investment in ecosystem-based adaptations such as the enhanced protection of wetlands (and their associated services). | Medium term | 60,000 | |
| To increase capacity of the DPNR to ensure developments follow climate-smart guidelines | Increase employment of more enforcement officers within the DPNR to ensure residential and commercial developments are following guidelines. | Medium to Long term | TBD[5] | Lead: USVI DPNR<br><br>Partner: Virgin Islands Territorial Emergency Management Agency, Foundation for Environmental Planning |
| | DPNR through partnerships should undertake capacity building projects, such as a tree reforestation program for those degraded hillsides and other key areas. | | TBD | |
| | Strengthen government's economic policymaking capacity, update Territory's Comprehensive Economic Strategy, and | | 300,000 | |

[5] TBD – To Be Determined

| OBJECTIVE | ACTIVITIES | TIMELINE | INDICATIVE COST (US$) | RESPONSIBLE AGENCIES |
|---|---|---|---|---|
| | Develop Economic Development Policy Institute | | | |
| Support post-disaster continuity among business entities so as to facilitate the recovery process following a catastrophic or less dislocating extreme event | Develop business and operational continuity guidelines for both the private sector and government entities<br><br>Incorporate guidelines into planning and permitting processes<br><br>Increase businesses' economic growth and sustainability by establishing Entrepreneurship Community Centres | Medium to Long term | 30,000<br><br>30,000<br><br>TBD | Lead: Virgin Islands Territorial Emergency Management Agency<br><br>Partner: American Red Cross of the Virgin Islands, St. Thomas-St. John Chamber of Commerce, St. Croix Chamber of Commerce, USVI DPNR |
| Investments in alternative sources of energy and water | Assessment on existing alternatives sources (e.g. solar or rainwater harvesting) examining prevalence, impact, and feasibility for expansion.<br><br>Conduct feasibility study on the introduction of new sources (e.g. natural gas).<br><br>Develop guidelines on alternative sources of energy and water to be incorporated at the planning and development level. | Short term<br><br>Short term<br><br>Medium term | 40,000<br><br>70,000<br><br>40,000 | Lead: USVI DPNR<br><br>Partner: Virgin Islands Water & Power Authority |
| Ensure vulnerable populations are given emphasis during planning for disaster prevention, preparedness, | Ensure that hospitals, elderly homes, youth centres, schools, rehabilitation centres etc. are high on the priority list for upgrades and improvements<br><br>Increase insurance options for vulnerable | Short term | - | Lead: Virgin Islands Department of Health (VIDOH)<br><br>Partner: Virgin Islands Territorial Emergency |

| OBJECTIVE | ACTIVITIES | TIMELINE | INDICATIVE COST (US$) | RESPONSIBLE AGENCIES |
|---|---|---|---|---|
| response, rehabilitation and recovery | populations<br><br>Ensure workforce in charge of vulnerable populations has high capacity and training for disasters | Medium term<br><br>Medium term | TBD<br><br>TBD | Management Agency |

**Note- Commencement of each activity should take place in the following timeframes: Immediate, Short term (1-2 yrs), Medium term (2-4 yrs), Long term (4 years and on-going)**

### 8.2.2 Planning Area 2: Policy Legal and Institutional

Based on the projected climate variability and change patterns, government institutions in the USVI will have to position themselves to adapt to the needs that will be generated by these potential impacts. It will also require an improved legal and regulatory system to guide and enforce the required actions. The focus of this outcome is therefore to ensure that the legal, regulatory, and institutional framework necessary for the adaptation to climate change in USVI is improved.

Several gaps were identified in previous sections including the need for policies and guidelines on wetland management, an institutional arrangement for sharing and collaborating between different programs and an integrated policy framework. Adaptation strategies within this planning area aim to address some of these gaps.

**Output:**

By the end of this strategic planning period, it is expected that the following is achieved:

- Updated policy and legislative frameworks
- Data management strategy including monitoring program
- Territorial Awareness Campaign on climate change
- An integrated policy framework in the form of a Territorial Comprehensive Plan for Climate Resilience
- Promulgate regulations that incorporate climate change
- Greater enforcement of existing legislation, through the provision of the necessary support from relevant government agencies

*Table 8.2: Objectives, Activities, Indicative Costs and Responsible Agencies for Planning Area 2 – Policy and Legal*

| OBJECTIVE | ACTIVITIES | TIMELINE | INDICATIVE COST (US$) | RESPONSIBLE AGENCIES |
|---|---|---|---|---|
| Update policy and legislative frameworks to incorporate the necessary adaptations to climate change | Conduct comprehensive review to identify gaps in frameworks and arrangements<br><br>Engage with stakeholders to develop new frameworks | Short term<br><br>Medium term | 70,000<br><br>100,000 | Lead: USVI DPNR<br><br>Partner: VITEMA, Foundation for Environmental Planning |
| Improve decision making in the development planning and development control processes. | Engage with civil society institutions into the information management process<br><br>Develop overall data management strategy which should ensure compatibility of data collection regimes and data management systems, as well as establishment of data sharing mechanisms.<br><br>Develop a comprehensive monitoring program to support informed resource management decision making, particularly for critical or fragile ecosystems | Short term<br><br>Medium term<br><br>Medium term | TBD<br><br>200,000<br><br>80,000 | Lead: USVI DPNR<br><br>Partner: VITEMA, Foundation for Environmental Planning |
| Develop and ensure cohesion between adaptation strategies among islands | Develop a Territorial Comprehensive Plan, including an integrated policy approach.<br><br>Adoption and implementation of the Plan among all islands. | Medium term<br><br>Long term | TBD<br><br>80,000 | Lead: USVI DPNR<br><br>Partner: TNC |

**Note- Commencement of each activity should take place in the following timeframes: Immediate, Short term (1-2 yrs), Medium term (2-4 yrs), Long term (4 years and on-going)**

### 8.2.3 Planning Area 3: Tourism

The tourism sector in USVI is currently considered to be ‘moderately’ to ‘highly’ vulnerable to climate change, with stressors in the form of increased temperatures, coastal erosion, decreasing annual rainfall, increases in storm events, increases in vector borne diseases, poor watershed management, and cumulative negative stressors to marine resources. Without adaptation, these could lead to increased energy consumption, heat stress, potable water availability, flood damage and associated indirect impacts such as post-disaster illnesses, loss of productivity, etc. Ultimately these can result in the loss of visitation from tourists to the islands.

**Output:**

By the end of this strategic planning period, it is expected that the following is achieved:

- Territorial Awareness Campaign on climate change
- Updated development guidelines (including post-disaster guidelines, business continuity)
- Sargassum Management Policy
- Tourism & climate change adaptation plan & campaign
- Infrastructure in place to preserve attractions
- Alternative energy and water use plan

*Table 8.3: Objectives, Activities, Indicative Costs and Responsible Agencies for Planning Area 3 – Tourism*

| OBJECTIVE | ACTIVITIES | TIMELINE | INDICATIVE COST (US$) | RESPONSIBLE AGENCIES |
|---|---|---|---|---|
| Improve tourism entities resilience for increased extreme events | Develop business and operational continuity guidelines for tourism entities so as to facilitate the recovery process following a catastrophic or less dislocating extreme event | Short to Medium term | 70,000 | Lead: Virgin Islands Territorial Emergency Management Agency<br><br>Partner: American Red Cross of the Virgin Islands, USVI DPNR, USVI Hotel & Tourism Association, Virgin Islands Department of Tourism |
| | Develop disaster management guidelines specific to the tourism sector including emphasis on, but not limited to:<br>- 'flood proofing' infrastructure<br>- storm water management | | 80,000 | |
| | Incorporate guidelines into planning and permitting processes and conduct review of Tourism Master Plan to ensure climate change and disasters are incorporated adequately | | 150,000 | |
| To improve capacity of developments to adapt to climate change impacts | Conduct review of existing guidelines to identify gaps and needs, considering national and regional /SIDS best practices | Short term | 70,000 | Lead: USVI DPNR<br><br>Partner: VITEMA, Foundation for Environmental Planning |
| | Identify planning guidelines for future developments e.g. incorporating flood and coastal protection strategies to protect tourism infrastructure | Short term | 70,000 | |
| | Update and amend guidelines with climate change considerations with emphasis on nature-based solutions | Medium term | 70,000 | |
| To increase capacity | Increase employment of more | Medium to Long | TBD | Lead: USVI DPNR |

| OBJECTIVE | ACTIVITIES | TIMELINE | INDICATIVE COST (US$) | RESPONSIBLE AGENCIES |
|---|---|---|---|---|
| of the DPNR to ensure developments follow climate-smart guidelines | enforcement officers within the DPNR to ensure residential and commercial developments are following guidelines.<br><br>DPNR through partnerships should undertake capacity building projects, such as a tree reforestation program for those degraded hillsides and other key areas. | term<br><br>Medium to Long term | <br><br>TBD | Partner: VITEMA, Foundation for Environmental Planning |
| Improve adaptability to and management of Sargassum influxes | Identify mechanisms for local coordination and pooling of resources to manage Sargassum.<br><br>Improve awareness on handling of Sargassum<br><br>Develop a Sargassum Management Policy to reduce impacts caused by influxes | Immediate - Short term<br><br>Immediate - Short term<br><br>Short term | 30,000<br><br>TBD<br><br>80,000 | Lead: Virgin Islands Territorial Emergency Management Agency<br><br>Partner: USVI DPNR, USVI Hotel & Tourism Association, Virgin Islands Department of Tourism, University of the Virgin Islands, TNC |
| Reduce demand and dependence on current sources of energy and water | Make water use a priority in plan and guideline development, e.g. drought tolerant landscaping or mandatory inclusion of alternative energy technology in new developments<br><br>Encourage water conservation among visitors (Develop and Implement Awareness Program) | Short term<br><br>Immediate | To be a part of the revision to planning guidelines presented in 8.2.1 above.<br><br>80,000 | Lead: USVI DPNR<br><br>Partner: Virgin Islands Water & Power Authority, USVI Hotel & Tourism Association, Virgin Islands Department of Tourism |
| Compensate for reduced tourism potential (from reduction in number of visitors and | Evaluate existing tourism seasons and assess potential for rescheduling based on changes in rain and/or hurricane seasons. Include methods for rescheduling such as marketing for off | Medium term | 70,000 | Lead: USVI Hotel & Tourism Association, Virgin Islands Department of Tourism |

| OBJECTIVE | ACTIVITIES | TIMELINE | INDICATIVE COST (US$) | RESPONSIBLE AGENCIES |
|---|---|---|---|---|
| decline in attractions such as beaches and coral reef) | seasons<br><br>Invest in both man-made and nature-based structures or technology that preserve attractions (beaches, coral reef, etc.)<br><br>Develop campaign to increase number or value of added attractions e.g. gastronomy tours, wellness packages | <br><br>Medium term<br><br>Short term | <br><br>TBD<br><br>80,000 | Partner: Virgin Islands Territorial Emergency Management Agency, TNC |

**Note- Commencement of each activity should take place in the following timeframes: Immediate, Short term (1-2 yrs), Medium term (2-4 yrs), Long term (4 yrs and on-going)**

### 8.2.4 Planning Area 4: Agriculture

The agricultural sector in USVI is currently considered to be 'highly' vulnerable to climate change, with stressors in the form of increased temperatures, heavy dependence on rainwater, low access to water, poor farming techniques, decreasing annual rainfall, increases in storm & flood events. Without adaptation, these can lead to a vicious cycle of increasing dependence on usable water, reduced productivity and yield, landslides and soil erosion, and invasive pests. Ultimately these can result in an unsustainable agricultural sector.

**Output:**

By the end of this strategic planning period, it is expected that the following is achieved:

- Investment Think Tank developed
- Campaigns targeting behavioral change in farmers to improve agricultural practices
- Plans to improve water use and availability
- Preliminary research into drought-tolerant crops
- Disaster Plans for agricultural sectors
- Roadmap for investment in value-added products
- Agreement for livelihood insurance

*Table 8.4: Objectives, Activities, Indicative Costs and Responsible Agencies for Planning Area 4 – Agriculture*

| OBJECTIVE | ACTIVITIES | TIMELINE | INDICATIVE COST (US$) | RESPONSIBLE AGENCIES |
|---|---|---|---|---|
| Improve understanding of soil characteristics and response to stressors | Invest in soil and crop monitoring equipment to improve understanding of droughts and other external climate stressors on agriculture sector | Short term | $50,000 | University of the Virgin Islands |
| Increase acceptance of resilient agricultural practices | Engage with professional behavior modification interventions to help improve the attitude of farmers<br><br>Develop a targeted, long term campaign to achieve behavioral change and should include among other things:<br>- how to prevent, identify and treat pathogens or invasive species<br>- farming practices that reduce water dependence<br>- farm design to reduce impact during flooding events | Short to Medium term<br><br>Short term - On-going | TBD<br><br>TBD | Lead: Virgin Islands Department of Agriculture<br><br>Partner: TNC |
| Increase investments in the sector | A think tank for brainstorming possible incentives should be held to encourage persons to invest in the sector.<br><br>Targeted sessions or committees engaged to explore and invest in value-added products and processes to improve yields. | Short term<br><br>Short- Medium term | 5,000<br><br>5,000 | Lead: Virgin Islands Department of Agriculture<br><br>Partner: Virgin Islands Economic Development Authority |
| Reduce demand and dependence on existing water supply. | Develop a strategic plan for the agriculture sector and make water use a priority, e.g. increased sun shade to improve farming practices, or for investments in improved sustainable water supply.<br><br>Provide incentives for farmers to invest in water-friendly systems e.g. close circuit | Immediate | 40,000<br><br>TBD | Lead: Virgin Islands Department of Agriculture<br><br>Partner: TNC, Reach out to various universities globally and explore partnerships to help |

| OBJECTIVE | ACTIVITIES | TIMELINE | INDICATIVE COST (US$) | RESPONSIBLE AGENCIES |
|---|---|---|---|---|
| Improve understanding of soil characteristics and response to stressors | Invest in soil and crop monitoring equipment to improve understanding of droughts and other external climate stressors on agriculture sector | Short term | $50,000 | University of the Virgin Islands |
| | water irrigation systems<br><br>Exploration of crops that require less water | | <br><br>100,000 | achieve these goals. |
| Reduce farmers' financial vulnerability during disaster events | Enroll in a parametric insurance program or similar for the agricultural sector<br><br>Develop Disaster Risk Management Plans for the agricultural sector including but not limited to:<br>- Conduct targeted campaigns to farmers bringing awareness on how improved farming practices can reduce financial strain during extreme events<br>- Develop farm design to prevent infrastructural damage during events<br>- Identify post-disaster priorities and actions | Short term<br><br>Short term | TBD<br><br>100,000 | Lead: Virgin Islands Department of Agriculture |

**Note- Commencement of each activity should take place in the following timeframes: Immediate, Short term (1-2 yrs), Medium term (2-4 yrs), Long term (4 yrs and on-going)**

### 8.2.5 Planning Area 5: Critical Infrastructure

This sector in USVI is currently considered to be 'moderately' vulnerable to climate change, with stressors in the form of increased damages (from storm and flood events) to road networks or utility structures and sea level rise impacting coastal infrastructure. Without adaptation these could lead to hindered transportation, lack of electricity and other necessary utilities. Ultimately these can greatly impact the islands, especially in a post-disaster event when the critical infrastructure becomes increasingly important.

Based on the results of the vulnerability assessment, there are a number of concerns for critical infrastructure in Charlotte Amalie and Fredericksted, the two largest population and commercial concentrations in the territory. The below adaptation measures, though for USVI overall, are in particular for these vulnerable areas.

**Output:**

By the end of this strategic planning period, it is expected that the following is achieved:

- Updated inventory and models for storm water management
- Conceptual schematics for Capital Improvement Plans
- A Green Infrastructure program
- Updated surveys and maps
- No Regrets guidelines for decision-makers
- Infrastructure and networks upgraded to standard to meet impacts of climate change
- Strengthened monitoring and response plans for critical infrastructure

*Table 8.5: Objectives, Activities, Indicative Costs and Responsible Agencies for Planning Area 5 – Critical Infrastructure*

| OBJECTIVE | ACTIVITIES | TIMELINE | INDICATIVE COST (US$) | RESPONSIBLE AGENCIES |
|---|---|---|---|---|
| Increase availability of data to better understand long-term exposure of coasts | Invest in shallow to intermediate instruments to monitor wave heights; invest in surveying equipment to monitor beach response to waves and sea-level rise as well as the drainage infrastructure to the impacts of sea-level rise | Short term | $60,000 | Lead: University of the Virgin Islands |
| Improve storm water master planning | Improve storm water data management including an updated inventory, incorporation into existing or new storm water models with revised boundary conditions.<br><br>Identify needed areas for improved management e.g. increased connectivity between components, potential impacts on groundwater table elevations and sea level, need for detention areas on site and reduction of impervious areas.<br><br>Develop preliminary conceptual schematics with planning-level cost estimates for the high priority areas that will be included in the storm water Capital Improvement Plans.<br><br>Develop & implement a Green Infrastructure program for public and the private realms. | Short term<br><br>Immediate to Medium term<br><br>Short- Medium term<br><br>Medium to Long term | 80,000<br><br>40,000<br><br>80,000<br><br>70,000 | Lead: Virgin Islands Department of Public Works<br><br>Partner: USVI DPNR, TNC, Virgin Islands Territorial Emergency Management Agency, Foundation for Development Planning, Inc. |
| Update surveys and maps | Using new LiDAR elevation surveys, complemented by detailed surveys of individual at risk facilities to determine vulnerabilities and determine most cost-effective strategies, and action time frames. | Short term | 80,000 | Lead: Virgin Islands Territorial Emergency Management Agency<br><br>Partner: USVI DPNR |
| Incorporate *no regret* | Develop guidelines for decision-makers on | Immediate to | 50,000 | Lead: USVI DPNR |

| OBJECTIVE | ACTIVITIES | TIMELINE | INDICATIVE COST (US$) | RESPONSIBLE AGENCIES |
|---|---|---|---|---|
| Increase availability of data to better understand long-term exposure of coasts | Invest in shallow to intermediate instruments to monitor wave heights; invest in surveying equipment to monitor beach response to waves and sea-level rise as well as the drainage infrastructure to the impacts of sea-level rise | Short term | $60,000 | Lead: University of the Virgin Islands |
| actions into the decision-making process | cost-effective and simple improvements, such as flood-proofing, and giving priority to measures that have clear, robust and long-term benefits such as those that address known risks and vulnerabilities; and promote public health, safety, security and well-being. | Long term | | Partner: TNC, Foundation for Development Planning, Inc. |
| Explore possible changes in Land Use, Design, Site Selection and Building Standards | Consider amendments to existing land use and zoning laws, regulations and building codes to account for expected climate change impacts when designing and constructing new infrastructure, repairing and upgrading existing infrastructure and evaluating sites suitable for infrastructure development. | Short to Long term | TBD | Lead: USVI DPNR<br><br>Partner: Virgin Islands Territorial Emergency Management Agency, Foundation for Development Planning, Inc. |
| Improve resilience of networked infrastructure (roads, telecommunications, electricity, storm water, wastewater, etc.) | Improve operations of existing infrastructure:<br>- replacement of inefficient, derelict units<br>- modernization of systems (hard and soft)<br><br>Harden existing infrastructure for climate impacts:<br>- reinforce and upgrade all critical assets to be able to withstand e.g. hurricane winds, rising seas, storm surge<br>- bury as many network and power cables as possible<br>- ensure that all repair jobs on networks are completed prior to hurricane season | Medium term<br><br>Medium term | TBD<br><br>TBD | Lead: USVI Water and Power Authority<br><br>Partner: Virgin Islands Territorial Emergency Management Agency, Federal Emergency Management Agency (FEMA) , and all associated agencies and departments for critical infrastructure including but not limited to US Department of Energy, Virgin Islands Energy |

| OBJECTIVE | ACTIVITIES | TIMELINE | INDICATIVE COST (US$) | RESPONSIBLE AGENCIES |
|---|---|---|---|---|
| Increase availability of data to better understand long-term exposure of coasts | Invest in shallow to intermediate instruments to monitor wave heights; invest in surveying equipment to monitor beach response to waves and sea-level rise as well as the drainage infrastructure to the impacts of sea-level rise | Short term | $60,000 | Lead: University of the Virgin Islands |
| | Harden future infrastructure for climate change through the updating design and construction standards<br><br>Explore and invest in new technologies and design e.g. microgrids (for power), round-a-bouts (vs intersections), concrete (vs asphalt)<br><br>Reduce reliance on central grids by:<br>- implementing alternative sources of energy<br>- installing back-up generators (and stockpile fuel) | Short term<br><br>Short term<br><br>Medium to Long term | TBD<br><br>TBD<br><br>TBD | Office, Virgin Island Waste Management Authority, Virgin Island Next Generation Network, Virgin Islands Department of Health, etc. |
| Strengthen the monitoring and regulation of critical facilities and infrastructure | Update processes and plans e.g.<br>- WAPA's tariff structure (to enable grid-tied distributed renewable energy)<br>- WAPA's Integrated Resource Plan, and Emergency Plan<br>- Develop rigorous maintenance policies and procedures<br>- Integrate studies across sectors for better planning e.g. using a comprehensive drainage study to guide road network development; e.g. linking maintenance plans to government financial plans<br>- Collaborate with federal government | Short term | TBD | Lead: USVI Water and Power Authority<br><br>Partner: Virgin Islands Territorial Emergency Management Agency, Federal Emergency Management Agency, and all associated agencies and departments for critical infrastructure including but not limited to US Department of Energy, Virgin Islands Energy |

| OBJECTIVE | ACTIVITIES | TIMELINE | INDICATIVE COST (US$) | RESPONSIBLE AGENCIES |
|---|---|---|---|---|
| Increase availability of data to better understand long-term exposure of coasts | Invest in shallow to intermediate instruments to monitor wave heights; invest in surveying equipment to monitor beach response to waves and sea-level rise as well as the drainage infrastructure to the impacts of sea-level rise | Short term | $60,000 | Lead: University of the Virgin Islands |
| | | | | Office, Virgin Island Waste Management Authority, Virgin Island Next Generation Network, Virgin Islands Department of Health, etc. |
| Improve disaster mitigation and preparedness for critical facilities and infrastructure | Develop and implement education plans e.g. water safety during disasters<br><br>Develop specific pre-disaster routines, e.g. topping up of all water supplies 72-hours before landfall<br><br>Identify priority critical facilities e.g. airports, ports, and:<br>- ensure they adhere to rigorous maintenance plans<br>- have backup sources of utilities<br>- have access to good communication<br>- updates response plans e.g. debris removal, provision of back-up power etc<br><br>Improve capacity to rebuild through:<br>- measures to expedite materials into territory when needed<br>- availability of materials locally<br>- highly developed contractor and workforce | Short term<br><br>Short term<br><br>Short term<br><br>Medium term | 70,000<br><br>TBD<br><br>-<br><br>TBD | Lead: Virgin Islands Territorial Emergency Management Agency |

| OBJECTIVE | ACTIVITIES | TIMELINE | INDICATIVE COST (US$) | RESPONSIBLE AGENCIES |
|---|---|---|---|---|
| Increase availability of data to better understand long-term exposure of coasts | Invest in shallow to intermediate instruments to monitor wave heights; invest in surveying equipment to monitor beach response to waves and sea-level rise as well as the drainage infrastructure to the impacts of sea-level rise | Short term | $60,000 | Lead: University of the Virgin Islands |
| | - ensure entry points (e.g. airports and ports) are very resilient and well protected during events (e.g. marine vessels in safe harbor) | | | |

**Note- Commencement of each activity should take place in the following timeframes: Immediate, Short term (1-2 yrs), Medium term (2-4 yrs), Long term (4 yrs and on-going)**

### 8.2.6 Planning Area 6: Institutional Capacity

Increasingly, local institutions are challenged to respond to increased exposure to risk and vulnerability of the local population as a result of climate change. For there to be effective local adaptation, local institutions need to be responsive, flexible and able to adapt to the uncertainties associated with climate change. However, local governance that is responsive to climate adaptation is constrained by weak technical and managerial capacity, poor funding, poor linkages with other institutions at different levels, weak systems for gathering and disseminating information, and unclear mandates and conflicting priorities between levels and agencies of government. This is often the case in many of the SIDS in the Caribbean. Therefore, the focus of this outcome is to ensure that there is improved physical/ infrastructural, technical and institutional capacity for the USVI to adapt to climate change.

**Output:**

By the end of this strategic planning period, it is expected that the following is achieved:

- Established relationship with the Climate Change Council
- Disaster risk management and operational continuity plans
- New data collection technologies
- Data sharing protocols and agreements
- Increased participation in regional initiatives
- Improved data and information access, especially during a disaster

*Table 8.6: Objectives, Activities, Indicative Costs and Responsible Agencies for Planning Area 6 – Other*

| OBJECTIVE | ACTIVITIES | TIMELINE | INDICATIVE COST (US$) (TBD) | RESPONSIBLE AGENCIES |
|---|---|---|---|---|
| Improve access to expert resources through partnerships | Develop relationship with the Climate Change Council which can provide expertise to help the government to implement measures required to build resilience. It is anticipated that outputs from this project will be taken into consideration by the Council for appropriate action. | Immediate | - | Lead: USVI DPNR |
| | Collaborate with federal government for the provision of emergency support to critical service providers | Short term | - | |
| | Develop water sharing partnerships with private entities | Short term | - | |
| | Establish formal relationships for supplies and to support post-disaster rebuilding | Short term | - | |
| Improve disaster risk management planning for the public sector | Develop public sector disaster risk management and operational continuity plans. | Medium term | 120,000 | Lead: Virgin Islands Territorial Emergency Management Agency |
| Mainstream data management for better utilization | Engage with key agencies such as VITEMA, DPNR, WAPA and Public Works in climate resilience planning activities to develop data sharing policies. | Short term | - | Lead: USVI DPNR<br><br>Partner: University of the Virgin Islands |
| | Introduce new data collection technology, e.g. drought monitoring products and early warning systems | Medium term | TBD | |
| | Increase capacity of the National Weather Service in USVI to integrate with Caribbean | Long term | TBD | |

| OBJECTIVE | ACTIVITIES | TIMELINE | INDICATIVE COST (US$) (TBD) | RESPONSIBLE AGENCIES |
|---|---|---|---|---|
| | initiatives, or to develop new capabilities to target threats specific to the USVI (as opposed to mainland USA) | | | |
| To increase participation in regional initiatives driven by entities such as the Caribbean Community Climate Change Centre (CCCCCs), Caribbean Tourism Organization (CTO), CIMH, and Caribbean Water and Wastewater Association (CWWA). | Increase participation in regional initiatives - These entities run various programs aimed at building resilience of the Caribbean countries and sectors. This will allow the USVI to align itself more with the Small Island Developing States of the Caribbean that share common characteristics. | Short to Medium term | TBD – would need to be a part of annual budget | Lead: USVI DPNR<br><br>Partner: TNC |
| Improve communication pre-, during- and post-disaster | Improve data collection and storage e.g. through use of cloud-based storage<br><br>Improve communication for key entities, e.g. satellite phones for government agencies; more public WiFi zones<br><br>Develop an improved radio system for updates and ensure all critical facilities have access | Short term<br><br>Short term<br><br>Medium term | 60,000<br><br>TBD<br><br>TBD | Lead: Virgin Islands Territorial Emergency Management Agency |

**Note- Commencement of each activity should take place in the following timeframes: Immediate, Short term (1-2 yrs), Medium term (2-4 yrs), Long term (4 yrs and on-going)**

## 8.3 Implementation of the Strategy

This TASAP requires that the USVI Department of Planning and Natural Resources be the main agency responsible for ensuring that the action items are carried out by the respective lead and partner agencies. However, it should be noted that the Virgin Islands Climate Change Council comprises key members whose input is valuable throughout all activities, and as such the Council should be engaged from the onset. Each of the identified Planning Areas above has a slate of activities to be undertaken over the five year period, and operational plans will need to be developed with appropriate phasing.

It is recommended that this Strategy and Action Plan be shared with all the partner agencies and awareness and capacity building programs be undertaken. Acceptance of the imperative for endorsing the Territorial Adaptation Strategy and Action Plan must be achieved before implementation.

To the maximum extent possible, elements of the TASAP should be integrated into the existing and proposed cooperation programs of USVI's bi-lateral and multi-lateral partners. Further funding may have to be sought for specific aspects where these cannot be accommodated within the respective Agency budgets.

## 8.4 Monitoring and Evaluation

The implementation of the TASAP for each sector has to be monitored and evaluated to ensure that the activities are successfully on track, and to ensure transparency and accountability. This will entail the monitoring of the actual implementation of the TASAP, and also evaluating and assessing the cause of any changes, both external and internal to the TASAP, to determine what corrective actions, if any, are needed. The results of this monitoring can then be incorporated into future planning and improvement of the TASAP.

Therefore, an implementation monitoring plan will have to be developed to monitor the progress of the activities and submitted to the appropriate Ministries or Agencies. This will include an annual implementation report that will review the year's activities and make recommendations for planning the activities of the coming year. It will also include reports from all agencies involved in the implementation of the TASAP. This will be initiated by the responsible Ministry.

It is also important to monitor changes in each sector, and to measure how the activities are contributing to the USVI's adaptation to climate change. A monitoring program should be developed, and some of the key indicators can be used to determine changes which may include:

- Changes in the policy and legal framework
- Shifts in human, institutional, and funding capacity, including shifts in cultural perceptions, practices and norms, appropriate orientation of technology, training and education, management information availability, and monitoring capacity.
- Status and trends of natural resources known to provide human well-being services related to climate change adaptation

Once these evaluations are done, the DPNR should prepare, or seek to prepare, evaluation reports, including recommendations to be included in the TASAP and submit it to the appropriate Ministries and Agencies

# 9 References


AccuWeather (2018) *Mysterious Sargassum seaweed outbreaks threaten tourism, marine life in Gulf and Caribbean* [Online] Website: https://www.accuweather.com/en/weather-news/massive-amounts-of-seaweed-threatens-tourism-at-beaches-along-the-gulf-coast/70005130 Retrieved: June 13, 2018

Adger, WN. (2006). Vulnerability. *Global Environmental Change*, *16*(3), 268-281.

American Public Health Association (2011) *Climate Change: Mastering the Public Health Role: A Practical Guidebook*. APHA

Associated Newspapers Limited (2017) *Metro UK Jose officially upgraded to hurricane status as Irma batters the Caribbean* [Online] Website: http://metro.co.uk/2017/09/06/jose-officially-upgraded-to-hurricane-status-as-irma-batters-the-caribbean-6908842/ Retrieved: September 13, 2017.

Barker, D. (2012). Caribbean Agriculture in a Period of Global Change: Vulnerabilities and Opportunities. *Caribbean Studies*, *40*(2), 41-61.

Benitez, J. and Mercado, A. (2014) *A storm surge atlas for the US Virgin Islands in support of emergency management, Poster: 6th General Assembly Caribbean Coastal Ocean Observing System*.

Buchanan, D (2018) 'Agriculture Slowly Recovering From Hurricanes' *The St. Croix Source* 26 February. Available from: https://stcroixsource.com/2018/02/26/agriculture-slowly-recovering-from-hurricanes/ [26 February 2018]

Burcharth, H.F., and Hughes, S.A. (2011). Fundamentals of Design. In Hughes, S.A. (Ed.) Coastal Engineering Manual, Part VI, Design of Coastal Project Elements, Chapter V, Engineer Manual 1110-2-1100. Washington, DC: U.S. Army Corps of Engineers.

Bureau of Economic Affairs. (2016). *News Release: Gross Domestic Product for the U.S. Virgin Islands Increases in 2015*. US Department of Commerce.

Bureau of Economic Analysis (2016) *Gross Domestic Product for the U.S. Virgin Islands Increases In 2015*. Department of Commerce

Bureau of Economic Research (2007) *US Virgin Islands Agriculture Census.* Government of the US Virgin Islands.

Bureau of Economic Research. (2016). *U.S. Virgin Islands Annual Tourism Indicators*. Office of the Governor

Bureau of Economic Research. (2017). *US Virgin Islands Economic Review & Outlook FY 2015-2016 & 1st Quarter FY 2016-2017*. Bureau of Economic Research

Burnett Penn, A. (2011). *The Virgin Islands' Climate Change Policy Achieving Low-Carbon, Climate-Resilient Development*.

Business Insider (2017). *Marriott sent a boat to rescue guests trapped on St. Thomas, but had to leave many other tourists stranded* [Online] Website: http://www.businessinsider.com/hurricane-irma-marriott-rescues-guests-leaves-others-stranded-2017-9 Retrieved October 17, 2017.

Campbell, J.D. et al. (2010) "Future climate of the Caribbean from a regional climate model" *International Journal of Climatology*, 31(12) 1866–1878. Available at: http://doi.wiley.com/10.1002/joc.2200.

Caribbean Community Climate Change Centre (CCCCC). (2011). The Review of the Economics of Climate Change (RECC/ECLACC). Economic Commission for Latin America and the Caribbean (ECLAC)

CCCCCs (2017): *The Caribbean Community Climate Change Centre* [Online] Website: http://www.caribbeanclimate.bz/ Retrieved 19th May 2017

CIA World Fact Book. (2014). https://www.cia.gov/library/publications/the-world-factbook/geos/vq.html Retrieved June 10, 2015

Coastal Engineering Manual, USACE, (2002). EM-1110-2-1100

Coastal Structures: Types, Functions and Applications, US Army Corps of Engineers Presentation to Shoreline Erosion Task Force, August 15, 2012, Hartford, CT

DEP 2012 RULES AND PROCEDURES FOR COASTAL CONSTRUCTION 62B-33 AND EXCAVATION

Environmental Protection Agency. (2016). *What Climate Change Means for the U.S. Virgin Islands.* United States Environmental Protection Agency

Environmental Solutions Limited (2013). *Final Report of the Regional Training Workshops in the Conduct of Vulnerability and Capacity Assessment (VCA) Studies in Caribbean Countries*. Caribbean Community Climate Change Centre.

Environmental Solutions Limited (2014). *Vulnerability and Capacity Assessment in the South West Coast and Watershed Area of Antigua*. Caribbean Community Climate Change Centre.

Environmental Solutions Limited (2014). *Vulnerability and Capacity Assessment and National Adaptation Strategy and Action Plan for St. Kitts and Nevis*. Caribbean Community Climate Change Centre.

Environmental Solutions Limited (2015). *Impact Assessment Report and National Adaptation Strategy and Action Plan to Address Climate Change in the Tourism Sector of Saint Lucia Volume I and II*. Caribbean Community Climate Change Centre.

Environmental Solutions Limited (2015). *Vulnerability and Capacity Assessment for the Chemin Watershed Area in Grenada*. Caribbean Community Climate Change Centre.

FDOT Bridge Scour Manual, (2005).

FDOT, DRAINAGE HANDBOOK, Bridge Hydraulics, 2012 http://bit.ly/1LADupA

FDOT, Evaluating Scour at Bridges, FDOT, (2012). Publication No. FHWA-HIF-12-003

First Edition of HEC-25 (FHWA 2004) Fort Collins, Colorado.

Fowler, J.E., (1992). .Scour Problems and Methods for Prediction of Maximum Scour at Vertical Seawalls, USACE

Fox News (2017). *Hurricane Irma 'devastates' US Virgin Islands, but their sense of community is unwavering* [Online] Website: http://www.foxnews.com/us/2017/09/09/hurricane-irma-devastates-us-virgin-islands-but-their-sense-community-is-unwavering.html Retrieved October 17, 2017.

Fox News (2017). *Virgin Islands bracing for long recovery after one-two punch from Irma, Maria* [online] Website: http://www.foxnews.com/us/2017/09/25/virgin-islands-bracing-for-long-recovery-after-one-two-punch-from-irma-maria.html Retrieved October 17, 2017

Gamble, D, Parnell, D, & Curtis, S. (2009). *Caribbean Vulnerability: Development of an Appropriate Climatic Framework. Global Change and Caribbean Vulnerability: Environment, Economy and Society at Risk.* Kingston: University of the West Indies Press.

Gardner, L. (2002). Management Framework for A system of Marine Protected Areas for The U.S. Virgin Islands. 111.

Godfrey, D. R. (2016). *Agricultural Experiment Station.* St. Croix: Dr. Robin Sterns, Editor & Publication Design.

Gould, W.A., S.J. Fain, I.K. Pares, K. McGinley, A. Perry, and R.F. Steele. (2015). Caribbean Regional Climate Sub Hub Assessment of Climate Change Vulnerability and Adaptation and Mitigation Strategies, United States Department of Agriculture, 67 pp

Hall, K. and K. KellerLynn. (2010). Virgin Islands National Park: geologic resources inventory

Hall, J.A., S. Gill, J. Obeysekera, W. Sweet, K. Knuuti, and J. Marburger (2016) *Regional Sea Level Scenarios for Coastal Risk Management: Managing the Uncertainty of Future Sea Level Change and Extreme Water Levels for Department of Defense Coastal Sites Worldwide, ,* U.S. Department of Defense, Strategic Environmental Research and Development Program

Holling, CS. (1973). Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics*, 1-23.

Hope Herron, H., Bohn, B., Roy, S., and Evans, W., (2016) *Climate Change Data and Risk Assessment Methodologies for the Caribbean.* Environmental Safeguards Unit, Inter-American Development Bank.

http://www.corpsclimate.us/ccaceslcurves.cfm

https://tidesandcurrents.noaa.gov/sltrends/sltrends.html

John P. Cangialosi, Andrew S. Latto, and Robbie Berg (2018). National Hurricane Center. Hurricane Maria (16-30 Sep 2017)

Karmalkar A.V., New M., Taylor M.A., Campbell J., Stephenson T. et. al. (2013). A review of observed and projected changes in climate for the islands in the Caribbean. Atmosfera 26(2):283–309

Lewsey, C, Cid, G, & Kruse, E. (2004). Assessing Climate Change Impacts on Coastal Infrastructure in the Eastern Caribbean. *Marine Policy, 28*, 393-409.

Marshall, NS. (2010). Understanding Social Resilience to Climate Variability in Primary Enterprises and Industries. *Global Environmental Change, 20*(1), 36-43.

Mehrer, S. E. (2016). *INDIGENOUS GOLD FROM ST. JOHN, U.S. VIRGIN ISLANDS.* Illinois: Northern Illinois University department of Anthropology.

Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., (2014). Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2. (Downloaded from http://1.usa.gov/1kOBpW5 October 2014)

Mimura, N, Nurse, L, McLean, RF, Agard, J, Briguglio, L, Lefale, P, Payet, R, & Sem, G. (2007). *Small Islands. Climate Change 2007: Impacts, Adaptation and Vulnerability*. Cambridge, UK: Cambridge University Press.

Mora C., et al. (2013). "The projected timing of climate departure from recent variability" *Nature* 502: 183-187.

National Hurricane Center (2017). *Hurricane Irma Intermediate Advisory Number 30A. (2017).*] Website: http://www.nhc.noaa.gov/archive/2017/al11/al112017.update.09062000.shtml Retrieved: September 21, 2017.

National Hurricane Center (2017). *Hurricane Maria Tropical Cyclone Update 11:00 PM AST Tuesday September 19, 2017* [Online] Website: http://www.nhc.noaa.gov/archive/2017/al15/al152017.update.09200157.shtml Retrieved: October 17, 2017.

National Hurricane Center (2017). *Hurricane Maria Tropical Cyclone Update 10:00 PM AST Tuesday September 19, 2017* [Online] Website: http://www.nhc.noaa.gov/archive/2017/al15/al152017.update.09200157.shtml Retrieved: October 17, 2017.

National Hurricane Center (2017). *Hurricane Maria Tropical Cyclone Update* [online] Website: http://www.nhc.noaa.gov/archive/2017/al15/al152017.update.09200357.shtml Retrieved October 13, 2017

National Oceanic and Atmospheric Administration (NOAA). (2010). *Adapting to Climate Change: A Planning Guide for State Coastal Managers*. NOAA Office of Ocean and Coastal Resource Management. http://coastalmanagement.noaa.gov/climate/adaptation.html

National Research Council. (2013). Climate and Social Stress: Implications for Security Analysis. eds. Committee on Assessing the Impacts of Climate Change on Social and Political Stresses, J.D. Steinbruner, P.C. Stern, and J.L. Husbands. Washington, D.C.: The National Academies Press. https://www.nap.edu/catalog/14682/climate-and-social-stress-implications-for-security-analysis

Nett, Katharina, and Lukas Rüttinger. (2016). Insurgency, Terrorism and Organised Crime in a Warming Climate. Berlin: German Federal Foreign Office.

New York Times (2017). *In the Virgin Islands, Hurricane Maria Drowned What Irma Didn't Destroy* [Online] Website: https://www.nytimes.com/2017/09/27/us/hurricane-maria-virgin-islands.html Retrieved 17th October, 2017

NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_pr.html

Oswalt, T. J. (2004). *The Status of U.S. Virgin Islands Forest.* United States Department of Agriculture.

Pendleton, E.A., Robert Thieler, E. and Jeffress Williams S. (2004). Coastal Vulnerability Assessment of Virgin Islands National Park (VIIS) to Sea-Level Rise. United States Geological Service

Potter, B, Towle, E.L, Browser, D.J. and Turnbull, B. (1995). Mitigation the Impacts of Natural Hazards in the U.S. Virgin Islands.

Puerto Rico Climate Change Council. (2013). State of Puerto Rico's Climate 2010-2013 Executive Summary. Assessing Puerto Rico's Social-Ecological Vulnerabilities in a Changing Climate *Puerto Rico Coastal Zone Management Program* (pp. 27). San Juan, PR: Department of Natural and Environmental Resources, Office of Ocean and Coastal Resource Management (NOAAOCRM).

Pulwarty, R. and Hutchinson, N., (2008). *Vulnerability and capacity assessment methodology: A guidance manual for the conduct and mainstreaming of climate change vulnerability and capacity assessments in the Caribbean*.

Rankin, D. W. (1631). *Geology of St. John, U.S. Virgin Islands.* St. John: U.S Department of the interior report. Natural Resource Report NPS/NRPC/GRD/NRR—2010/226. National Park Service,

Research, t. S. (2016). *The U.S. Virgin Islands Statewide Historic Preservation Plan.* Alabama.

Richard J. Pasch, Andrew B. Penny, and Robbie Berg (2018). National Hurricane Center, Hurricane Maria (16-30 Sep 2017)

Schill, S., Brown, J., Justiniano, A., and Hoffman A. (2014) *US Virgin Islands Climate Change Eco-system Based Adaptation: Promoting Resilient Coastal and Marine Communities, Guidance Document,* March, 2014 (Nature Conservancy).

Smit, B., and O. Pilifosova. (2001). Adaptation to Climate Change in the Context of Sustainable Development and Equity. Chapter 18 in Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.

Smith TB, Kadison E, Henderson L, Gyory J, Brandt ME, Calnan JM, Kammann M, Wright V, Nemeth

RS, Rothenberger P. (2011). *The United States Virgin Islands Territorial Coral Reef Monitoring Program*. The Center for Marine and Environmental Studies, University of the Virgin Islands.

Smith, J.B., et al. ( 2001). Vulnerability to Climate Change and Reasons for Concern: A Synthesis, Sec. 19.6.1. Chapter 19 in the Irregular Face of Climate Change. IPCC TAR WG2 2001.

Snover, A.K., L. Whitely Binder, J. Lopez, E. Willmott, J. Kay, D. Howell, and Simmonds. (2007). *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*. In association with and published by ICLEI-Local Governments for Sustainability, Oakland, CA.

St. Croix Source (2017). *Residents of Damaged Public Housing to be Relocated* [online] Website: http://stcroixsource.com/2017/09/15/residents-of-damaged-public-housing-to-be-relocated/ Retrieved: September 15, 2017.

St. John Source (2017). *Hurricane Damage to Other Islands Means St. Croix Getting More Cruise Ships* [Online] Website: http://stjohnsource.com/2017/09/15/hurricane-damage-to-other-islands-means-st-croix-getting-more-cruise-ships/

Sygma PCS. (2015). *The United States Virgin Islands Comprehensive Economic Development Strategy 2015*. Bureau of Economic Research

Sygma PCS. (2015). *The United States Virgin Islands Comprehensive Economic Development Strategy 2015*. Bureau of Economic Research

Tetra Tech, Inc, ( 2014). *Climate change data and risk assessment methodologies for the Caribbean* /Prepared for Inter-American Development Bank Environmental Safeguards Unit

The Virgin Islands Consortium (2017). *Mapp Issues Statement Following Maria: Government Will Not 'Rest Nor Grow Weary' To Rebuild USVI* [Online] Website: https://viconsortium.com/virgin-islands-2/mapp-issues-statement-following-maria-government-will-not-rest-nor-grow-weary-to-rebuild-usvi/

The Washington Post (2017). *After Irma, a once-lush gem in the U.S. Virgin Islands reduced to battered wasteland* [online] Website: https://www.washingtonpost.com/world/after-irma-a-once-lush-gem-in-the-us-virgin-islands-reduced-to-battered-wasteland/2017/09/12/b49532e0-9736-11e7-af6a-6555caaeb8dc_story.html?utm_term=.a0ae53ab7ddb Retrieved: September 29, 2017.

UNDP. (2001). *UNDP Adaptation Policy Framework*. United Nations Development Program (UNDP)

UNFCCCC. (2002). *Guidelines for the preparation of national adaptation programs of action*

U.S. Army Corps of Engineers (USACE, 2014), "Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation", Technical Letter No. 1100-2-1

US Department of Defense. (2014). FY 2014 Climate Change Adaptation Roadmap. Washington, D.C .

US Department of Energy (2017). *Situation Report #48 Hurricanes Maria, Irma, and Harvey September 27, 2017 Event Summary*, [Online] Website:

https://www.energy.gov/sites/prod/files/2017/09/f37/Hurricanes%20Maria%20Irma%20Harvey%20Event%20Summary%20September%2027.pdf

US Environmental Protection Agency (2014). *Being Prepared for Climate Change; A Workbook for Developing Risk Based Adaptation Plans.* EPA Office of Water.

US Environmental Protection Agency (2015). *EPA Climate Ready Water Utilities Toolkit.* EPA Office of Water.

US Virgin Islands Development Code – Pre-Adaption Draft (June 9, 2014.

USA Today (2017) *Battered by Hurricane Irma, thousands flee St. John island in path of the next storm* [online] Website: https://www.usatoday.com/story/news/world/2017/09/17/battered-hurricane-irma-thousands-flee-st-john-island-path-next-storm/675407001/ Retrieved: September 21, 2017

USA Today (2017). *Hurricane Irma cripples only hospital on St. Thomas as it churns through Caribbean* [Online] Website: https://www.usatoday.com/story/news/2017/09/07/hurricane-irma-cripples-only-hospital-st-thomas-churns-through-caribbean/641242001/ Retrieved October 17, 2017

Virgin Islands Department of Conservation and Cultural Affairs (DCCA). 1979. *Environmental Laws and Regulations of the Virgin Islands*, Title 12, Chapter 3, Trees and Vegetation Adjacent to Watercourses, § Cutting or Injuring Certain Trees, Equity Publishing Corporation, Oxford, New Hampshire.

VITEMA (2011). *Agency Overview*. [Online] Website: http://www.vitema.gov/about/overview.html Retrieved June 22, 2017.

VITEMA (2014). *Hazard Mitigation Plan Update*.

Walthall, CL, Hatfield, J, Backlund, P, Lengnick, L, Marshall, E, Walsh, M, Adkins, et al. (2012). *Climate Change and Agriculture in the United States: Effects and Adaptation. Usda Technical Bulletin 1935.* (Technical Bulletin 1935). Washington, DC.

What Climate Change Means for the U.S. Virgin Islands, November 2016 EPA 430-F-16-065

Willows, R., and Connell, R. (2003) *Climate adaptation: Risk, uncertainty and decision-making*. UK Climate Impacts Program

World Travel and Tourism Council. (2017). *Travel & Tourism Economic Impact 2017 Us Virgin Islands*. World Travel and Tourism Council

Wright, J.A. (1995) *Virgin Islands Environmental Protection Handbook*, Virgin Islands Nonpoint Source Pollution Control Committee, Virgin Islands Department of Planning and Natural Resources, St. Croix, U.S. Virgin Islands.

**Organizations**

| | |
|---|---|
| Center for Watershed Protection | www.cwp.org |
| Environmental Protection Agency | www.epa.gov |
| Natural Resources Conservation Service | www.nrcs.usda.gov |
| NOAA-National Marine Fisheries Service | www.nmfs.noaa.gov |
| UVI Marine Science Center | http://marsci.uvi.edu |
| VI-Coastal Zone Management Program | www.viczmp.com |
| VI-Department of Planning and Natural Resources | www.dpnr.gov.vi |
| VI-Division of Environmental Protection | www.dpnr.gov.vi/dep/home.htm |
| VI-Division of Fish and Wildlife | www.vifishandwildlife.com |
| Virgin Islands Water Resources Research Institute | http://rps.uvi.edu/WRRI/wrri.htm |

**Regulations**

| | |
|---|---|
| Clean Water Act | www.epa.gov/region5/water/cwa.htm |
| Federal Wildlife and Related Laws Handbook | http://ipl.unm.edu/cwl/fedbook/index.html |

Federal wetland protection programs and policies
http://water.usgs.gov/nwsum/WSP2425/legislation.html

| | |
|---|---|
| Virgin Islands Code | www.michie.com |

**Other Resources**

| | |
|---|---|
| Environmental Laboratory Wetlands | http://el.erdc.usace.army.mil/wetlands/ |

Virgin Islands Non-Point Source Pollution Conference
http://usvircd.org/NPS/VINPSconf2005.index.html

| | |
|---|---|
| Global Program of Action for the Protection of the Marine Environment from Land-based Activities | www.gpa.unep.org |

# Appendices

## Appendix I

***Table 1: Compiled examples of climate change vulnerability methodologies reviewed***

| Institution | Name of Methodology | Territory, State or Country | References |
|---|---|---|---|
| New York City Panel on Climate Change | Climate Change Adaptation in New York City: Building a Risk Management Response | City infrastructure managers | http://onlinelibrary.wiley.com/doi/10.1111/nyas.2010.1196.issue-1/issuetoc |
| NOAA Office of Ocean and Coastal Resource Management | Adapting to Climate Change: A Planning Guide for State Coastal Managers | State Coastal Managers | https://coast.noaa.gov/czm/media/adaptationguide.pdf |
| NOAA-CCCCC | NOAA-CCCCC methodology (Vulnerability and Capacity Assessment Methodology, 2008 | All sectors, all regions, particularly developing countries | http://www.gaportal.org/resources/detail/vulnerability-and-capacity-assessment-methodology-a-guidance-manual-for-the-conduct-and-mainstreamin |
| Climate Impacts Group-Joint Institute for the Study of the Atmosphere and Ocean, University of Washington and King County, Washington | Preparing for Climate Change: A Guidebook for Local, Regional and State Governments (2007). | Local, Regional and State Governments | http://climate.calcommons.org/bib/preparing-climate-change-guidebook-local-regional-and-state-governments |
| National Adaptation Programs of Action (NAPAs) | Guidelines for the preparation of NAPAs | Least developed countries | http://unfccc.int/adaptation/nairobi_work_program/knowledge_resources_and_publications/items/5376.php |
| United Nations Development Program | UNDP Adaptation Policy Framework | All sectors, all regions, particularly developing countries | http://www.start.org/Projects/AIACC_Project/resources/ele_lib_docs/UNDP_Frame_English.pdf |
| United Kingdom Climate Impacts | Climate Adaptation: Risk, Uncertainty and | All regions, all sectors. Written from the UK | http://www.ukcip.org.uk/wp-content/PDFs/UKCIP-Risk- |

| Institution | Name of Methodology | Territory, State or Country | References |
|---|---|---|---|
| Program | Decision Making | perspective but applicable internationally | framework.pdf |
| EPA Climate Ready Estuaries Program | Being Prepared for Climate Change; A Workbook for Developing Risk Based Adaptation Plans | Specific for estuary program managers but methodology applies to many other sectors | http://www.epa.gov/cre/risk-based-adaptation |
| EPA Climate Ready Water Utilities Program | EPA Climate Ready Water Utilities Toolkit | Water utilities in the US | http://www2.epa.gov/crwu |
| American Public Health Association | Climate Change: Mastering the Public Health Role | Public Health practitioners in the US | http://www.apha-environment.org/pdf/APHA_ClimateChg_guidebook.pdf |
| Inter-American Development Bank (IDB) | Climate Change Data and Risk Assessment Methodologies for the Caribbean | The Caribbean | https://publications.iadb.org/bitstream/handle/11319/6453/Climate%20Change%20Data%20and%20Risk%20Assessment%20Methodologies%20for%20the%20Caribbean.pdf |

Appendix II

| | Description | Type | Rank FEMA | Rank SLR | Final Rank |
|---|---|---|---|---|---|
| St. John | Theodore Eric Moorehead Marine Facility | Airport and Seaport | 4 | 4 | 4.00 |
| | Victor Willam Sewer Marine Facility | Airport and Seaport | 3 | 4 | 3.46 |
| | Pond Mouth Pump Station | Wastewater | 3 | 3 | 3.00 |
| | National Park Service Headquarters | Government Services | 3 | 3 | 3.00 |
| | Cruz Bay Post Office | Government Services | 3 | 3 | 3.00 |
| | Loredon Boynes Dock | Airport and Seaport | 4 | 2 | 2.83 |
| | De Castro Clinic | Public Health | 3 | 2 | 2.45 |
| | Cruz Bay Seaplane Base | Airport and Seaport | 4 | 1 | 2.00 |
| | Contant Westin Power Boyd Pump Station | Wastewater | 3 | 1 | 1.73 |
| | Saint John Fire Department Romeo Company | Public Safety | 3 | 1 | 1.73 |
| | Virgin Islands Environmental Resource Station | Government Services | 2 | 1 | 1.41 |
| | Cruz Bay Pump Station | Wastewater | 1 | 2 | 1.41 |
| St. Thomas | The Edward Wilmoth Blyden IV Marine Terminal | Airport and Seaport | 4 | 4 | 4.00 |
| | USCG Dock | Airport and Seaport | 4 | 3 | 3.46 |
| | Urman Victor Fredericks Marine Terminal | Airport and Seaport | 4 | 3 | 3.46 |
| | Virgin Islands Tourist Office | Government Services | 3 | 3 | 3.00 |
| | The Crown Bay Cargo Port | Airport and Seaport | 3 | 3 | 3.00 |
| | Alexander A. Farelley Justice Center | Government Services | 3 | 3 | 3.00 |
| | Fiber Access Point (FAP) | Communication | 4 | 2 | 2.83 |
| | Charlotte Amalie Seaplane Base | Airport and Seaport | 4 | 2 | 2.83 |
| | Capitol Building | Government Services | 3 | 2 | 2.45 |
| | Memorial Moravian Church | Place of worship | 3 | 2 | 2.45 |
| | Long Bay Pump Station | Wastewater | 3 | 2 | 2.45 |
| | Frenchtown Post Office | Government Services | 3 | 2 | 2.45 |
| | Territorial Virgin Island Government Visitors Bureau | Government Services | 3 | 2 | 2.45 |
| | Justice Department | Government Services | 3 | 2 | 2.45 |
| | Mangrove Nadir Pump Station | Wastewater | 3 | 2 | 2.45 |
| | Fire Department Headquarters | Public Safety | 2 | 3 | 2.45 |
| | Home Port Dock | Airport and Seaport | 4 | 1 | 2.00 |
| | Police Station/DPNR | Public Safety | 4 | 1 | 2.00 |

| | Description | Type | Rank FEMA | Rank SLR | Final Rank |
|---|---|---|---|---|---|
| | The Waterfront | Airport and Seaport | 4 | 1 | 2.00 |
| | WICO Cruise Ship Dock | Airport and Seaport | 4 | 1 | 2.00 |
| | Vessup Bay | Wastewater | 2 | 2 | 2.00 |
| | Cancryn Pump Station | Wastewater | 2 | 2 | 2.00 |
| | Office of Management and Budget | Government Services | 3 | 1 | 1.73 |
| | Emancipation Gardens Post Office | Government Services | 3 | 1 | 1.73 |
| | Austin "Babe" Monsanto Marine Terminal | Airport and Seaport | 3 | 1 | 1.73 |
| | Lucinda A. Millin Homes | Public Housing | 3 | 1 | 1.73 |
| | Fiber Access Point (FAP) | Communication | 3 | 1 | 1.73 |
| | DOCTOR'S CHOICE PHARMACY | Public Health | 2 | 1 | 1.41 |
| | WAPA Administration Office Building | Government Services | 2 | 1 | 1.41 |
| | Vessup Bay Pump Station | Wastewater | 2 | 1 | 1.41 |
| | Wesleyan Academy | School | 2 | 1 | 1.41 |
| | Virgin Islands Fire Department Lima Company Tutu Fire Station | Public Safety | 2 | 1 | 1.41 |
| | Beth Ha-Haim | Place of worship | 2 | 1 | 1.41 |
| | New Herrnhut Moravian Mission | Place of worship | 2 | 1 | 1.41 |
| | Bovoni Pump Station | Wastewater | 2 | 1 | 1.41 |
| | Seventh Day Adventist | School | 2 | 1 | 1.41 |
| | Church of God Academy | School | 2 | 1 | 1.41 |
| | Brassview | Wastewater | 2 | 1 | 1.41 |
| | Brassview Pump Station | Wastewater | 2 | 1 | 1.41 |
| | East End Family Health Center | Public Health | 2 | 1 | 1.41 |
| | Bournefield Pump Station | Wastewater | 2 | 1 | 1.41 |
| | Edith Williams | School | 2 | 1 | 1.41 |
| | Fiber Access Point (FAP) | Communication | 2 | 1 | 1.41 |
| | Aircraft Rescue and Firefighter Services | Public Safety | 2 | 1 | 1.41 |
| | 22 Police Station | Public Safety | 2 | 1 | 1.41 |
| | Tutu Substation | Energy | 2 | 1 | 1.41 |
| | CENTRAL RX | Public Health | 2 | 1 | 1.41 |
| | Armory | Public Safety | 2 | 1 | 1.41 |
| | Michael Kirwan Terrace | Public Housing | 2 | 1 | 1.41 |
| | Fiber Access Point (FAP) | Communication | 2 | 1 | 1.41 |
| | Fiber Access Point (FAP) | Communication | 2 | 1 | 1.41 |

| | Description | Type | Rank FEMA | Rank SLR | Final Rank |
|---|---|---|---|---|---|
| | Nana Gut Pump Station | Wastewater | 2 | 1 | 1.41 |
| | Ulla Muller | School | 2 | 1 | 1.41 |
| | Lower Valley Pump Station | Wastewater | 2 | 1 | 1.41 |
| | Donoe Substation | Energy | 2 | 1 | 1.41 |
| | Gladys Abraham | School | 2 | 1 | 1.41 |
| | Addelita Cancryn | School | 2 | 1 | 1.41 |
| | VI Legislature Facility | Government Services | 1 | 2 | 1.41 |
| | Property and Procurement | Government Services | 2 | 1 | 1.41 |
| | Special Operations | Public Safety | 2 | 1 | 1.41 |
| | Walgreens | Public Health | 2 | 1 | 1.41 |
| St. Croix | Christiansted Seaplane Base | Airport and Seaport | 4 | 3 | 3.46 |
| St. Croix | Old PW Barrack Yard Pump Station | Wastewater | 4 | 2 | 2.83 |
| St. Croix | LBJ Pump Station | Wastewater | 4 | 2 | 2.83 |
| St. Croix | Christiansted Library | Government Services | 4 | 2 | 2.83 |
| St. Croix | Gordon A. Finch Molasses Pier | Airport and Seaport | 4 | 2 | 2.83 |
| St. Croix | Lagoon Street Pump Station | Wastewater | 3 | 2 | 2.45 |
| St. Croix | Bay Road Pump Station | Wastewater | 3 | 2 | 2.45 |
| St. Croix | Port Terminal Pump Station | Wastewater | 4 | 1 | 2.00 |
| St. Croix | The Gallows Bay Dock | Airport and Seaport | 4 | 1 | 2.00 |
| St. Croix | Virgin Islands Energy Office | Government Services | 4 | 1 | 2.00 |
| St. Croix | Ann E. Abramson Marine Facility | Airport and Seaport | 3 | 1 | 1.73 |
| St. Croix | MOUNT WELCOME PHARMACY | Public Health | 3 | 1 | 1.73 |
| St. Croix | Senate Building | Government Services | 3 | 1 | 1.73 |
| St. Croix | CHRISTIAN'S PHARMACY | Public Health | 3 | 1 | 1.73 |
| St. Croix | Wilbur H. Francis - Bike Unit - Sub-Station | Public Safety | 3 | 1 | 1.73 |
| St. Croix | Athalie McFarlane Petersen Public Library | Government Services | 3 | 1 | 1.73 |
| St. Croix | Mon Bijou Pump Station | Wastewater | 3 | 1 | 1.73 |
| St. Croix | Fiber Access Point (FAP) | Communication | 3 | 1 | 1.73 |
| St. Croix | Old Frederiksted Public Library | Government Services | 3 | 1 | 1.73 |
| St. Croix | Ingeborg Nesbitt Clinic | Public Health | 3 | 1 | 1.73 |
| St. Croix | Alphonso 'Piggy' Gerard Comple | Public Housing | 3 | 1 | 1.73 |
| St. Croix | Christiansted Post Office | Government Services | 3 | 1 | 1.73 |
| St. Croix | St. Patrick's School | School | 3 | 1 | 1.73 |
| St. Croix | SAINT CROIX COMMUNITY BASED OUTPATIENT CLINIC | Public Health | 2 | 1 | 1.41 |

| | Description | Type | Rank FEMA | Rank SLR | Final Rank |
|---|---|---|---|---|---|
| | THE MEDICINE SHOPPE PHARMACY | Public Health | 2 | 1 | 1.41 |
| | Holy Cross Church | Place of worship | 2 | 1 | 1.41 |
| | GOLDEN ROCK PHARMACY | Public Health | 2 | 1 | 1.41 |
| | Saint Croix Fire Department | Public Safety | 2 | 1 | 1.41 |
| | Figtree Pump Station | Wastewater | 2 | 1 | 1.41 |
| | Ricardo Richards Pump Station | Wastewater | 2 | 1 | 1.41 |
| | Barren Spot Pump Station | Wastewater | 2 | 1 | 1.41 |
| | Free Will Baptist School | School | 2 | 1 | 1.41 |
| | Ann Schrader Command - Sub-Station | Public Safety | 2 | 1 | 1.41 |
| | Property and Procurement Central Warehouse | Government Services | 2 | 1 | 1.41 |
| | Ricardo Richards Elementary School | School | 2 | 1 | 1.41 |