Synthesis of Climate Change Related Knowledge and Information in the United States Virgin Islands: An Institutional Analysis

REPORT TO THE OFFICE OF INSULAR AFFAIRS, U.S. DEPARTMENT OF THE INTERIOR

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Synthesis of Climate Change Related Knowledge and Information in the United States Virgin Islands: An Institutional Analysis

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EXECUTIVE SUMMARY

Agencies and organizations are developing research and applying knowledge at many levels in order to help society reduce risk related to climate change through adaptation and mitigation. Climate change, climate uncertainty, extreme weather events and sea level rise have effects that ripple through many sectors of society. The responses of one sector affect the vulnerability and risks associated with other sectors. One way to maximize the effectiveness of climate adaptation and mitigation actions is to develop a comprehensive understanding of vulnerabilities and capacities across many sectors. With that understanding, organizations can support and foster actions that 1) are supportive and complementary to other organizations' actions, 2) open cross-sector bottlenecks in information flow, 3) fill knowledge gaps, and 4) have positive synergistic effects. To that end we examined the local and federal institutional programs in the United States Virgin Islands that have ongoing or completed projects related to risk reduction, climate change adaptation and climate change mitigation. In order to accomplish this goal, the team compiled a list of the territorial agencies defined in Executive Order No. 474-2015 *Preparing the Virgin Islands of the United States for Adapting to the Impacts of Climate Change*,[1] and all relevant federal agencies and academic institutions organized by the sectors laid out in the Executive Order. We then used a set of team-designed questions to research each entity's programs and outputs. The research was conducted through informal, unstructured interviews in St. Thomas or on the phone from locations in St. Thomas and St. Croix, in the USVI, and San Juan, Puerto Rico. Other information was compiled through desktop investigation and pre-existing knowledge of the team collaborators. Through this institutional analysis we also compile data and information for the current state of the knowledge on current and future vulnerability to climate change, climate variability and sea level rise, and to the adaptive capacity of sectors and agencies. We report on available resources, priorities, and plans by sector and by agency. The goal is to identify existing vulnerability assessments and resources, and identify gaps in information, capacity, or specific climate adaptation actions that can reduce the risks and improve the preparedness, adaptation, resilience of the Virgin Islands to climate change. It is important to stress that just as climate change affects every aspect of human life, cross-sector cooperation and collaboration between the institutions and agencies analyzed will be vital to addressing existing and emerging issues and opportunities in a way that positions the territory to prosper throughout the 21st century. This synthesis serves to aid the development of the 2016-2017 territory-wide vulnerability assessment and adaptation plan called for by Governor Kenneth Mapp's Executive Order No. 474-2015.

Human Health. According to the National Institute of Health, a changing climate affects our health and wellbeing. The major public health organizations of the world agree that climate change is a critical public health problem. Climate change makes many existing diseases and conditions worse, but it may also help introduce new pests and pathogens into new regions or communities. The most vulnerable people—children, the elderly, the poor, and those with underlying health

[1] Virgin Islands Executive Order No. 474-2015. https://www.doi.gov/sites/doi.gov/files/uploads/USVI%20EO.pdf

conditions—are at increased risk for health effects from climate change. Climate change also stresses our health care infrastructure and delivery systems.[2] These assertions are consistent with what United States Virgin Islands (USVI) experts from the USVI Department of Health and the University of the Virgin Islands (UVI) recently presented in a health panel at the Climate Change in the Caribbean 2015: Puerto Rico & U.S. Virgin Islands Conference.[3]

A review of the USVI health sector indicates that there has been limited published scholarly research that addresses health issues and health disparities in the U.S. Virgin Islands. The available studies are primarily national surveys such as the Behavioral Risk Factor Surveillance System (BRFSS) that have included participants from the USVI. The USVI has several health programs/outputs but none have addressed the direct impacts of climate change on the health sector, apart from a 2009-2011 UVI public awareness campaign. However, new guidance, national strategies, and web-based resources from the Federal Government for Healthy People 2030 from the U.S. Department of Health and Human Services, the U.S. Centers for Disease Control and Prevention and an assortment of agencies' environmental justice strategies and programs are potential opportunities for the territorial agencies responsible for health and wellbeing services to address challenges presented by climate change. Human Health appears to be the sector with the least amount of existing capacity in the territory to deal with climate adaptation or risk reduction, followed by the tourism sector. This is largely due to the limited amount of programs addressing health concerns poised by climate change, as well as the less direct linkages between health and the other sectors examined in this report.

Critical Infrastructure. The territory's critical infrastructure provides essential services that are vital to public confidence and the islands' safety, prosperity and well-being. There appears to be some amount of inclusion of climate change vulnerability in some programs/ projects related to key infrastructure development, most in the last five years but even as far back as a 2005 study completed by Dr. Aurelio Mercado funded by the Puerto Rico Sea Grant College Program, entitled, *An evaluation of the main ports and bays in Puerto Rico and the U.S. Virgin Islands as to their exposure to hurricane wave attack.*[4] Most of the programs and projects have been assessment and planning focused such as planning climate mitigation actions as part of the VI Department of Public Works Proposed 2030 Master Transportation Plan (goals 5.3 and 5.4) and the Virgin Islands Territorial Emergency Management Agency's Territorial Hazard Mitigation Plan[5] in 2014 that includes the effects of climate change in the assessment (qualitatively) and proposes programmatic and island actions to mitigate climate risks. A non-

[2] http://www.niehs.nih.gov/research/programs/geh/climatechange/

[3] Ragster, L., Ellis, E.M., L.E. Petersen, Jr., N. Michael. 2015. Public Health Concurrent Session. Responding to Climate Variability and Change – What's been working in climate mitigation and adaptation. Climate Change in the Caribbean 2015 Conference, Inter American School of Law, San Juan, PR. 17 November 2015.

[4] Mercado. 2005. Final Report: An evaluation of the main ports and bays in Puerto Rico and the U.S. Virgin Islands as to their exposure to hurricane wave attack. Sea Grant College Program. Available upon request.

[5] VITEMA. United States Virgin Islands Territorial Hazard Mitigation Plan (Final) July, 2014. http://www.vitema.gov/mitigation/mitigation-plan-2014.html

governmental study led by The Nature Conservancy used funding from the National Oceanic and Atmospheric Administration[6] and input from workshop participants to apply mapping and modeling tools to identify U.S. Virgin Islands' most vulnerable communities. The documented studies, assessments and plans are a good start for the territory, but many more like these are needed that focus on identifying specific critical infrastructure assets vulnerable to multiple climate parameters and viable solutions for mitigating those risks. A few of the institutions synthesized in the critical infrastructure sector have reached implementation, mostly related to energy infrastructure, such as a joint project between the Water and Power Authority (WAPA) and the Federal Emergency Management Agency (FEMA) to transfer overhead lines and pole mounted transformers to new underground electric infrastructure in Charlotte Amalie. Each of the critical infrastructure programs and projects also demonstrate a variety of inventorying, modeling and analysis, GIS and mapping, stakeholder engagement, and education and outreach technical capacities available in or for the territory.

Economic Development. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change found that the impacts of climate change will be felt by every sector of the economy and are relevant to all investors, financial services and businesses.[7] The VI Economic Development Authority (VI EDA), a semi-autonomous government organization responsible for the promotion and enhancement of economic development in the United States Virgin Islands, currently does not have a climate change policy or risk and vulnerability assessment publicly available; however, the VI EDA admisters a number of programs that work to build resiliency into the territory's economy. Additionally, the federal entities that provide funding and technical assistance to territorial programs, like the U.S. Department of Commerce, recognize the importance of factoring climate change impacts into their planning and grant processes. The U.S. Economic Development Administration (US EDA) is helping to build resiliency into communities by providing grant-based investments to communities and regions suffering from economic distress. These investments range from strategic economic development planning to public infrastructure construction.

According to the Bureau of Economic Research (BER) Comprehensive Economic Development Strategy (CEDS 2015),[8] the USVI is at a "critical juncture of economic crisis and change, after three successive years of economic decline..." The strategy recognizes the natural and human resources of the islands as core strengths for economic development as well as identifying the need to invest in "infrastructure, environment and quality of life", but does not make specific mention of climate change. Programs aimed at incorporating climate change vulnerabilities and solutions

[6] Schill, S., J. Brown, A. Justiniano, A. Hoffman. 2014. US Virgin Islands Climate Change Ecosystem-based Adaptation: Promoting Resilient Coastal and Marine Communities. The Nature Conservancy and NOAA Coral Reef Conservation Program. https://www.conservationgateway.org/ConservationPractices/Marine/crr/library/Documents/USVI%20EBA%20Guidance_Final.pdf

[7] IPCC. 2014. Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32. http://www.ipcc-wg2.gov/AR5/

[8] USVI CEDS: http://www.usviber.org/CEDS%20Plan%202015.pdf

into existing and emerging development strategies as well as diversifying the economy of the USVI represent important strategic opportunities for this sector. Through the programs described in this report it appears technical capacity is strong in the economic development sector for statistical analysis and research, strategic planning, financial management and advice, loan programs, tax credits and market-based incentives.

Food Security. Many programs exist within the USVI that are geared toward increasing production, food security, and overall resilience of the agricultural sector. Unfortunately, these programs have struggled to reverse an overall downward trend in agriculture within the islands. According to the last available U.S. Department of Agriculture (USDA) census of agriculture for the territory (2007), the amount of land in farms declined by 36 percent from 2002 to 2007 with total sales declining by a similar 31 percent over the same period.[9] The territory now imports ~97 percent of its food supply. Feedback from producers and agriculture sector advisors suggest that any intervention geared at reversing these trends need to be tailored to the specific and unique culture and economic needs of Virgin Islands' producers. Training courses in planning, record keeping, and overall business management have been suggested as necessary to help farmers access assistance as well as potential local and tourist retail markets. Increasing participation in any new or existing programs may depend on addressing cultural stigmas surrounding both agricultural work and government services. Fostering more public/private partnerships that seek local input during program planning phases may alleviate some of these barriers by allowing agricultural intervention to be locally driven, placed-based, and in line with local population values, priorities and demands. The relatively small size of the agricultural community within the islands, as well as the small scale of many farms, suggest that even minor investments, if properly planned and guided by a placed-based understanding of local needs, could potentially have a profound effect in increasing food production and security in the face of social and climate change related challenges.

Tourism. Tourism is a critical piece of the economy of the U.S. Virgin Islands. In 2015, tourism accounted for 30 percent of GDP and more than 79,000 direct jobs. In 2013, the industry attracted 2.7 million air and cruise ship passengers. A review of the VI Department of Tourism, the VI Economic Development Authority, the VI State Historic Preservation Division within the VI Department of Planning and Natural Resources, the VI Port Authority, the VI Hotel and Tourism Association, and the VI Chambers of Commerce did not result in finding any programs, projects or strategies directly related to climate change. However, as in many of the other sectors, a wide host of tourism projects were found that could indirectly contribute to climate adaptation or mitigation initiatives, such as energy reduction, infrastructure improvements and natural resource protection (the 2015 Comprehensive Economic Development Strategy specifically cites the importance of natural assets to the USVI tourism product).

[9] USDA USVI Census of Agriculture 2007: http://www.agcensus.usda.gov/Publications/2007/Full_Report/Outlying_Areas/usvi.pdf

Since tourism is the flagship industry in the territory, special attention must be given to conducting assessments, planning and implementing climate adaptation projects immediately. Two recent comments from territorial government representatives illustrate that despite the lack of projects, there is awareness: "the VI needs to expand our tourism products to include options away from the coasts to adapt to climate change" and "the climate challenge calls for reimagining our tourism products." Much work remains to determine the specifics of how to achieve that. Three federal agency programs were found to have connections to the VI tourism sector as related to Marine Protected Areas Management and Historic and Cultural Resources. Of all the territorial and federal initiatives found, all but two were still in planning and assessment. The two that were in implementation phase were addressing impacts to historic and cultural resources. Tourism appears to be one of the sectors with the least amount of existing capacity in the territory to deal with climate adaptation or risk reduction, the first being the Human Health sector.

An important factor in adaptation and resilience building is the ability to collaborate with other sectors. While the tourism institutions in the U.S. Virgin Islands do not have many programs, studies, mandates, policy guidance, educational and training resources available to them for climate-related work, the tourism sector does benefit from the climate work of the economic development, critical infrastructure and natural resources sectors.

Natural Resources. The natural resources of the USVI are of paramount importance to the islands' continued cultural and economic vitality. Territorial authorities are working with federal partners on a number of terrestrial and marine based programs to help adapt to changes already being experienced, as well as prepare for future scenarios. Preserving and restoring ecosystem health across the islands will minimize vulnerability and risk in the face of climate change. The territory's coral reef ecosystem is an invaluable asset that provides a number of critical ecosystem services such as healthy fisheries, protection from storm surges and tourism opportunities. The health and resilience of this ecosystem in the face of increasing threats from climate change is tied to management and development practices across the islands.

Two divisions of the Virgin Islands Department of Planning and Natural Resources (DPNR) work directly to study and plan for the effects of climate change: the Division of Coastal Zone Management and the Division of Fish and Wildlife. The divisions work in partnership with National Oceanic and Atmospheric Administration's (NOAA) Office of Coastal Management and Coral Reef Conservation Program and the U.S. Fish and Wildlife Service (USFWS). The mission of DPNR and the programs its division implements is critical to maintaining and restoring healthy marine and terrestrial ecosystems that will be resilient to stresses from climate change. A variety of other federal programs such as U.S. Geological Survey (USGS), National Park Service (NPS), and U.S. Environmental Protection Agency (EPA) play a strong role working with DPNR and other territorial agencies to protect natural resources. A review shows that all of these federal agencies have climate-explicit programs completed or in-development in USVI. These efforts are

complimented by programs currently being administered by the Virgin Islands Department of Agriculture (VIDOA) in partnership with the U.S. Forest Service, the University of the Virgin Islands Cooperative Extension Service, the Natural Resource Conservation Service (NRCS), and various other USDA entities aimed at improving agricultural and land management practices that have a direct impact on biodiversity, water quality, and overall natural resource health. Technical capacities in this sector run the gamut from climate and coastal hazards science, modeling and spatial analysis, ecosystem dynamics, monitoring, strategic planning, and decision support, and many other fields of expertise. Based on this analysis it appears that the institutions in this natural resources sector have greater expertise and capacity to understand climate change vulnerabilities, propose and implement best adaptation and risk reduction practices for natural resources than other sectors.

The information in this report on available data and knowledge, education and training resources, online tools, and implementation projects is as known by the project team as of February 29, 2016. One more review period will be conducted with members of the Caribbean Landscape Conservation Cooperative and Virgin Islands Climate Change Council and from this, new institutions, programs and information might be uncovered. A final public version will be designed and distributed subsequent to the final review. As is the case with all institutional analyses, the information will need to be updated periodically for as long as this tool is considered a valuable resource for the users.

INTRODUCTION

Local institutions play an important, if not the most important, role in the global response to climate change. Arguably, this is even truer for island institutions. Continental economies and institutions drive many global processes such as carbon enrichment of the atmosphere, and island societies are often on the front lines of vulnerability and risk. Local island institutions are the mechanisms that have largely shaped how society and its industries and residents have responded to global and environmental challenges in the past. Because adaptation to climate change must happen locally, it is impossible to craft a national, regional or international strategy that will be effective in its implementation without a strong understanding of the role of our sub-national institutions. Furthermore, the understanding gleaned should include the networks local institutions inhabit when shaping adaptation and improving capacities.

Climate change effects are projected to influence many, if not all sectors of society. Coordinated efforts among government agencies to understand vulnerabilities to climate change and take actions that reduce risk represent a positive step in responding to climate change. Currently, agencies and departments often make independent assessments of vulnerabilities for adaptation actions, focusing only on a subset of affected resources, services, or economic sectors. This compartmentalization makes integrated planning and responses more difficult and governmental policy and incentives do not align in a way that makes the most efficient use of resources. As such there is a strong need to develop a comprehensive base of information and a coordinated set of partnerships and relationships among agencies in order for any one agency to most effectively deliver support for climate adaptation projects. The U.S. Territory of the Virgin Islands is establishing a comprehensive base of information and set of relationships among territorial agencies, Federal partners, Non-Governmental Organizations (NGOs), and university partners in order to best quantify current vulnerabilities to climate change, prioritize adaptation and mitigation plans, and take actions to reduce risks associated with climate change.

As a part of this process, we examine the local and federal institutional programs that have ongoing or completed projects related to risk reduction, climate change adaptation and climate change mitigation. Through this institutional analysis we also compile data and information on current and future vulnerability to climate change, climate variability and sea level rise, and to the adaptive capacity of sectors and agencies. We report on available resources, priorities, and plans by sector and by agency. The goal is to identify existing vulnerability assessments and resources, and identify gaps in information, capacity, or specific climate adaptation actions that can reduce the risks and improve the preparedness, adaptation, resilience of the Virgin Islands to climate change. This synthesis serves to aid the development of the 2016-2017 territory-wide vulnerability assessment and adaptation plan called for by U.S. Virgin Islands Governor Kenneth Mapp's Executive Order No. 474-2015 *Preparing the Virgin Islands of the United States for Adapting to the Impacts of Climate Change*.

The Governor's Executive Order No. 474-2015 defines preparedness, adaptation, and resilience and includes reference to assessment, planning, implementation, monitoring and evaluation. Through the Executive Order, the Governor established the U.S. Virgin Islands Climate Change Council (VICCC) that coordinates climate change interventions. One of the primary goals of the VICCC is the development of U.S. Virgin Islands policy on climate change and the subsequent implementation of a public engagement strategy.

SCOPE AND METHODOLOGY

The objective of this report is to compile and evaluate existing programs and knowledge related to both acute and chronic vulnerabilities in the areas of:

- **Human Health**: Human well-being, safety and security, infectious diseases, records and access to health care, clean air and clean water;

- **Critical infrastructure:** Housing, hospitals, utilities, flood control, transportation, education, and industry;

- **Economic Development**: Economic competitiveness, education and workforce development, infrastructure, environment and quality of life, health care, and government support systems;

- **Food Security:** Agriculture, forest products, fisheries, freshwater availability, livestock and dairy, soils, market chains, and supplies;

- **Tourism:** Infrastructure, transportation, cultural and historical resources;

- **Natural Resources:** Water, corals and seagrass systems, wetlands, cay systems, endemic and threatened and endangered species, landscapes, seascapes, viewscapes and soundscapes.

In order to accomplish this goal, the team compiled a list of the territorial agencies defined in Executive Order No. 474-2015, all relevant federal agencies, and academic institutions and using a set of team-designed questions researched each entity's programs and outputs. The research was conducted through informal, unstructured interviews, desktop investigation and pre-existing knowledge of the team collaborators. The questions used were: (1) Have any research studies been conducted by your agency on risks, vulnerabilities and/or reduction measures? Status of those studies and assessments? Based on response, what has stopped the agency from doing those studies? Barriers to doing assessments or studies; (2) Has your agency worked specifically on

climate change in any capacity? (3) Are the results of any of these climate change studies written into strategic planning documents, policies, secretarial orders, reports, etc.? (4) What risk reduction policies or measures has your agency taken either internally or in your programs and policies for the territory? (5) What training programs or educational opportunities does your agency offer employees and the public?

The information collected was then reviewed and written up. Additionally, any specific projects with outputs identified were categorized[10] by their status (assessment, planning, implementation, and/or monitoring and evaluation), approach (impact based, vulnerability based, adaptation based, integrated assessment, or and/risk management based), and motivation (research driven, decision driven, and/or stakeholder driven). If a project was completed, in-progress or funded for a future fiscal year annotations were made when possible. These categorizations can be found in the text boxes to the right of each of the project outputs. Each sector section ends with *Notable Nuggets: Climate Change Research and Program Results in the U.S. Virgin Islands* that provide short factoids about climate change trends, projections, or implementation project results for each sector. These "notable nuggets" were collected informally as we conducted the institutional synthesis. Even though this is an institutional synthesis and not a vulnerability assessment we still wanted to provide the readers known climate trends and projections as we came across them, and, more importantly, known implementation projects. We made a point not to list reports, assessments and evaluations in these "notable nuggets" sections unless they could provide us with new knowledge on climate change in the Territory.

The synthesis was then reviewed by members of the Virgin Islands Climate Change Council and the Caribbean Landscape Conservation Cooperative (CLCC) in order to fill in gaps and correct information for territorial and Federal programs. This synthesis was completed in less than three months and by a small team so omissions and inaccuracies are expected. Another review period was then conducted before disseminating the findings publicly. It is also important to note that the terms "institution" and "institutional analysis" mean different things to different people and social scientists. In this report, institution is not to be used interchangeably with the terms "organization" and "agency" as we also assess legal frameworks, market mechanisms, and networks. However, we do not go deeper into informal institutions, cultural values, and political processes.

Table 1. *Territorial and Federal institutions relevant to climate adaptation and mitigation in USVI. Not all entities were assessed in this report. Those assessed are listed in each sector*

[10] Categories were chosen by examining other climate adaptation or resilient literature and eventually arriving at the Plan NYC model. http://s-media.nyc.gov/agencies/sirr/SIRR_singles_Lo_res.pdf

section. This list might not be exhaustive as it was generated based on the team's collective knowledge and experiences.

Sector	Territorial Agency	Federal Agency
Human Health	VI Department of Health VI Department of Planning and Natural Resources VI Housing Authority VI Department of Education University of the Virgin Islands	U.S. Health and Human Services U.S. Environmental Protection Agency U.S. Housing and Urban Development U.S. Department of Transportation U.S. Centers for Disease Control and Prevention
Critical Infrastructure	VI Department of Public Works VI Territorial Emergency Management Authority VI Waste Management Authority VI Water and Power Authority VI Energy Office VI Department of Health VI Department of Planning and Natural Resources VI Department of Education VI Housing Authority VI Port Authority VI Public Services Commission	U.S. Department of the Interior Federal Emergency Management Agency U.S. Department of Transportation U.S. Department of Health and Human Services U.S. Environmental Protection Agency National Oceanic and Atmospheric Administration U.S. Army Corps of Engineers U.S. Department of Commerce
Economic Development	VI Economic Development Authority VI Bureau of Economic Research	U.S. Department of Commerce USDA Rural Development DOI Office of Insular Affairs
Food Security	VI Department of Agriculture VI Department of Education VI Department of Planning and Natural Resources	U.S. Department of Agriculture Natural Resource Conservation Service

Sector	Territorial Agency	Federal Agency
	University of the Virgin Islands Cooperative Extension Service	U.S. Department of Agriculture Farm Service Agency U.S. Department of Agriculture Forest Service State & Private Forestry U.S. Department of Agriculture International Institute of Tropical Forestry U.S. Department of Agriculture Caribbean Climate Hub for Agriculture & Tropical Forestry U.S. Geological Survey U.S. Geological Survey Southeast Climate Science Center National Oceanic and Atmospheric Administration
Tourism	VI Department of Tourism VI Economic Development Authority VI State Historic Preservation Office (VI Department of Planning and Natural Resources) VI Port Authority VI Hotel and Tourism Association VI Chambers of Commerce	U.S. National Park Service U.S. Department of Commerce U.S. Fish and Wildlife Service

Sector	Territorial Agency	Federal Agency
Natural Resources	VI Department of Planning and Natural Resources University of the Virgin Islands	National Oceanic and Atmospheric Administration US Fish and Wildlife Service US Geological Survey US Department of Agriculture Natural Resource Conservation Service US Department of Agriculture Forest Service US Environmental Protection Agency National Park Service US Coral Reef Task Force Caribbean Fisheries Management Council

SETTING

The U.S. Virgin Islands (USVI) are a set of subtropical,[11] small islands in the eastern Caribbean basin, the northwestern most of the Lesser Antilles. USVI's annual mean temperature at sea level lower than 24ºC (75.2 ºF).[12]The islands are located at 18.2ºN and 64.5ºW, between the Caribbean Sea and the Atlantic Ocean. They are composed of three main islands, St. Thomas, St. John and St. Croix, and more than 60 recognized cays and off-shore rocks. In all, the islands have a land area of 346 km^2, with 1564 km^2 of marine area and 188 km of coastline. The islands are characterized by hilly interiors with limited coastal plain. The highest peak being Crown Mountain on St. Thomas with a height of 437 meters.

St. Thomas and St. John, on the north, are geologically part of the Puerto Rican bank and were connected in the past, but not St. Croix, located some 60 km to the south. It has been estimated that the northern islands separation occurred some 8,000 to 10,000 years ago, at the end of the last Ice Age. St. Croix on the other hand, either has been isolated for much longer or was never connected to the other islands.[13] A sea channel more than 3,600 meters deep separates St. Croix from the other islands and a distance of 64 km. The USVI are of volcanic origin but also contain some limestone derived soils particularly in St. Croix.[14]

DEMOGRAPHICS

According to data from the Virgin Islands Community Survey (2013),[15] the USVI had a total population of 104,760 with a male to female ratio of 1:1.11. The median age of the population was 40 years. Fifty percent of persons 16 years and older make up the labor force. There were a total of 42,371 occupied housing units. More than 97% had complete plumbing. Of that figure, 25.6% were connected to the public system only, 23.6% were connected to both the public system and cistern while more than 50% used a cistern, tank, drum or lake. Most households had at least one vehicle, a cellphone and no air conditioning. More than 50% of households had a computer with internet connection.

Tourism, trade, and other services were the primary source of economic activity as of 2010, accounting for roughly 57 percent of Gross Domestic Product (GDP) and about half of total civilian employment. The islands hosted nearly 2.74 million visitors in 2011, 2.2 million of which arrived by cruise ship. Industry and government each account for about one-fifth of GDP. The

[11] Ewel, John J., and Jacob L. Whitmore. "The ecological life zones of Puerto Rico and the US Virgin Islands." (1973).
[12] Wiley, J. W., and F. J. Vilella. "Caribbean islands." Status and trends of the nation's biological resources 2 (1998): 315-349.
[13] Wiley, J. W., and F. J. Vilella. "Caribbean islands." Status and trends of the nation's biological resources 2 (1998): 315-349.
[14] Rankin, Douglas W. Geology of St. John, US Virgin Islands. No. 1631. US Geological Survey, 2002.
[15] University of the Virgin Islands. 2013. Virgin Islands Community Survey (2013). Eastern Caribbean Center.

agriculture sector is small, with most food being imported (~97 percent).[16] As of 2014, unemployment in the islands was around 13 percent (compared with 5.5 percent in continental U.S.) with workers receiving an average hourly wage of $16.81 (26 percent less than U.S. average).[17]

The National Oceanic and Atmospheric Administration's Digital Coast provides downloadable socioeconomic data for each jurisdiction covered.[18] While not all national datasets in the tool include the U.S. Virgin Islands, the Territory is included in the coastal economy dataset for the years 1990 and 2011.[19] Using the tool on February 20, 2016, we found that the number of establishments in all industry sectors dipped between 1998 and 1999 and rose again between 2003 and 2005 and that the greatest number of industry establishments across all years is in trade, transportation and utilities (Figure 1).

A study commissioned by NOAA's Office of Coastal Management and released in 2016[20] found most economic activity in the territory can in some way, whether directly or indirectly, be linked to the ocean. The study found this to be particularly true since the closing of the HOVENSA oil refinery on St. Croix in 2012, which had generated $1.5 billion annually in GDP for the territory, but was not directly dependent on the ocean. Based on discussions with local representatives, the study further found that tourism likely accounts for 70 – 80 percent of the territories 'post-HOVENSA' GDP. This is largely due to the fact that many sectors not dependent on tourism elsewhere in the U.S., such as retail, car rental, and taxis, are dependent on tourism within USVI.

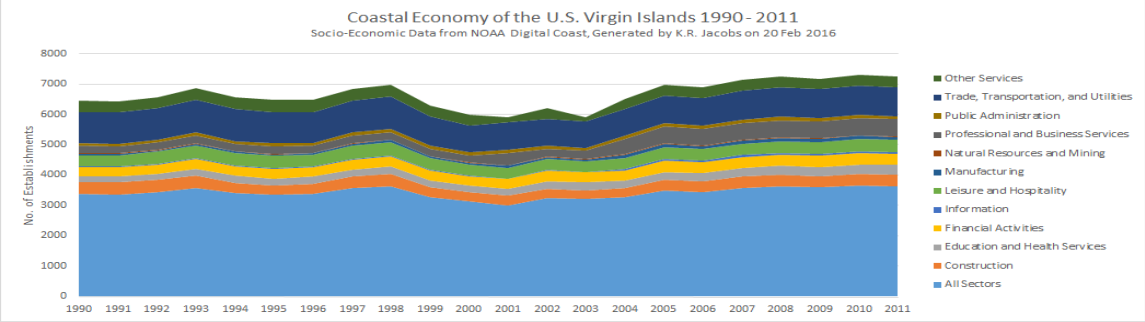

Figure 1. Coastal Economy of the U.S. Virgin Islands 1990 - 2011. Figure shows number of economical establishments by year. Data follows NOAA's Digital Coast Socio-Economic Data for the U.S. Virgin Islands

[16] 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

[17] US Bureau of Labor Statistics: http://www.bls.gov/regions/new-york-new-jersey/virgin_islands.htm#eag

[18] https://coast.noaa.gov/quickreport/

[19] Total Economy of Coastal Areas. NOAA Digital Coast: https://coast.noaa.gov/dataregistry/search/dataset/info/coastaleconomy

[20] National Oceanic and Atmospheric Association (NOAA) Office of Coastal Management (OCM) project, Describing the Ocean Economies of the U.S. Virgin Islands and Puerto Rico (Task Order EA- 133C-14-BA-0039/C-003).

KNOWN TRENDS AND PROJECTIONS FOR USVI

The U.S. Virgin Islands fall within a subtropical climate zone and experience moderate annual temperature variations with relatively dry winters and wet summers. The surrounding seas and easterly trade winds have a cooling effect on the islands. Temperature and rainfall are affected by regional weather patterns, and on larger islands in the region, by elevation. Due to their smaller land mass, the U.S. Virgin Islands experience less topographically-induced precipitation than neighboring Puerto Rico or other islands in the Greater Antilles.

Temperatures range from wintertime lows of 18 ºC (64.4 °F) to summertime highs of 35 ºC (95°F). Average 21 ºC temperatures are 21 ºC to 32 (70°F to 90° F), with average temperature variations of 3 ºC (37.4°F) between the winter and summer months.[21] The warmest average months in the region are July, August, and September and the lowest are in January or February.[22] The Caribbean as a whole is characterized as subtropical with relatively dry winters and wet summers.[23]

The dominant large-scale atmospheric influence on the climate is the North Atlantic subtropical high (NAH). A secondary, but also influential global phenomena affecting climate in the region is the El Niño Southern Oscillation (ENSO).[24] El Niño Southern Oscillation is a coupled ocean-atmosphere phenomenon consisting of periodic anomalous conditions in atmospheric circulation patterns and ocean temperatures in the tropical Pacific. In general, the Southeastern Caribbean experience drier weather patterns during positive ENSO years (known as El Niño years). However, shifts in atmospheric circulation can lead to more than average precipitation in early rainy seasons (May to July) following El Niño events. This pattern reverses during La Niña events (negative ENSO events) with drier than average early rainfall seasons. The late rainfall season (August, September, October, November) tends to be drier in El Niño years and wetter in La Niña years, thus accounting for the overall tendency for lower (higher) than average annual precipitation during positive (negative) ENSO phases in the Caribbean basin.[25]

Various institutions and bodies have analyzed and modeled how global climate change will affect the Caribbean at differing scales. Climate analysis specific to the Caribbean region is generally

[21] Southeastern Regional Climate Center. (2015). Historical Climate Summaries for Puerto Rico and the Us Virgin Islands. from http://www.sercc.com/climateinfo/historical/historical_pr.html

[22] NOAA National Weather Service. Climate Normals (1981-2010) of the U.S. Virgin Islands. https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/climate-normals/1981-2010-normals-data

[23] Taylor, M. A., & Alfaro, E. J. (2005). Central America and the Caribbean, Climate of. In Encyclopedia of world climatology (pp. 183-189). Springer Netherlands

[24] Stephenson, T. S., Chen, A. A., & Taylor, M. A. (2008). Toward the development of prediction models for the primary Caribbean dry season. *Theoretical and Applied Climatology*, *92*(1-2), 87-101.

[25] Puerto Rico Climate Change Council. (2013). State of Puerto Rico's Climate 2010-2013 Working Group 1: Geophysical and Chemical Scientific Knowledge Observed Trends and Future Projections. p63. San Juan, PR: Department of Natural and Environmental Resources, Office of Ocean and Coastal Resource Management (NOAA-OCRM).

complicated by a lack of long-term records[26] as well as its dynamic interactions with local and global factors such as topography, and the North Atlantic subtropical high (NAH) respectively.[27]

REGIONAL AND NATIONAL INSTITUTIONS

NATIONAL INSTITUTIONS IN THE UNITED STATES

US GLOBAL CHANGE RESEARCH PROGRAM (USGCRP) / NATIONAL CLIMATE ASSESSMENT

The U.S. Global Change Research Program (USGCRP) was established by Presidential Initiative in 1989 and mandated by Congress in the Global Change Research Act (GCRA) of 1990 to develop and coordinate "a comprehensive and integrated United States research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change." In consultation with White House officials and the Subcommittee on Global Change Research (SGCR), USGCRP's Executive Director ensures that the Program meets all mandated requirements. Understanding global change is critical to our Nation's welfare and economic vitality. U.S. Global Change Research Program conducts state-of-the-art research to understand the interactive processes that influence the total Earth system—which includes the atmosphere, oceans, land, ice, ecosystems, and people.

The USGCRP has a legal mandate to conduct a National Climate Assessment (NCA) every four years, the third and most recent of which was released in May 2014. The U.S. Virgin Islands are covered in the third National Climate Assessment (2014) under Chapter 17 Southeast and Caribbean,[28] however there is a lack of data and information available on specific trends and projections for the USVI and the islands are not included in the regional maps for different climate variables. This is true of much of the available climate change analysis for the Caribbean. Only recently have downscaled global projections become available for Puerto Rico;[29] however, the USVI still lacks this level of analysis. Despite this gap in understanding how global changes may interact with local conditions across the island's varied topography and life zones, understanding general projected trends for the islands can still provide managers and policy makers with valuable information in guiding preparedness, planning and adaptive policy.

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[26] Hayhoe, K. (2013). Quantifying Key Drivers of Climate Variability and Change for Puerto Rico and the Caribbean Final Report 1 Oct 2011-30 Sep 2012. (pp. 241).

[27] Karmalkar, A.V., Taylor, M.A., Campbell, J., Stephenson, T., New, M., Centella, A., Benzanilla, A. and Charlery, J. (2013). A review of observed and projected changes in climate for the islands in the Caribbean. *Atmósfera,* 26(2), 283-309.

[28] Carter, L. M., J. W. Jones, L. Berry, V. Burkett, J. F. Murley, J. Obeysekera, P. J. Schramm, and D. Wear, 2014: Ch. 17: Southeast and the Caribbean. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 396-417. doi:10.7930/J0NP22CB.

[29] Harmsen, EW, Miller, NL, Schlegel, NJ, & Gonzalez, JE. (2009). Seasonal Climate Change Effects on Evapotranspiration, Precipitation Deficit and Crop Yield in Puerto Rico. *Agricultural Water Management, 96*, 1085-1095.

Hayhoe, K. (2013). Quantifying Key Drivers of Climate Variability and Change for Puerto Rico and the Caribbean Final Report 1 Oct 2011-30 Sep 2012. (pp. 241).

Henareh Khalyani, A., Gould, W. A., Harmsen, E., Terando, A., Quinones, M., & Collazo, J. A. (2015). Climate change implications for tropical islands: Interpolating and interpreting statistically downscaled GCM projections for management and planning. *Journal of Applied Meteorology and Climatology*, (2015).

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

The National Oceanic and Atmospheric Administration (NOAA) of the U.S. has a long history of collaboration and work in the Caribbean related to climate. In 2014, NOAA published a new Caribbean Strategy which outlines its strategic approach to coordinate and integrate the capabilities of all NOAA staff and line offices to address regional issues and improve the effectiveness of its mission and international cooperation in the Caribbean Region.[30]

Climate Change Research

NOAA's research strategy in the Caribbean is based on using models and observations to understand and characterize the role of the oceans and atmosphere in climate variability and change and transferring research findings into operational and outreach products and decision support services. Examples of such services include the constantly evolving hurricane prediction and tracking tools that provide critical early warning and save lives in storm threatened areas. Research programs and observations are either inclusive of the Caribbean or are hemispheric to global in scope. Examples of Caribbean-centric programs include the Ocean Acidification Product Suite for the Caribbean and coral reef habitat mapping and classification.[31] Programs and observation more hemispheric or global in scope and apply to the Caribbean include the Climate Variability and Predictability (CLIVAR) CO_2 repeat hydrography program,[32] The Global Drifter Program,[33] and the The Meridional Overturning Circulation and Heat-Flux Array (MOCHA).[34]

Decision Support Tools

Examples of NOAA's ecosystem decision-support systems include: The Integrated Coral Observing Network (ICON) and the Coral Reef Watch (CRW) suite of products which utilize remote sensing and in-situ tools and data to provide resource managers both near-real-time and long-term monitoring, modeling, and reporting of physical environmental conditions of coral reef ecosystems.[35]

Building Local capacity

NOAA also assists in building local capacity to help communicate science findings to stakeholders through graduate-level training of regional resource managers in collaboration with the University of the West Indies and participation in the Caribbean Regional Climate Outlook Forum (CariCOF). Caribbean Regional Climate Outlook Forum produces seasonal outlooks that aid in decision-

[30] NOAA 2014. National Oceanic and Atmospheric Administration Caribbean Strategy: http://www.regions.noaa.gov/secar/wp-content/uploads/2014/07/NOAA-Caribbean-Strategy-Final-June-23-2014-FINAL.pdf
[31] NOAA Ocean Acidification Product Suite: http://coralreefwatch.noaa.gov/satellite/oa/
[32] Climate Variability and Predictability: http://www.clivar.org/
[33] The Global Drifter Program: http://www.aoml.noaa.gov/phod/dac/index.php
[34] The Meridional Overturning Circulation and Heat-Flux Array (MOCHA): http://www.aoml.noaa.gov/phod/mocha/index.php
[35] NOAA Integrated Coral Watch Network: http://coralreefwatch.noaa.gov/creios.php

making and planning.[36] In September of 2015, CariCOF released its seasonal outlook[37] covering October of 2015 to March of 2016, which indicates persisting and potentially strengthening El Niño conditions will continue to drive below average rainfall throughout the US Caribbean through December with the potential to shift to average or above average rainfall from January to March. Above average to normal temperatures are expected throughout that time period.

Sea Grant extension and Outreach

NOAA also supports activities in the Caribbean conducted by the International Research Institute for Climate and Society (IRI), including the development of integrated applications tools, as well as training and capacity building. Next steps in this region are being discussed with U.S. Agency for International Development (USAID) that would be conducted via the next phase of the NOAA Climate Program Office's international program, the International Research and Applications Project (IRAP). The IRAP is intended to be an international mechanism for interpreting and translating NOAA's (and that of other U.S. government and international entities, where appropriate) evolving climate information products and services—including training and capacity building—and for collaborating with partners to integrate the applications, impacts assessment, and decision-support research. In addition, NOAA is working with the Caribbean Community Climate Change Centre (CCCCC) on implementation plans to support regional adaptation strategies that were adopted by the Caribbean Community and Common Market (CARICOM) heads of state in 2009. Specifically, NOAA is assisting with the development and coordination of research teams to develop regionally specific methods to assess vulnerability and capacity in Caribbean Islands.

NOAA provides Coastal Zone management Act funding and technical assistance to the USVI Coastal Zone Management Program to promote and encourage the revision of territorial coastal shoreline management policies to better consider climate change as well as develop territorial or community-level adaptation plans[38], and is providing data and trainings to improve and build capacity for risk assessment and communication with regard to sea level rise and other climate change impacts.[39] NOAA also provides competitive funding for regional coastal resilience grants to enhance both community and ecosystem resilience in the face of climate change[40].
NOAA works to acquire, collect and provide access to topo-bathy and other data that is helpful to conducting risk and vulnerability analyses including for the USVI through NOAA's Digital Coast.[41]

[36] CariCOF Caribbean Seasonal Outlook: http://www.meteosxm.com/wp-content/uploads/caricofondjfm2015.pdf
[37] Caribbean Climate Outlook Forum. 2015. October 2015 to March 2016. http://rcc.cimh.edu.bb/files/2015/10/caricofondjfm.pdf?iframe=true
[38] NOAA Coastal Zone Management Program: https://coast.noaa.gov/czm/
[39] NOAA Office for Coastal Management Digital Coast: https://coast.noaa.gov/digital coast
[40] Regional Coastal Resilience Grant Program at https://coast.noaa.gov/resilience-grant/
[41] NOAA Office for Coastal Management Digital Coast: https://coast.noaa.gov/digital coast

NOAA's National Center for Coastal Ocean Science (NCCOS) undertakes a range of projects to evaluate ecosystem responses to climate change[42] including: development of scenario models, maps, and forecasts to predict the extent and types of coastal, climate-related impacts; support for interdisciplinary, multi-year sponsored research to investigate how coastal ecosystems respond to climate variability and change[43]; development of a new storm water runoff modeling system which calculates runoff volumes and rates based on changing precipitation patterns and coastal development; support for research on the ways ocean acidification changes coastal food webs and impacts economically important resources, and evaluations of the relative effectiveness of popular shoreline stabilization approaches, identifying the conditions most appropriate for each stabilization approach, and predicting how each will do in likely climate scenarios. For some climate impacts, such as coral bleaching and the spread of invasive species, NCCOS is building predictive models and early warning systems for coastal managers.

NOAAs Center for Operational Oceanographic Products and Services (CO-OPS) provides the national infrastructure, science, and technical expertise to monitor, assess, and distribute water level data that is the basis for historic sea level rise (SLR) rates. They also conduct analyses of Sea level rise trends, extreme water levels, and inundation (nuisance flooding) analyses and trends.

NOAA and the National Weather Service provide daily weather and marine forecasts and observation specific to the Virgin Islands. This data provides an invaluable source of information in understanding long and short term trends as well as how global trends may affect local conditions.[44] One critical NOAA product is the computation of "climate normals" or the expected value (e.g., temperature, precipitation, etc.) for a particular location during a particular time of year. For monthly and annual values, normals are typically the average values during the 30-year period. Meteorologists and climatologists regularly use normals for placing recent climate conditions into a historical context. Annual temperature and precipitation normals for the U.S. Virgin Islands can be found on the NWS website.[45] The National Weather service has been one of the major sponsors of the growing Community Collaborative Rain, Hail & Snow Network in the USVI, a non-profit, community-based network of volunteers of all ages and backgrounds working together to measure and map precipitation (rain, hail and snow)[46].

[42]National Centers for Coastal and Ocean Science: Climate Impacts: https://coastalscience.noaa.gov/research/climate/
[43] NOAA National Centers for Coastal and Ocean Science Ecological effects of Sea Level Rise Program: https://coastalscience.noaa.gov/research/climate/sea_level_rise
[44] NOAA and NWS Conditions for Puerto Rico and Virgin Islands: http://www.srh.noaa.gov/sju/?n=marine01
[45] NOAA National Climatic Data Center: https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/climate-normals/1981-2010-normals-data
[46] About CoCoRHAs: http://cocorahs.org/Content.aspx?page=aboutus

NOAA and the National Weather Service also support a storm surge unit as part of the technical support branch of the National Hurricane Center. The unit models and predicts storm surges associated with hurricanes over a large area that includes the US Virgin Islands.[47]

NOAA's National Marine Fisheries Service incorporates climate change in its analyses of vulnerable species as part of listings under the Endangered Species Act. This has resulted in the listing of 5 additional coral species as threatened in September 2014 that are found around USVI, as well as the reaffirmation of a 2006 listing of elkhorn and staghorn corals as threatened. The main reason for ESA listing of corals was the impacts of climate change. The completed recovery plan for elkhorn and staghorn corals specifically considers climate change impacts such as sea surface temperatures and enables states and territories to request ESA Section 6 funds to address climate change issues.

CARIBBEAN COASTAL OCEAN OBSERVING SYSTEM (CARICOOS)

Caribbean Regional Association for Coastal Ocean Observing (CaRA) is one of eleven Regional Associations (RAs) devoted to coastal ocean observing throughout the United States coastal oceans and the Great Lakes. These RAs bring together data users and data providers representing the private, governmental and corporate sectors and provide forums for establishing regional stakeholder needs and priorities for coastal ocean observing. The eleven coastal ocean observing systems focus on providing data and data products that to serve commerce and recreation, promote safety and security and contribute to protecting and preserving the coastal ocean environment.

CariCOOS, the United States Caribbean Coastal Ocean Observing System, is the observing arm of CaRA and operates a network of observing assets including data buoys, coastal meteorological stations, vessels, instruments and radars. This effort, funded by the NOAA IOOS office,[48] is one of eleven coastal observing systems and regional associations which along with federal agencies constitute the national coastal component of the US Integrated Ocean Observing System. Data from these assets and value-added data products such as graphs and maps are provided free of charge to the general public through their web page.[49] In addition, numerical models of winds, waves, currents and coastal inundation, initialized with observational data, provide near-term forecasts for coastal ocean conditions. CariCOOS is a NOAA program in partnership with and based at the University of Puerto Rico. The U.S. Virgin Islands are under its jurisdiction as well and there are two CariCOOS buoys in U.S. Virgin Islands: one off of St. John and the other off of St. Thomas.

[47] NOAA & NWS Storm Surge Unit: http://www.nhc.noaa.gov/surge/ssu.php
[48] NOAA Integrated Ocean Observing System (IOOS): http://ioos.noaa.gov/
[49] Caribbean Coastal Ocean Observing System (CariCOOS): www.caricoos.org

U.S. ARMY CORPS OF ENGINEERS (USACE)

The Army Corps of Engineers (USACE) developed a sea level rise curve tool for all areas of the United States using NOAA tide gauge data.[50] Beginning in 2009, USACE policy and guidance required that all coastal projects be evaluated with respect to changes in sea level throughout the project life-cycle. The need to incorporate projected changes to Local Mean Sea Level (LMSL) into the design of USACE Civil Works projects required the development of a simple, web-based tool to provide repeatable analytical results. The Sea Level Change Curve Calculator[51] was developed under the Comprehensive Evaluation of Projects with Respect to Sea Level Change (CESL) component of the Responses to Climate Change Program. The calculator is also used in the CESL screening level vulnerability assessments for USACE coastal projects.

U.S. GEOLOGICAL SURVEY (USGS)

The mission of Department of the Interior's United States Geological Survey (USGS) is to provide reliable scientific information to describe and understand the geological processes of the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect the nation's quality of life. USGS has eight interdisciplinary program areas: (1) water resources, (2) climate and land use change, (3) energy and minerals and environmental health, (4) natural hazards, (5) core science systems, (6) ecosystems, (7) administrative and enterprise information, and (8) facilities. Much of the work relevant to climate change adaptation is done through the climate and land use change program area; portions of several other program areas also relate to climate change adaptation. USGS is primarily a science agency. Unlike other U.S. Department of the Interior (DOI) agencies, USGS does not manage large tracts of lands, or construct infrastructure or modify waterways or habitat. Further, the agency does not have regulatory authority under any laws. Consequently, USGS addresses climate change adaptation through conducting scientific studies; collecting and analyzing data related to climatic variables; modeling and predicting the effects of climate variability on natural resources, natural processes (e.g., natural hazards), wildlife, and ecosystems; and monitoring resources such as water flows, habitat changes, and wildlife. For example, USGS provides data on natural resources and scientific analysis to support adaptive management strategies implemented by DOI land management agencies (as well as for other federal agencies, state and local governments, and others) that address climate change adaptation. DOI agencies rely on USGS for scientific data and interpretations to inform their land management decisions. Memorandums of understanding (MOUs) and scientific agreements between USGS and other federal and state agencies allow USGS to provide research results on climate change processes and impacts, as well as data for making decisions on specific geographic areas.

The USGS began a partnership with the National Park Service (NPS) in 2001 to conduct hazard assessments of future sea-level change. As part of the project, a coastal vulnerability index (CVI)

[50] USACE Sea level rise curve tool: http://www.corpsclimate.us/ccaceslcurves.cfm
[51] Ibid.

was used to map the relative vulnerability of the coast to future sea level rise within Virgin Islands National Park on St. John. The most influential variables in the CVI were geomorphology, coastal slope, and wave energy. The report presents the results of the vulnerability assessment and provides insight into what areas of St. John are more vulnerable to sea level rise.[52] The USGS supports the Water Resource Research Institute (WRRI) at the University of the Virgin Islands. Water Resource Research Institute is one of 54 such research institutes located at land-grant universities throughout the United States. The institute supports research projects that promote the efficient use and resilience of the islands' limited water supply.[53]

DOI CLIMATE SCIENCE CENTERS

The U.S. Department of the Interior's Climate Science Centers (CSC) support research, assessment, and synthesis of global change data for use at regional levels. The CSCs aim to evaluate global climate change models to scales that are appropriate for research managers of species and habitats, and facilitate data integration and outreach to collaborators and stakeholders including federal agencies. The Southeast and Caribbean Climate Science Center (SECSC), based in Raleigh, NC, has a great interest in supporting the U.S. Virgin Islands and is partnering with the Caribbean Landscape Conservation Cooperative (CLCC) on many projects relevant to climate change planning and adaptation within the islands.[54] In particular, the SECSC has funded North Carolina State University and Florida State University researchers to develop multi-model ensemble projections of climate variables for the U.S. Virgin Islands (and Puerto Rico).[55] To do so the team is developing a suite of dynamically downscaled, nonhydrostatic climate model projections at 2km resolution. The variables and time steps selected were derived with input from local researchers and natural resource managers in collaboration with the Caribbean Landscape Conservation Cooperative in November 2013. The results will be presented in April 2016 and made available to the U.S. Virgin Islands shortly thereafter.[56]

CLIMATE CHANGE RESEARCH AND DEVELOPMENT

One of the objectives of USGS's climate change research and development is to understand regional responses to climate change and estimate how climate change might affect future scenarios or processes. Two areas of research under this program include understanding the effects of sea-level rise on coastal communities and infrastructure, and studying the long-term effects of drought. Under both lines of research, USGS plans to provide insight into how various stakeholders in the country can adapt to these changes.

[52] USGS Virgin Islands NP Coastal Vulnerability Report: http://pubs.usgs.gov/of/2004/1398/images/pdf/report.pdf
[53] UVI Water Resource Research Institute (WRRI): http://uvi.edu/research/water-resources-research-institute/default.aspx
[54] SECSC and CLCC projects within the USVI: http://caribbeanlcc.org/projects/
[55] Developing multi-model ensemble projections of ecologically relevant climate variables for Puerto Rico and the US Caribbean: https://globalchange.ncsu.edu/secsc/projects/developing-multi-model-ensemble-projections-of-ecologically-relevant-climate-variables-for-puerto-rico-and-the-us-caribbean/
[56] Dr. Adam Terando (project PI) communication with Kasey R. Jacobs, February 2016

BIOLOGICAL CARBON SEQUESTRATION

USGS is in the process of conducting a quantitative assessment of the carbon released and stored in the ecosystems of the United States. This work is intended to help quantify interactions between carbon storage, land use, and climate change, which can inform land management policies and practices.

DATA COLLECTION AND MONITORING

USGS collects data and monitors natural processes that are relevant to climate change adaptation. For example, The National Streamflow Information Program, along with the Cooperative Water Program, monitors stream gages throughout the country that collect data on streamflow. These data can be analyzed to determine changes in water flows and water quality over time, and can be used in projecting future flows under various climate scenarios. Anticipating how climate change may influence the timing and levels of flows in the future could inform federal land managers, federal infrastructure investments and preparedness, and non-federal decision making. U.S. Virgin Islands does not have stream gages under this program.

The USGS has historical surface water records available, but appears to have discontinued gathering data for most or all of its locations throughout the islands.[57] The USVI is administratively included with Puerto Rico but all scientific products seem to be focused on Puerto Rico. The U.S. Virgin Islands are not included in the USGS Drought Monitor website, however, efforts in 2015 by NOAA, USGS, USDA and territorial representatives resulted in the U.S. Virgin Islands being included in 2016 U.S. Drought Monitor Product Enhancements programming through a Cooperative Agreement between USDA and the National Drought Mitigation Center. The U.S. Drought Monitor is slated to be online in the territory in Summer 2016.[58]

REGIONAL INSTITUTIONS

UNIVERSITY OF THE WEST INDIES MONA CLIMATE STUDIES GROUP

The University of the Virgin Islands (UVI) has a strategic partnership with the University of the West Indies (UWI). Through this collaboration the institutions foster the exchange of research faculty and students engaged in scientific and scholarly research in areas of mutual interest through the exchange of personnel for short periods of time; hosting of faculty sabbaticals where feasible; collaboration for equipment time and training; and collaboration on research methodologies and other areas of focus of the institution. Most recently this partnership resulted in a two-day workshop and public lecture *Climate Matters* at UVI St. Thomas campus where Dr. Michael Taylor, UWI Physics Department Director, and his team trained participants on understanding climate terminology and concepts, climate scenarios and modeling, global/Caribbean/and USVI climate trends and projections, climate impacts by sector and across sectors, and potential tools that can assist the territory's adaptation efforts.[59]

[57] USGS USVI Surface Water Data: http://waterdata.usgs.gov/vi/nwis/sw
[58] NOAA NWS and Climate Services communication with Kasey R. Jacobs, December 2015 and January 2016
[59] UVI Caribbean Green Technology Center: http://cgtc.uvi.edu/partnerships/default.aspx,

UNIVERSITY OF PUERTO RICO, SANTA CLARA UNIVERSITY AND OAK RIDGE NATIONAL LABORATORY STUDY

Researchers from the University of Puerto Rico, Mayagüez, Santa Clara University and the Oak Ridge National Laboratory used a Global Climate Model (the Parallel Climate Model or PCM) to investigate possible climate change in the Caribbean under three future emission scenarios.[60] The results showed that for the period 2041 to 2058 increases in sea surface temperatures (SST) of approximately 1ºC (1.8 ºF) are possible along with increases in precipitation during the Caribbean wet seasons (early and late rainfall seasons) and a strengthened vertical wind shear. They note that the PCM under predicts SSTs so this is a conservative estimate. Strengthened vertical wind shear along with SSTs greater than 26.5 ˚C (79.7 ºF) provides favorable conditions for possible future increases in tropical storm frequency.

UNIVERSITY OF OXFORD AND UNITED NATIONS DEVELOPMENT PROGRAM

In a report that was commissioned by the United Nations Development Programme (UNDP) Sub-Regional Office for Barbados and the Organization of Eastern Caribbean States (OECS) and by the UK Department for International Development (DFID), with support from Australia's International Climate Change Adaptation Initiative, 14 GCMs were used to create climate projections for 3 emissions scenarios (A1B, A2, and B1[61]) for the 15 CARICOM countries of the Caribbean[62]. Under these scenarios, the results indicate average air temperatures will rise in the future in all seasons. Typical projected temperature increases in CARICOM countries are consistent with global trends (i.e. the Caribbean region largely tracks projected global temperature changes). However, the temperature increase is less in coastal regions and islands with greater warming over land masses. This is related to the thermal inertia of the ocean and the greater internal heat capacity of water compared to land. All countries warm by at least 0.7°C (1.26º F) by the time mean global temperatures have increased 2.0º C (3.6º F) above historic conditions. According to these projections, there is little uncertainty that the trend of temperature is upwards, the main uncertainties are in the timing and extent.[63]

Total annual rainfall was projected to decrease through all CARICOM countries by between 10% to 20% according to the ensemble mean, with larger declines as temperatures increase. The exception is in the north, particularly over the Bahamas, where the projections suggest hurricane-season rainfall will increase slightly. However, examination of standard deviations indicates that

[60] Angeles, M. E., J. E. Gonzalez, D. J. Erickson III, and J. L. Hernández. 2007. Predictions of change in the Caribbean region using global general circulation models. *International Journal of Climatology* 27:555-569.

[61] What are emissions scenarios? See guide by the World Meteorological Organization: https://www.wmo.int/pages/themes/climate/emission_scenarios.php

[62] Simpson, M.C.,1 Scott, D.,2 New, M.,1 Sim, R.,2 Smith, D.,1 Harrison, M., 3 Eakin, C.M.,4 Warrick, R.,11 Strong, A.E.,4 Kouwenhoven, P.,5 Harrison, S.,3 Wilson, M.,6 Nelson, G.C.,7 Donner, S.,8 Kay, R.,9 Geldhill, D.K.,4 Liu, G.,4 Morgan, J.A.,4 Kleypas, J.A.,10 Mumby, P.J.,11 Palazzo, A.,7 Christensen, T.R.L.,4 Baskett, M.L.,12 Skirving, W.J.,4 Elrick, C.,12 Taylor, M.,13 Magalhaes, M.,7 Bell, J.,13 Burnett, J.B.,14 Rutty, M.K.,2 and Overmas, M.,15 Robertson, R.7 (2009) An Overview of Modelling Climate Change Impacts in the Caribbean Region with contribution from the Pacific Islands, United Nations Development Programme (UNDP), Barbados, West Indies

[62] UNDP Climate Change Country Profiles Project: http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

[63] Ibid.

while the majority of projections simulate rainfall decreases, a few projections simulate rainfall increases.

THE UNITED NATIONS DEVELOPMENT PROGRAM (UNDP) CLIMATE CHANGE COUNTRY PROFILES PROJECT

The UNDP Climate Change Country Profiles Project uses existing data to generate a collection of country-level analyses of recent climate observations and the multi-model projections made available through the World Climate Research Program's Coupled-Model Intercomparison Project. They produce "off the shelf" analysis of the data to provide basic observed and model output summaries. Their analyses have included the Caribbean and the Lesser Antilles model outputs include the U.S. Virgin Islands. Using the Intergovernmental Panel on Climate Change's (IPCC) Emissions Scenarios A2, A1B, and B1 and 15 GCMs, results for the Caribbean show:

- All projections indicate substantial increases in the frequency of days and nights that are considered "hot" in current climate. And all projections indicate decreases in the frequency of days and nights that are considered "cold" in current climate. Cold events are expected to become exceedingly rare, not occurring at all in most projections. (The project considers a "hot" day or night one that the temperature exceeded on 10% of days or nights in current climate of that region and season).

- The mean annual temperature is projected to increase by 0.5 to 2.3ºC (0.9 and 4.14º F) by the 2060s and 1.1 to 3.6ºC (1.98 and 6.48º F) by the 2090s. The projected rate of warming is most rapid in winter (December, January, February).

- Projections of mean annual rainfall from different models in the ensemble are broadly consistent in indicating decreasing rainfall, largely due to decreases in wet season (June, July, August) rainfall. Projected changes in the wet season vary from -78% to +21% by the 2090s. Annual changes range from -55% to +20%.

- The proportion of total rainfall that falls in heavy events is projected to decrease by most models by the 2090s.[64]

CARIBBEAN COMMUNITY CLIMATE CHANGE CENTER

The Caribbean Community Climate Change Center commissioned a study that combined the HadRM3P and PRECIS regional models the results of which indicated annual temperatures increasing over the Caribbean under all emissions scenarios. The models project greater than 2°C (3.6ºF) increase in annual average temperature over the Caribbean, with the greatest warming for the larger islands of Cuba, Jamaica, Hispaniola, Central America and northern South America across all seasons. The rainfall response varies with season with one of the more robust changes

[64] UNDP Climate Change Country Profiles Project: http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

being an intensification of a gradient pattern in November-January, in which the northern Caribbean (i.e., north of 22ºN) gets wetter and the southern Caribbean gets drier. There is also a drying signal from June-October.[65]

PUERTO RICO CLIMATE CHANGE COUNCIL (PRCCC)

In 2010, over 50 researchers, planners, economists, architects, sociologists, health professionals, and hydrologists, as well as several other professionals and experts of other fields relevant to the study of climate variability and change met and agreed to contribute to assess potential effects and impacts associated to climate variability and change in Puerto Rico. The main objective of the initial group was to assess the vulnerability of coastal communities, critical infrastructure, and biodiversity and to initiate the development of adaptation strategies. However, it was necessary to broaden the scope of work as new members from other sectors and disciplines joined the group. This group of volunteers adopted the name Puerto Rico Climate Change Council (PRCCC). The Council's work was conducted under four sub-groups: (1) Geophysical and Chemical Scientific Knowledge; (2) Ecology and Biodiversity; (3) Economy and Society; and (4) Communicating Climate Change and Coastal Hazards. The Puerto Rico Coastal Zone Management Program coordinates and serves as Executive Secretariat of the Puerto Rico Climate Change Council. At the time of publishing the report the Council has 157 members and collaborating partners. The PRCCC State of the Climate Report 2010-2013 is available online along with a data portal to access important climate information specific to Puerto Rico.[66]

The PRCCC used the visualization tool Climate Wizard[67] to assess recent climatic trends and possible future changes in the Caribbean based on output from 16 Global Climate Models used in the IPCC Fourth Assessment Report The output of the Climate Wizard Change Map displays the 50th percentile or median projection for temperature and precipitation change averaged over the period 2080-2099 compared to 1961-1990. The results are displayed for the A2 emissions scenario, corresponding to high future emissions of greenhouse gasses (GHG). The results show warming across the Caribbean, although less-so compared to continental regions due to the marine influence over the islands.

Overall the higher emissions scenario projects more warming and less precipitation for the region. The average warming for the Antilles is 2.8ºC (5.04º F) for the A2 scenario versus 1.7ºC (3.06º F) for the B1 emissions stabilization scenario. The median precipitation projection indicates drying for most of the region with the exception of some areas in the southern Caribbean near the Panamanian Isthmus. The mean change for the median projection for the A2 scenario is a decrease

[65] Campbell, J. D., Taylor, M. A., Stephenson, T. S., Watson, R. A. and Whyte, F. S. (2011). Future climate of the Caribbean from a regional climate model. *International Journal of Climatology*, 31: 1866–1878. doi:10.1002/joc.2200

[66] Puerto Rico Climate Change Council (PRCCC). (2013). Puerto Rico's State of the Climate 2010-2013: Assessing Puerto Rico's Social Ecological Vulnerabilities in a Changing Climate. Puerto Rico Coastal Zone Management Program, Department of Natural and Environmental Resources, NOAA Office of Ocean and Coastal Resource Management. San Juan, PR.: http://pr-ccc.org/publications/prccc-documents/

[67] Girvetz, E. H., Zganjar, C., Raber, G. T., Maurer, E. P., Kareiva, P., & Lawler, J. J. (2009). Applied climate-change analysis: the climate wizard tool. *PLoS One*, *4*(12), e8320.

in precipitation of 15.8% compared to the 1961-1990 average precipitation and the mean change for the B1 scenario is a decrease of 8.5%.

Given the uncertainty in precipitation projections, the results are noteworthy in that the 80th percentile projection (that is, leaving out the 20% of model results that showed the greatest future drying) shows a consensus amongst the models for drying in the Caribbean by the end of the century (for the high emissions scenario). Studies conducted using lower emissions scenarios (A1b) show similar results.[68] They tie the regional drying to the broader dynamical response of the tropical circulation to greater relative increases in SST in the tropical Pacific and Atlantic compared to the sub-tropical Caribbean.

SUMMARY OF TRENDS AND PROJECTIONS BY CLIMATE STRESSOR

SEA LEVEL RISE

Global mean sea level rise is projected to continue during the 21st century, very likely at a faster rate than observed from 1971 to 2010. It is very likely that sea level will rise in more than 95% of the world's ocean area. About 70% of the coastlines worldwide are projected to experience a sea level change within ±20% of the global mean. The rate of increase during 1901-1990 was 1.5 [1.3 to 1.7] mm/year as compared to 3.2 [2.8 to 3.6] mm/year during 1993-2010. By the end of the 21st century, global mean sea level could be .26m to .98m (~10 to 38in.) above current levels. Rates of rise are expected to slow toward the end of the century if warming is limited to 1.5°C and accelerate if warming reaches 2°C (3.6°F). This is one of the driving factors for island nations all over the world pushing the Paris COP21 to adopt a goal of limiting warming to 1.5° as opposed to its previously identified goal of 2°C.[69]

Sea level rise of around 1.5 to 3 mm per year (0.05 to 0.1 in. per year) (1950-2000) has been observed at tidal gauging stations around the Caribbean making the regional trend similar to that for the globe.[70] Portions of the U.S. Virgin Islands are highly vulnerable to sea level rise. How much sea level rise is experienced in any particular place depends on whether and how much the local land is sinking (also called subsidence) or rising, and changes in offshore currents (see USGS Coastal Vulnerability Index USVI Study[71] and The Nature Conservancy's sea level rise analysis for the USVI that identifies vulnerable estates[72]).

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[68] Biasutti, M., Sobel, A. H., Camargo, S. J., & Creyts, T. T. (2012). Projected changes in the physical climate of the Gulf Coast and Caribbean. *Climatic Change*, *112*(3-4), 819-845.

[69] IPCC (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

[70] Church, J. A., White, N. J., Coleman, R., Lambeck, K., & Mitrovica, J. X. (2004). Estimates of the regional distribution of sea level rise over the 1950-2000 period. *Journal of Climate*, *17*(13), 2609-2625.

[71] USGS Coastal Vulnerability Index USVI Study: http://pubs.usgs.gov/of/2004/1398/images/pdf/report.pdf

[72] Schill, S., J. Brown, A. Justiniano, A. Hoffman. 2014. US Virgin Islands Climate Change Ecosystem-based Adaptation: Promoting Resilient Coastal and Marine Communities. The Nature Conservancy and NOAA Coral Reef Conservation Program. https://www.conservationgateway.org/ConservationPractices/Marine/crr/library/Documents/USVI%20EBA%20Guidance_Final.pdf

Future sea level projections are uncertain mainly owing to difficulties in predicting the melt rates of the Greenland and Antarctic ice sheets.[73] However, in 2012, at the request of the U.S. Climate Change Science Program and in collaboration with twelve contributing authors from ten different federal and academic science institutions—including NOAA, NASA, the U.S. Geological Survey, the Scripps Institution of Oceanography, the U.S. Department of Defense, the U.S. Army Corps of Engineers, Columbia University, the University of Maryland, the University of Florida, and the South Florida Water Management District, NOAA's Climate Program Office conducted a review of the research on global sea level rise projections, and concluded that there is very high confidence (greater than 90% chance) that global mean sea level will rise at least 8 inches (0.2 meter) but no more than 6.6 feet (2.0 meters) by 2100. A study conducted in 2009 emphasized that projected global sea level increases over the next century could result in greater increases in the Caribbean region due to gravitational and geophysical factors. Modeling indicates that in the event the Greenland Ice sheet and West Antarctic Ice Sheet melt over the next 100 years the Caribbean will experience rises in sea surface levels up to 25% above global averages.[74] Even partial melting of the ice sheets could result in greater rises in Caribbean Sea surface levels than in most other areas of the Earth.

For the U.S. Virgin Islands there are two tide stations, Lime Tree Bay, VI off the south coast of St. Croix and the other is off of Charlotte Amalie. The USACE tool uses the nearest NOAA gauge to develop Relative Sea Level Rise (RSLR) curves. The rate used to develop the local relative SLC is a combination of the widely accepted eustatic rate of 1.7 mm/year plus the Vertical Land Movement (VLM). On February 3, 2016 we used the tool to generate RSLR curves for USVI:

- St. Thomas: Using the NOAA published historic sea level rise rate of 1.2mm/year (0.05 in/year) for the St. Thomas tide gauge by the year 2040 U.S. Virgin Islands will experience a sea level rise between 58 mm and 317mm (2.2 in. and 12 in.).

- St. Croix: Using the NOAA published historic sea level rise rate of 1.7mm/year (0.07 in.) for the St. Croix tide gauge by the year 2040 U.S. Virgin Islands will experience a sea level rise between 82mm and 345mm (3.3 in. and 13.6 in.).

[73] Melillo, Jerry M., Terese Richmond, and Gary W. Yohe (eds.) (2014). Climate Change Impacts in the 12 United States: *The Third National Climate Assessment*. U.S. Global Change Research Program, 13 2014.

[74] Simpson, M.C., Scott, D., New, M., Sim, R., Smith, D., Harrison, M., Eakin, C.M., Warrick, R., Strong, A.E., Kouwenhoven, P., Harrison, S., Wilson, M.D., Nelson, G.C., Donner, S., Kay, R., Geldhill, D.K., Liu, G., Morgan, J.A., Kleypas, J.A., Mumby, P.J., Palazzo, A., Christensen, T.R.L., Baskett, M.L., Skirving, W.J., Elrick, C., Taylor, M., Magalhaes, M., Bell, J., Burnett, J.B., Rutty, M.K., and Overmas, M., Robertson. (2009) An Overview of Modelling Climate Change Impacts in the Caribbean Region with contribution from the Pacific Islands, *United Nations Development Programme* (UNDP), Barbados, West Indies

INCREASING STORM INTENSITY AND POSSIBLE FREQUENCY – WIND DAMAGE

The number of Category 4 and 5 hurricanes in the Atlantic basin has increased substantially since the early 1980s compared to the historical record that dates back to the mid 1880s.[75] Atlantic tropical storm and hurricane destructive potential as measured by the Power Dissipation Index (which combines storm intensity, duration, and frequency) has increased substantially since about 1970, and is likely substantial since the 1950s and 60s, in association with warming Atlantic Ocean sea surface temperatures. The occurrence of tropical storms has fluctuated on a decadal scale. Significant trends are difficult to analyze due to the data uncertainty prior to the satellite era that began in 1965. Notwithstanding these uncertainties, the United States Global Change Research Program concludes that the overall occurrence of tropical storms, hurricanes, and major hurricanes has likely increased over the past 100 years.[76]

Large fluctuations in frequency and intensity, as well as the limitations of historical data, have complicated the detection of significant trends or their correlation to increasing atmospheric greenhouse gases. Despite these limitations, future projections based on theory and high-resolution dynamic models consistently indicate that increasing levels of greenhouse gases will lead to global increases in tropical cyclones intensity. Globally averaged cyclone intensities are expected to increase by 2-11% by 2100. However, while intensities of storms are projected to increase, modeling studies consistently indicate a decline in global cyclone frequencies by 6-34%. These less frequent, but more intense cyclones are expected to deliver significantly increased rates of precipitation within 100 km of the storm centers.[77]

INCREASING STORM INTENSITY AND POSSIBLE FREQUENCY – STORM SURGE

There is evidence for an increase in extreme wave height characteristics over the past several decades, associated with more frequent and more intense hurricanes.[78] CariCOOS maintains a storm surge atlas for the USVI that maps potential surges under various hurricane categories using google earth.[79]

NOAA and the National Weather Service (NWS) maintain a Storm Surge unit as part of the National Hurricane Center. The unit uses the Sea, Lake and Overland Surges from Hurricanes (SLOSH) model to estimate and map storm surge heights based on historical, hypothetical, or predicted hurricanes. The model takes into account atmospheric pressure, size, forward speed, and track data. The model takes into account the unique topography and bathymetry of an area when predicting potential storm surge heights. The US Virgin Islands are covered under this model under

[75] Melillo, Jerry M., Terese Richmond, and Gary W. Yohe (eds.) (2014). Climate Change Impacts in the 12 United States: *The Third National Climate Assessment*. U.S. Global Change Research Program, 13 2014.
[76] US Global Change Research Project 2009 Report: https://nca2009.globalchange.gov/islands/index.html
[77] Knutson, T. R., J. L. McBride, J. Chan, K. Emanuel, G. Holland, C. Landsea, I. Held, J. P. Kossin, A. K. Srivastava, and M. Sugi. (2010). Tropical cyclones and climate change. *Nature Geoscience*, *3*(3), 157-163.
[78] US Global Change Research Project 2009 Report: https://nca2009.globalchange.gov/islands/index.html
[79] Storm Surge Atlas for the USVI: http://www.caricoos.org/drupal/usvi_storm_surge

basin designation V12.[80] Surge predictions are made as storms develop and their potential tracks are modeled and mapped.

Studies conducting for the northern coast of the Gulf of Mexico have indicated that hurricane-induced storm surge height and coastal inundation could be exacerbated by future global sea-level rise and subsidence;[81] however, the same models indicate responses of storm surge to the effects of sea-level rise and subsidence are highly nonlinear and vary on temporal and spatial scales, so study findings in other areas may not apply to the Virgin Islands. However, it is reasonable given study results regarding sea level rise and storm intensities, to conclude that climate change effects will lead to an increased vulnerability to storm surges and flooding within the USVI. The authors of this report suggest monitoring NOAA and NWS SLOSH model outputs ahead of approaching storms to inform real-time mitigation tactics and potential evacuations. The territory may benefit from commissioning studies and models designed and tailored specifically to the islands. Such studies could help inform future planning, development, and emergency management.

CHANGING PRECIPITATION PATTERNS

Decadal oscillation have been the dominant mode of variability in regional precipitation in the Caribbean. These oscillations are related to interactions between the global ocean and regional atmosphere and is influential in precipitation patterns within the Virgin Islands and other southeastern Antilles islands. The shifts are driven by a tri-pole pattern of sea surface temperatures and upper level zonal winds that involve shifts in the Hadley circulation and the subtropical jet stream every eight to eleven years. This decadal mode of climate variability also plays a role in the frequency of hurricanes in the region.[82]

Most of the models used in the Fourth Assessment Report of the IPCC project decreases in annual precipitation for the region with a few increases, varying from -39 to + 11% of historic norms, with a median of a 12% decrease. This annual mean decrease is projected to be spread across the entire region. December, January, February in the Greater Antilles is expected to see increased precipitation and June, July, August to see a region-wide decrease.[83]

CariCOF analysis of recent climate events including the strong El Niño event in the tropical Pacific indicate a continued drying trend for the Caribbean south of 16°N with normal to above average rainfall north of this latitude. The outlook does not make a specific prediction for the U.S. Caribbean territories for this time period in regard to rainfall. The impact of these changes to any

[80] Storm Surge Unit SLOSH Model coverage: http://www.nhc.noaa.gov/surge/slosh.php#COVERAGE

[81] Yang Z, Wang T, Leung R, Hibbard K, Janetos T, Kraucunas I, Rice J, Preston BL, Wilbanks, T. (2014). A modeling study of coastal inundation induced by storm surge, sea-level rise, and subsidence in the Gulf of Mexico. *Natural hazards*, *71*(3), 1771-1794.

[82] Jury, M. R. (2009). An interdecadal American rainfall mode. Journal of Geophysical Research: Atmospheres, 114(D8).
Jury, M. R., & Gouirand, I. (2011). Decadal climate variability in the eastern Caribbean. Journal of Geophysical Research: Atmospheres, 116(D21).

[83] Solomon, S. (2007, December). IPCC (2007): Climate Change The Physical Science Basis. In AGU Fall Meeting Abstracts (Vol. 1, p. 01).

specific location are difficult to project and depend on factors ranging from local topography to ocean current. Data and projections specifically developed for the U.S. Virgin Islands are currently unavailable. However, Caribbean-wide dynamical downscaling has been completed and updated since 2003 by the University of the West Indies Mona Climate Studies Group and repeatedly found there to be a general tendency for drying by the end of the century (drying between 25-30%) with a possible wetter future for the northern Caribbean's dry season.[84,85] The results of this work provide climate projections for the entire Caribbean and the four 25km grid cells the cover the U.S. Virgin Islands show a possible precipitation change of -1.36% to 0.56% annual precipitation by the 2030s.

Downscaling global climate models for the U.S. Virgin Islands may provide insight into how general precipitation trends will play out spatially as well as temporally. As most models for the region are indicating an ongoing drying trend, the territory would do well to continue efforts to prepare for an increasing occurrence of droughts similar to the one experienced in the summer of 2015.

INCREASING AIR TEMPERATURES

The globally averaged combined land and ocean surface temperature data show a warming of 0.85°C [0.65 to 1.06°F] over the period 1880 to 2012, when multiple independently produced datasets exist. Global average temperatures have risen by 0.6ºC (1.1°F) since 1970 and can be expected to rise another 1-4 ºC (1.8-7.2°F) by the end of the 21st Century, depending on future societal practices and the amount of greenhouse gas emissions released into the atmosphere.[86]

In 2007, the 4th IPCC report projected that temperature increases for the Caribbean over this century would be slightly below the global average of 2.5 - 4°C (4.5 – 7.2°F), but slightly above the tropical average.[87] This is in contrast to the findings of Hayhoe (2013)[88] who used 32 different global climate models to simulate observed temperature and rainfall variability over the Caribbean and to generate future projections of temperature and precipitation for Puerto Rico. These future projections were analyzed in terms of model performance and changes projected for a range of global mean temperature targets, from +1 to +3°C, relative to 1971-2000 and indicated that Puerto Rico could warm faster than global averages. Likewise, Henareh et al. (2015)[89] found projected

[84] J.D. Campbell, M.A. Taylor, T.S. Stephenson, R.A. Watson, F.S. Whyte Future climate of the Caribbean from a regional climate model Int. J. Clim., 31 (2010), pp. 1866–1878 doi:10.1002/joc.2200

[85] Taylor, M. A., Whyte, F. S., Stephenson, T. S. and Campbell, J. D. (2013), Why dry? Investigating the future evolution of the Caribbean Low Level Jet to explain projected Caribbean drying. *International Journal of Climatology*, 33: 784–792. doi:10.1002/joc.3461

[86] IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

[87] Solomon, S. (2007, December). IPCC (2007): Climate Change The Physical Science Basis. In AGU Fall Meeting Abstracts (Vol. 1, p. 01).

[88] Hayhoe, K. (2013). Quantifying Key Drivers of Climate Variability and Change for Puerto Rico and the Caribbean Final Report 1 Oct 2011-30 Sep 2012. (pp. 241).

[89] Henareh Khalyani, A., Gould, W. A., Harmsen, E., Terando, A., Quinones, M., & Collazo, J. A. (2015). Climate change implications for tropical islands: Interpolating and interpreting statistically downscaled GCM projections for management and planning. *Journal of Applied Meteorology and Climatology*, (2015).

increases in temperature for Puerto Rico to be higher than that of global averages (4.6 °C to 9 °C (8 °F to 16 °F)). These findings provide insight into the dynamic nature of climate modeling and the variance in projections depending on the geographic scale being analyzed. They do not necessarily indicate that the Virgin Islands will warm at the same rate as Puerto Rico.

Caribbean-wide dynamical downscaling has been completed and updated since 2003 by the University of the West Indies Mona Climate Studies Group and repeatedly has found that irrespective of scenario or general circulation model used, the Caribbean is expected to warm (between 1ºC and 5ºC).[90,91] The results of this work provide climate projections for the entire Caribbean and the four 25km grid cells the cover the U.S. Virgin Islands show a possible increase of 1.39°C to 1.44°C mean annual temperature by the 2030s. CariCOF projections for January, February, and March of 2016 indicated above average temperatures for U.S. Caribbean territories.[92]

INCREASING SEA SURFACE TEMPERATURES

Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy accumulated between 1971 and 2010, with only about 1% stored in the atmosphere. On a global scale, the ocean warming is largest near the surface, and the upper 75 m warmed by 0.11 [0.09 to 0.13] °C per decade (0.20 [0.16 to 0.23] °F per decade) over the period 1971 to 2010. It is virtually certain that the upper ocean (0−700 m) warmed from 1971 to 2010, and it likely warmed between the 1870s and 1971.[93] Some studies put warming of the Caribbean Sea at 1.5°C over the last century.[94] Overall, sea temperatures are warmer (+0.7°C), and pH (−0.1 pH units) and carbonate-ion concentrations (~210 mmol kg−1) lower than at any other time during the past 420,000 years.[95]

While other factors affect coral health and play a part in triggering bleaching events, long-term data has suggested that repeated bleaching events may be the consequence of a steadily rising background sea temperature that will in the future expose corals and the species that depend on them to an increasingly hostile environment.[96] A study conducting at coral reef sites in La Parguera, Puerto Rico compared bleaching events to a 30 year record of sea surface temperatures

[90] Taylor, M. A., Whyte, F. S., Stephenson, T. S. and Campbell, J. D. (2013), Why dry? Investigating the future evolution of the Caribbean Low Level Jet to explain projected Caribbean drying. *International Journal of Climatology,* 33: 784–792. doi:10.1002/joc.3461

[91] J.D. Campbell, M.A. Taylor, T.S. Stephenson, R.A. Watson, F.S. Whyte Future climate of the Caribbean from a regional climate model *International Journal of Climatology*, 31 (2010), pp. 1866–1878 doi:10.1002/joc.2200

[92] CariCOF Seasonal Outlook for the Caribbean: http://www.meteosxm.com/wp-content/uploads/caricofondjfm2015.pdf

[93] IPCC (2014): Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

[94] Tompkins, E., S. A. Nicholson-Cole, L. Hurlston, E. Boyd, G. Brooks Hodge, J Clarke, G. Gray, N. Trotz, and L. Varlack. (2005). Surviving climate change in small islands. A guidebook. *Tyndall Centre for Climate Change Research*. (pp. 128)

[95] O. Hoegh-Guldberg, P. J. Mumby, A. J. Hooten, R. S. Steneck, P. Greenfield, E. Gomez, C. D. Harvell, P. F. Sale, A. J. Edwards, K. Caldeira, N. Knowlton, C. M. Eakin, R. Iglesias-Prieto, N. Muthiga, R. H. Bradbury, A. Dubi, M. E. Hatziolos (2007). Coral reefs under rapid climate change and ocean acidification. *Science*, *318*(5857), 1737-1742.

[96] Brown, B. E. (1997). Coral bleaching: causes and consequences. *Coral reefs*, *16*(1), S129-S138.

(SST) and found that three indices (max daily SST, days over 29.5°C, days over 30°C) correlated with severe bleaching events in 1969, 1987, 1990, and 1995.[97]

OCEAN ACIDIFICATION

Since the beginning of the industrial era, global oceanic uptake of CO_2 has resulted in acidification of the ocean with the pH of ocean surface water decreasing by 0.1. This change represents a 26% increase in acidity, measured as hydrogen ion concentration.[98] Earth System Models project a global increase in ocean acidification for all emission scenarios by the end of the 21st century, with a slow recovery after mid-century under reduced emission scenarios. The decrease in surface ocean pH is in the range of 0.06 to 0.07 (15 to 17% increase in acidity) up to 0.30 to 0.32 (100 to 109%) for the potential emissions scenarios analyzed in the IPCC's 5th report.[99] The combination of ocean acidification and sea surface temperature increases combine with issues of water quality and overexploitation of key species to present acute threats to coral health globally as well as within the Caribbean.[100] Studies have found ocean acidification to be rapidly changing the carbonate system of the world oceans and linked past mass extinction events to ocean acidification.[101]

Video monitoring of 100 randomly chosen, permanent transects at five study sites in the US Virgin Islands revealed widespread coral mortality following the Caribbean wide bleaching event of 2005. In the year following the event, disease outbreaks on the weakened coral reefs led to a reduction of coral cover at all study sites between 42.4 and 61.8%. Continued losses through October of 2007 reduced the average coral cover of the sites by 61% compared to pre 2005 levels.[102] Such events will likely become more common for the islands unless global GHG emissions are curbed dramatically. Healthy marine ecosystems provide a range of services to the USVI including viable fisheries, protection from storm surges and tourism.

SUMMARY

While climate projections for the Caribbean vary, most studies reviewed for this report agree that the region will experience continued warming (1° to 5°C) under all likely emission scenarios. The most recent Conference of Parties to the United Nations Framework Convention on Climate Change (COP21 UNFCCC) held in Paris in 2015 recognized the acute threat that climate change

[97] Winter, A., Appeldoorn, R. S., Bruckner, A., Williams Jr, E. H., & Goenaga, C. (1998). Sea surface temperatures and coral reef bleaching off La Parguera, Puerto Rico (northeastern Caribbean Sea). *Coral reefs*, *17*(4), 377-382.
[98] IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland (pp. 151)
[99] Ibid
[100] van Hooidonk, R., Maynard, J. A., Manzello, D. and Planes, S. (2014), Opposite latitudinal gradients in projected ocean acidification and bleaching impacts on coral reefs. Glob Change Biol, 20: 103–112. doi:10.1111/gcb.12394
Hoegh-Guldberg O1, Mumby PJ, Hooten AJ, Steneck RS, Greenfield P, Gomez E, Harvell CD, Sale PF, Edwards AJ, Caldeira K, Knowlton N, Eakin CM, Iglesias-Prieto R, Muthiga N, Bradbury RH, Dubi A, Hatziolos ME. (2007). Coral reefs under rapid climate change and ocean acidification. *science*, *318*(5857), 1737-1742.
[101] Guinotte, J. M., & Fabry, V. J. (2008). Ocean acidification and its potential effects on marine ecosystems. *Annals of the New York Academy of Sciences*, *1134*(1), 320-342.
[102] Miller J, Muller E, Rogers CS, Waara R, Atkinson A, Whelan KRT, Patterson M, Witcher B (2009). Coral disease following massive bleaching in 2005 causes 60% decline in coral cover on reefs in the US Virgin Islands. *Coral Reefs*, *28*(4), 925-937.

presents to the viability of life within small islands nations and agreed to set a new goal of limiting global mean temperature increase to 1.5°C above pre-industrial levels.[103] Given the potentially amplified effects of global climate change within the Caribbean and the US Virgin Islands,[104] the adoption of this goal represents a very positive step; however, as of February, 2016 the agreement had not yet been ratified by most conference parties and nationally determined emission reduction goals were believed to remain insufficient to achieve such goals.[105] Industrial countries such as the United States and China have pledged to significantly reduce GHG emissions prior by 2025, with promises to revisited progress and potentially increase reductions targets after 2020.[106] Global and national efforts to reduce GHG emissions will play a critical role in the extent to which the U.S. Virgin Islands experience negative impacts from climate change.

There is a strong need for downscaled climate model data at higher resolutions in order to better understand the how climate change effects will be felt throughout the varied life zones and ecosystems within the U.S. Virgin Islands. Dynamically downscaled data for Puerto Rico has revealed interesting potential trends in temperature as well as yielding critical insights into how precipitation patterns may vary and change in the future.[107] To address this need, the Southeastern Climate Science Center (SECSC) has funded North Carolina State University and Florida State University researchers to develop multi-model ensemble projections of climate variables for the U.S. Virgin Islands (and Puerto Rico). To do so the team is developing a suite of dynamically downscaled, nonhydrostatic climate model projections at 2 km resolution. The variables and time steps selected were derived with input from local researchers and natural resource managers in collaboration with the Caribbean Landscape Conservation Cooperative (CLCC) in November 2012. The results may provide the most spatially explicit portrait of the changes the islands may expect in the coming years, giving planners and policy makers within the territory a powerful planning tool. The resulting projections will include the period 2040 to 2060, and additional dynamic downscaling efforts will need to be initiated to provide relevant information beyond 2060.

The projected impacts of global climate change present some very significant challenges to the US Virgin Islands. Rising temperatures, intense tropical storms and ocean acidification may simultaneously threaten the islands' ability to produce or harvest its own food as well as draw in outside capital from marine based tourism. Comprehensive planning that employs the most up-to-date and accurate models will be necessary in order to avoid the most detrimental effects of climate change and put the islands' socio-economic and ecological systems on solid footing.

[103] UNFCCC Adoption of the Paris Agreement: https://unfccc.int/resource/docs/2015/cop21/eng/l09.pdf
[104] Hayhoe, K. (2013). Quantifying Key Drivers of Climate Variability and Change for Puerto Rico and the Caribbean Final Report 1 Oct 2011-30 Sep 2012. (pp. 241).
[105] UNFCCC Adoption of the Paris Agreement: https://unfccc.int/resource/docs/2015/cop21/eng/l09.pdf
[106] White House press statement on US-China Emissions deal: https://www.whitehouse.gov/the-press-office/2014/11/11/fact-sheet-us-china-joint-announcement-climate-change-and-clean-energy-c
[107] Henareh Khalyani, A., Gould, W. A., Harmsen, E., Terando, A., Quinones, M., & Collazo, J. A. (2015). Climate change implications for tropical islands: Interpolating and interpreting statistically downscaled GCM projections for management and planning. *Journal of Applied Meteorology and Climatology*, (2015).

HUMAN HEALTH

SECTOR OVERVIEW

According to the National Institute of Health, a changing climate impacts our health and wellbeing. The major public health organizations of the world have said that climate change is a critical public health problem. Climate change worsens many existing diseases and conditions, but it may also help introduce new pests and pathogens into new regions or communities. The most vulnerable people—children, the elderly, the poor, and those with underlying health conditions—are at increased risk for health effects from climate change. Climate change also stresses our health care infrastructure and delivery systems.[108] These assertions are consistent with what VI experts from the VI Department of Health and the University of the Virgin Islands recently presented in a health panel at the Climate Change in the Caribbean 2015: Puerto Rico & U.S. Virgin Islands Conference.[109]

INSTITUTIONAL FUNDING AND TECHNICAL CAPACITIES

The VI Department of Health currently depends on a staff of more than five hundred and a budget of more than forty-four million dollars.[110] Much of the funding comes from the General Fund, the Health Revolving Fund, other local funds as well as from U.S. Department of Health and Human Services, the Affordable Care Act (in recent years), and the Centers for Disease Control and Prevention. The FY 2016 budget includes $19.3 million in Federal Grants funding for the VI Department of Health, though the funds are not for climate change preparedness. They are in the areas of special supplemental nutrition program for women, infants and children, hospital preparedness and public health emergency preparedness aligned cooperative agreement, and immunization cooperative agreements project.

RELEVANT INSTITUTIONS

- VI Department of Health
- VI Department of Planning and Natural Resources Environmental Protection Division
- University of the Virgin Islands
- U.S. Department of Health and Human Services
- U.S. Environmental Protection Agency
- U.S. Department of Housing and Urban Development
- U.S. Department of Transportation
- U.S. Centers for Disease Control and Prevention

[108] http://www.niehs.nih.gov/research/programs/geh/climatechange/
[109] Ragster, L., Ellis, E.M., L.E. Petersen, Jr., N. Michael. 2015. Public Health Concurrent Session. Responding to Climate Variability and Change – What's been working in climate mitigation and adaptation. Climate Change in the Caribbean 2015 Conference, Inter American School of Law, San Juan, PR. 17 November 2015.
[110] VI Executive Budget 2016: http://stcroixsource.com/files/userfiles/file/0%202015/06%20June%202016/Executive%20Budget%202016_rfs.pdf

PROGRAMS AND RELEVANT PROJECTS BY INSTITUTION

AGENCY: *U.S. VIRGIN ISLANDS (VI) DEPARTMENT OF HEALTH*

The VI Department of Health functions as both the state regulatory agency and the territorial public health agency for the U.S. Virgin Islands. As set forth by the Virgin Islands Code, Titles 3 and 19, the VI Department of Health (DOH) has direct responsibility for conducting programs of preventive medicine, including special programs in Maternal and Child Health, Family Planning, Environmental Sanitation, Mental Health, and Drug and Substance Abuse Prevention. VI Department of Health also is responsible for health promotion and protection, regulation of health care providers and facilities, and policy development and planning, as well as maintaining the vital statistics for the population.

VI Department of Health provides Emergency Medical Services, issues birth and death certificates, performs environmental health services, and conducts health research and surveys. The VI Department of Health is also responsible for regulating and licensing health care providers and facilities, and assumes primary responsibility for the health of the community in the event of a disaster. Specifically the divisions of DOH are: Division of Community Health Services (including health care centers, nursing services, dental health and social services), Division of Mental Health, Alcoholism and Drug Dependency Services, Division of Epidemiology, Division of Communicable Disease, Division of Health Statistics & Research, Division of Environmental Health, Division of Family Health, Division of Chronic Disease and Prevention, Division of Facilities Management, Division of Health Insurance, Division of Fiscal Affairs, and the Division of Federal Grants Management.

PROGRAMS/OUTPUTS

VI Healthy People 2010

STATUS:	Assessment and Planning
APPROACH:	Integrated Assessment
MOTIVATION:	Decision and Stakeholder-driven

Healthy People 2010 is a U.S. national health promotion and disease prevention initiative launched in January 2000, through the U.S. Department of Health and Human Services. The ultimate goals are to increase the quality and years of healthy life and to eliminate health disparities among populations. Healthy People 2010 contains 467 objectives designed to serve as a road map for improving the health of all people in the United States during the first decade of the 21st century. These objectives are organized in 28 focus areas, each representing an important health area.

The Virgin Islands Department of Health, through a collaborative effort of a Task Force and community input, selected 21 Focus Areas and 127 objectives that are reflective of key health issues affecting the people of the territory. Each Focus Area has a target for improvements to be achieved by the year 2010. In 2003, DOH Office of Monitoring Health and the Bureau of Health Planning with the assistance of an inter-departmental Steering Committee and Focus Area Team Leaders and Members completed the plan *Virgin Islands Healthy People 2010: Improving Health*

for All,[111] a comprehensive plan of territorial health care objectives. The report was supported by a State Partnership Grant from the U.S. Department of Health and Human Services, Office of Minority Health, a grant from the U.S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion and by the U.S. Department of Health and Human Services, Public Health Service, Region 2, Regional Health Administrator's Office and Office of Minority Health.

The USVI selected twenty-one focus areas and one hundred twenty-seven objectives to create the plan using the national Healthy People 2010 Plan as a guide. The top priorities were nutrition, access to quality health care, disease control and prevention, substance abuse and family planning. Environmental exposures were not made a priority in the VI Healthy People 2010 Plan.[112] However, a number of objectives under Goal 8: Environmental Health could be affected by climate change and this section discusses the presence of health disparities. "While the environment affects human health in general, environmental health threats do not weigh evenly on all segments of the population. Unfortunately, there are many populations that are more vulnerable to the environmental health challenges than others. The elderly, children and in many cases monitoring populations and the impoverished are among these vulnerable populations.[113]". The report writers did not use local USVI statistics for this report section, though did mention the USVI agencies connected with environmental health objectives. The environmental health objectives that are affected by climate change are:

- 8-5: Increase the proportion of persons served by the community water systems who receive a supply of drinking water that meets the regulation of the Safe Drinking Water Act. (Potential Data Source: DPNR)

- 8-10: Reduce the number of beach closings that result from the presence of harmful bacteria. (Potential Data Source: DPNR)

- 8-12: Minimize the risks to human health and environment posed by hazardous sites. (Potential Data Source: DPNR, VITEMA, DOH)

- 8-21: Ensure that State health departments establish training, plans, and protocols and conduct annual multi-institutional exercises to prepare for response to natural and technological disasters. (Potential Data Source: DPNR, VITEMA)

[111] Plan found through google search. [Accessed on 13 Feb 2016]: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwiY5MX73fXKAhXCOCYKHSfhBzkQFggdMAA&url=http%3A%2F%2Fwww.ibrarian.net%2Fnavon%2Fpaper%2FUnited_States_Virgin_Islands_Healthy_Virgin_Islan.pdf%3Fpaperid%3D3234307&usg=AFQjCNE8ooCoiOCXaeH33u_o98TM7GzCdw

[112] Note: Update on the priority for the Health People 2020 Plan unknown

[113] Page 48 of the Healthy People 2010 Plan

At least three other health goals in the 2003 report that are affected by climate change are infectious diseases, respiratory diseases, and public health infrastructure.
The VI Department of Health is currently beginning to plan for Healthy People 2030.[114]

Program of Public Health Preparedness

The U.S. Virgin Islands Department of Health (VIDOH) Office of Public Health Preparedness Program (PHP) was created in 2001. The purpose of the program is to improve public health preparedness capacity by ensuring coordination among local, territorial, state, and federal agencies, including health care partners before, during, and after public health events.

Local, territorial, and state public health authorities have always played an important role in all phases of the emergency management system, including: preparedness planning and hazard mitigation, emergency response, and disaster recovery. This new level of commitment to public health preparedness improves local and territorial capacity to respond to any health emergency.
The Public Health Preparedness Program is funded by the U.S. Department of Health and Human Services through the U.S. Centers for Disease Control and Prevention (CDC) Cooperative Agreement and the Health Resource and Service Administration (HRSA).

Public Health Preparedness activities include ongoing, periodic assessments of public health system capacities related to pandemics, outbreaks, chemical & biological events, and other public health emergencies to improve planning, coordination, and implementation, developing and exercising a comprehensive public health emergency preparedness plan to respond to emergencies caused by bioterrorism and other public health emergencies, coordinating with federal agencies to ensure state, local, and regional preparedness for bioterrorism and other public health emergencies, ensuring the U.S. Virgin Islands Healthcare Delivery system has the capacity to respond to all public health emergencies, managing the CDC Strategic National Stockpile (SNS), should it be deployed in U.S. Virgin Islands and preparing SNS plans and periodic exercises to train individuals who are part of SNS preparedness, and lastly operating the Secure Virgin Islands Health Alert Network (HAN), as part of the national CDC HAN program and its affiliated information systems.

Environmental Justice

The VI Department of Health directed us to the environmental justice strategies of key federal agencies as the programs, actions, and resources included in these strategies have the potential to benefit the Territory in its climate adaptation and mitigation work. *Environmental Justice* is defined by the U.S. EPA as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies".[115] On February 11, 1994, President

[114] Dr. Michelle Davis (USVI Commissioner Nominee of VI DOH) in discussion with Stevie Henry, February 10, 2016
[115] U.S. Environmental Protection Agency (EPA). "Environmental Justice;" http://www.epa.gov/environmentaljustice/

William J. Clinton signed Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.*[116] The Executive Order requires each federal agency to "make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations;" Specifically, the Executive Order 12898 requires that each agency develop an agency-wide environmental justice strategy specific to the agency's mission. Additionally, a Federal Interagency Working Group on Environmental Justice of 17 Federal agencies and White House offices was established under the Executive Order to guide, support and enhance federal environmental justice and community-based activities.

In the U.S. Virgin Islands , four federal programs that work on public health and have an environmental justice strategy are: U.S. Department of Health and Human Services,[117] U.S. Environmental Protection Agency,[118] U.S. Department of Transportation,[119] and U.S. Department of Housing and Urban Development.[120] Each strategy (and their associated annual progress reports) describes the agency's statutes, regulations and practices, interagency collaborations, available education and training resources, and case studies (none in the U.S. Virgin Islands to our knowledge), Additionally, potential funding opportunities are available to the U.S. Virgin Islands for climate projects that are related to environmental justice. The Interagency Working Group has a guide for all 17 agencies and the funding programs available.[121]

AGENCY: *UNIVERSITY OF THE VIRGIN ISLANDS*
UNIVERSITY OF THE VIRGIN ISLANDS PROGRAMS/OUTPUTS

STATUS:	Assessment
APPROACH:	Risk Management
MOTIVATION:	Research

In response to an application submitted by the Division of Nursing, University of the Virgin Islands (UVI), in 2004 the National Institutes of Health, National Center on Minority Health and Health Disparities (NIH/NCMHD) awarded a three-year grant to establish "The Caribbean EXPORT Center for Research and Education in Health Disparities." The Export Center provided support for UVI faculty to develop the capacity and infrastructure to begin to investigate and address health issues and disparities in the USVI. Later, in October 2007, a five-year NCMHD grant was awarded

[116] Executive Order No. 12898, 59 Fed Reg. 7629 (Feb. 11, 1994)
[117] http://www.hhs.gov/environmental-justice/
[118] http://www3.epa.gov/environmentaljustice/ej2020/index.html
[119] http://www.fhwa.dot.gov/environment/environmental_justice/ej_at_dot/dot_ej_strategy/index.cfm
[120] http://portal.hud.gov/hudportal/HUD?src=/program_offices/economic_resilience/Environmental_Justice_Strategy
[121] https://www3.epa.gov/environmentaljustice/resources/publications/interagency/resource-guide.pdf

to establish the "Caribbean Exploratory Research Center[122]" (CERC) and continue and expand this work.

In 2009, the National Institute of Minority Health and Health Disparities funded CERC for basic research into public health challenges linked to climate change and efforts to increase public awareness of the related challenges. In addition to a 2011 Sunday television program, "Climate & Health: New Challenges for the Virgin Islands", which is now available on YouTube,[123] the public awareness effort also included conducting several focus groups, disseminating information to the media and creating a website to share information (the website is no longer operational but was www.myhealthwhatsclimategottodowithit.com). Drs. Glorida Callwood and LaVerne Ragster were the project's co-principal investigators.

In 2012, the Center conducted a study[124] to improve the understanding of the top health challenges facing residents of the USVI using the rough sketch provided by the VI Healthy People 2010 Plan as a basis. The researchers wanted to know how do residents of the USVI view health, their health status, health problems, and the quality of their health care delivery system? They collected data from six focus group sessions that were conducted on the three largest islands. Participants varied in age and education and had a range of ethnic heritages that were similar to the age, education and ethnicity distributions in the wider population. The study found the following results:

1. What constitutes good health? There was consensus both between and within groups that "health" was not simply the absence of disease or disability. Instead, typical responses defined "health" as;

    - "feeling good, energized, without *disease*; i.e., not in pain or discomfort"
    - "in physical, mental, and spiritual balance"
    - "being physically fit"
    - "meeting accepted standards for levels for blood pressure, sugar, cholesterol, and weight"
    - "good stress management"
    - "strong self-esteem"

In the USVI, where geographical proximity leads to lifelong relationships perhaps more so than on the mainland, having positive relationships with others was also seen as an important dimension of good health. Indeed, two older participants stated that to them "health" meant an ability to help others. All participants acknowledged that one's perception of health was dependent on culture and lifestyle, so, indeed, health was not understood as a monolithic or one-dimensional concept.

[122] http://www.cercuvi.com/
[123] https://www.youtube.com/watch?v=CsXmRKZnNwM
[124] Callwood, G. B., Campbell, D., Gary, F., & Radelet, M. L. (2012). Health and Health Care in the U.S. Virgin Islands: Challenges and Perceptions. *The ABNF Journal : Official Journal of the Association of Black Nursing Faculty in Higher Education, Inc*, *23*(1), 4–7. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3573759/

For some, the definition of health was strongly linked to their religious beliefs. This finding is important when considering how to address climate change impacts to health in the Virgin Islands and designing interventions. This concept was stressed at the Climate Change in the Caribbean 2015: Puerto Rico & U.S. Virgin Islands conference VI Health Panel in 2015 in San Juan, Puerto Rico.

2. Health Care Problems: What are the most crucial health care problems? The five most important health issues identified by members of the focus groups were Diabetes, Heart Disease, HIV/AIDS, Asthma, and Hypertension. The majority of participants expressed concerns about limited resources and high costs, such as the Medicare gap, high cost of insurance and co-pay, large number of uninsured residents, and the overall cost of services.

3. Barriers to good health and good health care: Next, the focus groups talked about what they saw as barriers to good health and good health care. All groups talked about financial constraints, which were seen as more of a national than a local problem. Three additional types of barriers were identified that are more specific to the USVI.
   First, there are barriers to good health that can be addressed by better professional training and education. There was concern that health care providers from the U.S. mainland were not culturally competent, and about significant provider-patient communication obstacles based on patients' use of language that providers may misunderstand. Several female participants felt that male providers were not sufficiently respectful. There was also concern about a declining number of Public Health Nurses, who were active in communities until the mid-1980s, following up on patients discharged from hospitals and on newborn infants and their mothers.
   Second, some barriers to good health can be addressed by more rigorous enforcement of existing policies. By far the most widespread concern, expressed by several participants in different focus groups, concerned patient confidentiality and privacy. Overall, trust and confidence in the health system is markedly low; concern for confidentiality is high. While part of the problem may stem from insufficient training for health professionals, it is also clear that participants feel that enforcement of rules protecting confidentiality is sorely lacking. In part this may be because health care staff who are overworked and underpaid can become careless, but the comments indicate that some concerns with confidentiality stem from living in an island community where everyone seems to know everyone else.
   Third, some barriers could be addressed by better coordination, planning, and/or financing. Included here is confusion about where best to go to receive specific health services and doubt about the range and limits of services provided by the Department of Health. Some participants did not know which problems were best treated in local clinics or physicians' offices vs. hospital emergency rooms.

4. Personal Responsibility. What is the role of personal responsibility in attaining good health? Regardless of whether one uses "mainstream" or "alternative" sources of health

care, all respondents agreed that good health requires at least some personal responsibility. For example, the older respondents pointed to health problems caused by fast-food obesity and a declining participation (among all age groups) in physical activities. They stated that behaviors such as going to Church or to the beach were important in achieving and maintaining good health. All participants recognized the importance of healthy diets and proper exercise in achieving good health. Several participants also stated that because of the high cost of health care, they would exhaust home remedies before seeking professional medical health care. All groups reported the use of herbs, bush tea, alternative medical practitioners (usually without disclosure to mainstream health providers), and suggested that the health care establishment develop high standards for, and dispel myths about, complementary and alternative medicine.

5. How Health Care Providers are Viewed: Next, the focus groups were asked to share their feelings about health care professionals' "customer service." Neither surprisingly nor unique to the USVI, several respondents pointed to long waiting times as a problem in clinics, physicians' offices, and hospitals. Some stated that the health care providers do not spend enough time with patients (especially the elderly), and/or that the providers do not give their undivided attention to the patient during the office or clinic visit. Further, several participants saw a need to adjust clinic hours so that services are available in the evenings and on weekends. Others suggested that it was necessary to go off-island (e.g., to Puerto Rico or even to the U.S. mainland) to get decent health care. Some felt there was an insufficient level of cultural understanding and respect throughout the health care system, and insufficient appreciation of the subtleties of the culture in the USVI from non-native health care providers who had been trained off-island. In short, the data revealed a crucial need for better training for health care providers in customer service, which is categorized as inefficient, insensitive, and of such poor quality that staff sometimes make clients feel like "victims".

6. Sources for Health Information: Where do people in the USVI obtain health information? Two principal sources were identified: the Health Department and family/friends. Respondents felt that there was plenty of "formal" or written information available, although the information was not always disseminated in effective ways (e.g., in Spanish). Respondents identified several effective means of communicating health care information: brochures, radio and TV spots, public gatherings (e.g., races and walks), and through churches, barber shops, and beauty salons. Overall, respondents tended to see more health information as an opportunity for empowerment and increasing the level of personal responsibility for health.

AGENCY: U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

UNITED STATES DEPARTMENT OF HEALTH AND HUMAN SERVICES PROGRAMS/OUTPUTS

It is the mission of the U.S. Department of Health & Human Services (HHS) to enhance and protect the health and well-being of all Americans. They fulfill that mission by providing for effective health and human services and fostering advances in medicine, public health, and social services. The U.S. Department of Health and Human Services and the Environmental Protection Agency has a long history of focusing on health consequences of environmental exposures.[125] The U.S. Department of Health and Human Services Healthy People initiatives set national goals for a robust and efficient health care system. For example, the Healthy People 2010 (HP2010) identified ozone exposure as a component of air pollution. In 2009, the ozone exposure of Americans was 36% this exceeded the HP2010 target of 0%.[126] The progress on each of the goals is assessed by an ecological model of health. As described previously the VIDOH uses the Healthy People guidance for local strategic planning and indicator setting. Additionally, HHS has a Climate Adaptation Plan[127]

Agency: U.S. Centers for Disease Control and Prevention[128]

The U.S. Centers for Disease Control and Prevention (CDC) works 24/7 to protect America from health, safety and security threats, both foreign and in the United States. Whether diseases start at home or abroad, are chronic or acute, curable or preventable, human error or deliberate attack, CDC fights disease and supports communities and citizens to do the same. The CDC's Climate and Health Program[129] is the only HHS investment in climate change adaptation. They support state and city health department efforts to develop and pilot methods to adapt to the present and future health effects of climate change, such as from extreme heat, severe storms, floods and droughts, pollen and air quality and infectious disease. Their program accomplishes this through funding provided to 16 states and two cities through the Climate Ready States and Cities Initiative (CSCRI). The Virgin Islands is not currently a grantee of CSCRI. Funded states use the Building Resilience Against Climate Effects (BRACE) framework to identify likely climate impacts in their communities, potential health effects associated with these impacts, and their most at-risk populations and locations. BRACE helps states develop and implement health adaptation plans that impact health and address gaps in critical public health functions and services.

Climate and health programs by the CDC were not identified for the U.S. Virgin Islands, however, the CDC is working with the VI DOH to respond to Dengue outbreaks and the spread of Chikungunya and Zika to the region. They also frequently update their heath information for

[125] Fielding et al. 2012. Healthy Reform and Healthy People Initiative. Am J Public Health 102(1): 30-33. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3490564/

[126] Fielding et al. 2012. Healthy Reform and Healthy People Initiative. Am J Public Health 102(1): 30-33. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3490564/

[127] http://www.hhs.gov/sites/default/files/about/sustainability/2014-climate-change.pdf

[128] Information compiled in this section was gathered by Amanda Leinberger, NOAA Coastal Management Fellow in the Puerto Rico Coastal Zone Management Program.

[129] http://www.cdc.gov/climateandhealth/default.htm

travelers to the U.S. Virgin Islands (for clinicians[130] and travelers[131]). In their communications they always encourage actions by local residents to get rid of mosquitoes around the house by emptying or eliminating mosquito breeding sites and wearing a mosquito repellant. Recently, for Zika they are also issuing strong recommendations for pregnant women. We could not find climate analyses by the CDC related to these vector-borne diseases in the U.S. Virgin Islands. Studies have been completed in other areas, such as Puerto Rico.

US CENTERS FOR DISEASE CONTROL AND PREVENTION PROGRAMS/OUTPUTS

Online resources available to the VI Department of Health

The CDC Climate and Health Program website[132] has a variety of online information and a few tools. One such tool is *Assessing Health Vulnerability to Climate Change: A Guide for Health Departments*.[133] This document provides guidance for health departments on how to assess local vulnerabilities to health hazards associated with climate change. A climate and health vulnerability assessment allows health departments to understand the people and places in their jurisdiction that are more susceptible to adverse health impacts associated with climate change. This assessment of people and place vulnerability can then be used to implement targeted public health interventions to reduce the burden of public health impacts.

[130] http://wwwnc.cdc.gov/travel/destinations/clinician/none/usvirgin-islands
[131] http://wwwnc.cdc.gov/travel/destinations/traveler/none/usvirgin-islands
[132] http://www.cdc.gov/climateandhealth/default.htm
[133] http://www.cdc.gov/climateandhealth/pubs/AssessingHealthVulnerabilitytoClimateChange.pdf

HUMAN HEALTH SECTOR SUMMARY

According to the National Institute of Health, a changing climate impacts our health and wellbeing. The major public health organizations of the world have said that climate change is a critical public health problem. Climate change makes many existing diseases and conditions worse, but it may also help introduce new pests and pathogens into new regions or communities. The most vulnerable people—children, the elderly, the poor, and those with underlying health conditions—are at increased risk for health effects from climate change. Climate change also stresses our health care infrastructure and delivery systems. These assertions are consistent with what USVI experts from the VI Department of Health and the University of the Virgin Islands recently presented in a health panel at the Climate Change in the Caribbean 2015: Puerto Rico & U.S. Virgin Islands Conference.

A review of the USVI health sector indicates that there has been limited published scholarly research that addresses health issues and health disparities in the U.S. Virgin Islands. The available studies are primarily national surveys such as the Behavioral Risk Factor Surveillance System (BRFSS) that have included participants from the USVI. The USVI has several health programs/ outputs but none have addressed the direct impacts of climate change on the health sector, apart from a 2009-2011 UVI public awareness campaign. However, new guidance, national strategies, and web-based resources from the Federal Government for Healthy People 2030 from the U.S. Department of Health and Human Services, the U.S. Centers for Disease Control and Prevention and an assortment of agencies' environmental justice strategies and programs are potential opportunities for the territorial agencies responsible for health and wellbeing services to address climate change. Human Health appears to be the sector with the least amount of existing capacity in the Territory to deal with climate adaptation or risk reduction, followed by the tourism sector. This is largely because of the limited programs found as well as the limited linkage between health and other sectors. Public health institutions do not benefit as directly from the work of other sectors.

Notable Nuggets
Climate Change Research and Program Results in the
U.S. Virgin Islands for Human Health

While the above programs have not explicitly addressed climate change in the past some of their information is relevant:

- "A unique factor, which affects the territory's infrastructure, is the increased incidence of powerful hurricanes, that have struck the territory in the past decade. In 1989, the devastating Hurricane Hugo struck St. Croix and destroyed 95% of the homes. In 1995, Hurricane Marilyn, a powerful Category III hurricane, struck St. Thomas. On St. Thomas, 92% of the homes were damaged (habitable) or destroyed (inhabitable); on St. Croix and St. John, 71% and 86%, respectively of housing units were affected[134]).

- In 1997, Hurricane Georges, a Category II caused additional infrastructure damage. Millions of dollars in disaster loans have accumulated and millions of dollars have been lost due to the impact on the tourist industry. In November 1999, Hurricane Lenny – Category II – passed south of St. Croix and caused additional damage to buildings and the infrastructure. While there were no major storms in the past year, the territory and its residents experience the economic impact of high insurance rates and construction costs" (VI Health People Plan 2003).

[134] Source: MMWR Vol. 45/No.4

CRITICAL INFRASTRUCTURE

SECTOR OVERVIEW

The Territory's critical infrastructure provides essential services that are vital to public confidence and the islands' safety, prosperity and well-being. According to the U.S. Department of Homeland Security, there are 16 critical infrastructure sectors whose assets, systems, and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof: chemical sector, commercial facilities, communications, critical manufacturing, dams, the defense industrial base, emergency services, energy, financial services, food and agriculture, government facilities, healthcare and public health, information technology, nuclear reactors, materials and waste, transportation systems, and water and wastewater systems.[135] Not all of these sectors apply to the Virgin Islands and some are covered in other sections of this report. Here we concentrate on transportation, communications, energy, materials and waste, and water and wastewater systems.

Critical infrastructure must be secure and able to withstand and rapidly recover from all hazards and to achieve this a coordinated and integrated effort across prevention, protection, mitigation, response and recovery is required. Additionally, the operations and functions of critical infrastructure may result, depending on the asset in question, in increased emissions that contribute to the climate changes already being experienced and that will be experienced in the future in USVI. A number of efforts are underway that have made progress in climate adaptation and mitigation though quite a few strategic planning efforts around the territory's critical infrastructure sectors by owners and operators do not include climate-risk management and are identified as potential opportunities.

INSTITUTIONAL FUNDING AND TECHNICAL CAPACITIES

RELEVANT INSTITUTIONS

- VI Department of Public Works
- VI Waste Management Authority
- VI Water and Power Authority
- VI Emergency Management Agency
- VI Energy Office
- VI Public Services Commission
- VI Port Authority
- U.S. Department of Energy
- U.S. Department of Transportation
- U.S. Federal Emergency Management Agency
- National Oceanic and Atmospheric Administration
- U.S. Environmental Protection Agency
- U.S. Department of Commerce
- U.S. Depatment of Interior

[135] U.S. Department of Homeland Security, Critical Infrastructure Sectors as defined by section 1016(e) of the USA Patriot Act of 2001 (42 U.S.C. 5195c(e)),: http://www.dhs.gov/critical-infrastructure-sectors

As in other sectors, the programs in the Territory around critical infrastructure are conducted heavily in partnership with the U.S. Federal government. Funding comes from the VI General Fund and federal grant programs. Each of the critical infrastructure programs and projects also demonstrate a variety of inventorying, modeling and analysis, GIS and mapping, stakeholder engagement, and education and outreach technical capacities available in or for the Territory.

PROGRAMS AND RELEVANT PROJECTS BY INSTITUTION

AGENCY: U.S. VIRGIN ISLANDS DEPARTMENT OF PUBLIC WORKS

The USVI Code lays out the functions of U.S. Virgin Islands Department of Public Works (VI DPW)[136] as planning, supervising the construction of, repairing and maintaining all government buildings, public roads, highways, seawalls, wharves, seaways, public recreation areas, airports, and properties of like character as well as repairing and maintaining other government-owned public utilities, and recommend methods for their maintenance, provide engineering and land survey services, plan for public works, and cooperate with the Federal Government.

USVI DEPARTMENT OF PUBLIC WORKS PROGRAMS/OUTPUTS

U.S. Virgin Islands Comprehensive Transportation Master Plan (CTMP)

STATUS:	Planning
APPROACH:	Impact-based
MOTIVATION:	Stakeholder and Decision-driven

In 2009 the VI Department of Public Works initiated the development of the 2030 USVI Comprehensive Transportation Master Plan (CTMP).[137] The purpose of the plan is to identify transportation strategies based on our future growth and development, and serve as a framework to prioritize what transportation investments are most important to insure the continued quality of life of Virgin Islanders. A number of agencies comprise the CTMP Executive Committee: Department of Public Works, Port Authority, Federal Highways Administration, the Federal Transit Administration, Department of Planning and Natural Resources, and the Office of the Governor. An advisory committee of over 15 public and private entities and a community advisory group are part of the process as well. The plan has recommendations for the Territory's entire transportation network and covers all modes of travel: private automobiles, buses, taxis, safari taxis, ferries, and seaplanes. The committee chose the year 2030 to follow the Federal Highway Administration's guidelines for master planning, which requires a horizon year 20 years out. The guidelines also require that existing conditions are examined; plans for the short-term, or immediate needs identified; and the long-term, or future

[136] http://dpw.vi.gov/wp-content/uploads/2015/06/Functions-of-Commissioner-Public-Works.pdf
[137] 2030 USVI Comprehensive Transportation Master Plan (draft - not adopted): http://usvitransportationplan.com/the_plan/

needs based on the direction of the plan in terms of overall solutions and strategies. To develop the draft plan, currently not adopted, committee meetings were held on all three islands to discuss the data collected and the transportation needs of the islands. Territory-wide public meetings were first held in July of 2009 to introduce the project team and preliminary data collected and an overview of the planning process. Public meetings occurred again in May of 2013 on St. John, St. Thomas and St. Croix to provide an update on the USVI 2030 Transportation Master Plan that included a summary of the goals and objectives of the study, the data collected to date, and a presentation of the list of projects identified as needs by the community.

The data collected for the draft plan in 2013 included 1980, 1990, and 2000 census data, visitor surveys, household surveys, transit surveys and ridership, zoning and subdivision ordinance, USVI National Park transportation plan, final report on assessment of zoning and subdivision ordinance, traffic counts on all three islands, roadway inventory on all three islands, land use parcel data, USVI Executive Order 333 1991, major project permits, and roadway classification data. In 2009 the project team had presented on the need to have land use data from 1999-2009, future land use projections to 2030, vehicle registrations, emission data, historic, cultural and archaeological resources, bridge data, economic development projections, employment centers and densities, airport and seaport master plans, rental car statistics, U.S. Virgin Islands Transportation Improvement Program (TIP), the American Recovery and Reinvestment Act (ARRA), local aid, bond project descriptions and mapping, traffic counts, visitors survey results and transit ridership. It is unclear based on the materials available on the master plan whether all this data was successfully collected. A progress report presentation in 2013[138] lists on-going efforts to develop the GIS database to include: sidewalk inventory, VITRAN system inventory and mapping, sign and sign inventory, road centerline/street names, guardrail inventory, visual assessment of pavement conditions, accident analysis database assessment, GIS needs assessment, and staff training. At a 2009 community meeting organized by the Environmental Association of St. Thomas-St. John the Public Works Commissioner Darryl Smalls presented the transportation plan and described how the data was collected. The analyses confirmed that the territory's road conditions are deteriorating and congestion is increasing. At this 2009 meeting the Commissioner stated the St. Thomas waterfront has approximately 28,000 more vehicle trips per day than it was designed to carry. The traffic counts were not conducted during the height of the tourist season but most were done on days when there were two or three ships in the harbor.

The USVI DPW leaders and project team developed the vision, 9 goals, and objectives with public involvement. A few of the plan's goals could arguably be affected by climate change, in particular Goal 5, which is described as, "Environmental Sustainability and Land Use: to ensure that the transportation system supports the development of communities that provide transportation choices and preserves the Territory's natural, historic and cultural resources".[139] While not stated explicitly, a few of the objectives apply to climate mitigation and adaptation, such as "reduce the reliance on fossil fuel use of the transportation system" through increased public transit services

[138] 2030 USVI Master Transportation Plan Project Overview, May 2013: http://usvitransportationplan.com/pdfs/0513_presentation_stx.pdf
[139] 2030 Comprehensive Transportation Master Plan Vision, Mission, Goals & Objectives: http://www.usvitransportationplan.com/pdfs/goals_chart_040309.pdf

and bicycle and pedestrian facilities, "avoid, minimize, or mitigate potential adverse effects of transportation on the natural, historical, and cultural resources of USVI", and "reduce impervious surfaces where possible".

AGENCY: U.S. VIRGIN ISLANDS WASTE MANAGEMENT AUTHORITY

The U.S. Virgin Islands Waste Management Authority (VIWMA) was established in January 2004 by Act. No. 6638 as an autonomous Government Corporation, independent of the Government of the U.S. Virgin Islands and similar in structure to the U.S. Virgin Islands Water and Power Authority. As part of the legislation, a Board of Directors[140] was created, comprised of seven (7) experienced and knowledgeable community members and representatives of the U.S. Virgin Islands. Government. The VIWMA was created to develop and implement a comprehensive waste management program which would provide financial accountability, fiscal management and operational efficiency of the Territory's waste management programs, thus ensuring the continued protection of public health and the environment. It is responsible for its own debts, assets, contracts, expenditures, funds, facilities and property.

The VIWMA is comprised of two main operations divisions: Solid Waste[141] and Wastewater.[142] The Office of Compliance Management and Environmental Enforcement[143] is the support arm of the operations division. These divisions are additionally supported by the Office of the Executive Director, which also includes the General Counsel, Communications Management,[144] Information Technology,[145] and Environmental Health and Safety,[146] the Division of Program Development,[147] which includes Planning, Environmental Programs[148] and Engineering,[149] and the Divisions of Finance, Human Resources, and Procurement and Property.[150] As of April 2015, VIWMA accepts solid waste at the Bovoni Landfill and the St. Croix Transfer Station daily, operates and maintains 8 wastewater treatment plants, 30 pump stations, and approximately 210 miles of 193 underground pipelines which collect, transport, treat and dispose of approximately 1.7 Billion gallons of wastewater annually. They serve approximately 60% or 23,000 residential and commercial properties territory wide for wastewater treatment. All facilities and infrastructure are currently operated by in-house staff with the exception of the two largest 198 treatment plants, the Harold M. Thompson (Anguilla) and Pedrito A. Francois (Red Point) WWTP's, which are operated by the contractor Veolia Water North America (VWNA). The VIWMA's other contract partners provide resources for infrastructure repairs, support services and system repairs & maintenance.

[140] http://www.viwma.org/About_WMA/Board-of-Directors.aspx
[141] http://www.viwma.org/Business_Information/Solid_Waste_2.aspx
[142] http://www.viwma.org/Divisions/Wastewater.aspx
[143] http://www.viwma.org/Divisions/Compliance_Management_n_Environmental_Enforcement.aspx
[144] http://www.viwma.org/Divisions/Communications_Management.aspx
[145] http://www.viwma.org/Divisions/Administrative_Services.aspx
[146] http://www.viwma.org/Divisions/Environmental_Health_and_Safety.aspx
[147] http://www.viwma.org/Item not found: %5bSitefinity%5db668c2ab-c995-47b6-b178-17387cb4bb6b
[148] http://www.viwma.org/Divisions/Solid_Waste/Environmental_Programs.aspx
[149] http://www.viwma.org/Divisions/Engineering.aspx
[150] http://www.viwma.org/Divisions/Procurement.aspx

USVI WASTE MANAGEMENT AUTHORITY PROGRAMS/OUTPUTS[151]

Periodic pre-hurricane and post-hurricane assessment of sewage pump stations; the LBJ Pump Station and Lagoon Street Pump stations most critical due to multiple 100 year flood event within 5 years.

STATUS:	On-going Assessment and Needs-based
APPROACH:	Impact and Vulnerability-based
MOTIVATION:	Decision-driven

Assessments are being completed on an as-needed basis of coastal erosion impacting sewage lines allowing salt water intrusion.

STATUS: Assessment and Needs-based	
APPROACH:	Impact and Vulnerability-based
MOTIVATION:	Decision-driven

Utilization of treated sewage water to supplement water use of agriculture production. VIWMA started discussions during 2015 drought with Department of Planning & Natural Resources and the Department of Agriculture.

STATUS:	In progress Assessment
APPROACH:	Integrated Assessment
MOTIVATION:	Decision-driven

AGENCY: U.S. VIRGIN ISLANDS WATER AND POWER AUTHORITY

USVI WATER AND POWER AUTHORITY PROGRAMS/OUTPUTS

The U.S. Virgin Islands Water and Power Authority (WAPA) is a semi-autonomous agency of the Government of the U.S. Virgin Islands that produces and distributes electricity and potable water, as of 2014, to approximately 55,000 electrical customers and 13,000 potable water customers. WAPA does not have an explicit policy or assessment of the Authority's risk and vulnerabilities to the impacts of climate; however, it has been building its capacity to conduct such an assessment. Over the past five years, WAPA has been investing and integrating GIS technology into monitoring and managing the utility's assets. The managers of the system have given testimony to the return on the investment in GIS/GPS technology in the restoration efforts of Post Hurricane Irene.[152]

[151] Anne Hanley of the Virgin Islands Waste Management Authority, interview by Stevie Henry, January 2016
[152] Leedy, The Source Newspaper Article, April 21, 2011

The PWD Proposed 2030 Master Transportation Plan goals 5.3 and 5.4 identify mitigation and adaptation efforts for addressing climate change:

5.3 Reduce the reliance on fossil fuel use of the transportation system.

STATUS:	Planning
APPROACH:	Integrated Assessment
MOTIVATION:	Decision & Stakeholder

5.4 Improve mobility, promote healthy lifestyles, and reduce air pollution and congestion through increased public transit services and bicycle and pedestrian facilities.

Additionally, WAPA partnered with FEMA on a multi-million dollar project on St. Thomas called Backstreet Underground Project. This project is part of the hazard mitigation program to transfer overhead lines and pole mounted transformers to a new underground electric infrastructure. Work includes the electrical manholes, pad mounted transformers, installation and termination of primary and secondary cables for Wilmeskafts Gade in Charlotte Amalie.[153] Current status of the project is unknown by the report writing team but an October 2013 WAPA[154] newsletter describes the project as complete (at a total cost of $3,175,819) and states, "With the installation of this primary underground system in downtown, the risk of distribution system damages caused by high winds during storms and the risk to human life in the area are reduced. It also decrease line loss on the distribution system, enhances future load expansion...makes the area more aesthetically pleasing".

STATUS:	Implementation
APPROACH:	Impact Based
MOTIVATION:	Decision & Stakeholder

AGENCY: U.S. VIRGIN ISLANDS EMERGENCY MANAGEMENT AGENCY

The U.S. Virgin Islands Emergency Management Agency (VITEMA) is the territorial agency with primary responsibility for ensuring the territory's resilience to disasters. VITEMA's staff of professional planners, communications specialists, logicians, operations managers and support personnel is committed to an all hazards approach to emergency management. The components of VITEMA include logistics, preparedness, operations, grant management, administration, finance and recovery. Most directly related to climate change, is the Preparedness unit that develops and exercises the Territorial Emergency Operations Plan (TEOP), as well as monitors its implementation. The unit identifies critical areas in the community and recommends priorities for

[153] Page 49 of http://www.usviber.org/CEDS%20Plan%202015.pdf
[154] VI WAPA. 2013. The Current Flow http://www.viwapa.vi/Libraries/PDFs/Current_Flow--Oct_2013.sflb.ashx

addressing gaps. It accomplishes this through hazard mitigation, training, exercises and public education to reduce loss of life and property.

The TEOP is a guide to how the Virgin Islands conducts all-hazards response.[155] Before its update in 2010 the last time it had been updated was around 1997 and had been obsolete for years. The 2010 update was modeled off of the National Response Framework, the national plan that governs the federal government's response to any natural or man-made disaster and the National Incident Management System. It is built upon scalable, flexible, and adaptable coordinating structures to align key roles and responsibilities across the Territory and our Federal partners, linking all levels of government, nongovernmental organizations, and the private sector. It is intended to capture specific authorities and best practices for managing incidents that range from the serious but purely local, to large-scale natural or man-made disasters. Perhaps more directly related to climate adaptation is the Virgin Islands Territorial Hazard Mitigation Plan[156] that identifies strategies and actions that can be taken before a disaster strikes to greatly reduce human suffering, damage to property, and the long-term economic impact of natural hazards.

The TEOP does not address climate change nor climate stressors explicitly, however, the Hazard Mitigation Plan does.

VITEMA's work has been focused on building resilient communities through its tsunami evacuation maps and storm readiness programs and its mass alert and information system that reaches communities through various means using new risk communication strategies.[157] One of the major areas of concern of VITEMA is the Coastal Flood Risk posed by climate change. USVI's coastlines are lined with commercial businesses, numerous public facilities to include first responder stations, water and energy infrastructure, three ports that accommodate the world's largest cruise ships, schools for more than 1,500 students, shoreline hotels, housing communities and residential properties. All are at risk for the effects of climate change, particularly the Tourism Industry which the lifeline of the Virgin Islands economy. VITEMA's Director has set a goal to work with key stakeholders in the community to identify problem areas, to determine the extent of vulnerability to climate change, recognizing that there will be socio-economic disparities, and to look at options for mitigation and adaption. This outreach has will be coupled with support from the scientific community which has the tools to help identify a range of climate-related outcomes. The VITEMA Director mentioned that support from the scientific community is an opportunity for collaboration and cooperation in the Caribbean region. VITEMA already works very closely with federal partners in the region, like FEMA's Caribbean Area Division, NOAA's National Weather Service and NOAA's Caribbean Tsunami Warning Office. It is anticipated VITEMA will look to them for support both in technical expertise, strategic planning and federal grant funding.

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[155] VITEMA. 2010. The Virgin Islands Territorial Emergency Operations Plan. http://www.vitema.gov/teop/TEOP-2010-09-23.pdf

[156] United States Virgin Islands Territorial Hazard Mitigation Plan (Final) July, 2014. http://www.vitema.gov/mitigation/mitigation-plan-2014.html

[157] Barnes, Mona. Presentation in the session Risk Management: Disaster Response and Hazard Mitigation at Climate Change in the Caribbean 2015. Inter American School of Law, San Juan, PR, 18 November, 2015.

USVI EMERGENCY MANAGEMENT AGENCY PROGRAMS/OUTPUTS

USVI Territorial Hazard Mitigation Plan.[158]

The 2014 plan updated the coastal flooding profile to the include the effects of climate change, specifically sea level rise, so as to understand better coastal flooding and secondary coastal hazards such as coastal erosion. It is important to note, as VITEMA does in the plan, that the potential impact of climate variability on natural hazards identified in the plan was discussed qualitatively in the description of the hazards as well as the deficiencies in addressing the impacts of climate change in a more quantitative manner.

STATUS:	Assessment & Planning
APPROACH:	Integrated Assessment
MOTIVATION:	Decision

The mitigation strategy lays out programmatic actions related to climate change directly, such as action "USVI-9" in the strategy which proposes to update the multi-hazard risk assessment to incorporate climate change models into the hazard and vulnerability analysis and USVI-7 to develop a database to track past and future instances of drought, wildfires and landslides, which also has implications for integrating the impact of climate variability by associating occurrences with rainfall events in the case of landslide or lack of precipitation in the case of drought and wildfire. Other programmatic actions in the mitigation strategy also reduce risk and build resilience for the Territory but do not explicitly mention climate change, such as USVI-1 to collaborate with DPW to remove build up sediment, debris and maintain natural guts, roadside ditches, drainage channels and storm drains in certain areas or USVI-4 to conduct a watershed planning study based on a hydrological and hydraulic model that could provide the quantitative basis for assessing flood mitigation measures on basin and sub-basin levels.

In addition, we identified one island action in the mitigation strategy that could be labeled climate adaptation and that is to be completed on the island of St. Croix, STX-19: FEMA Community Rating System (CRS). Initiative a planning project to have STX become a CRS Community by developing a strategy and action plan for improving the flood management program on the island. The planning study would include an outreach strategy and series of community meetings on the NFIP Program, first living floor and base flood elevation determinations, LOMARS, and other flood insurance questions and concerns.

AGENCY: U.S. VIRGIN ISLANDS ENERGY OFFICE (IN PARTNERSHIP WITH THE U.S. DEPARTMENT OF ENERGY)

The U.S. Virgin Islands Energy Office (VIEO) establishes, monitors, and coordinates the integration of policies relating to conservation, use, control, distribution, and allocation of energy with respect to all energy matters. The VIEO is also the state-designated agency for the planning,

[158] VITEMA. United States Virgin Islands Territorial Hazard Mitigation Plan (Final) July, 2014. http://www.vitema.gov/mitigation/mitigation-plan-2014.html

implementation, oversight, and administration of federal funds to include the State Energy Program (SEP) and the Weatherization Assistance Program (WAP). The VIEO has four strategic priorities: (1) reduce the cost of energy; (2) increase efficiency of energy use and production; (3) increase fuel diversity; and (4) promote clean energy production. The Virgin Islands Energy Office administers two federal grants provided by the U.S. Department of Energy known as the State Energy Program and the Weatherization Assistance Program. The Territory has a variety of initiatives under each program. All of these assist the Virgin Islands to get closer to their established USVI Energy Road Map goal of achieving a 60% reduction of fossil fuel use by the year 2025.[159] Specifically, the VI aims to deploy 9 MW of solar PV and install solar hot water in 40% of VI homes, reducing fossil fuel use by the equivalent of 160,000 barrels of oil per year by 2025. The reasons for this goal are to minimize dependence on fossil fuels, to reduce energy costs, to enhance energy affordability and reliability, to reduce environmental threats associated with global warming, build a thriving clean energy sector that generates local green jobs and preserve the natural beauty that is the lifeblood of the islands. From 2008 to 2014 the U.S. Virgin Islands has achieved a 30% reduce in fossil fuel use and electricity rates were down to approximately $0.33/kWh in 2015 (at its height the rates were greater than $0.50/kWh in 2008).[160] The VIEO continues to collaborate with the Virgin Islands Water Power Authority, the U.S. Department of Energy, and the U.S. Department of the Interior through an initiative branded VIEnergize. Below is just a handful of recent programs and their results as they related to climate change mitigation.

PROGRAMS/OUTPUTS

State Energy Program

STATUS:	Implementation
APPROACH:	Integrated Assessment
MOTIVATION:	Stakeholder

The U.S. Department of Energy (DOE) State Energy Program (SEP)[161] provides funding and technical assistance to state and territory energy offices to help them advance their clean energy economy while contributing to national energy goals. SEP also provides leadership to maximize the benefits of energy efficiency and renewable energy in each state through communications and outreach activities and technology deployment, and by providing access to new partnerships and resources. The State Energy Program (SEP) provides leadership to maximize the benefits of energy efficiency and renewable energy in each state through communications and outreach activities and technology deployment, and by providing access to new partnerships and resources. Additionally, SEP helps states improve the security of their energy infrastructure by assisting them with the development of state energy plans. Each state shares its plan with SEP, sets short-term objectives, and outlines its long-term goals. SEP also supports the states in preparing for natural disasters by

[159] Energy Development in Island Nations. USVI Energy Road Map: Charting the Course to a Clean Energy Future. National Renewable Energy Laboratory. http://www.nrel.gov/docs/fy11osti/51541.pdf

[160] Walls, Stephen. 2015. De-Risking Island Energy System Investments. IEA EGRD. Energy Transition Initiative, US Department of Energy. Presentation. https://www.iea.org/media/workshops/2015/egrdoct/09Walls_DOE.pdf

[161] http://energy.vi.gov/programs/

helping them develop energy emergency plans. For USVI Initiatives under the SEP are: energy assurance plan, LED instant rebates, solar water heater rebates, sun power loan programs and wind anemometer loan program.

Three recent successes through this program was the installation of Energy Star-rated light bulbs in both Government Houses through the Government Energy Demand Reduction Program under a State Energy Program grant, the procurement of the first two all-electric vehicles for the Government fleet as a demonstration project, and the funding of $50,000 in solar water heater rebates to assist residents wishing to switch from conventional water heaters.[162]

Weatherization Assistance Program

STATUS:	Implementation
APPROACH:	Integrated Assessment
MOTIVATION:	Stakeholder

The U.S. Department of Energy (DOE) Weatherization Assistance Program[163] provides grants to states, territories, and some Indian tribes to improve the energy efficiency of the homes of low-income families. These governments, in turn, contract with local governments and nonprofit agencies to provide weatherization services to those in need using the latest technologies for home energy upgrades.

Government Energy Savings Program

STATUS:	Implementation
APPROACH:	Integrated Assessment
MOTIVATION:	Stakeholder

In FY2014 the VI Government Energy Savings Program, concluded a 14-month energy efficiency retrofit for schools and other Department of Education facilities. The project was a $10.8 million bond financed initiative, which utilized an energy performance contract to replace lighting and plumbing systems with more efficient systems. Due to the installation of these energy conservation measures the Department of Education requested a $5,892,446 reduction in their utility allotment for their FY2015 budget, a significant savings.[164] Another recent energy conservation project was the signing of MOUs with the VI Waste Management Authority, the VI Port Authority with the VIEO and its contracted Electrical Service Companies.

[162] Testimony to provide an update on past and present energy projects supported by the Virgin Islands Energy Office, presented to the VI Senate Committee on Energy and Environmental Protection. By Elmo D. Roebuck, Jr., Director, VI Energy Office, 8 April 2015

[163] http://energy.vi.gov/weatherization-assistance-program/

[164] Testimony to provide an update on past and present energy projects supported by the Virgin Islands Energy Office, presented to the VI Senate Committee on Energy and Environmental Protection. By Elmo D. Roebuck, Jr., Director, VI Energy Office, 8 April 2015 http://www.legvi.org/CommiteeMeetings/31st%20Legislature%20Committees/COMMITTEE%20OF%20ENERGY%20&%20ENVIROMENTAL%20PROTECTION/4-8-15/Testimony%20Elmo%20D.%20Roebuck,%20Jr..pdf

AGENCY: U.S. VIRGIN ISLANDS PUBLIC SERVICES COMMISSION

The Public Service Commission (PSC) is a quasi-judicial, regulatory agency established under Title 3, VIC Sec. 237 of the VI Code. Currently operating under the provisions of Title 30 Virgin Islands Code Chapter 1, the PSC has broad mandate to maintain an important balance between the public utilities in the U.S. Virgin Islands and the territory's ratepayers. The Commission sets rates that provide regulated utilities an opportunity to earn a return on their investment in order for them to provide adequate and reliable service and, that are also reasonable for the customer. The PSC also seeks to help consumers better understand its functions and how they can participate in the rate-making process. The PSC has regulatory jurisdiction over the following utilities: VI Telephone Company, VI Water and Power Authority, St. Croix Cable TV, St. Thomas/St. John Cable TV, Transportation Services of St. John and Varlack Ventures, Inc. (passenger ferryboat service providers), Choice Communications (Wireless), and VI Waste Management Authority.
The PSC role in climate adaptation and mitigation is not as direct as the work of other institutions, however, the role the PSC plays in transitioning local energy markets to renewable sources or diversifying energy sources is critical to both adaptation and mitigation and creating a resilient energy sector in the U.S. Virgin Islands. The PSC does not have a lot of specific programs for us to synthesize, except net-metering described below, but recent insights from a panel discussion with VI PSC Chair Johann A. Clendenin at *Climate Change in the Caribbean 2015* have value in this institutional analysis for the U.S. Virgin Islands. [165] Integrating renewable energy into the grid has benefits to the utilities, to the customers and to society. The benefits to the utilities are the electrical generation cost savings (though the question is always asked who gets the cost savings?) and the cost avoidance of efficient systems. The benefits to customers is also the cost savings and reductions. To society, the benefits include improved public health, especially for vulnerable stakeholders. When discussing climate resilience of the energy utility sector in the U.S. Virgin Islands, Mr. Clendenin asserted that resilience would be the robustness of utility generator systems to recover and continue to provide service to customers. He also stressed that cyber security threats have become a real issue and physical threats also play a role, so it's not just natural hazards and climate change threatening the resilience of the energy sector in the region. As a regulator, how do they protect their consumers if energy producers have to recover from a catastrophic event, such as hurricanes? He ended with an important point about the unintended consequences of interconnectivity between communications infrastructure and energy production. An illustrative example was given using fiber optics. Fiber optics used for communications may have consequences (for instance if in a smart grid using smart meters) if there is a loss of communication as this could then cause loss of control for the energy providers. The above sheds light on the questions the VI Public Services Commission is grappling with when thinking about climate resilience of the energy and communications utility critical infrastructure sectors.

[165] Clendenin, Johann A. "PR and USVI Making the Transition to a Regulated Electricity Market." Climate Change in the Caribbean 2015: Puerto Rico & U.S. Virgin Islands Conference. Inter American University School of Law, San Juan, PR. 18 November 2015. Panel Discussion.

USVI PUBLIC SERVICES COMMISSION PROGRAMS/OUTPUTS

STATUS:	Implementation
APPROACH:	Impact Based
MOTIVATION:	Stakeholder

The PSC approved a limited net-metering program in February of 2007 for residential and commercial photovoltaic (PV), wind-energy or other renewable energy system up to 10 kilowatts (kW) in capacity. The Solar Energy Industries Association (SEIA) defines net metering as, "… a billing mechanism that credits solar energy system owners for the electricity they add to the grid. For example, if a residential customer has a PV system on the home's rooftop, it may generate more electricity than the home uses during daylight hours. If the home is net-metered, the electricity meter will run backwards to provide a credit against what electricity is consumed at night or other periods where the home's electricity use exceeds the system's output. Customers are only billed for their 'net' energy use."

STATUS:	Implementation
APPROACH:	Impact Based
MOTIVATION:	Stakeholder

In July 2009, the legislature passed Act 7075 that raised the capacity limits to 20 kW for residential systems, 100 kW for commercial systems, and 500 kW for public (which includes government, schools, hospitals). In December of 2014, Act 7705 was enacted to amend Act 7075 to limit net-metering to "systems 10 Kilowatts and smaller". Further it states that "... the net metering program expires January 1, 2025, for a customer- generator that has a generating capacity larger than 10 kilowatts residential". The amendment also defines a "residential customer" as a customer who owns the property where the solar system is located, disqualify renters or those who have leased property. The aggregate capacity limit of all net-metered systems is five megawatts (MW) on St. Croix, and 10 MW on St. Thomas, St. John, Water Island and other territorial islands. These limits are equal to 10% of the peak load of the Virgin Islands Water and Power Authority's electric system. This program, coupled with the relatively high cost of electricity and cost sharing programs available to homeowners seeking to install forms of renewable energy has led to increase in the amount of solar energy being generated on the islands.

AGENCY: UNIVERSITY OF THE VIRGIN ISLANDS

The University of the Virgin Islands (UVI) Energy Management Office has set the main goal to reduce the electrical consumption of the University and to achieve a 60% reduction on the dependence on fossil fuels by 2015. This goal is accomplished by use of alternative energy,

upgrades to current systems, capital investment, and setting up protocols and policies on how the University uses its energy.[166]

Specific to energy research and education, UVI developed the Caribbean Green Technology Center (CGTC) to foster research, education and public service on sustainability, to promote Caribbean inter-island's cooperative, to advance interdisciplinary investigations and learning, to collaborate with governmental agencies and industry partners and to research, develop, demonstrate and monitor green technology. The Caribbean Green Technology Center at the University of the Virgin Islands has four major functional areas: (1) to enhance the renewable energy workforce in the Virgin Islands, (2) to assist in the development of progressive energy policy, (3) to serve the Virgin Islands energy community by providing information to the public through outreach and educational programs, and (4) to encourage basic and applied research in renewable energy at the University of the Virgin Islands through collaborations with other universities, national labs, industry and governmental agencies.

The CGTC has a variety of energy projects and courses[167] as well as a strategic plan for 2014-2017[168] and strategic partnerships with Arizona State University, Brookhaven National Lab, Energy and Climate Partnerships of Americas, Illinois Institute of Technology, the University of the West Indies and the U.S. Virgin Islands Energy Office.

UNIVERSITY OF THE VIRGIN ISLANDS PROGRAMS/OUTPUTS

Caribbean Green Technology Center Outreach Project

In collaboration with Brookhaven National Lab, CGTC provides an annual workshop on Open Space Stewardship for educators. Teachers are encouraged to construct science projects that foster students' stewardship of their local environment into their existing curriculum while meeting local and national standards. CGTC also holds a Policy Forum for community leaders. The forum highlights public policy energy issues that affect communities' sustainability and livability. It also addresses a range of important local, state, and federal issues such as green buildings, infrastructure, land use, water conservation, and small business regulation. The goal is to offer expertise available from CGTC and its partners to deal with these policy matters.

UVI Solar Project

In July of 2013 UVI entered into a 20- year power purchase agreement (PPA) with New Generation Power for a 3MW Solar System. With a PPA UVI will not be responsible for the construction or the maintenance of the system. They will be required to pay for the energy produced, at a rate cheaper than what UVI is paying WAPA. At the end of the 20 years UVI will have the option to

[166] http://www.uvi.edu/administration/administration-and-finance/energy_management.aspx
[167] http://cgtc.uvi.edu/projects/default.aspx
[168] http://cgtc.uvi.edu/partnerships/default.aspx

buy the system. The system will be split between the St. Thomas and the St. Croix campus. This project was developed to help UVI hit its goal of a 60% reduction on the dependence of fossil fuel by 2015. The system is estimated to produce 4.5M kWh. The project will also provide electric vehicle charging stations, fixed labs, and mobile labs. The labs will help create an educational component for the whole USVI community.

Biofuel Initiative

The burning of fossil fuels to generate energy for transportation, electricity as well as other residential, commercial and industrial processes has resulted in copious emissions of greenhouse gases (GHGs). A number of restaurants, hotels and cruise ships which operate in the USVI, produce significant quantities of waste vegetable oil (WVO). This WVO, a waste product that requires safe disposal, is a potential fuel source as it may be converted to biodiesel. Biodiesel is a carbon positive fuel that is readily manufactured from used or freshly produced vegetable oil or animal fat using technology that is widely available and readily accessible. Based on the success of the Alternative Energy programs and the biodiesel project at The University of the West Indies (UWI), a partnership was forged in 2013 between the Caribbean Green Technology Center (CGTC) and The UWI. Under this partnership The UWI, through the Departments of Physics and Chemistry support and collaborate with CGTC to develop and implement a project for converting WVO, into biodiesel. Additionally, this project attempts, through training and capacity building at the community and school-level, to target USVI citizens in an effort to highlight the importance of environmental protection and enhance involvement in the climate change mitigation process. A three-member team from The UWI, Dr. Michael Coley, Mr. Dale Rankine and Mrs. Cherri-Ann Scarlett, led the scoping mission to facilitate talks with relevant USVI stakeholders and assist with the development of the CGTC biodiesel project.

AGENCY: U.S. DEPARTMENT OF TRANSPORTATION

The U.S. Department of Transportation (U.S. DOT) aims to serve the United States and the territories by ensuring a fast, safe, efficient, accessible and convenient transportation system that meets vital national interests and enhances the quality of life of the American people, today and into the future. Much of the transportation work in the Territory is done in collaboration with the Federal Highways Administration (FHWA), an authority under the U.S. DOT.

In 2012, President Obama signed into law the Moving Ahead for Progress in the 21st Century[169] (MAP-21) to provide needed surface transportation funds.[170] MAP-21 is the first multi-year transportation authorization enacted since 2005 funding Fiscal Years 2013 and 2014, funding surface transportation programs at over $105 billion. MAP-21 also transforms the framework of

[169] P.L. 112-141

[170] Overview of U.S. Department of Transportation Programs in the Territories: https://www.doi.gov/sites/doi.gov/files/migrated/oia/igia/2013/upload/42-Transportation-Overview-of-Territorial-Programs-at-DOT.pdf

investments to guide the growth and development of the country's vital transportation infrastructure. A number of programs for the territories was included in MAP-21.

UNITED STATES DEPARTMENT OF TRANSPORTATION PROGRAMS/OUTPUTS

STATUS:	Assessment, Planning, & Implementation
APPROACH:	Impact based and Risk Management
MOTIVATION:	Decision and Stakeholder-driven

The Federal Highway Administration (FHWA) Puerto Rico and U.S. Virgin Islands Division Office is a local field office that provides leadership, guidance, and direction to the Puerto Rico Highway and Transportation Authority and the USVI Department of Public Works in the planning, construction and maintenance of transportation projects. Working collaboratively with State partners, Puerto Rico and U.S. Virgin Islands Division Office ensures that the nation's roads, bridges and tunnels are safe and continue to support economic growth and environmental sustainability. Additionally, to ensure accountability, the FHWA Division Offices work with the State to develop, track and analyze activities and recommend innovative techniques and strategies to improve the performance of the transportation system. FHWA and its Division Offices are responsible for working with State Departments of Transportation to ensure that the nation's strategic investments preserve and modernize the U.S. highway system - and ultimately to save lives.

On June 23, 2015 U.S. Virgin Islands Governor Kenneth Mapp and Federal Highway Administration Acting Administrator Gregory G. Nadeau signed the *Territorial Highway Program Implementation and Stewardship Agreement* to carry out a program to assist the USVI in the construction and improvement of a system of arterial and collector highways and necessary inter-island connectors. The agreement lays out a number of eligible types of projects and stewardship and oversight responsibilities. It also states that the FHWA will continue to support, "The USVI's efforts to promote and maintain a long-range highway development program by providing technical assistance to the USVI, on a continuing basis, in the acquisition, and relocation assistance programs, and the design, construction, operation, and maintenance of the USVI's THS and other arterial and collector highways as applicable under the terms of this Agreement." The agreement describes all applicable laws, regulations and procedures related to road construction and maintenance, including those related to emergency relief in the event of serious damages to THS highways by a natural disaster over a wide area or a catastrophe. Chronic hazards or climate-related risks do not appear to be included in this agreement and might be a missed opportunity for climate adaptation measures to be built into future territorial transportation improvements. There is potential climate-integration under the Technical Assistance portion of the agreement (section XII), where FHWA has committed to conduct environmental evaluations for USVI and engage in

highway planning and the design, construction, operation and maintenance of the system of arterial and collector highways.

Managed by the FHWA, the Territorial Highway Program was created for the purpose of constructing and improving a system of arterial and collector highways and necessary inter-island connectors (including ferry boats, terminal facilities and approaches) in the U.S. Virgin Islands and other territories. Prior to MAP-21, the Territorial Highway Program was a National Highway System set aside program funded from the Highway Trust Fund where the set aside was divided between all the territories with USVI and Guam both receiving 40% and American Samoa and the Northern Mariana Islands receiving 10% each. With the enactment of MAP-21, the Territorial Highway Program is no longer a set-aside program and the funding is now directly authorized out of the Highway Trust fund and Territorial Highway Program funds will continue to be allocated to the four territories by administrative formula using the previous percentages. In FY2013 and FY 2014 MAP-21 funds were $40.0M, not including American Recovery and Reinvestment Act (ARRA) funds, which authorized an additional $45M for the Territorial Highway Program. Unexpended funds expired in September of 2015. Under MAP-21, territories receive funding through several different formula programs. The USVI in its entirety is treated as an urbanized area under MAP-21 and therefore received urbanized area formula funds. The USVI also receives funds under the Section Transit for Elderly and Disabled Individuals and Bus and Bus facilities program.

The U.S. DOT, pursuant to Federal Executive Orders No. 13514 and 13653, as well as U.S. Council on Environmental Quality (CEQ) Implementing Instructions, was required to submit a Climate Adaptation Plan.[171] They completed their first plan in 2012 and updated it in 2014 to include new requirements of E.O. 13653 and guidance from CEQ. The plan does not mention the U.S. island territories nor the U.S. Virgin Islands but does provide information on notable potential impacts generally to the agency, a description of programs, policies and plans put in place and future actions the agency will take. One accomplishment that applies to USVI is On 23 September 2012, FHWA published a memorandum clarifying that State, Local, and Federal agency climate change adaptation planning and resiliency features of highway projects would be eligible for reimbursement under the Federal-Aid and Federal Lands Highway Programs.[172]The U.S. Department of Transportation has conducted and/or is planning a number of pilot projects for planning, asset management, and tools and educational resources for each of the DOT programs that operate in USVI, including the Federal Aviation Administration, Federal Highway Administration, Federal Transit Administration, and the Maritime Administration.

[171] U.S. DOT. 2014. U.S. Department of Transportation Climate Adaptation Plan 2014: Ensuring Transportation Infrastructure and System Resilience: https://www.transportation.gov/sites/dot.gov/files/docs/2014-%20DOT-Climate-Adaptation-Plan.pdf
[172] Source: http://www.fhwa.dot.gov/federalaid/120924.cfm

Transportation and Climate Resources

DOT and the Federal Highways Administration have several tools and resources available and under development to assist agencies with identifying climate change vulnerabilities of their transportation systems:

Climate Change and Transportation Resource Website from the DOT Office of Planning, Environment and Realty. Many of the tools below can easily be found at this web portal.

Transportation and Climate Change Clearinghouse more geared towards the quantification and reduction of greenhouse gas emissions from the transportation sector

Climate Change and Extreme Weather Vulnerability Assessment Framework (Complete FY 2013) – This is a comprehensive resource and guidebook for transportation agencies conducting vulnerability assessments and it includes discussion, resources, and in-practice examples of the major tasks involved. The Framework is an update of a draft version that FHWA released in FY 2010.

Assessment of the Body of Knowledge on Incorporating Climate Change Adaptation Measures into Transportation Projects - This report highlights adaptation actions that transportation agencies are pursuing and articulates a growing set of best practices for implementing adaptation. The report also discusses strategies, examples, and best practices for evaluating the costs and benefits of adaptation. The purpose of the report is to provide transportation practitioners with a guide to the current "state of practice" in this field.

Transportation Climate Change Sensitivity Matrix – This Excel file documents how different climate stressors affect several types of transportation infrastructure. The tool contains a macro-based user interface that allows users to generate reports related to specific stressor-asset combinations per their needs.

CMIP Climate Data Processing Tool – This tool processes raw climate data, which users download from a third party site. Outputs are projected temperature and precipitation changes in a local area. The tool provides a relatively quick and easy way for users to determine the potential magnitude of certain changes in their area.

Vulnerability Assessment Scoring Tool (VAST) – This Excel tool allows users to design and structure a score-based vulnerability assessment. Once complete, users will have a relative vulnerability score for each asset evaluated.

a. **Webinar Series on Planning for Climate Change Adaptation** – FHWA has held webinar series aimed at State and local governments, which included sessions on: (Recordings of the FY 2013 webinars are available on FHWA's website.)Determining assets to study and climate information;
b. System-level vulnerability assessments;
c. Applying vulnerability assessment results into decision making; and
d. Lessons learned from Superstorm Sandy.

AGENCY: FEDERAL EMERGENCY MANAGEMENT AGENCY

The mission of the Federal Emergency Management Agency (FEMA) Caribbean Area Division (CAD) is to implement and coordinate all emergency management programs in the Commonwealth of Puerto Rico and the Territory of the U.S. Virgin Islands. The CAD functions as a satellite office for Region II in San Juan, Puerto Rico, providing a permanent FEMA presence in an area which is vulnerable to recurrent hurricanes and flooding, and is also located within a major earthquake risk zone. The CAD has enabled FEMA to significantly reduce the response time to any disaster in our jurisdictions. FEMA describes climate change as a "threat multiplier" for emergency management operation planning purposes, as it impacts: sea levels, weather patterns, disease patterns, migration patterns and infrastructure.

FEMA has a variety of Emergency Planning Resources online and through their training programs. Specific to USVI their planning resources include a Region II All Hazards Catastrophic Plan, for USVI it's for earthquakes and tsunamis, as well as a USVI Commodity Distribution Plan (currently under review).

FEMA PROGRAMS/OUTPUTS

FEMA Climate Change Adaptation Policy[173]

STATUS:	Assessment & Planning
APPROACH:	Integrated Assessment
MOTIVATION:	Research, Decision and Stakeholder-driven

In the National Security Strategy (2010), President Barack Obama identified climate change as a major challenge for the Nation and a significant threat to national security. In October 2009, the President issued Executive Order (EO) 13514, requiring Federal Agencies to support the U.S. Government's efforts to develop a national climate change adaptation strategy. FEMA's Climate Change Adaptation Policy (2011-OPPA[174]-01) directs FEMA programs and policies to integrate considerations for climate change adaptation. The mitigation planning regulation[175] requires consideration of the probability of future hazard events as part of the risk assessment in order to reduce risks and potential damage. To enhance climate research, monitoring, and adaptation capabilities, FEMA will continue to establish partnerships with other agencies and organizations that possess climate science and climate change adaptation expertise, continue to study the impacts of climate change on the National Flood Insurance Program (NFIP) and incorporate climate change considerations in the NFIP reform effort, and evaluate how climate change considerations can be incorporated into grant investment strategies with specific focus on infrastructure and evaluation methodologies or tools such as benefit/cost analysis.

[173] De La Campa, Alejandro. "Risk Management: Disaster Response and Hazard Mitigation." Climate Change in the Caribbean 2015: Puerto Rico & U.S. Virgin Islands Conference, Inter American School of Law, San Juan, PR. November 18, 2015.
[174] * Office of Policy and Program Analysis (OPPA)
[175] (44 CFR Part 201)

FEMA encourages communities to incorporate methods to mitigate the impacts of climate change into eligible Hazard Mitigation Assistance (HMA) funded risk reduction activities by providing initial guidance on Climate Resilient Mitigation Activities. These include: Green infrastructure methods, expanded ecosystem service benefits, and three flood reduction and drought mitigation activities:

- Aquifer Storage and Recovery (ASR)
- Floodplain and Stream Restoration (FSR)
- Flood Diversion and Storage (FDS)

One way in which FEMA is supporting resilience and climate change is through the inclusion of environmental considerations in the Benefit-Cost Analysis (BCA) Tool for certain mitigation activities. For example, FEMA has:

- Incorporated sea level rise into the HMA BCA Tool
- Allowed communities to use HMGP grants to fund the additional 5 percent set-aside amount to address impacts from all hazards. This includes the development and use of disaster-resistant building codes, an important step in promoting community resilience. In the past, the 5 percent funding could only be used to address impacts from tornadoes and high winds.

Effective March 2016, State Mitigation Plans, such as the VI Hazard Mitigation Plan, "must" include a summary of the probabilities of future events as well as future changing conditions conducting Risk Assessments based on climate change future hazard events (Multi-Hazards). There is a State Mitigation Plan Review Guide available to the states. Additionally there will be annual plan reviews between FEMA and the State/Territory, they will use the "whole community concept" to build partnerships, they will identify long-term, cost effective strategies for risk reduction, and they will communicate priorities to potential sources of funding.

U.S. DEPARTMENT OF COMMERCE – PROVIDES FUNDS FOR CRITICAL INFRASTRUCTURE THROUGH THE ECONOMIC DEVELOPMENT AUTHORITY AND NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION (CHECK WHETHER VINGN HAD A CLIMATE CHANGE COMPONENT SINCE NTIA I BELIEVE PROVIDED SOME FUNDING)

AGENCY: NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NOAA PROGRAMS/OUTPUTS

NOAA National Sea Grant College Program

NOAA's National Sea Grant College Program is a network of 33 Sea Grant programs located in every coastal and Great Lakes state, Puerto Rico, Lake Champlain and Guam. These programs serve as the core of a dynamic, national university-based network of over 300 institutions involving more than 3,000 scientists, engineers, educators, students and outreach experts. The network engages the power of academia and a wide variety of partners to address issues such as coastal hazards, sustainable coastal development and seafood safety.

The University of Puerto Rico Sea Grant College Program (UPR Sea Grant) is one of the 33 national programs and an educational program dedicated to the conservation and sustainable use of coastal and marine resources in Puerto Rico, the US Virgin Islands, and the Caribbean region. Their mission is twofold: (1) to fund scientific research in the thematic areas of conservation and the use of coastal and marine resources; (2) to offer marine extension services by making use of experience and by applying the scientific knowledge that is generated through research to the problems and issues that their community of users face everyday.

Investigation and research projects constitute an indispensable component of achieving the Sea Grant Program's goals. Because of this, UPR Sea Grant is a critical source of funding for large and small research projects that produce the information needed for the development of sound management plans for the region's marine resources and decision making in the archipelago of Puerto Rico and the U.S. Virgin Islands.

Their research focuses on the development of theoretical and applied research that is meant to increase the existing understanding of marine and coastal ecosystems, the coastal communities and their economy, coastal hazards, urban coastlines, and the application of digital technologies. Every two years the program makes a call for proposals in which researchers from Puerto Rico, the U.S. Virgin Islands, and those from the U.S. mainland who have research interests in the Caribbean are encouraged to compete for research funds in a peer reviewed process.

STATUS:	Assessment
APPROACH:	Impact Based
MOTIVATION:	Research and Decision

In 2005, Dr. Aurelio Mercado completed one of these research projects funded by the Puerto Rico Sea Grant College Program, titled, *An evaluation of the main ports and bays in Puerto Rico and the U.S. Virgin Islands as to their exposure to hurricane wave attack.*[176] Dr. Mercado and his team used a combination of sophisticated wave transformation models and high-resolution bathymetry in order to estimate how exposed the infrastructure lying inside Puerto Rico's and USVI's ports and harbors are to hurricane-driven

[176] Mercado. 2005. Final Report: An evaluation of the main ports and bays in Puerto Rico and the U.S. Virgin Islands as to their exposure to hurricane wave attack. Sea Grant College Program. Available upon request.

wind waves. The USVI ports assessed were Charlotte Amalie Bay, St. Thomas, Christiansted Bay, St. Croix, Frederiksted, St. Croix, Port Alucroix, St. Croix. This study was a first, and preliminary, attempt to estimate the wave climatology inside the main bays, ports, and harbors in Puerto Rico and the USVI under extreme weather (i.e., hurricane) conditions. Being an island, we depend a lot on our port infrastructure, and events like Hurricane Hugo (especially its effect in San Juan and Culebra's bays), was the motivation for this study. Results by Port with images and figures are available in the full report.

NOAA Coral Reef Conservation Program

STATUS:	Assessment
APPROACH:	Impact and Vulnerability Based
MOTIVATION:	Research, Decision and Stakeholder-driven

The Nature Conservancy Caribbean program directed a project with the objective of developing decision-support tools and conservation strategies that will advance the implementation of ecosystem-based adaptation to climate change within USVI through a cooperative agreement with the NOAA Coral Reef Conservation Program, *Addressing Global Threats at Local Scales in Coral Reef Communities.* The Nature Conservancy (TNC) provided matching funds. There is a growing body of evidence that suggests in some situations, the most successful and cost-effective actions to protect people and infrastructure assets from hazards and the impacts of climate change are to preserve, enhance and restore natural systems that provide critical protection from these elements, or that provide food, water or work opportunities. We have included this project under Critical Infrastructure instead of Natural Resources because the main objective of ecosystem-based adaptation is to protect communities, their people and their infrastructure assets. The utilization of nature to accomplish this objective is just the methodology. An example of ecosystem-based adaptation, or EbA, that the project report from 2014[177] gives is the protection of recharge zones or restoration of floodplains and wetlands to secure water resources; or restoration and protection of natural infrastructure such as barrier beaches, mangroves or coral reefs to lessen storm and wave impacts on human communities. Before an ideal EBA implementation site can be identified, future climate change impacts need to be modeled in order to understand how people and nature may be impacted. GIS plays an important role in estimating the extent of potential impacts, while the development of spatial models helps to provide insight into how people and nature may respond to these impacts. The report describes the process used in detail by TNC to map socioeconomic impacts from climate change within the USVI and consequently identify optimal areas to implement EBA solutions.

[177] Schill, S., J. Brown, A. Justiniano, A.M. Hoffman. 2014. US Virgin Islands Climate Change Ecosystem-Based Adaptation: Promoting Reislient Coastal and Marine Communities. The Nature Conservancy. NOAA Coral Reef Conservation Program. https://www.conservationgateway.org/ConservationPractices/Marine/crr/library/Documents/USVI%20EBA%20Guidance_Final.pdf

As part of this project, TNC developed a decision-support tool for ecosystem-based planning in USVI called Coastal Resilience[178] that includes infrastructure and demographic data, socio-economic vulnerability maps, sea level rise models using the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model, and species and habitat distribution maps. Mapping and modeling using the decision support tool and input from workshop participants, revealed the ten coastal areas most vulnerable to climate change and likely to respond: Two Brothers, Demarara, Kings Quarter, Honduras, Nadir, East Street, Mount Pleasant and Retreat, Bovoni, and Enighed.

This would be a good place to highlight Digital Coast
NOAA CRCP funded Green Building Program NMFS Caribbean Field Office did with DPNR as a key partner – program was passed to DPNR.

NOAA Office for Coastal Management

NOAAs OCM provides data and a number of tools to assess a community's critical infrastructure vulnerability to Climate changes – especially sea level rise, nuisance flooding, and storm surges.

- Critical Facility Datasets for USVI: OCM's Digital coast houses critical facilities data sets which are derived from the U.S. Geological Survey's Structures Inventory Database (June 2015). The derived data set displays aggregated totals of law enforcement facilities, fire stations and EMS facilities, hospital and other medical facilities, and schools within several coastal footprints. These footprints include coastal shoreline counties, coastal watershed counties, coastal states, the coastal zone, and FEMA flood zones.

- HAZUS: OCMs Digital Coast also provides access to FEMA's HAZUS model that provides a nationally applicable, standardized method estimates potential losses from earthquakes, hurricane winds, and floods. State-of-the-art GIS software maps and displays hazard data and estimates of damage and economic losses to buildings and infrastructure.

- Coastal Flood Exposure Mapper (CFEM): This online visualization tool developed by NOAA, supports communities that are assessing their coastal hazard risks (coastal flooding, storm surge inundation as potential affected by SLR) and vulnerabilities. The tool creates a collection of user-defined maps that show among other the people, natural resources and critical infrastructure exposed to coastal flooding. The maps can be saved, downloaded, or shared to communicate flood exposure and potential impacts. In addition, the tool provides guidance for using these maps to engage community members and stakeholders. While the current geography includes only the East Coast and Gulf of

[178] www.coastalresilience.org

Mexico, OCM Staff are engaging PR and USVI representatives to expand coverage of the CFEM to Puerto Rico and US Virgin Islands in 2017.

AGENCY: U.S. ENVIRONMENTAL PROTECTION AGENCY

Born in the wake of elevated concern about environmental pollution, EPA was established on December 2, 1970 to consolidate in one agency a variety of federal research, monitoring, standard-setting and enforcement activities to ensure environmental protection. EPA works for a cleaner, healthier environment for the American people. The U.S. Virgin Islands are in the jurisdiction of EPA Region 2, along with New York, New Jersey, eight tribal nations, and Puerto Rico. A variety of EPA regulations and programs have already assisted the Territory mitigate environmental hazards and build resilience to climate change. To strengthen the existing programs and expand the level of implementation in the U.S. Virgin Islands, the U.S. Environmental Protection Agency Region 2 and Governor Kenneth E. Mapp signed a Memorandum of Understanding on November 18, 2015,[179] to cement a commitment to share expertise to address climate change. Examples of the ways or areas in which the U.S. Virgin Islands and EPA may collaborate in promoting the reduction of carbon pollution and increasing resiliency through smart growth, sustainable planning, and clean energy include:

WaterSense - EPA partnership program seeking to protect the future of our nation's water supply by offering people a simple way to use less water with water-efficient products, new homes, and services--reducing energy use and greenhouse gas emissions in the process.

Clean Energy-Environment State Partnership – a voluntary state-federal partnership that encourages states to develop and implement cost-effective clean energy and environmental strategies.

Climate Ready Water Utilities – an initiative that provides resources for water providers to adapt to climate change by promoting a clear understanding of climate science and adaptation options and by promoting consideration of integrated water resources management planning in the water sector.

Climate Ready Estuaries[180] - working with the EPA National Estuary programs to help coastal managers assess climate change vulnerabilities, implement adaptation strategies, and educate the public.

Sustainable Communities[181] - a partnership involving the Department of Housing and Urban Development, the Department of Transportation, and EPA, working to create communities that have a variety of housing and transportation choices, with destinations close to home, in order to lower transportation costs, reduce air pollution and stormwater runoff, among other benefits.

[179] Malone, Shawn-Michael. Climate Change in the Caribbean 2015: Puerto Rico & U.S. Virgin Islands Conference. Inter American University School of Law, San Juan, PR. 23 November 2015. Conference speech.
[180] http://www2.epa.gov/cre
[181] http://www.sustainablecommunities.gov/

Smart Growth Program[182] **-** includes resources to help local governments, and the private sector build in ways that bring multiple environmental, economic, health, and social benefits, including reducing greenhouse gas emissions and preparing for climate change.
ENERGY STAR®[183] - promoting energy efficient products and practices.
Green Power Partnership[184] - promoting partnership between EPA and organizations interested in using green power (electricity produced from a subset of renewable resources).
Methane Reduction Voluntary Programs – promoting methane partnership programs between EPA and industries, along with state and local governments, to promote profitable opportunities for reducing emissions of CH4, with programs such as AgSTAR, Natural Gas STAR, Global Methane Initiative, and Landfill Methane Outreach Program.
Transportation and Air Quality Voluntary Programs - promoting partnerships between EPA and small and large businesses, citizen groups, industry, manufacturers, trade associations, and state and local governments aimed in reducing pollution and improve air quality by implementing programs such as National Clean Diesel Campaign, and the SmartWay Transport Partnership.
An internet review of EPA's smart growth, air, water utility, energy and transportation programs and resources shows that while there are funding and technical assistance programs available for the U.S. Virgin Islands, only a few lack resources specific to the Virgin Islands and a few where it appears the U.S. Virgin Islands has not applied for support or participation to-date (Table 3). Specific to energy, there are at least four programs available but that do not appear to have been included in recent territorial energy overhaul efforts and could be an opportunity to achieving the U.S. Virgin Islands' goal of reducing fossil fuel use by 60% by 2025.

Table 3. A list of the EPA Programs related to climate change and their current status for whether available in USVI or not (as of February 28, 2016). Y=Yes; N=No.

EPA Program	Available in USVI? (Y/N)
Smart Growth	
EPA Smart Growth Technical Assistance: The Office of Sustainable Communities occasionally offers grants to support activities that improve the quality of development and protect human health and the environment.	Y[185]

[182] http://www.epa.gov/smartgrowth/
[183] https://www.energystar.gov/
[184] https://www.epa.gov/greenpower
[185] This includes Building Blocks for Sustainable Communities, Smart Growth Implementation Assistance, and Local Foods, Local Places; Greening America's Communities.

EPA Smart Growth Self-Assessment for Rural Communities (2015): a compilation of strategies, organized by 11 common "goal areas", that villages, towns, and small cities can use to evaluate their existing policies to create healthy, environmentally resilient and economically robust places.	Y
EPA Smart Growth Guidelines for Sustainable Design and Development: Guidelines that can serve as a checklist to ensure that programs, plans, and proposed developments incorporate the elements needed at the location, site, and building levels to result in more sustainable, affordable housing.	Y
EPA Smart Growth Scorecards: Useful Examples from Across the Country	Y (scorecards could be applied in USVI but has not yet been applied in USVI)
Sustainable Communities HotReport: Web-based tool that gives community leaders and residents a quick and easy way to determine how well their community is performing on a variety of sustainability indicators, including transportation, housing, economic development, income, and equity.	N
Sustainable Community Indicator Catalogue: Catalogue of indicators to help communities measure progress toward their sustainability objectives.	Y
Partnership for Sustainable Communities: an interagency partnership of HUD, DOT and EPA. The Partnership for Sustainable Communities (PSC) works to coordinate federal housing, transportation, water, and other infrastructure investments to make neighborhoods more prosperous, allow people to live closer to jobs, save	Y[186]

[186] Online map shows USVI has not been a grant recipient yet.

households time and money, and reduce pollution.	
Air	
Air Data & Air Quality Index: The AirData website gives you access to air quality data collected at outdoor monitors across the United States, Puerto Rico, and the U. S. Virgin Islands. The data comes primarily from the AQS (Air Quality System) database. You can choose from several ways of looking at the data: download data into a file (or view it on the screen); output the data into one of AirData's standard reports; create graphical displays using one of the visualization tools; investigate monitor locations using an interactive map. AirData lets you display and download monitored hourly, daily, and annual concentration data, AQI data, and speciated particle pollution data	Y
AirNow.gov: Every day the Air Quality Index (AQI) tells you how clean or polluted your outdoor air is, along with associated health effects that may be of concern. The AQI translates air quality data into numbers and colors that help people understand when to take action to protect their health.	N
Water	
WaterSense: a partnership program by the U.S. Environmental Protection Agency, seeks to protect the future of our nation's water supply by offering people a simple way to use less water with water-efficient products, new homes, and services. WaterSense labeled products are backed by independent, third–party testing and certification, and meet EPA's specifications for water efficiency and performance.	Y

Climate Ready Water Utilities: CRWU resources provide water utility managers with tools, training, and technical assistance needed to adapt to climate change.	YEAT Climate Scenarios for Water Utilities, associated tool with CRWU, not available for USVI CREAT Climate Scenarios for Water Utilities, associated tool with CRWU, not available for USVI. Scenarios can be entered manually. Coastal Storm Surge Scenarios for Water Utilities, associated tool with CRWU, is technically available for USVI as it is on the map and shows the 100 and 500 year-flood plains, but it does not include hurricane return period or SLOSH modeling for categories 1-5. EPA is currently working on SLOSH models for Puerto Rico and the USVI.
Climate Ready Estuaries: The Climate Ready Estuaries program works with the National Estuary Programs and the coastal management community to assess climate change vulnerabilities, develop and implement adaptation strategies, and engage and educate stakeholders. CRE shares NEP examples to help other coastal managers, and provides technical guidance and assistance about climate change adaptation.	N USVI is not currently part of the National Estuary Program[187]
State Revolving Loan Fund- EPA's Clean Water State Revolving Fund and Drinking Water State Revolving Fund programs provide capitalization grants to states and territories to finance water infrastructure.	Y The USVI has received direct-grant funding for the following years in the following amounts:

[187] USVI is not currently part of the National Estuary Program however "Being Prepared for Climate Change" EPA Workbook for Developing Risk-Based Adaptation Plans could be used in the USVI. http://www.epa.gov/sites/production/files/2014-09/documents/being_prepared_workbook_508.pdf

	USVI Awarded Capitalization Grants Year / CWSRF / DWSRF 2016 / TBD... / $ 4,349,000 2015 / TBD... / $ 4,378,000 2014 / $ 4,336,378 / $ 4,367,000 2013 / $ 4,140,000 / $ 4,654,000 2012 / $ 3,149,164 / $ 4,869,000 Note that VIDPW is currently working on the applications for the FY 2015 and FY 2016 grants (grey highlighted cells) and will be submitting them in the future.
Energy	
Clean Energy-Environment State Partnership Program: This EPA voluntary partnership program is designed to help states review and adopt policies and programs that effectively integrate clean energy into a low-cost, clean, reliable energy system for the state.	Y (USVI is not one of the voluntary programs)
Energy Star: a U.S. Environmental Protection Agency (EPA) voluntary program that helps businesses and individuals save money and protect our climate through superior energy efficiency. Today, more than 85 % of Americans recognize the ENERGY STAR label.	Y
Green Power Partnership: a voluntary program that encourages organizations to use green power as a way to reduce the environmental impacts associated with conventional electricity use.	Y (USVI could be part of this program but has not not yet been applied in USVI)
Methane Reduction Voluntary Programs: EPA's voluntary methane (CH4) partnership programs work with U.S. industries, along with state and local governments, to promote profitable opportunities for reducing emissions of methane. Programs include AgSTAR, Natural Gas STAR, and Landfill Methane Outreach Program.	Y (USVI could be part of these program but has not yet been applied in USVI)

Transportation	
National Clean Diesel Campaign: Through EPA's Office of Transportation and Air Quality (OTAQ) NCDC works aggressively to reduce the pollution emitted from diesel engines through the implementation of varied innovative control strategies involving international, national, state, and local partners.	Y USVI participated in the Clean Diesel program from 2011-2013, and continues to implement prior year funding through 2016 without applying for new funding in 2014-2015. Across 2011-2013 they were awarded $93,713.00 (they became eligible for these state allocations in 2011). USVI is eligible for new Diesel Emissions Reduction Program (DERA) funding in 2016 and applications are due April 26, 2016.

Through EPA Region 2's Environmental Finance Center at Syracuse University[188] a number of waste management, energy, and green infrastructure training programs and partnerships have been facilitated in the U.S. Virgin Islands. This includes the VI Recycling Partnership[189] and its *U.S. Virgin Islands Integrated Solid Waste Strategy*[190] in 2011 and Workshops in 2013 on Energy Management (Rates and Finance).

Additionally, the U.S. Environmental Protection Agency has a climate adaptation strategy, *The U.S. EPA Climate Change Adaptation Plan*[191] that identifies vulnerabilities to EPA's mission and goals from climate change. It also identifies short-term actions that EPA has sufficient levels of funding and resources available for implementation.

[188] http://efc.syr.edu/
[189] http://virecycles.com/
[190] http://virecycles.com/wp-content/uploads/2013/03/VI_SWM__Integrated_Plan_FINAL_4-25-11.pdf
[191] Cuevas, David. Communication with Stevie Henry. January 2016. https://www3.epa.gov/climatechange/Downloads/EPA-climate-change-adaptation-plan.pdf

CRITICAL INFRASTRUCTURE SECTOR SUMMARY

The Territory's critical infrastructure provides essential services that are vital to public confidence and the islands' safety, prosperity and well-being. There appears to be some amount of inclusion of climate change vulnerability in some programs/ projects related to key infrastructure development, most in the last five years but even as far back as a 2005 study completed by Dr. Aurelio Mercado funded by the Puerto Rico Sea Grant College Program, titled, *An evaluation of the main ports and bays in Puerto Rico and the U.S. Virgin Islands as to their exposure to hurricane wave attack.* Most of the programs and projects have been assessment and planning focused such as planning climate mitigation actions as part of the VI Department of Public Works Proposed 2030 Master Transportation Plan (goals 5.3 and 5.4) and the VITEMA Territorial Hazard Mitigation Plan in 2014 that includes the effects of climate change in the assessment (qualitatively) and proposes programmatic and island actions to mitigate climate risks. A non-governmental study led by The Nature Conservancy used funding from the National Oceanic and Atmospheric Administration and input from workshop participants to apply mapping and modeling tools to identify USVI's most vulnerable communities. The studies, assessments and plans documented are a good start for the Territory, but many more like these are needed that focus on identifying specific critical infrastructure assets vulnerable to multiple climate parameters and viable solutions for mitigating those risks. A few of the institutions synthesized in the critical infrastructure sector have reached implementation, mostly related to energy infrastructure, such as a WAPA-FEMA project to transfer overhead lines and pole mounted transformers to new underground electric infrastructure in Charlotte Amalie.

Notable
Climate Change Research and Program Results in the
U.S. Virgin Islands for Critical Infrastructure

- Coastal erosion already observed impacting sewage lines allowing salt water intrusion (VI WAPA).

- From the USVI Hazard Mitigation Plan 2014[192] (VITEMA):

  - **Landslides.** Landslides are expected to increase in intense precipitation events for St. Thomas and St. John.

  - **Floods.** Floods are expected to increase in intense precipitations events in St. Thomas, St. John and St. Croix.

  - **Coastal Flooding.** Projected rise in sea level will augment surge and wave heights to increase projected coastal flood depths and extents in St. Thomas, St. John and St. Croix.

  - **Drought.** Expected reduction in average rainfall which could bring the impact of drought and average temperature increases could reduce the water availability for drought and wildfire hazards in St. Croix.

  - **Hurricane.** Percent increases in wind speed may be applied over the hurricane hazard to derive projected hurricane wind speeds taking into consideration variability in St. Thomas, St. John, St. Croix (*the plan describes a potential decrease in hurricane hazard intensity due to climate change*)

  - **Wildfire.** Expected reduction in average rainfall which impact of wildfire and average temperature increases reduce the water availability for drought and wildlife hazards.

From 2008 to 2014 the Territory has achieved a 30% reduce in fossil fuel use and electricity rates were down to approximately $0.33/kWh in 2015 (at its height the rates were greater than $0.50/kWh in 2008).[193]

[192] VITEMA. United States Virgin Islands Territorial Hazard Mitigation Plan (Final) July, 2014. http://www.vitema.gov/mitigation/mitigation-plan-2014.html
[193] Walls, Stephen. 2015. De-Risking Island Energy System Investments. IEA EGRD. Energy Transition Initiative, US Department of Energy. Presentation. https://www.iea.org/media/workshops/2015/egrdoct/09Walls_DOE.pdf

- Mapping and modeling using tools available at coastalresilience.org[194] and input from workshop participants, The Nature Conservancy found that ten coastal areas were identified in the Territory as most vulnerable to climate change and likely to respond: Two Brothers, Demarara, Kings Quarter, Honduras, Nadir, East Street, Mount Pleasant and Retreat, Bovoni, and Enighed.

- DOT identified three general vulnerability to climate change: existing infrastructure resilience, new infrastructure resilience, and system resilience.[195]

    - Transportation is and will continue to be affected by climate change.

    - Adaptation to climate change can include adjusting how transportation infrastructure is planned, designed, built and operated. Mainstreaming consideration of climate in all activities related to planning, constructing, operating and maintaining transportation infrastructure and providing transportation services can ensure that resources are invested wisely and that services and operations remain effective.

    - More frequent/severe flooding of underground tunnels and low-lying infrastructure, requiring drainage and pumping, due to more intense precipitation, sea level rise, and storm surge.

    - Increased numbers and magnitude of storm surges and/or relative sea level rise potentially shorten infrastructure life.

    - Increased thermal expansion of paved surfaces, potentially causing degradation and reduced service life, due to higher temperatures and increased duration of heat waves.

    - Asphalt degradation and shorter replacement cycles; leading to limited access, congestion, and higher costs, due to higher temperatures.

    - Culvert and drainage infrastructure damage, due to changes in precipitation intensity, or snow melt timing.

    - Decreased driver/operator performance and decision-making skills, due to driver fatigue as a result of adverse weather.

[194] Schill, S., J. Brown, A. Justiniano, A. Hoffman. 2014. US Virgin Islands Climate Change Ecosystem-based Adaptation: Promoting Resilient Coastal and Marine Communities. The Nature Conservancy and NOAA Coral Reef Conservation Program. https://www.conservationgateway.org/ConservationPractices/Marine/crr/library/Documents/USVI%20EBA%20Guidance_Final.pdf
[195] U.S. DOT. 2014. U.S. Department of Transportation Climate Adaptation Plan 2014: Ensuring Transportation Infrastructure and System Resilience: https://www.transportation.gov/sites/dot.gov/files/docs/2014-%20DOT-Climate-Adaptation-Plan.pdf

- Increased risk of vehicle crashes in severe weather.

- System downtime, derailments, and slower travel times, due to rail buckling during extremely hot days.

- Reduced aircraft performance leading to limited range capabilities and reduced payloads.

- Air traffic disruptions, due to severe weather and precipitation events that impact arrival and departure rates.

- Reduced shipping access to docks and shore equipment and navigational aid damage.

- Restricted access to local economies and public transportation.

    - Results from the Mercado Report for the U.S. Virgin Islands' Ports:[196]

- There are bays which are obviously well exposed to big wind waves, in some cases not even requiring a wave simulation to reach this conclusion. Frederiksted (St. Croix) is of this category. Then there are bays on the opposite extreme in that their geometry and shape lead one to conclude beforehand that they are well protected. Then are the ones that only a simulation will help in clarifying its exposure. And in this case, results vary as follows: Christiansted, St. Croix – this bay is well protected by the fringing reefs lying offshore. Port Alucroix, St. Croix – the western side of the port is relatively well protected by an offshore fringing reef (Long Reef), but on its eastern side, not being protected by the reef, large waves (2.5 m under no storm surge and no wind conditions; 4.5 m under both conditions) can be seen in the results.

- Charlotte Amalie, St. Thomas: large waves (4 - 5 m) are capable of reaching the entrance to both channels even under no storm surge and wind conditions. On East Gregerie Channel this can continue all the way up to Transect 2, with Hs between 2 - 2.5 m. Along the channel leading to the main bay of Charlotte Amalie, wave energy seems to dissipate somewhat better (compare Transects 2 and 4), but not much (again, for no storm surge and wind conditions), with Hs values hovering around 2 m. Well inside the bay, Transect 5, waves hover around 1 - 1.5 m under no storm

[196] Mercado. 2005. Final Report: An evaluation of the main ports and bays in Puerto Rico and the U.S. Virgin Islands as to their exposure to hurricane wave attack. Sea Grant College Program. Available upon request.

surge and no wind conditions, implying some good protection for these conditions. Under storm surge and wind conditions things are very rough along East Gregerie Channel, with Hs values reaching 4 - 4.5 m along Transect 2 well inside the channel. Along the main channel to the main bay of Charlotte Amalie things are not much different, with Hs values between 2 - 3.5 m along Transect 4. Deep inside Charlotte Amalie Bay (Transect 5), under storm surge and wind conditions, we can see Hs values hovering between 2.5 to 3 m, decaying at both ends of the transect.

- Christiansted, St. Croix: It can be seen that this location is protected by a natural breakwater consisting of offshore reefs fronting the location practically all along its length. Deepwater waves propagating from the northeast, north, and northwest were simulated. It shows that under no storm surge and no wind conditions, practically nothing penetrates through, irrespective of the offshore wave direction. Under storm surge and wind conditions Hs starts with half a meter at the western end of the slice (Point A), increasing to 1.5 - 2 m at halfway between Points A and B, and hovering around these two values until Point C, where it increases to around 2 m. Thus we can conclude that this location is well protected.

- Frederiksted, St. Croix: Three deepwater wave directions were simulated: from the northwest, west, and southwest. This location is similar to Aguadilla [Puerto Rico], with a very narrow shelf and a very exposed coastline. Very large waves crash very close to the coastline. Waves varying between 2 and 3.5 m break very close to the Mean Sea Level shorelines, depending on whether a storm surge is present or not. It is obvious that this is a very exposed location.

- Port Alucroix, St. Croix: This is another location with a very narrow shelf and unprotected with the exception of a fringing reef (called Long Reef) protecting the entrance to the Krause Lagoon Channel. As expected, under no storm surge conditions Long Reef offers good protection to the western side of the transect, but once outside its protection Hs values start to increase rapidly. For waves from the south and southeast Hs values on the eastern side (close to Point B) hover around 2.75 m. When a storm surge is added, submerging the reef, then, in combination with the strong wind forcing, Hs values on the previously well protected back-side increased to around 2 m, while on the eastern side increase to around 4.5 m.

ECONOMIC DEVELOPMENT

SECTOR OVERVIEW

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change found that the impacts of climate change will be felt by every sector of the economy and are relevant to all investors, financial services and businesses.[197]

Economic development is simultaneously a concept, an activity and a professional practice, and not easy to define.[198] It is a popular topic of discussion because of its importance and because there are high expectations, high stakes, and significant investments of public money. This section is focused on the three main responsible institutions for USVI: VI Economic Development Authority, VI Bureau of Economic Research, and the U.S. Department of Commerce. Arguably, other territorial, federal and private entities, such as the VI Departments of Agriculture and Tourism, should be included to get a more comprehensive picture of climate adaptation and mitigation efforts in the Territory. Information on these other economic development entities can be found in other sections of this report.

INSTITUTIONAL FUNDING AND TECHNICAL CAPACITIES

The majority of funds for economic development in the Territory come from the general fund, federal grants, and of course private sector investment. Through the programs described below it appears technical capacity is strong for statistical analysis and research, strategic planning, financial management and advice, loan programs, tax credits and market-based incentives.

RELEVANT INSTITUTIONS

- VI Economic Development Authority
- VI Bureau of Economic Research
- U.S. Department of Commerce

[197] IPCC. 2014. Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32. http://www.ipcc-wg2.gov/AR5/

[198] Feldman, F., T. Hadjimichael, T. Kemeny, L. Lanahan. Nd. Economic Development: A Definition and Model for Investment. Available through the Economic Development Administration website: https://www.eda.gov/tools/files/research-reports/investment-definition-model.pdf

PROGRAMS AND RELEVANT PROJECTS BY INSTITUTION

AGENCY: U.S. VIRGIN ISLANDS ECONOMIC DEVELOPMENT AUTHORITY

USVI Economy Development Authority Programs/Outputs

The U.S. Virgin Islands Economic Development Authority (VI EDA) is a semi-autonomous government organization responsible for the promotion and enhancement of economic development in the United States Virgin Islands. There are four divisions within the VI EDA with four distinct functions: (1) Economic Development Commission (EDC) administers a tax incentive program for businesses in which approved applicants could be granted 90-100% tax exemptions and a 1% customs duty from the standard 6%; (2) Economic Development Park Corporation (EDPC) operates an industrial park facility where rental spaces are available for local businesses for manufacturing and storage activities. The enabling legislation requires the EDPC to coordinate and collaborate with the VI Department of Agriculture; (3) Economic Development Bank (EDB) provides assistance to entrepreneurs and existing business owners with access to loans and loan guarantees needed to create, expand or own small businesses; and (4) Enterprise Zone Commission (EZC) program administer the redevelopment of economic blighted and distressed communities that were once socially and economically vibrant. There are four designated: Savanne-Down-street and Garden Street-Up-Street on St. Thomas. And Christiansted and Frederiksted in St. Croix.

Currently, EDA has no policy or risk and vulnerability assessment publicly available. This does not mean, however, that EDA programs do not contribute to building resilience in the U.S. Virgin Islands. One program, under the Small Business Development Agency, the team found that has a climate link is the Virgin Islands Economic Development Authority Post-Disaster Relief Revolving Loan Fund[199] focused on natural disaster resiliency and economic diversification. A displaced St. Croix worker or owner of a small U.S. Virgin Islands business, particularly minority-owned, can borrow up to $75,000.002 to assist in recovery if they had been affected by tropical storms Otto and Thomas. Other loan programs are available through EDA that may have the potential to assist the Territory adapt to climate change, though might not be explicitly available for that purpose.

AGENCY: U.S. VIRGIN ISLANDS BUREAU OF ECONOMIC RESEARCH

USVI BUREAU OF ECONOMIC RESEARCH PROGRAMS/OUTPUTS

The Bureau of Economic Research (BER) is a unit under the Virgin Islands Office of the Governor. BER compiles, produces and provides information on the state of the economy of the U.S. Virgin Islands in support of decision-making in both the public and private-sector. BER is the Territory's

[199] http://www.usvieda.org/grow-business/financing-options/post-disaster-relief-revolving-loan-fund

lead agency responsible for collaborating with the Department of Commerce - Economic Development Administration (EDA) in carrying out its mission to foster economic development. The Bureau also collaborates with the US Census Bureau in the conducting the Virgin Islands Economic Census (BER, 2016). In 2009 and again in 2015 the agency published *U.S. Virgin Islands Comprehensive Economic Development Strategy*[200] that was developed through a collaboration involving private, nonprofit and public sectors. The report was prepared under a financial assistance award granted to the U.S. Virgin Islands BER from the U.S. Economic Development Administration. In the past, assessing risks and vulnerabilities of the Territory's economy to the impact of climate change was not identified a priority. If made a priority BER has stated to our team they would need consultants to build the bureau's capacity to conduct the assessment.The Director attended a 2016 climate change orientation workshop sponsored by the University of the Virgin Islands. Due this experience the Director is seeking a similar workshop for the bureau's staff.

Part of the USVI Economic Development Strategy is a strengths, weaknesses, opportunities and threats (SWOT) assessment that arrived at a number of conclusions about the competitiveness of the USVI economy. According to the report, "it revealed that the USVI has valuable assets that can be leveraged to support its core industries and establish new production platforms which drive high value-added growth with spill-over effects. The assessment substantiates that the USVI's core strengths for economic development are its natural resource endowment, human assets, tax incentive program, and its strategic location and ties to the United States." The first two assets from the SWOT assessment are highly vulnerable to a changing climate: natural resource endowment and human assets. Despite this fact though the Strategy makes no mention of climate change. Generally, however, the five overarching priorities the strategy deems essential for growth and sustainability for the USVI economy do contribute to increasing the Territory's resilience. They are: (1) Economic Competitiveness; (2) Education and Skills; (3) Infrastructure, Environment and Quality of Life; (4) Healthcare; and (5) Government Support Systems. The third priority area specifically mentions how "equally important to business and community development are long-term investments in air and sea ports, roads, public structures, broadband and communication, and the environment." The Territory can ensure that future climate scenarios are factored into the selection and implementation of "long-term investments" by adopting guidelines developed and used by the Department of Commerce - Economic Development Administration in considering resiliency in grant-making investment decisions.

One action item in the U.S. Virgin Islands' Economic Development Strategy could be considered a climate adaptation for critical infrastructure that has an economic development benefit. This project would transfer overhead lines and pole mounted transformers to a new underground electric infrastructure in St. Thomas. More information about this hazard mitigation project can be found in the critical infrastructure section.

[200] http://www.usviber.org/CEDS%20Plan%202015.pdf

Similarly, one item in the Strategy could be considered a climate mitigation action that reduces the cost of doing business in the Territory by lowering the cost of electricity. The added benefit is the reduction of greenhouse gas emissions (provided the lower energy costs don't create the malincentive for consumers to use more electricity). The U.S. Virgin Islands has the goal to reduce its dependency on utilizing fossil fuel for generating electricity by 60 percent by the year 2025. To do this they have begun to promote the use of alternative energy and switching from petroleum fuel oils to Liquefied Petroleum Gas. More information about this climate mitigation effort can be found in the critical infrastructure section.

AGENCY: U.S. DEPARTMENT OF COMMERCE

UNITED STATES DEPARTMENT OF COMMERCE PROGRAMS/OUTPUTS

The U.S. Department of Commerce does have a Climate Change Adaptation Strategy, most recently updated in 2014,[201] and it states, "Climte variability and climate change will affect a range of Departmental services, operations, programs and assets. A changing climate will also result in financial, operational, social, and environmental risks and opportunities across diverse industries and sectors at local, regional, national, and international levels, impacting the Department's partners and the customers it serves." The U.S. Virgin Islands is not exempt from these impacts.

STATUS:	Assessment
APPROACH:	Impact-based
MOTIVATION:	Decision

The U.S. Department of Commerce (DOC) through its scientific and economic bureaus has positioned itself to develop and deliver services to its national stakeholders to help prepare and reduce the vulnerabilities to climate variability and change.[202] Within DOC the Economic Development Administration (EDA) provides grant-based investments to communities and regions suffering from economic distress. These investments range from strategic economic development planning to public infrastructure construction.[203] Since 2014, the Federal Economic Development Administration has been leveraging its Comprehensive Strategy Content Guidelines along with its participation in shaping the National Disaster Recovery Framework (NDRF) with its leadership on the Economic Recovery Support Function of this framework. As such for FY 14, the EDA identified as a milestone finalizing "internal guidance on how to factor resiliency (including resiliency to the effects of climate change) into its grant-making investment decisions."

[201] http://www.osec.doc.gov/ofeq/Documents/OSEEP/Annual%20Rpts%20&%20Scrcards/Final%20DOC%20Adaptation%20Plan_Final_2014-6-10.pdf
[202] Ibid. page 5
[203] http://www.osec.doc.gov/ofeq/Documents/OSEEP/Annual%20Rpts%20&%20Scrcards/Final%20DOC%20Adaptation%20Plan_Final_2014-6-10.pdf (page 11)

The 2014 Department of Commerce Climate Adaptation Strategy[204] is only explicit to how the DOC will address climate change in the U.S. Virgin Islands in one FY14 action item under the category *Science and Information* and the implementing DOC office/bureau was the National Oceanic and Atmospheric Administration (NOAA). Action 5 of the Strategy is to develop frameworks and tools to help local coral reef managers incorporate climate change information into effective decision making that minimizes their risks to climate change. The key vulnerability or opportunity that this action item addresses is "the demand for Department-produced tools to help governmental and non-governmental entities and the private sector transform this science and data into effective decision making that minimizes their risks to climate change will increase as more climate and other science and data becomes available." The implementation method identified is a collaborative project already underway through the Climate Change Working Group of the U.S. Coral Reef Task Force and involves many NOAA offices and programs, The Nature Conservancy, USGS, state and territorial governments and agencies, academic institutions and others. The project reviewed recent advances in assessment and planning for climate change by coral reef practitioners, and used this information to tailor theoretical adaptation methods into a form that is more useful for coral reef management. Specific to USVI the milestones were supporting partnerships and grants to complete coral resilience assessments. This project is also listed as an action in the DOC Climate Adaptation Strategy under *Interagency Coordination on Climate Change Adaptation.* Through the NOAA Coral Reef Conservation Program Liasion we were able to track down how this action item was actually implemented in USVI. See the Natural Resources sector session for more information.

Climate change may have an even more pronounced impact on the USVI economy than that of the mainland as NOAA's recently released report, "Describing the Ocean Economies of the U.S. Virgin Islands and Puerto Rico,"[205] indicates that the Virgin Islands are more reliant on ocean-related activity than most continental U.S. states.

ECONOMIC DEVELOPMENT SECTOR SUMMARY

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change found that the impacts of climate change will be felt by every sector of the economy and are relevant to all investors, financial services and businesses.[206] The VI Economic Development Authority (VI EDA), a semi-autonomous government organization responsible for the promotion and enhancement of economic development in the United States Virgin Islands, currently does not have a climate change policy or risk and vulnerability assessment publicly available; however, the

[204] http://www.osec.doc.gov/ofeq/Documents/OSEEP/Annual%20Rpts%20&%20Scrcards/Final%20DOC%20Adaptation%20Plan_Final_2014-6-10.pdf

[205] https://coast.noaa.gov/data/digitalcoast/pdf/econ-usvi-pr-executive-summary.pdf

[206] IPCC. 2014. Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32. http://www.ipcc-wg2.gov/AR5/

VI EDA admisters a number of programs that work to build resliency into the territories economy. Additionally, the federal programs that provide funding and technical assistance to territorial programs, like the US Department of Commerce, recognizes the importance of factoring climate change impacts into its planning and grant processes. The Federal Economic Development Administration (US EDA) is helping to build resiliency into communitties by providing grant-based investments to communities and regions suffering from economic distress. These investments range from strategic economic development planning to public infrastructure construction.

According to the Bureau of Economic Research (BER) Comprehensive Economic Development Strategy (CEDS 2015),[207] the USVI is at a "critical juncture of economic crisis and change, after three successive years of economic decline..." The strategy recognizes the natural and human resources of the islands as core strengths for economic development as well as identifying the need to invest in 'infrastructure, environment and quality of life', but does not make specific mention of climate change. Programs aimed at incorporating climate change vulnerabilities and solutions into existing and emerging development strategies as well as diversifying the economy of the USVI represent important strategic opportunities for this sector.

[207] USVI CEDS: http://www.usviber.org/CEDS%20Plan%202015.pdf

FOOD SECURITY

SECTOR OVERVIEW

Public and private efforts have been made to strengthen and revive the agricultural sector within the U.S. Virgin Islands in recent years. Concepts of vulnerability and resilience in the face of a changing global climate have underpinned some of these efforts. Unfortunately, the islands remain almost wholly dependent on food imports to supply the daily needs of residents and tourists.[208] This import dependency contributes to the vulnerability of the islands' food supply in a variety of ways: potential supply chain disruptions from hurricanes and tropical storms, inflated cost of imported products, lack of availability and high cost of fresh foods leading to diets heavy in processed foods, among others. These factors negatively affect many social, economic, and environmental facets of life within the territory.

In general, the concept of food security deals with food supply and individuals ability to access it. The United Nations Food and Agriculture Organization (FAO) defines four main dimensions of food security: 1) Availability- this addresses the supply side and is determined by production, stock levels, and net trade. 2) Access- this acknowledges that sufficient production and stock levels alone do not ensure food security. The focus here is on incomes, expenditure, markets and prices. 3) Utilization- this dimension is concerned with sufficient energy and nutrient intake by individuals. 4) Stability- this dimension addresses the stability of the other three dimensions over time. [209] The United States Department of Agriculture (USDA) defines food security broadly as "…the ability to obtain and use sufficient amounts of safe and nutritious food…" and have adopted the four pillars as laid out by the FAO. A USDA report released in 2015 concluded that, "Climate change is very likely to affect global, regional, and local food security by disrupting food availability, decreasing access to food, and making utilization more difficult".[210]

RELEVANT INSTITUTIONS

US Virgin Islands Department of Agriculture

University of the Virgin Islands Cooperative Extension Service

United States Department of Agriculture Natural Resources Conservation Service

United States Department of Agriculture Farm Service Agency

United States Department of Agriculture Caribbean Climate Sub Hub for Agriculture and Tropical Forestry

[208] 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
[209] UN FAO, 'A Introduction to the Basic Concepts of Food Security': http://www.fao.org/docrep/013/al936e/al936e00.pdf
[2103] Climate Change, Global Food Security and the US Food System: http://www.usda.gov/oce/climate_change/FoodSecurity2015Assessment/FullAssessment.pdf

INSTITUTIONAL FUNDING AND TECHNICAL CAPACITIES

The USDA invested over $535 million in the U.S. Virgin Islands in the six-year period from 2009-2014.[211] A large portion of these funds ($165 million) were directed toward promoting and implementing conservation land management techniques that seek to keep land productive while improving the condition of vital natural resources. The USDA also invested $15.6 million in research efforts designed to improve agricultural and natural resources in the face of challenges such as climate change and growing populations. Some of these funds were invested in partnership with local entities such as the U.S. Virgin Islands Department of Agriculture and the University of Virgin Islands Cooperative Extension Service in order to promote new farmers and sustainable cultivation practices.

The U.S. Virgin Islands Department of Agriculture (VIDOA) was appropriated $3,500,000 for FY2016 which represented an increase of $500,000 over its FY2015 budget. This increase is designated for capital improvement projects, specifically to bring animal slaughtering facilities into compliance with USDA standards. The department's budget includes another $600,297 in non-appropriated funds, which include federal grants and income from land leases and services provided to producers, which are classified under the department's revolving funds. The 2016 budget includes several drought impact mitigation efforts including the purchase of additional water storage tanks and water delivery trucks.

PROGRAMS AND RELEVANT PROJECTS

AGENCY: UNIVERSITY OF THE VIRGIN ISLANDS COOPERATIVE EXTENSION SERVICE (UVI-CES)

UVI-CES PROGRAMS/OUTPUTS

STATUS:	Implementation
APPROACH:	Impact Based
MOTIVATION:	Decision/Research

The University of the Virgin Islands Cooperative Extension Service (UVI-CES), founded in 1972 following the Universities' receiving Land-Grant status by the U.S. Congress, provides a range of services and programs with the intent of improving agricultural production and quality of life within the Virgin Islands. These programs aim to empower local agricultural communities by providing them with technical and educational support and generally promoting local agricultural products. Local extension agents are available to advise local producers regarding a range of climate related

[211] USDA USVI Investment Factsheet: http://www.usda.gov/documents/USVirginIslands_Investments.pdf

challenges such as pest and disease control, drought mitigation, water and irrigation management, and cultivar selection. To address the acute challenges of maintaining the islands' unique cultural and environmental character, UVI-CES has developed the Natural Resource and Environmental Management Program (NREM) to develop and promote holistic environmental practices and ethics that are uniquely suited to the islands.

Agricultural programs offered by UVI-CES include:

- Beginning Farmers Training Program[212]
- Integrated Pest Management [213]
- Livestock Improvement Program[214]
- Natural Resource and Environmental Management Program (NREM)[215]
- Pesticide Safety Education Program (PSEP)[216]
- Urban Garden[217]
- Sustainable Agriculture[218]
- Water Quality[219]

The UVI-CES also seeks to aid the local agricultural community through the Agricultural Experiment Station (AES). The AES strives to generate information that will help local farmers increase production and efficiency, develop new enterprises, and cope with challenges unique to the islands' growing environment. The program currently has research projects in animal science, aquaculture, biotechnology, forage agronomy, fruit, ornamental and vegetable crops. By preserving germ plasms unique to the islands, developing new cultivars, more resilient animal breeds, and promoting innovative and sustainable production techniques, the UVI-CES bolsters agriculture in the islands against acute shocks from large storm damage as well as more chronic stressors such as increasing temperatures and more frequent droughts. All these programs strive to improve food security within the USVI and mitigate risk among individual producers and the agricultural industry of the islands at large.

Sustainable Agriculture Research and Education (SARE)

The U.S. Virgin Islands Sustainable Agriculture Research and Education (SARE) is a professional development program sponsored by the USDA Southern Region SARE and coordinated by the University of the Virgin Islands. The program works to deliver programs that enhance the environmental, social, and economic sustainability of the state through research and education.

[212] Beginning Farmers Training Program: http://uvi.edu/files/documents/Research_and_Public_Service/CES/BFRDP%20Brochure.pdf
[213] Integrated Pest Management: http://uvi.edu/community/cooperative-extension-service/agriculture-and-natural-resources/integrated-pest-management.aspx
[214] Livestock Improvement Program: http://uvi.edu/community/cooperative-extension-service/agriculture-and-natural-resources/livestock.aspx
[215] Natural Resource and Environmental Management Program: http://uvi.edu/community/cooperative-extension-service/agriculture-and-natural-resources/natural-resources-and-environmental-management.aspx
[216] Pesticide Safety Education Program (PSEP): (http://uvi.edu/community/cooperative-extension-service/agriculture-and-natural-resources/pesticide-safety-education.aspx)
[217] Urban Garden: http://uvi.edu/community/cooperative-extension-service/agriculture-and-natural-resources/urban-gardening.aspx)
[218] Sustainable Agriculture: (http://uvi.edu/community/cooperative-extension-service/agriculture-and-natural-resources/sustainable-agriculture.aspx)
[219] Water Quality: http://uvi.edu/community/cooperative-extension-service/agriculture-and-natural-resources/water-quality.aspx)

U.S. Virgin Islands SARE partners with researchers, extension faculty, producers, and community organizations to research and implement the best science-based practices available in all aspects of the U.S. Virgin Islands agricultural system. In addition to research, SARE is dedicated to providing education in sustainable agriculture through various trainings offered each year. The SARE state coordinator is vital for expanding sustainable agriculture training for Extension, Natural Resources and Conservation Services (NRCS), and other agricultural professionals who will then help producers transition to a more sustainable agriculture.[220]

AGENCY: USDA CARIBBEAN CLIMATE HUB (USDA CCH)

CCH PROGRAMS/OUTPUTS

STATUS:	Assessment/Planning
APPROACH:	Integrated Assessment/Risk Management
MOTIVATION:	Research/Stakeholder

Started in 2014 as part of a nation-wide network of 10 hubs, the Caribbean Climate Hub for Tropical Forestry and Agriculture (CCH) is working to assess and address a range of climate change related issues within the agricultural and forestry communities of the U.S. Caribbean. The mission of the Hub is to develop and disseminate climate science that is tailored to the needs of local producers and advisors while providing an arena for inter-agency communication and collaboration. The CCH has formed important partnerships with the International Institute of Tropical Forestry (IITF) in San Juan, the Caribbean Region NRCS, the USDA Tropical Agriculture Research Station (TARS), the Virgin Islands Department of Agriculture (VIDOA), and many other federal, territorial, NGO, and private entities. CCH and IITF staff worked together to develop the most spatially explicit climate projections available for the region and continue to partner with faculty from the Universities of Puerto Rico and the U.S. Virgin Islands to develop actionable climate science and technological tools that improve adaptive capacity among producers. Members of the CCH team have met with many local producers and advisors in St. Thomas and St. Croix to discuss their understanding of how global climate change may affect farming in the region as well as what adaptive options may be available. The CCH has hosted a number of informational webinars and workshops, as well as producing a number of publications, educational materials, and demonstrative videos to draw attention to the latest climate science, model projections, and mitigation and adaptation techniques.[221] In 2015, the CCH completed and published the first climate change vulnerability assessment for agriculture and forestry within the US Caribbean.[222] The CCH is actively improving adaptive capacity in working land communities within the Islands

[220] Virgin Islands SARE Program: http://www.southernsare.org/SARE-in-Your-State/U.S.-Virgin-Islands
[221] Caribbean Climate Hub Website: http://www.climatehubs.oce.usda.gov/caribbean
[222] Caribbean Regional Assessment of Climate Change Vulnerability in Agriculture and Forestry: http://www.climatehubs.oce.usda.gov/sites/default/files/Caribbean Region Vulnerability Assessment Final.pdf

by working to facilitate communication and cooperation across institutional and disciplinary boundaries.

The CCH's mission, vision, and strategic plan are built around limiting working land risk in the face of climate change. Projects under the CCH have included:

- *Vulnerability Assessment for Caribbean Working Lands.* Publication broadly assesses regional agricultural sensitivity and vulnerability to projected climate change impacts. More specifically investigates potential impacts on coffee, livestock, fruit and vegetables, grasses, and forest systems.[223]

- *Interviews with working lands advisors and producers regarding barriers to resilience and perceptions of climate change risk.* Producers and sector advisors broadly agree that the effects of climate change are being felt in the region and poise a threat to agriculture; however, specific regional impacts are poorly understood and many see overcoming social and institutional barriers as more important to growing the sector. Concepts of vulnerability and adaptation are either narrowly defined or poorly understood. Producers and advisors have expressed a desire for more on-farm demonstrations as an effective way to disseminate adaptive management practices.

- *Demonstrating adaptive farming techniques through the ADAPTA video project.*[224] In response to stakeholder's desire for adaptive demonstrations that are specific to conditions within the Caribbean region, the CCH has begun production of a series of videos highlighting adaptive practices currently being undertaking in the sectors of livestock and dairy, coffee and forestry, plantain and specialty crops, and fruit, herbs and vegetables. The first of these videos has been completed and is available for viewing.

- *Fostering cross-boundary information sharing through interactive webinars, workshops, and conferences.* The CCH hosted a workshop in San Juan Puerto Rico on September 22-23, 2015 in order to communicate USDA strategies for greenhouse gas (GHG) mitigation and explore how these strategies interact with regional activities and partner agencies. The workshop also served as a platform to discuss what tools and techniques are currently proving effective in communicating climate science and adaptive practices within Caribbean working lands. The workshop was attended by the Virgin Islands Assistant Commissioner of Agriculture, Errol Chichester who presented on drought and other challenges facing USVI producers. In August of 2015, the CCH hosted USDA representatives from the Caribbean, Central America, Southwestern US,

[223]

[224]ADAPTA video project: http://caribbeanclimatehub.org/projects/

Washington DC, and met with government and non-government delegates from seven countries in Central America to discuss the USDA Regional Climate Hub network. The workshop enabled international participants to examine the USDA Regional Climate Hub model at the IITF in Puerto Rico. The group explored opportunities for institutions to interact with the USDA Hubs and to establish and support similar networks throughout Latin America and the Caribbean.

AGENCY: USDA FOREST SERVICE

USDA FOREST SERVICE PROGRAMS/OUTPUTS

State and Private Forestry Program

STATUS:	Assessment/Planning
APPROACH:	Impact Based
MOTIVATION:	Research/Decision

The State and Private Forestry Program is collaboration between the U.S. Virgin Islands Department of Agriculture and the USDA Forest Service in order to improve the quality of private forests throughout the islands and ensure that ecologically sensitive areas are managed and/or conserved to preserve their vital ecosystem service providing functions. By working with local private landowners, foresters are able to craft management plans that accomplish multiple use objectives such as increased biodiversity, income from timber and non-timber forest products, public recreation opportunities, and watershed protection. By improving the overall health of private forest lands within the U.S. Virgin Islands and targeting high-value conservation areas for protection via easements, the program increases forest and watershed resilience to potential impacts from climate change such as drought, intense rainfall events, hurricanes, and the proliferation of pests and disease. Assistance is focused on cooperative programs such as: Cooperative Fire Protection, Forest Health, Urban and Community Forestry, Forest Stewardship and Forest Legacy.[225] The primary goals of the forestry programs in the U.S. Virgin Islands are: 1)Contiguous Forest Conservation and Management; 2) Urban Forest Management and 3) Coastal Forest Ecosystems Protection. [226]

Cooperative Fire Protection

USDA Forest Service grant funds ($80,000 in FY2014) were used to purchase firefighting gears, firefighting supplies, educational supplies, and other items educational tools that were distributed to the students during Prevention Week.

[225] Source: http://www.fs.usda.gov/main/iitf/spforestry
[226] State and Private Forestry US Virgin Islands Factsheet: http://www.stateforesters.org/sites/default/files/publication-documents/VI%20State%20and%20Private%20Forestry%20Fact%20Sheet.pdf

Preserving ecosystems functions and services through private lands partnerships

In FY 2014, 34 stewardship clients were visited by the Forest Stewardship Program Coordinator to ensure that program participants were following through with management plans. Approximately 29 were assisted in preparing their tax exemption applications. One new forest stewardship plan was approved.

Striving to conserve areas of high conservation value throughout region

During FY2014, the Forest Legacy program purchased two properties in the Virgin Islands, one at Estate Hamm's Bluff Plot #3 of 35 acres, and one at Estate Northstar Plots # 1, 1A, and 5, of 102 acres. These two purchases are the third and fourth purchased through the program, bringing the total of acres protected in the islands to 212.

AGENCY: USDA FARM SERVICE AGENCY

USDA FARM SERVICE AGENCY PROGRAMS/OUTPUTS

STATUS:	Implementation
APPROACH:	Risk Management
MOTIVATION:	Decision

The USDA Farm Service Agency (FSA) administers a number of assistance programs designed to limit and reducing risks associated with farming, incentivize the conservation of ecologically sensitive lands, and assist new farmers throughout the United States. Many programs, such as Noninsured Crop Disaster Assistance Program (NAP), provide financial assistance to eligible producers directly affected by climatic events such as drought, flood, hurricane, or other natural disasters. County committees are locally elected and play a critical role of the day-to-day operations of the FSA. These committees help deliver FSA farm programs at the local level and help decide what types of programs their counties will offer. To be eligible for many FSA assistance programs requires farmers submit records quantitatively demonstrating financial losses during such climate events. This has proven a significant barrier for many USVI producers.[227]

The FSA cites leading efforts to mitigate and adapt to climate change as an objective within the second goal of its 2012- 2016 national strategic plan. [228]

AGENCY: USDA NATURAL RESOURCES CONSERVATION SERVICE

[227] FSA Virgin Islands website: http://www.fsa.usda.gov/FSA/stateoffapp?mystate=vi&area=home&subject=prog&topic=landing
[228] FSA 2012- 2016 Strategic Plan: http://www.fsa.usda.gov/Internet/FSA_File/fsa-strategic_plan_12-16.pdf

USDA NATURAL RESOURCES CONSERVATION SERVICE PROGRAMS/OUTPUTS

Caribbean Area Natural Resource Conservation Services (NRCS) is helping to combat climate change by adopting and implementing several initiatives to improve farm energy efficiency and increase carbon sequestration. Converting land to forest, grassland or other perennial vegetation helps remove carbon from the atmosphere. Likewise, reducing on-farm energy use reduces greenhouse gas emissions to the atmosphere. NRCS is an active member of the Caribbean Climate Hub. [229]

NRCS offers technical and financial assistance to Caribbean Area producers to conserve resources through a variety of programs. [230]

Water Conservation

Since 2010, NRCS has invested over $12 million to provide more than 130 million gallons of irrigation water to Caribbean Area producers by funding irrigation reservoirs and water and sediment control basins, responding to frequent droughts and farmers' concerns. NRCS has also planned and obligated funds to build over 30 additional irrigation reservoirs in the near future. Water can also be harvested from impervious areas and farm buildings' roof runoff, and stored in tanks or cisterns. NRCS Caribbean Area had included new Practices/Scenarios in the Payment Schedule for FY 2016 that will help producers to collect and store rainwater for agricultural uses.[231]

Environmental Quality Incentives Program (EQIP)

The Environmental Quality Incentives Program (EQIP)[232] is a voluntary conservation program reauthorized in the 2014 Farm Bill. EQIP provides financial and technical assistance to farmers and ranchers to help them install and implement conservation practices on eligible agricultural land. Through EQIP, farmers in Puerto Rico and the U.S. Virgin Islands can receive assistance to improve their agricultural production and environmental quality. Many conservation practices such as terracing, cover cropping, and no-till practices increase resilience to climate change effects by guarding against soil loss during moderate to heavy rainfall events.[233]

Other Climate Change Projects To-Date

- St. Croix East End watershed restoration project[234]
- Providing technical assistance and cost sharing to increase producer resilience
- Addressing threats to coral reefs through participation in the US Coral Reef Task Force[235]

[229] Source: http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/pr/technical/?cid=stelprdb1256077
[230] NRCS Caribbean Area home page: http://www.nrcs.usda.gov/wps/portal/nrcs/site/pr/home/
[231] Source: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/pr/programs/financial/eqip/?cid=NRCSEPRD411409)
[232] NRCS EQIP Program: http://www.nrcs.usda.gov/wps/portal/nrcs/main/pr/programs/financial/eqip/
[233] Source: http://www.nrcs.usda.gov/wps/portal/nrcs/main/pr/programs/financial/eqip/)
[234] NRCS St. Croix East End watershed restoration project:
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/pr/programs/landscape/?cid=stelprdb1166717
[235] Coral Reef Initiative: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/pr/programs/landscape/?cid=nrcs141p2_037233

AGENCY: US VIRGIN ISLANDS DEPARTMENT OF AGRICULTURE (VIDOA)

VIDOA PROGRAMS/OUTPUTS

VIDOA addresses climate vulnerabilities within the U.S. Virgin Islands agriculture by providing a number of programs intended to build capacity among island producers, many of whom depend on the department for critical services such as water supply and use of heavy equipment.

STATUS:	Implementation
APPROACH:	Vulnerability Based
MOTIVATION:	Decision

Virgin Fresh Program

The Virgin Island Department of Agriculture (VIDOA) is a beneficiary of the USDA – Farmers Market Nutritional Program (FMNP) grant award FY2011, which enabled VIDOA to issue supplementary checks to eligible WIC[236] recipients. These checks are redeemable at the local participating Farmers' Markets and Farm Stands.

The "Virgin Fresh" WIC Farmers Market Nutrition Program (FMNP) is associated with the Special Supplemental Nutrition Program for Women, Infants and Children, popularly known as WIC. The WIC Program provides supplemental foods, health care referrals and nutrition education at no cost to low-income pregnant, breastfeeding and non-breastfeeding post-partum women, and to infants and children up to 5 years of age, who are found to be at nutritional risk. Eligible WIC recipients receive nutrition education and exposure to a variety of fresh, nutritious, unprepared, locally grown fruits, vegetables and herbs, through their participation in "Virgin Fresh" FMNP. Access to a healthy food supply is an important component of food security that this program addresses directly. The Virgin Fresh program also mitigates some measure of market risk among producers by ensuring a steady demand and market for products. [237]

Agricultural Development

The Agriculture Development Division of VIDOA works with farmers to transform overgrown, cleared or uncultivated land into a field that's suitable for planting row crops. The Agriculture Development Division has three sections that work together to provide services to local farmers for the productions of food and fiber. These sections are:

- **Food Production** - Provides subsidized land preparation services and hay baling for farmers and livestock owners in the Territory.

[236] Special Supplemental Nutrition Program for Women, Infants, and Children
[237] Source: http://www.vifresh.com/project_detail.php?detail_id=47

- **Heavy Equipment Maintenance** - Provides vital maintenance services for machinery used in land preparation as well as VIDA vehicles.

- **Building and Grounds Maintenance** - Provides general maintenance and repairs to all Department structures and grounds occupied by the Department grounds.[238]

AGENCY: VARIOUS PRIVATE FARMS

VARIOUS PRIVATE FARMS PROGRAMS/OUTPUTS

Community Supported Agriculture (CSA), Farmers Markets

The Islands of St. Thomas and St. Croix are home to many private farms that play perhaps the most critical role the food security of the islands. Although many of these farms are quite small (40% < 3 acres)[239] the year-round growing season of the islands and the ingenuity and creativity of the producers allow them to play a vital role in the food supply of the islands. Many of these private farms maintain their own Community Supported Agriculture (CSA) programs and private farmer's markets. While accounting for a relatively small portion of the territories overall food consumption, these farms provide an important source of fresh fruits and produce as well as many great examples of innovative and adaptive cultivation practices. Caribbean Climate Hub staff have been conducting formal and informal interviews with many of these growers to gain a better understanding of how they conceptualize climate change risk, vulnerability, and adaptation. In partial response to feedback from both producers and advisors, the CCH has created the Caribbean Climate and Agriculture Geodatabase (CClimAG).[240] The web based tool helps connect farmers with potential markets as well as consumers with markets and CSA's in their region. While understanding of how global climate change interacts with local factors in the Virgin Islands varies widely, all producers engage in adaptive practices that represent a fluid response to existing and emerging threats from drought, pests, and storms. Many of these farmers express frustration with territorial and federal agricultural support services with complaints ranging from inaccessibility to irrelevance. Accessing federal programs requires proof of land tenure and in some cases detailed financial records. Farmers have expressed an inability to obtain land leases from VIDOA as a barrier to expansion and access to services. Likewise, VIDOA personnel have expressed frustration with many farmers' lack of record keeping and planning. Restaurant owners have expressed a desire to purchase more locally produced food, but claim that inconsistencies and unpredictability in supply make such offerings difficult to infeasible. Many producers remain skeptical of becoming involved with government programs.

[238] Source: http://www.vifresh.com/land.php
[239] USDA USVI Census of Agriculture 2007: http://www.agcensus.usda.gov/Publications/2007/Full_Report/Outlying_Areas/usvi.pdf
[240] Caribbean Climate and Agricultural Database: http://caribbeanclimatehub.org/?portfolio=view-sites

FOOD SECURITY SECTOR SUMMARY

In summary, many programs exist within the U.S. Virgin Islands that are ostensibly aimed at increasing production, food security, and overall resilience of the agricultural sector. Unfortunately, these programs have had seemingly little effect in reversing an overall downward trend in agriculture within the islands. According to the last available USDA census of agriculture for the territory (2007), the amount of land in farms declined by 36% from 2002 to 2007 with total sales declining by a similar 31% over the same period.[241] Feedback from producers and agriculture sector advisors suggest that any intervention geared at reversing these trends need to be tailored to the specific and unique culture and needs of Virgin Islands' producers. Training courses in planning, record keeping, and overall business management have been suggested as being needed to help farmers access assistance as well as potential local and tourist retail markets. Increasing participation in any new or existing programs may depend on addressing cultural stigmas surrounding both agricultural work and government services. Fostering more public/private partnerships that seek local input during program planning phases may alleviate some of these barriers by allowing agricultural intervention to be locally driven, placed-based, and in line with local population values, priorities and demands. The relatively small size of the agricultural community within the islands, as well as the small scale of many farms, suggest that even minor investments, if properly planned and guided by a placed-based understanding of local needs, could potentially have a profound effect in increasing food production and security in the face social and climate change related challenges.

[241] USDA USVI Census of Agriculture 2007: http://www.agcensus.usda.gov/Publications/2007/Full_Report/Outlying_Areas/usvi.pdf

Notable Nuggets
Climate Change Research and Program Results in the
U.S. Virgin Islands for Food Security

Reducing the threat of wildfires

- USDA Forest Service grant funds ($80,000 in FY2014) were used to purchase firefighting gears, firefighting supplies, educational supplies, and other items educational tools that were distributed to the students during Prevention Week.

Increasing agricultural sector ability to respond and cope with frequent and severe drought

- The VIDOA has secured funds in its FY2016 budget for two 10,000 gallon water storage tanks in St. Croix and is applying for a special federal grant from the Department of the Interior for a 'large capacity storage tank' to be placed in Estate Bordeaux.

- The VIDOA was awarded NRCS funding from the Farmland Infrastructure Improvement Program in 2014, these funds will be used in the upcoming year to enhance and expand irrigation infrastructure on public farmland territory wide. [242]

[242] Budget testimony of VIDOA Commissioner Carlos Robles: http://www.legvi.org/CommiteeMeetings/31st%20Legislature%20Committees/COMMITTEE%20OF%20FINANCE/FY2016%20Budget%20Process/09-01-2015%20-%20DOA,%20DLCA,%20Election/Testimony%20-%20DOA.Carlos%20Robles.Commissioner%20Designee.FY2016.pdf

TOURISM

SECTOR OVERVIEW

Tourism is a critical piece of the economy of the U.S. Virgin Islands.[243] Through the regions' various economic transitions, tourism has proven to be among the most consistent economic drivers and an important source of capital. In 2015, tourism accounted for 30 percent of GDP and more than 79,000 direct jobs. In 2013, the industry attracted 2.7 million air and cruise ship passengers.[244]

The U.S. Virgin Islands Comprehensive Economic Development Strategy lists the Territory's beaches, national park and monument, trails, nature reserve, and historic sites and churches as tourism product assets. For that reason, we have included historic and cultural preservation programs and projects in this sector section. However, we have kept natural resources solely in the natural resources section to reduce duplication of information in this report.

NOAA's Office for Coastal Management released a new report, "Describing the Ocean Economies of the U.S. Virgin Islands and Puerto Rico,"[245] that combines federal data, local sources, and interviews with industry experts to provide a more accurate and complete picture of the Caribbean economy's dependence on the ocean.

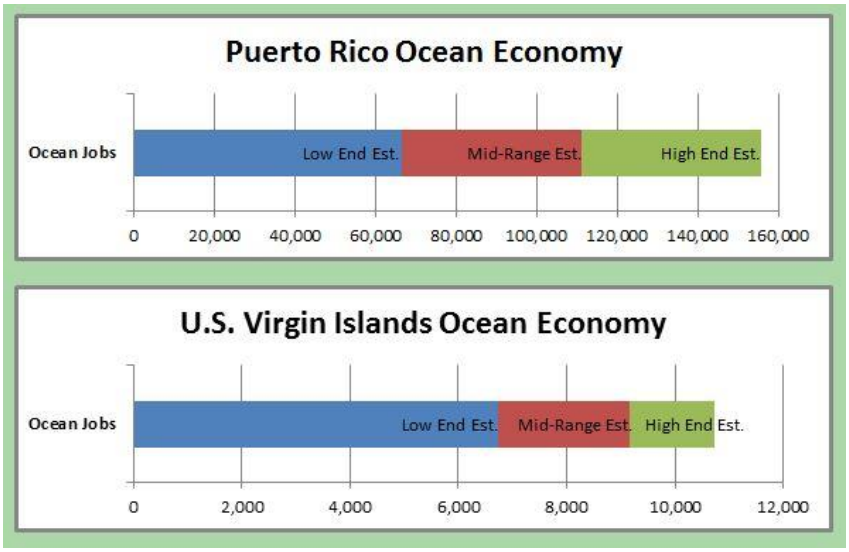
Given its unique nature as islands and tourist destinations, **the Virgin Islands are more reliant on ocean-related activity** than most continental U.S. states. The ocean economy, as defined in the mainland U.S., supported the employment of 6,700 persons in the Virgin Islands in 2012[i]. This accounts for 19 percent of total employment, compared to 2.2 percent in the mainland U.S. The 2016 NOAA study found that tourism likely accounts for 70 – 80

RELEVANT INSTITUTIONS

- VI Department of Tourism
- VI Economic Development Authority
- VI Department of Planning and Natural Resources
- VI Port Authority
- VI Hotel and Tourism Association
- National Oceanic and Atmospheric Administration
- National Parks Service
- U.S. Fish & Wildlife Service

[243] The CIA World Factbook: https://www.cia.gov/library/publications/the-world-factbook/geos/vq.html
[244] http://www.usviber.org/CEDS%20Plan%202015.pdf
[245] National Oceanic and Atmospheric Association (NOAA) Office of Coastal Management (OCM) project, Describing the Ocean Economies of the U.S. Virgin Islands and Puerto Rico (Task Order EA- 133C-14-BA-0039/C-003). Available: https://coast.noaa.gov/data/digitalcoast/pdf/econ-usvi-pr-executive-summary.pdf

percent of the territories 'post-HOVENSA' GDP. This is largely due to the fact that many sectors not dependent on tourism elsewhere in the U.S., such as retail, car rental, and taxis, are dependent on tourism within USVI. Most if not all tourist related activities in the territory are directly or indirectly ocean-related[246]
The chart below shows the direct contribution of ocean economy to the Caribbean territories according to the findings in the study.



- Low-end estimate: traditional ocean sectors
- Mid-range estimation: plus additional and informal businesses that are entirely ocean-related
- High-end estimation: plus industries that are partially ocean-related

INSTITUTIONAL FUNDING AND TECHNICAL CAPACITIES

Out of all the sectors, tourism appears to be the sector with the least amount of capacity to deal with climate adaptation or risk reduction. Some Federal agencies do have projects, resources and funding related to tourism but usually as it links to other sectors. Despite the report findings that the U.S. Virgin Islands is lacking in tourism and climate change projects, there is evidence leadership is thinking about the implications of climate change on this sector. Two territorial government representatives, one from the U.S. Virgin Islands Department of Tourism, stated at a recent climate workshop on St. Thomas, "the VI needs

[246] National Oceanic and Atmospheric Association (NOAA) Office of Coastal Management (OCM) project, Describing the Ocean Economies of the U.S. Virgin Islands and Puerto Rico (Task Order EA- 133C-14-BA-0039/C-003). Available: https://coast.noaa.gov/data/digitalcoast/pdf/econ-usvi-pr-executive-summary.pdf

to expand our tourism products to include options away from the coasts to adapt to climate change" and "the climate challenge calls for reimagining our tourism products."[247]

PROGRAMS AND RELEVANT PROJECTS BY INSTITUTION

AGENCY: U.S. VIRGIN ISLANDS DEPARTMENT OF TOURISM

The U.S. Virgin Islands Department of Tourism (DOT) was established on May 8, 1995, as an executive department. The Department of Tourism was formerly a part of the Virgin Islands Economic Development & Agriculture (VI EDA). The VI EDA was then broken down into different departments with the Department of Tourism as one of them. The department is primarily responsible for the economic development of the Territory through the promotion of tourism and related activities. The department is under the supervision of the Commissioner of Tourism and its responsibilities include but are not limited to the formulation, implementation, administration and coordination of programs and policies pertaining to all aspects of tourism. Activities conducted by the Department of Tourism include the following: develop strategies that will make the Territory competitive and desirable as a tourism destination; communicate and cooperate with all local tourist or tourist-related businesses to determine their needs and how best to promote the industry; promote Virgin Islands culture as a part of the tourism experience; promote an understanding of the importance of the tourism experience; develop strategies for the U.S. Virgin Islands in all businesses and industries throughout the Territory; identify and promote the unique features of St. Croix, St. John, St. Thomas, and Water Island in tourism advertising; and, develop long-term strategies to successfully develop the overall economy. The mission of the Department of Tourism (DOT) is to increase visitor expenditures, to aid in the economic development of the Territory. In order to fulfill its mission the Department has developed a strategic marketing plan that positions the USVI as a unique, competitive and desirable tourist destination.

Its strategic plan is based on these four (4) core goals:[248]

1. increase the number of domestic and international visitors and expenditures;
2. improve community awareness of tourism;
3. ensure the uniqueness of each island is represented in marketing efforts; and
4. build brand equity to create growth of travel to St. Croix.

In order to achieve these goals, the Department's approach involves the following:

[247] Climate Matters Workshop at the University of the Virgin Islands in partnership with the University of the West Indies Mona Climate Studies Group. January 12 and 13, 2016. Organized by the Caribbean Green Technology Center's Director Wayne Archibald. First quote by Annice Canton of the VI Department of Tourism and the second by Senator Tregenza Roach.

[248] VI Department of Tourism. Budget Hearing FY2016. Committee on Finance Fiscal Year 2016 Budget Hearing. June 17, 2015. http://www.legvi.org/CommiteeMeetings/31st%20Legislature%20Committees/COMMITTEE%20OF%20FINANCE/FY2016%20Budget%20Process/07-02-2015%20-%20DOT,%20WTJX,%20VIBE/Post%20Audit%20Analysis%20-%20Department%20of%20Tourism.FY2016.pdf

1. maintaining good communication with partners (i.e. hoteliers, attractions, the National Park Service, tour operators, travel agents, airlines, the media and the community);
2. maintaining market share for St. Thomas and St. John with a steadfast commitment to seeking new opportunities and increased market share for St. Croix;
3. using non-traditional approaches to market the Virgin Islands so as to make us distinctive and memorable; and
4. adjusting our marketing plan as needed, evaluating tactics and measuring results to ensure we remain on course.

USVI DEPARTMENT OF TOURISM PROGRAMS/OUTPUTS

Through a recent correspondence with the U.S. Virgin Islands Department of Tourism (DOT) we learned that DOT does not have any research studies on risks, vulnerabilities and/or reduction measures and that climate change or risk reduction is not written into strategic planning documents, policies, secretarial orders, or reports. It appears the agency has not worked specifically on climate change in any capacity and training programs or educational opportunities does not fall under the scope of responsibility of DOT.

However, it was communicated to us that risk reduction policies or measures in the tourism sector both internallyin the agency and in the programs and policies for the Territory does fall under the scope and responsibility of the Department of Tourism. To-date the team has not learned of specific programs or projects around this theme, but the Commissioner of DOT is also a board member on several semiautonomous agencies critical to economic development and critical infrastructure such as the West Indian Corporation (manages 1 or 2 cruise ships docking on St. Thomas), VI Port Authority (managing the airport and all other public docking facilities) and the Economic Development Authority. As this report has already demonstrated, EDA and VI Port Authority have a few climate-related projects and initiatives that could benefit the tourism sector and with the Commisioner's link to these institutions there is evidence of a network in place for potential future opportunities with DOT.

AGENCY: U.S. VIRGIN ISLANDS ECONOMIC DEVELOPMENT AUTHORITY

See the VI EDA synthesis under the Economic Development Section.

AGENCY: U.S. VIRGIN ISLANDS DEPARTMENT OF PLANNING AND NATURAL RESOURCES

In the U.S. Virgin Islands the State Historic Preservation Office, (VISHPO), is a division within the Department of Planning and Natural Resources (DPNR). The DPNR Commissioner serves as the State Historic Preservation Officer and the Director of the

VISHPO serves as the Deputy State Historic Preservation Officer. The VISHPO helps communities identify, evaluate, preserve, and revitalize their historic, archeological, and cultural resources. The VISHPO administers programs authorized by both the National Historic Preservation Act of 1966 and the U.S. Virgin Islands Antiquities and Cultural Properties Act of 1998. These programs include the Statewide Historic Resources Survey, the Virgin Islands Registry of Historic Buildings, Sites and Places, the National Register of Historic Places, the federal historic rehabilitation tax credit program, the Certified Local Government program, the state historic preservation grants program, state and federal environmental review, and a wide range of technical assistance, are provided through two teams assigned to the territory. The VISHPO works with the territory and federal governments, the public, and educational and not-for-profit organizations to raise historic preservation awareness, to instill in Virgin Islanders a sense of pride in our unique history and to encourage heritage tourism and community revitalization.

U.S. VIRGIN ISLANDS DEPARTMENT OF PLANNING AND NATURAL RESOURCES PROGRAMS/OUTPUTS

The VISHPO's strategic plan is currently in-development. It is anticipated it will include the effects of climate change in it's assessment and strategy.[249] VISHPO in the mean time has participated in the following risk reduction and/or climate change partnerships.

Fort Frederik, St. Croix

STATUS:	Implementation
APPROACH:	Impact Based
MOTIVATION:	Decision

Conservation and stabilization of this National Historic Landmark, with specific emphasis on roof renovations to prevent water damage to historic archives. A partnership between federal, local, private and foundation partners, namely the VI Department of Public Works, the VI Department of Planning and Natural Resource's State Historic Preservation Office and the Division of Libraries, Archives and Museums.[250]

Caribbean Landscape Conservation Cooperative (CLCC).[251]

[249] Sean Krigger (VISHPO Acting Director) in discussion with Kasey Jacobs, October 2015 and previously
[250] VI Comprehensive Economic Development Strategy 2015. http://www.usviber.org/CEDS%20Plan%202015.pdf (page 51)
[251] www.caribbeanlcc.org

STATUS:	Assessment and Planning
APPROACH:	Vulnerability-based
MOTIVATION:	Research, Decision and Stakeholder

The CLCC is a partnership of management and research agencies, non-governmental organizations, businesses and individuals working together to achieve a sustainable future for the Caribbean. The CLCC is one of a network of 22 public-private partnerships initiated by the U.S. Department of the Interior to respond to climate change and other large-scale stressors. The Landscape Conservation Cooperative Network's mission is to develop and provide science-based information to help conserve land, water, wildlife and cultural resources. VI DPNR and SHPO are Steering Committee members of the CLCC. In 2015, the CLCC Steering Committee decided to expand on the work of the previous year's CLCC Science Strategy: Mission Alignment in order to develop a framework for implementation. 9 federal and territorial agencies and 1 NGO in the Steering Committee worked together to agree upon four fundamental objectives to frame all future collaborative efforts for conserving, restoring, and sustaining ecological and cultural resources and human well-being: 1) Maximize use of available operation resources; 2) Maximize human well-being and public satisfaction; 3) Maximize structure and function of aquatic and terrestrial resources; and 4) Maximize integrity of cultural and historical resources. In 2016, the CLCC will continue towards landscape conservation design and identifying priority geographic focal areas based on shared objectives. With the continued participation of VI SHPO, cultural resources should be included in these 2016 landscape conservation design efforts, which could serve as one method of climate adaptation for the tourism sector.

AGENCY: U.S. VIRGIN ISLANDS PORT AUTHORITY

The U.S. Virgin Islands Port Authority (VIPA) is a semi-autonomous agency that owns and manages the two airports and the majority of the public seaports in the United States Virgin Islands. They are also charged with maintaining the harbors in the territory. Their mandate is to promote the wise use of these facilities for the betterment of the U.S. Virgin Islands and its people, and to assist the USVI government and community in fostering and sustaining sound economic development.

U.S. VIRGIN ISLANDS PORT AUTHORITY PROGRAMS/OUTPUTS

Solar Energy

STATUS:	Implementation
APPROACH:	Risk Management
MOTIVATION:	Stakeholder

The VI Port Authority has constructed one of the largest solar energy panel systems in the U.S. Virgin Islands at the Cyril E. King Airport on St. Thomas to help reduce the airport's monthly utility costs, with the added benefits of contributing to climate mitigation and adaptation. This project was made possible through the American Recovery and Reinvestment Act (ARRA) funding from the VI Energy Office.[252]

AGENCY: U.S. VIRGIN ISLANDS HOTEL AND TOURISM ASSOCIATION

U.S. Virgin Islands Hotel and Tourism Association Programs/Outputs

No programs were discovered in our research, however, there is evidence of how attune the U.S. Virgin Islands Hotel and Tourism Association is to the effects of climate, or at least seasonal weather, on the U.S. Virgin Islands Tourism Industry. An October 16, 2012 article in Caribbean News Now focused on the U.S. Virgin Islands' "fewer visitors and more empty hotels rooms" that year. According to data released that week by the U.S. Virgin Islands Bureau of Economic Research, which tracks airline and cruise ship passenger arrivals, as well as hotel occupancy rates, on a monthly basis, the total number of visitors to the Territory fell between 2011 and 2011 – a drop of 16,823 visitors, or about 1 percent. Lisa Hamilton, president of the U.S. Virgin Islands Hotel and Tourism Association, attributed the dip in occupancy rates to an unusually warm winter in the northeastern United States. She described how the associated canvassed other Caribbean tourism agencies and most other islands reported less hotel demand between January and April of 2012 because of the warm weather.[253] This connection of stateside temperatures affecting tourism in U.S. Virgin Islands is consistent with a Puerto Rico climate vulnerability assessment highlighting that as a real climate risk for the region.[254]

AGENCY: NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

The U.S. Virgin Islands Comprehensive Economic Development Strategy 2015 included natural resources in one of their five overarching priorities deemed essential for growth and sustainability for the USVI economy, specifically as natural assets relate to tourism:

[252] VI Port Authority Press Release. VIPA is Going Green. April 5, 2011. ofhttp://www.viport.com/newsreleases/2011/2011%20April%204%20News%20Release%20Media%20Tour%20CEKA%20Solar%20Panel%20Project.pdf

[253] "USVI reports fewer visitors and more empty hotels rooms." *Caribbean News Now* 16 October 2012. Online. http://www.caribbeannewsnow.com/topstory-USVI-reports-fewer-visitors-and-more-empty-hotels-rooms-13029.html

[254] Puerto Rico Climate Change Council. 2013. State of the Climate. Working Group 3 Report: Society and Economy. www.pr-ccc.org

Infrastructure, Environment and Quality of Life. Invest in quality infrastructure and enhancement management and conservation of natural resources.[255]

The NOAA in the Caribbean Strategy (2014)[256] lists tourism as one of the services provided by Caribbean reef ecosystems. They cite an estimate that if Caribbean coral reef decline continues from human activities it could cost the region, by 2050, between $350 million and $870 million per year in lost revenue in fisheries and tourism, combined with the net value of lost benefits from reef-associated shoreline protection.

The Strategy includes four actions that are specifically geared to assist the regional tourism industry:

- Develop a sustained and credible process to produce early warning systems across relevant climate time scales through the collaborative Caribbean Climate Outlook Forum to provide input for preparedness, risk reduction, and adaptation activities relevant to critical sectors (e.g., tourism, agriculture) supported by the International Research Applications Program, among other NOAA programs.

- Provide technical capacity and assistance to implement innovative management approaches to support local coastal communities, such as within the fishing, aquaculture, and tourism industries.
- Support NOAA's sustainable tourism assistance to the region to promote wise use and stewardship of resources that stimulate the economy for the long term.

- Increase capacity for monitoring long-term trends in socioeconomic data, conduct analyses, and provide resource planning tools to help governments and local communities advocate for sustainable and disaster-resilient communities and waterfronts encompassing diverse uses such as fishing, marinas, shops and restaurants, tourism, and public access.

NOAA programs related to natural resources are described in the Natural Resources section but we include one effort here as it so strongly relates to the tourism sector.

NOAA PROGRAMS/OUTPUTS

Marine Protected Area Research and Management.

[255] VI Bureau of Economic Research. 2015. United States Virgin Islands Comprehensive Economic Development Strategy 2015. http://www.usviber.org/CEDS%20Plan%202015.pdf
[256] NOAA in the Caribbean Strategy 2014. http://www.regions.noaa.gov/secar/wp-content/uploads/2014/07/NOAA-Caribbean-Strategy-Final-June-23-2014-FINAL.pdf

There are now more than 30 Marine Protected Areas (MPAs) in the U.S. Virgin Islands. These include MPA units operated by the Government of the Virgin Islands, federally managed MPAs, as well as two co-managed MPAs. Although all MPAs share the goal of protecting resources, MPAs have a wide range of objectives that focus on managing human uses, including tourism. The 2014 report Marine Protected Areas of the U.S. Virgin Islands: Ecological Performance Report[257] by the NOAA Center for Coastal Monitoring and Assessment describes more than a decade of work by NOAA and the National Park Service to assess status and trends within and around federally managed marine protected areas of the U.S. Virgin Islands. According to report authors, this report is the first time that an assessment of ecological performance has been conducted for MPAs in the U.S. Virgin Islands. The information, data synthesis, interpretation and recommendations could help the Territory with management actions to enhance coral reef system protect and thus potentially ensure a vibrant nature tourism sector.

STATUS:	Assessment
APPROACH:	Impact Based
MOTIVATION:	Research, Decision, and Stakeholder-driven

AGENCY: U.S. NATIONAL PARK SERVICE

U.S. National Park Service Programs/Outputs

NPS Climate Friendly Parks Program.

The Climate Friendly Parks (CFP) Program[258] is one of many initiatives supporting the National Park Service (NPS) Green Parks Plan.[259] The program, which stemmed from a partnership with the U.S. Environmental Protection Agency, provides parks with the tools and resources to address climate change and ensure the most sustainable operations across the agency. National parks, because of their location and unique, protected resources, are places where the effects of climate change are particularly noticeable. The program provides national

STATUS:	Assessment and Planning
APPROACH:	Vulnerability and Adaptation-based
MOTIVATION:	Decision and Stakeholder-driven

[257] Pittman, S.J., L. Bauer, S.D. Hile, C.F.G. Jeffrey, E. Davenport and C. Caldow. 2014. Marine protected Areas of the U.S. Virgin Islands: Ecological Performance Report. NOAA Technical Memorandum NOS NCCOS 187. Silver Spring, MD. 89 pp file:///C:/Users/kaseyrjacobs/Downloads/MPAs%20Working%20Final%20tagged%20LQ%20(1).pdf

[258] http://www.nps.gov/subjects/climatechange/cfpprogram.htm

[259] http://www.nps.gov/greenparksplan

parks with comprehensive support to address climate change within park boundaries and within surrounding communities. The goals of the CFP Program include:

- Measure park-based greenhouse gas (GHG) emissions.

- Educate staff, partners, stakeholders, and the public about climate change and demonstrate ways individuals and groups can take action to address the issue.

- Assist parks in developing strategies and specific actions to address sustainability challenges, reduce GHG emissions, and anticipate the impacts of climate change on park resources.

The CFP Program is structured around 4 Milestones. Upon successful completion of all milestones, a park becomes an official Member Park. The four milestones are: 1) submit a CFP application; 2) Complete a greenhouse gas inventory to develop a baseline emissions inventory for park operations; 3) conduct a workshop or webinar training to provide park staff, partners and stakeholders with an educational opportunity to learn more about the potential impacts of climate change on park resources and discuss response strategies, and 4) complete an action plan or comprehensive environmental management system to outline planned sustainability and climate change response actions as well as educational initiatives to help educate visitors.

Christiansted National Historic Site, Salt River Bay National Historic Park & Ecological Preserve, and Buck Island Reef National Monument are Climate-Friendly Parks. Their CFP Action Plan (2014)[260] describes the baseline greenhouse gas emissions profile as well as a number of climate change response and sustainability goals for all three park units. Adaptation actions include exploring opportunities to re-establish regular use of cisterns, research opportunity to install water filling stations, work with partners, like the Caribbean Landscape Conservation Cooperative, to conduct assessments of climate change vulnerabilities of cultural resources, develop park-specific climate change messages to increase awareness among visitors, and develop a sea level rise exhibit for Salt River Bay.

An additional to the benefit of the NPS Climate Friendly Parks Program is two assessment tools that are (or will be) available for use in the near future and potentially could be applied to other territorial historic sites and parks.

- Coastal Hazards and Climate Change Asset Vulnerability Assessment Tool.[261] NPS has partnered with the Program for the Study of Developed Shorelines at Western Carolina University to create this tool. It establishes a standard methodology and set of best practices for conducting vulnerability assessments in the built

[260] Christiansted National Historic Site, Salt River Bay National Historic Park & Ecological Preserve, and Buck Island Reef National Monument: Climate Friendly Parks Action Plan. 2014. http://www.nps.gov/subjects/climatechange/upload/CHRI_CFP_EMS_Plan_-Final_August_2014.pdf

[261] http://www.nps.gov/subjects/climatechange/vulnerabilityandadaptation.htm

environment. The assessments are currently focused on assets at risk to coastal hazards and sea-level rise within coastal parks. Ultimately, the general methodology can be applied to additional natural hazards and climate stressors in non-coastal parks, as long as georeferenced hazard data exists or can be mapped.

- Climate Leadership in Parks Tool.[262] Used by U.S. Virgin Islands NPS Staff, the tool was developed for NPS to enable national parks to easily complete an emissions inventory. The CLIP Tool is a user-friendly, Microsoft Excel-based tool that consists primarily of two modules. The first module inventories the park's greenhouse gas (GHG) emissions and CAPs while the second module walks park staff through calculators and other resources that help them develop a Climate Action Plan aimed at reducing their GHGs and criteria air pollutants (CAPs).

AGENCY: U.S. FISH AND WILDLIFE SERVICE

The majority of U.S. Fish and Wildlife Service programs, as related to climate change, fall under natural resources (see the Natural Resources sector). Here we focus on one program on St. Croix that is related to historic and cultural resources, and thus the tourism sector.

U.S. FISH AND WILDLIFE SERVICE PROGRAMS/OUTPUTS

Sandy Point National Wildlife Refuge's Aklis Site

STATUS:	Implementation
APPROACH:	Risk Management
MOTIVATION:	Decision-driven

The Aklis site is an important pre-Columbian archaeological site in the Caribbean. This former settlement is located on the southeast corner of the refuge, on land that was acquired by the refuge to protect it and a nearby stand of endangered Vahl's boxwood. For more than two decades this site has been subjected to severe erosion from seasonal storms and hurricanes. Artifacts and human skeletal remains have been exposed in a number of areas, resulting in unauthorized removal by artifact hunters. As requested by the National Park Service, Panamerican Consultants, Inc., conducted an archaeological investigation of the site in 1994. This investigation was undertaken partly to assess the damage wrought by Hurricane Hugo to the exposed and eroding western shoreline boundary of the site. The study also aimed to establish the limits of the Aklis site, to reconstruct site-specific cultural material, settlement, subsistence and demographic patterns, and to integrate these patterns with those from other Virgin Islands and Puerto Rican sites. In addition the investigation report furnished recommendations on management, conservation and future research. Back in 1994, the report included

[262] http://www.icfi.com/insights/products-and-tools/clip

recommendations, such as: (1) Investigate the entire Aklis site; (2) If additional serious beach erosion continues, additional investigations and sampling in the area should be considered; (3) Monitor the site on a regular basis to evaluate vandalism and to assess any significant damage to the site which may have occurred from natural causes.[263]

The U.S. FWS refuge manager has been checking on its condition monthly for more than 20 years, daily during storms. He has collected hundreds of artifacts and remains that have fallen out of the coastal site on a weather-exposed promontory at the refuge. In the Summer of 2014, for the first time, he and his staff got help documenting and fortifying the site, which is highly subject to sea-level rise. A team of 11 college students and their advisors from Mississippi State University helped the NPS recove loose artificacts and remains and shore up the prehistoric shell midden, habitation and burial site as part of a five-week field school.[264] All materials goes to the Southeast Archaeological Center, an NPS repository in Florida. It is anticipated that with continued funding the students and advisors will be able to return in 2016.

[263] NPS. 2010. Sandy Point, Green Cay and Buck Island National Wildlife Refuge Comprehensive Conservation Plan. http://www.fws.gov/southeast/planning/PDFdocuments/VirginIslandsFINALCCP/FinalCCPVirginIslandsRefugesForWeb.pdf

[264] http://www.fws.gov/refuges/RefugeUpdate/JulAug_2015/race-against-time.html

TOURISM SECTOR SUMMARY

Tourism is a critical piece of the economy of the U.S. Virgin Islands. In 2015, tourism accounted for 30 percent of GDP and more than 79,000 direct jobs. In 2013, the industry attracted 2.7 million air and cruise ship passengers A review of the VI Department of Tourism, the VI Economic Development Authority, the VI State Historic Preservation Division within the VI Department of Planning and Natural Resources, the VI Port Authority, the VI Hotel and Tourism Association, and the VI Chambers of Commerce did not result in finding any programs, projects or strategies directly related to climate change. However, as in many of the other sectors, a wide host of tourism projects were found that could indirectly contribute to climate adaptation or mitigation initiatives, such as energy reduction, infrastructure improvements and natural resource protection (the 2015 Comprehensive Economic Development Strategy 2015 specifically cites the importance of natural assets to the U.S. Virgin Islands tourism product). Being that tourism is one of two flagship industries in the Territory (the second being an oil refinery) special attention must be given to conducting assessments, planning and implementing climate adaptation projects immediately. Two recent comments from territorial government representatives illustrate that despite the lack of projects, there is awareness: "the VI needs to expand our tourism products to include options away from the coasts to adapt to climate change" and "the climate challenge calls for reimagining our tourism products." A lot of work remains to determine the specifics of how to do just that. Three federal agency programs were found to have connections to the VI tourism sector as related to Marine Protected Areas Management and Historic and Cultural Resources. Of all the territorial and federal initiatives found, all but two were still in planning and assessment. The two that were implementing were addressing impacts to historic and cultural resources. Tourism appears to be one of the sectors with the least amount of existing capacity in the Territory to deal with climate adaptation or risk reduction. The first being the Human Health sector. An important factor in adaptation and resilience building is the ability to collaborate with other sectors. While the tourism institutions in the U.S. Virgin Islands do not have many programs, studies, mandates, policy guidance, educational and training resources available to them for climate-related work, the tourism sector does benefit from the climate work of the economic development, critical infrastructure and natural resources sectors.

Notable
Climate Change Research and Program Results in the
U.S. Virgin Islands for Tourism

- The Territory has one known implementation project in the Tourism sector that is climate-related. VI Government agencies are working in partnership to conserve and stabilize Fort Frederik on St. Croix, with specific emphasis on roof renovations to prevent water damage to historic archives.[265]

- The VI Port Authority has constructed one of the largest solar energy panel systems in the U.S. Virgin Islands at the Cyril E. King Airport on St. Thomas to help reduce the airport's monthly utility costs.[266]

- There is already evidence in USVI of how warmer temperatures in the Northeastern United States has affected the total number of visitors in the Territory in 2011 and 2012.[267]

- NPS staff for Christiansted NHS, Salt River Bay NHP & Ecological Preserve, and Buck Island NM has already embedded sustainability actions in their operations that could be considered climate mitigation and adaptation actions.[268]

    - Reduced GHG Emissions: Installed tinted windows to reduce heat gain and reduced the energy used to cool NPS buildings and Installed programmable thermostats to efficiently cool facilities.

    - Energy: Replaced several exterior lighting fixtures with high-efficiency LED fixtures and skylights are utilized in public restrooms to reduce energy use.

    - Education/Communication: Hosted a Climate Friendly Parks workshop in May 2014 and developed new educational brochures.

[265] VI Comprehensive Economic Development Strategy 2015. http://www.usviber.org/CEDS%20Plan%202015.pdf (page 51)
[266] VI Port Authority Press Release. VIPA is Going Green. April 5, 2011. ofhttp://www.viport.com/newsreleases/2011/2011%20April%204%20News%20Release%20Media%20Tour%20CEKA%20Solar%20Panel%20Project.pdf
[267] "USVI reports fewer visitors and more empty hotels rooms." *Caribbean News Now* 16 October 2012. Online. http://www.caribbeannewsnow.com/topstory-USVI-reports-fewer-visitors-and-more-empty-hotels-rooms-13029.html

[268] Christiansted National Historic Site, Salt River Bay National Historic Park & Ecological Preserve, and Buck Island Reef National Monument: Climate Friendly Parks Action Plan. 2014. http://www.nps.gov/subjects/climatechange/upload/CHRI_CFP_EMS_Plan_-Final_August_2014.pdf

- Water: Installed low-flow fixtures and waterless urinals in several areas of the parks and established a limited-vehicle washing water conservation initiative.

- U.S. Fish & Wildlife Service staff in partnership with Mississippi State University helped mitigate erosion impacts from sea level rise to a prehistoric settlement in Sandy Point National Wildlife Refuge in St. Croix.[269]

[269] http://www.fws.gov/refuges/RefugeUpdate/JulAug_2015/race-against-time.html

SECTOR OVERVIEW

A variety of Federal, Territorial, and Academic institutions are responsible for protecting the Virgin Islands' land and water natural resources. The management of these resources is largely characterized by the struggle to balance the demand for greater use of these resources with the need to conserve and protect them for the benefit of future generations.

Terrestrial

The natural vegetation in the United States Virgin Islands can be classified as coastal vegetation, thicket vegetation, forest vegetation, or freshwater vegetation.[270] Over 500 indigenous or naturalized plant species grow in the Virgin Islands, some unique to this area. Important species and habitat issues of the terrestrial conditions of some VI offshore cays provide critical habitat for threatened and endangered seabirds and some migratory species.

Marine

The marine environment in the Virgin Islands consists of several distinct habitat types. These habitats are limited to shallow water and coastlines, where nutrients and oxygen are more abundant. Each habitat is defined by one or more dominant species. While some organisms, such as algae, sponges and fishes can survive in several different habitats; others are exclusively found in one specific habitat. Three habitats in the Virgin Islands Territorial Sea, coral reefs, seagrass beds and mangroves, are areas of high-energy production and species richness. Other habitats, such as rocky shores, beaches and salt ponds, require specific adaptations.

According to a 2002 report and much anecdotal evidence by this VI Climate report's authors, few other areas in the

RELEVANT INSTITUTIONS

- VI Department of Planning and Natural Resources
- University of the Virgin Islands
- National Oceanic and Atmospheric Administration
- U.S. Fish and Wildlife Service
- U.S. Forest Service
- U.S. Geological Survey
- National Park Service
- U.S. Coral Reef Task Force
- Caribbean Fisheries Management Council

[270] Borgesen, F. 1923. On the vegetation of the Virgin Islands of the United States, formerly the Danish West Indies. Gov. Print. Office, St. Thomas [as cited in Davis, J. Soil Survey of the U.S. Virgin Islands: http://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/puerto_rico/PR690/0/VI.pdf]

Caribbean have the benefit of so much information marine resources. Most other Caribbean island nations are data poor in this sector. Thanks to efforts by NOAA, NPS, USGS (especially the Biological Resources Division based in St. John), the VI Department of Natural and Environmental Resources Coastal Zone Management Division and Fish and Wildlife Division, the University of the Virgin Islands and many others in recent years, the VI has some of the longest and most comprehensive data sets on marine resources in the Caribbean.[271]

INSTITUTIONAL FUNDING AND TECHNICAL CAPACITIES

Natural resource institutions receive their funding from a mix of sources, namely the U.S. Virgin Islands General Fund, Federal funds (established program funds and special grants), and other grants. Technical capacities run the gamut from modeling and spatial analysis, ecosystem dynamics, monitoring, strategic planning, and decision support, and many other fields of expertise. Based on this analysis it appears that the institutions in this natural resources sector have greater expertise and capacity to understand climate change vulnerabilities, propose and implement best adaptation and risk reduction practices for natural resources than other sectors.

[271] Island Resources Foundation, 2002. Resource Description Report. University of the Virgin Islands and Department of Planning and Natural Resources. USVI, 14 August, 2002.

PROGRAMS AND RELEVANT PROJECTS BY INSTITUTION

AGENCY: U.S. VIRGIN ISLANDS DEPARTMENT OF PLANNING AND NATURAL RESOURCES

The **Department of Planning and Natural Resources (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. DPNR is also responsible for oversight and compliance of land survey, land subdivision, development and building permits, code enforcement, earth change permits, zoning administration, boat registration, and mooring and anchoring of vessels within territorial waters. DPNR formulates long-range comprehensive and functional development plans for the human, economic and physical resources of the territory. The Division of Coastal Zone Management (CZM) works to develop and implement a variety of projects and programs, including review, processing and enforcement of minor and major development permits in the first tier of the coastal zone. The Division of Comprehensive and Coastal Zone Planning (CCZP) has the broad responsibility for long-range comprehensive planning, subdivision and zoning administration. The Division of Environmental Protection (DEP) is responsible for environmental protection and the enforcement of environmental laws and regulations in the US Virgin Islands. The DEP receives funding and has been delegated responsibility for environmental protection by the US Environmental Protection Agency (EPA). The Division of Fish and Wildlife (DFW) 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.

PROGRAMS/OUTPUTS

Division of Coastal Zone Management

STATUS:	Assessment, Planning, Implementation, Monitoring & Evaluation
APPROACH:	Impact and Adaptation-based
MOTIVATION:	Decision and Stakeholder-driven

In 1978, the U.S. Virgin Islands Legislature enacted the Virgin Islands Coastal Zone Management Act[272] as a means of regulating development and managing coastal resources in the Territory. The U.S. Virgin Islands Coastal Zone Management Program (VICZMP) was established to carry out the mandates and objectives of this Act.

One of VICZMP's goals is to protect, preserve and, where feasible, enhance and restore the overall quality of the environment in the coastal zone.

[272] Virgin Islands Coastal Zone Management Act of 1978, § 1, 12 V.I.C. § 913(b)(1)

VICZMP works, coordinates and partners with various local and national government agencies to develop and implement a variety of projects and programs, including review, processing and enforcement of minor and major development permits in the first tier of the coastal zone.

In 2003, the University of the Virgin Islands commissioned Hinds, Unlimited under the DPNR Division of Coastal Zone Management's VI Marine Park Project to complete a Socio-economic assessment of marine resource utilization in the U.S. Virgin Islands.[273] A multitude of reports and projects like this one have been commissioned by this office before and since then. However, the VICZMP is just one of many coral reef managers in USVI. Others include,[274] NOAA National Marine Fisheries Service (NMFS)/Southeast Regional Office, NOAA NMFS/Caribbean Field Office, Caribbean Fishery Management Council, National Park Service/Virgin Islands National Park and Buck Island National Marine Monument, US Fish and Wildlife Service, US Department of Agriculture– Natural Resources Conservation Service (NRCS), Department of Planning and Natural Resources (DPNR)–Division of Environmental Protection, DPNR–Division of Fish and Wildlife, DPNR–Division of Environmental Enforcement, and St. Croix Environmental Association (SEA).

The DPNR Division of Coastal Zone Management is also a lead partner in a number of initiatives that contribute to coastal adaptation in the Territory:

- Caribbean Regional Ocean Partnership
- Caribbean Landscape Conservation Cooperative
- U.S. Coral Reef Task Force

AGENCY: NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

The Caribbean Strategy, approved in 2014, is the strategic approach of the National Oceanic and Atmospheric Administration (NOAA) to coordinate and integrate the capabilities of all NOAA staff and line offices to address regional issues and improve the effectiveness of its mission and international cooperation in the Caribbean region. The NOAA in the Caribbean Strategy supports NOAA's Next Generation Strategic Plan (NGSP), the National Ocean Policy, and the president's Climate Action Plan, addressing many high-priority objectives, but with a focus on the Caribbean region. Two goals of the NOAA in the Caribbean Strategy specifically address climate change adaptation and resilience building efforts in the U.S. Virgin Islands as related to the Natural Resources

[273] http://dloc.com/CA01300653/00001/2j
[274] NOAA Coral Reef Conservation Program. Nd. United States Virgin Islands' Coral Reef Management Priorities. http://coralreef.noaa.gov/aboutcrcp/strategy/reprioritization/managementpriorities/resources/usvi_mngmnt_clr.pdf

Sector. Goal 1: Improved Conservation and Management of Ocean and Coastal Ecosystems and Resources. NOAA partners with the Caribbean Fishery Management Council to conserve and manage fishery resources within Federal waters of the U.S. Caribbean, providing information and expertise on decisions such as essential fish habitat designations, annual catch limits, and identification of ways to minimize the adverse effects of fishing activities on such habitat to preserve its ecological value in support of sustainable fisheries. Goal 2: Strengthened Understanding of, and Adaptation to, a Changing Climate.

Additionally, NOAA has created the NOAA Digital Coast,[275] a web-based resources that provides not only coastal data, but also the tools, training, and information needed to make these data truly useful for a variety of coastal management issues, not just related to natural resources. Content comes from many sources, all of which are vetted by NOAA. Data sets range from economic data to satellite imagery. The site contains visualization tools, predictive tools, and tools that make data easier to find and use. Training courses are available online or can be brought to the user's location. Information is organized by topic—the top picks from the site, for instance, that relate to green infrastructure or climate adaptation. Many of these data, tools, and training have or could assist in the USVI's response to climate change (see table 4).

A search on Feb 20th reveals that NOAA Digital Coast contains 51 collections / 143 datasets that mention the U.S. Virgin Islands. Upon further inspection the majority of these data sets and map products do not actually contain the USVI. The ones that do, however, may have direct relevance to climate change adaptation as the majority pertain to coastal planning (see table below). Energy facilities, critical facilities, coastal flooding impacts, flood frequency, social vulnerability index are important climate adaptation tools available to the continental U.S. but not the Territory. Examples of climate relevant data sets for climate adaptation planning available on the NOAA Digital Coast are: coastal LIDAR, critical habitat designations, essential fish habitat, habitat areas of particular concern, historical hurricane tracks, tropical cyclone exposure, and sea level rise (mean sea level to 6ft rise can be viewed on map). Despite the data unavailability to the Virgin Islands, there are users from the Territory. According to a 2015 NOAA Digital Coast data analysis[276] there were 218 U.S. Virgin Islands visitors to the Digital Coast website, 4 U.S. Virgin Islands communities that used the Digital Coast, 115 Gigabytes of high-resolution elevation data available for the territory, 456,615 total visitors to the Digital Coast website and a 411% return on investment to the Territory. However, one tool that is mentioned as a top tool for the USVI does not actually have USVI data available on the online viewer so it is unclear how the Territory benefited from this tool. Additionally according to the

[275] https://coast.noaa.gov/digitalcoast/
[276] https://coast.noaa.gov/data/digitalcoast/pdf/states/virgin-islands.pdf

analysis, the Digital Coast CanVis tool helped the U.S. Virgin Islands visualize sea level rise and green infrastructure techniques. This visualization tool helps users "see" potential impacts from coastal development or water level change. Users can download background pictures and insert objects (hotels, houses, and other features) of their choosing.

Table 4 A list of the NOAA climate adaptation tools, trainings, and information available online and their current status for whether available in USVI or not (as of February 28, 2016). Y=Yes; N=No.

NOAA Climate Adaptation Tool, Training, Information[277]	**Available for USVI? (Y/N)**
DATA	
Benthic Cover (LINK), Land Cover (LINK) Bathymetric Contours (LINK), Multi-beam Bathymetry (LINK) and Critical Facility Datasets (LINK)	**Y**
TOOLS	
Coastal County Snapshots: Assess your county's exposure and resilience to flooding to help with adaptation planning. Facts and data are displayed in easy-to-use graphics and handouts.	N
Sea Level Rise and Coastal Flooding Viewer: Use the tool's slider bar to see how various levels of sea level rise will impact your community. Results are portrayed on a map and through local photographs.	Y
Coastal Flood Exposure Mapper: Create a collection of maps for flood hazards, societal exposure, infrastructure exposure, and ecosystem exposure to communicate flood exposure and start conversations about local risk reduction strategies.	As of November 2016 NOAA is in the process of expanding coverage of the CFEM to PR and USVI hopefully in calendar year 2017-2018.
Coastal Resilience 2.0 (The Nature Conservancy): Access a suite of interactive tools that support decisions to reduce the ecological and socioeconomic risks of coastal hazards.	Y
Coastal Change Hazards Portal: The Coastal Change Hazards Portal organizes	N

[277] A number of NOAA's most popular tools , trainings resources are outlined in the Climate Change Adaptation Topic area of the Digital Coast and can be easily accessed through the Digital Coast Climate Change Adaptation Topic Area (see https://coast.noaa.gov/digitalcoast/topic/climate-adaptation)

relevant products and information under three specific coastal hazard themes: extreme storms, shoreline change, and sea level rise. The products fulfill critical needs for information that is scientifically credible and usable for increasing resilience to storms and climate change. This information supports land use planning, infrastructure, and ecosystem and cultural resource management decisions, as well as storm response and recovery.	
Historical Hurricane Tracks: More than 6,000 tropical cyclones, ranging from 1842 and occurring in over seven major ocean basins around the world, are now searchable thanks to the incorporation of NOAA's International Best Track Archive for Climate Stewardship (IBTrACS) data set.	Y
Data Access Viewer (DAV): This online tool allows a user to search for and download lidar, imagery, land cover, and benthic data—hosted by the NOAA Office for Coastal Management—by drawing an area of interest on a map. Once a data set has been identified, additional information and an easy-to-use checkout interface to download the data are provided. The checkout provides for free custom processing of the data according to user selections.	Y[278]
ENOW Explorer: View and interact with Economics: National Ocean Watch (ENOW) data for your state or county without having to download the data set. Use the ENOW Explorer to describe and compare the six sectors of the ocean and Great Lakes economy: · living resources · marine construction	N[279]

[278] Data Available for USVI include: 2012 Frederiksted Harbor, USVI IOCM DSS Natural Color 8 Bit Imagery
2012 Christiansted, USVI IOCM DSS Natural Color 8 Bit Imagery
2011-2011 St. Croix, USVI USACE 4-Band 8 Bit Imagery
2011 Cruz Bay, USVI IOCM DSS Natural Color 8 Bit Imagery
2011 Anguilla Harbor, USVI IOCM DSS Natural Color 8 Bit Imagery
2010-2012 St. John & St. Thomas, USVI USACE 4-Band 8 Bit Imagery
2006-2007 Puerto Rico ADS40 8-Bit Natural Color Imagery (Includes USVI)

[279] Note: NOAA is currently working with both USVI and PR to extend the Economics: National Ocean Watch (ENOW) Data framework and associated products to PR And VI

· marine transportation · offshore mineral resources · ship and boat building · tourism and recreation	
TRAINING	
Climate Adaptation for Coastal Communities: This three-day instructor-led course gives you a thorough grounding in the topic of adaptation – and time in class to apply what you've learned to your own adaptation projects. The course covers these essentials: understanding climate science and impacts; determining community vulnerabilities; communicating effectively; identifying adaptation strategies; and finding mechanisms to implement those strategies. Opportunities for local collaboration and next steps for adaptation planning and implementation are emphasized through discussion, participant activities, and incorporation of local speakers and examples.	Y
Coastal Inundation Mapping: This two-day instructor-led course offers a combination of lectures and hands-on exercises to give students a better understanding of coastal inundation issues and mapping methods using a geographic information system (GIS). The course is designed for certified floodplain managers and county, state, and municipal officials, including planners, emergency managers, and coastal resource managers. Lecture topics include the different types of coastal inundation, the applications and limitations of various types of inundation products, elevation data sets and datums, and the spatial methods used to map flood areas in coastal environments.	Y
CanVis: Use this easy-to-use visualization tool to "see" potential community impacts from coastal development or sea level rise. This 30-minute self-guided training is divided into two e-learning parts online.	Y
Coastal Community Planning and Development: This training course will	Y

actively engage participants in learning about land-use planning processes, conventional patterns of development, impacts from these development patterns, and alternative options for development in their communities.	
Coastal Planning Advisory (online training): Decision making, particularly in a team environment, benefits from a process. This tool provides an easy-to-use process for 12 coastal management issues, from climate change to land use planning. People are using the Coastal Planning Advisor to get teams on the same page, facilitate a collaborative process, assign tasks, and write grant proposals. The list is endless.	Y
Coastal Restoration Project Design and Evaluation: This course provides coastal restoration professionals with the knowledge, skills, and tools to design and implement projects that have measurable impacts on the intended target. Participants will learn to increase restoration project effectiveness by applying a systems approach to designing a new project or reassessing an existing one. This approach helps build in accountability, reveal assumptions, create a targeted effort and strategic thinking, and better articulate the impacts on the issue.	Y
Green Infrastructure Mapping Guide (online): When planning for the flood-related impacts of coastal hazards, communities are realizing the important role that green infrastructure plays. The Green Infrastructure Mapping Guide shows spatial analysts how to incorporate green infrastructure strategies into their GIS work. This online guide offers a GIS work plan and easy access to examples, process guidance, case studies, and templates.	Y
Habitat Priority Planner (online): This 1.5-hour self-guided training is divided into three parts, each based on one of the tool modules. Each part contains three components: an automated tool	Y

demonstration, content explaining tool functionality, and a guided simulation that allows you to test your knowledge by running an analysis.	
Needs Assessment Guide (online): This step-by-step online guide serves as a helpful reminder for those who have an understanding of and some experience with needs assessment. It offers simplified just-in-time guidance to support you on the job. Also included are case studies addressing coastal issues, dozens of coastal needs assessment reports, and access to technical assistance.	Y
Using Flood Exposure Maps Webinar (formerly Roadmap for Adapting to Coastal Risk Webinar): After participating in this webinar, participants will be able to create local maps using the Coastal Flood Exposure Mapper and then use those maps to engage stakeholders in discussions directed toward improving community resilience to coastal flooding.	Y
Seven Best Practices for Risk Communication: This 90-minute interactive webinar introduces participants to seven best practices, numerous techniques, and examples for how to more effectively communicate about coastal hazards. Whether you are just starting, or trying to keep people motivated to better prepare for future hazards, applying risk communication principles can lead to more effective conversations and products.	Y
Information	
Understanding Coastal Inundation Webpage Series	Y
What Will Adaptation Cost? An Economic Framework for Coastal Community Infrastructure. This guide helps communities understand baseline risk, assess what to do differently, calculate costs and benefits, make a decision	Y

Adapting to Climate Change: A Planning Guide for State Coastal Managers. This guide offers a framework for state coastal managers to follow as they develop and implement climate change adaptation plans in their own states.	Y
What does tidal flooding look like training module?	Y

More specific to ecosystem resilience, NOAA has a number of data, tools, and trainings related to land cover and green infrastructure that can be easily accessed through the Land Cover and Green Infrastructure Digital Coast Topic Areas. A search on 22 Feb 2016 found that 3 of the products were available to USVI. See Table 5 below.

Table 5. NOAA data, tools, and trainings related to land cover and green infrastructure and their current status for availability to USVI.

Ecosystem Resilience data, tools and trainings in NOAA Digital Coast	**Available in USVI (Y/N)?**
Coastal Change Analysis Program High Resolution Land Cover and Change: These nationally standardized, raster-based inventories cover coastal intertidal areas, wetlands, and adjacent uplands for the coastal U.S. Data are derived from the analysis of multiple dates of remotely sensed imagery.	Y 2002 USVI St. Croix High Res Land Cover 2002-2007 USVI St. Croix High Res Land Cover Change 2003 USVI St. Thomas High Res Land Cover 2003-2007 USVI St. Thomas High Res Land Cover Change 2005 USVI St. John High Res Land Cover 2005-2007 USVI St. John High Res Land Cover Change 2007 USVI St. Croix High Res Land Cover 2007 USVI St. John High Res Land Cover 2007 USVI St. Thomas High Res Land Cover 2007-2012 USVI St. John High Res Land Cover Change 2007-2012 USVI St. Thomas High Res Land Cover Change 2012 USVI St. Croix High Res Land Cover

	2012 USVI St. John High Res Land Cover 2012 USVI St. Thomas High Res Land Cover
C-CAP Land Cover Atlas: This online data viewer provides user-friendly access to regional land cover and land cover change information developed through NOAA's Coastal Change Analysis Program (C-CAP).	N *Note: USVI C-CAP data is not currently available online on the Land Cover Atlas, however, it can be downloaded at coast.noaa.gov/ccapftp/*/. One EPA project used C-CAP data for USVI to explore the relationship between landscape and coral reef condition in the watersheds of St. Croix.*
How to Use Land Cover Data as a Water Quality Indicator: Land cover data provides a unique and useful perspective that helps local land use decision makers understand what is actually on the ground as opposed to what might have been planned or permitted. With this how to, users will see how land cover data can be used to assess several water quality indicators.	Y
Coastal Change Analysis Program Wetland Potential Layer: This product uses a combination of data and modeling methods to determine how likely an area is to be a wetland	N
Sea Level Rise Viewer: Select a geography and use the slider bar to simulate various sea level rise scenarios (from one to six feet above the average highest tides) and the corresponding areas that would be impacted by flooding.	Y
Evaluating Land Loss from Sea Level Rise along the Atlantic Coast: In an effort to communicate climate change indicators, the Environmental Protection Agency (EPA) worked with coastal management organizations to identify the amount of land lost to sea level rise along the Atlantic coast.	N

NOAA PROGRAMS/OUTPUTS

NOAA Office of Coastal Management

The Coastal Zone Management Act (CZMA) allows for funding to the Virgin Islands Coastal Zone Management Program at the Department of Planning and Natural Resources to address a number of issues including issues related to climate change and adaptation including: (1) the management of coastal development to minimize the loss of life and property caused by improper development in flood-prone, storm surge, geological hazard, and erosion-prone areas and in areas likely to be affected by or vulnerable to sea level rise, land subsidence, and saltwater intrusion, and by the destruction of natural protective features such as beaches, dunes, wetlands, and barrier islands, (CZMA Section 303(2)(b); (2) the study and development, in any case in which the Secretary considers it to be appropriate, of plans for addressing the adverse effects upon the coastal zone of land subsidence and of sea level rise; CZMA Section 303(2)(K); (3) to encourage the preparation of special area management plans which provide for increased specificity in protecting significant natural resources, reasonable coastal-dependent economic growth, improved protection of life and property in hazardous areas, including those areas likely to be affected by land subsidence, sea level rise, or fluctuating water levels of the Great Lakes, and improved predictability in governmental decision-making; CZMA Section 303(3); and (4) preventing or significantly reducing threats to life and destruction of property by eliminating development and redevelopment in high-hazard areas, managing development in other hazard areas, and anticipating and managing the effects of potential sea level rise and Great Lakes level rise. CZMA Section 309 (a)(2).

NOAA National Marine Fisheries Service[280]

The NOAA National Marine Fisheries Service (NMFS) Protected Resources Division has incorporated climate change in its analysis of potential species listings under the Endangered Species Act[281] and this has resulted in the listing of 66 coral species in September 2014 (5 new in the U.S. Virgin Islands plus 2 that were already listed reaffirmed listing status and the rest in the Pacific). The main reason for the listing was the impacts of climate change.[282] The completed recovery plan for Elkhorn and Staghorn corals specifically considers climate change impacts such as sea surface temperatures.[283] Additionally, NMFS Habitat Conservation Division is developing climate smart habitat conservation initiatives[284] and strategic planning.[285] States and territories can apply for ESA Section 6 funds to support recovery of listed species, including corals, projects can specifically address mitigation of climate change impacts.

Should add NMFS funding opportunities related to fisheries all of which recognize the need to incorporate climate change impacts into research projects

NOAA Coral Reef Conservation Grant Program

NOAA's Coral Reef Conservation Program (CRCP) provides funding and technical assistance to U.S. domestic and international partners to catalyze coral reef stewardship and assembles expertise across the agency to provide a multidisciplinary approach to understand and manage coral reef ecosystems and address top coral reef threats: climate change, fishing impacts, and land-based sources of pollution. The CRCP has engaged in considerable effort to develop 20-year strategic goals and five-year objectives to effectively address each of the top three threats to coral reef ecosystems, both domestic and internationally. Selected products for the U.S. Virgin Islands generated through the NOAA Coral Reef Conservation Grant Program are highlighted on the next page. For a complete list of products available on this site please search through the CoRIS Geoportal.[286] NOAA also provides coral funds to the National Wildlife Foundation (NFWF) for a grant program specific to coral reefs. NFWF funds have supported projects in USVI, including a project in Coral Bay related to the impacts of land-based sources of pollution and the development of best management practices to control them particularly due to effects of storms.

[280] Carrubba, Lisamarie, in communication with Kasey R. Jacobs. 22 Feb 2016.
[281] http://www.nmfs.noaa.gov/stories/2013/12/12_4_2013climate_and_the_esa.html
[282] http://sero.nmfs.noaa.gov/protected_resources/coral/index.html
[283] http://sero.nmfs.noaa.gov/protected_resources/coral/documents/acropora_recovery_plan.pdf
[284] http://www.habitat.noaa.gov/ourwork/climate.html
[285] http://www.habitat.noaa.gov/habitatblueprint/objective.html
[286] http://www.coris.noaa.gov/geoportal/

One example of a grant project funded by NOAA CRCP that assists the territory adapt to climate change was completed in 2014 by researchers from the Marine Applied Research Center in Wilmington, NC, The Department of Ecology and Evolutionary Biology at Cornell University, The Nature Conservancy, St. Croix, and World Wildlife Fund: *Assessing the relative resilience of the coral reefs of St. Croix, USVI.*[287] This report describes an assessment of the relative resilience of reef sites near St. Croix, USVI based on key resilience indicators, like herbivore biomass and coral diversity. The resultant rankings for sites and assessment of all sites as having high, medium or low relative resilience can aid with targeting management actions. Expected follow-on actions include: identifying potential sites for future marine protected areas (MPAs) and defending existing MPAs, prioritizing sites for coral transplantation to support recovery and communication and engagement with stakeholders and the public. Resilience has been hugely popular in the conservation community as a conceptual framework but there are very few examples of operationalizing resilience into decision-support for managers. This report is thus a critically important example others can learn from and is unique in two important ways. The analysis was conducted as desktop-only by compiling a range of existing data; there are many datasets on coral reef condition around the world that could be analysed using the approach described here. Secondly, the highly consultative and collaborative process used is a model for scientist-manager interactions that has strengthened inter-agency relationships and will maximize uptake of the analysis outputs.

Another example of NOAA CRCP grant funds going to use to address climate change in USVI was conducted by the Coral Health and Monitoring Program (CHAMP) at NOAA's Atlantic Oceanographic and Meteorological Laboratory in Miami.[288] Researchers collected atmospheric and meteorological data via its Coral Reef Early Warning System (CREWS) station at St. Croix's Salt River Bay from 2006 - 2014; those data are now available through NOAA's Coral Reef Information System.[289] The CHAMP program also collects sea temperature data at many other sites, including St. Thomas, USVI, throughout the Caribbean via its virtual station (satellite data) network. To see those data, as well as ecological forecasts (ICON) for most of these sites, users can visit the CHAMP Portal.[290]

[287] Maynard, J., K. Lewis, J. Brown, G. Ahmadia. 2014. Assessing the relative resilience of the coral reefs of St. Croix, USVI. Report prepared for The Nature Conservancy and NOAA Coral Reef Conservation Program. (NA09NOS4190173 NOAA CRCP-TNC Cooperative Agreement)

[288] Hendee, James C. communication with Kasey R. Jacobs. 23 Feb 2016.

[289] http://www.coris.noaa.gov/

[290] http://www.coral.noaa.gov/champportal/

NOAA Coral Reef Conservation Grant Program
Climate-Related Products for the U.S. Virgin Islands

Monitoring Data Reports

A summary of biophysical data relevant to the management of the East End Marine Park, St. Croix, US Virgin Islands
Targeted supplemental environmental assessment (TSEA) for the Threatened Coral Recovery Project

Near Real-Time Data

Coral Reef Watch Satellite Monitoring

Biophysical Science Reports

Seasonal Variability in Coral Immunity in the Florida Keys, the US Virgin Islands, and Puerto Rico
A comparative study of fringing reefs below developed v. undeveloped watersheds, U.S.Virgin Islands
Developing surface water GPS digital mapping technology to map the spatial distribution of size classes and disease prevalence of Elkhorn coral in the nearshore waters of St. Thomas and St. Croix

Management

Lionfish response management plan. U.S. Virgin Islands. Update

USVI's Coral Reef Management Priorities

US Virgin Islands Capacity Assessment Report and Coral Reef Conservation Time Line

Volume 1: Marine Protected Areas Managed by U.S. States,Territories, and Commonwealths. NOAA Technical Memorandum CRCP 2 February 2007

U.S. Virgin Islands Local Action Strategy Factsheet

Socioeconomic monitoring guidelines for coastal managers in the Caribbean:

State of the Reef Reports

The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2008.

The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2005.

The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2002.

Watershed Management Plans

Coral Bay watershed management plan : a pilot project for watershed planning in the USVI

Fish Bay management plan for Fish Bay watershed, St. John, United States Virgin Islands Department of Planning & Natural Resources 2001

St. Croix East End Watersheds Management Plan

2013 St. Thomas East End Reserves Watershed Management Plan

2013 STEER Watershed Existing Conditions Report

Caribbean Large Marine Ecosystem Project[291]

The Caribbean Large Marine Ecosystem Project (CLME) Project assists participating countries from the Wider Caribbean Region to improve the management of their shared Living Marine Resources -most of which are considered to be fully or overexploited- through an Ecosystem-Based Management (EBM) approach.

A preliminary Transboundary Diagnostic Analysis (TDA) identified three priority transboundary problems that affect the Caribbean Large Marine Ecosystem (CLME) and Adjacent Regions:

- Unsustainable exploitation of fish and other living marine resources
- Habitat degradation and community modification
- Pollution

The final TDAs prepared under the full-sized CLME Project serve as the science basis for the development of an agreed program of interventions (called "SAP"), which may include policy, legal and institutional reforms, conservation measures and pollution control.

This Strategic Action Program (SAP) will document the shared, and commonly-agreed upon vision of the countries participating in the CLME Project with regard to the priority interventions, reforms and investments that are required to ensure the sustainable provision of goods and services from living marine resources in the Wider Caribbean Region (WCR). More specifically, the CLME Project will facilitate the strengthening of the governance of key fishery ecosystems in the WCR, at the regional, sub-regional and national levels. For this purpose, CLME will give particular attention to the strengthening of horizontal and vertical (technical and political) linkages between existing structures.

To assist this process, the project will create an integrated Information Management System (IMS), bringing together congruent fisheries, biological, pollution and socio-economic data and information as a powerful management tool.Similarly, a framework for periodic monitoring and evaluation of progress towards the achievement of the CLME goals and objectives will be developed.

Caribbean Marine Protected Area Management Network

The Caribbean Marine Protected Area Network and Forum (CaMPAM) is a partnership among managers, educators, NGOs, GOs, and other users of MPAs in the Gulf of Mexico and Caribbean region. CaMPAM is dedicated to building the capacity of MPAs to ensure their success. Some of the activities of CaMPAM include a Training of Trainers course, an Internet distribution list, annual scientific and management technical sessions at GCFI, a Small Grants program, and a regional MPA database. CaMPAM receives support from the United Nations Environment Programme's Caribbean Environment Programme, NOAA's

[291] http://www.clmeproject.org/

National Ocean Services Coral Reef Conservation Programme, the Gulf and Caribbean Fisheries Institute, the Italian Ministry of Foreign Affairs (International Development Cooperation), the Spain Ministry of Foreign Affairs, and several others.

NOAA Centers for Coastal Ocean Science Biogeography Branch (Center for Coastal Monitoring and Assessment)

The Center for Coastal Monitoring and Assessment conducts field research and data analysis to support marine resource management at local, regional, and national levels. We partner with groups ranging from Tribal organizations to state governments to other federal agencies to identify research and monitoring questions of importance to communities. Based in Silver Spring, Maryland, our scientists work throughout the coastal United States, its territories, and the Freely Associated States. Major research programs include:

- Biogeographic assessments, in support of ecosystem management
- Monitoring and research to help find sources of coastal contamination
- Assessments of the ecological impacts of climate change
- Forecasts to help to protect the public from harmful algae blooms

Comprehensive Regional Decision-support Framework to Prioritize Sites for Coral Reef Conservation in the U.S. Virgin Islands

NOAA is currently developing a Decision-support tool to help answer the following questions related to prioritization of sites for coral reef conservation in USVI:

- Where are the best examples of coral reefs?
- How many of the best reefs are protected?
- Where are the most resilient reefs?
- Which reefs will respond best to management actions?

STATUS:	ASSESSMENT AND PLANNING (IN-DEVELOPMENT 2016)
APPROACH:	INTEGRATED ASSESSMENT AND RISK MANAGEMENT
MOTIVATION:	DECISION-DRIVEN

NCCOS scientists are working with territory managers to answer these questions by developing a data-driven decision support framework to prioritize coral reef ecosystems

for management action across the USVI. The proposed prioritization framework combines essential biological data on biodiversity collected from thousands of underwater surveys across the region together with detailed seafloor maps and new sociological data on the importance of coral reefs to local marine users, such as SCUBA divers. Priority reefs are then evaluated relative to exposure to threats. The decision support tool will be designed to allow managers to map and rank coral reefs, with user-defined weightings, for biological importance, connectivity, human use value and resilience. This process is intended to inform a number of local management activities, including: Territorial and Federal Government permitting systems, Local and regional ocean planning, Habitat restoration, Research prioritization, and Increasing public awareness of local marine assets.

AGENCY: *UNIVERSITY OF THE VIRGIN ISLANDS*

The University of the Virgin Islands (UVI) has a variety of programs and departments that support natural resource management in the Territory and have climate change-related research and action projects. The Center for Marine and Environmental Studies (CMES) seeks to advance knowledge and learning in marine, coastal and watershed systems through research, education, student training and outreach programs and to disseminate such knowledge to the academic body, scientific community, government agencies and to the general public. The Virgin Islands Marine Advisory Service (VIMAS) is part of the University of Puerto Rico Sea Grant College Program, located within the Center for Marine and Environmental Studies (CMES) at the UVI. Virgin Islands Marine Advisory Service agents develop outreach and education activities and publications relevant to the marine environment. Cooperative Extension Service (CES) is funded by the U.S. Department of Agriculture and does outreach and education for the community. The Conservation Data Center (CDC) compiles, analyzes, and disseminates natural resource and socioeconomic data. The data being collected are stored in a Geographic Information System (GIS)—a computerized system that links maps to data. The CDC also provides training in GIS. The U.S. Virgin Islands Experimental Program to Stimulate Competitive Research (VI-EPSCoR) promotes the development of the Territory's science and technology resources. VI-EPSCoR is hosted by the University of the Virgin Islands on behalf of the people of the Virgin Islands and is currently focused on work related to the seas surrounding the territory.

UVI PROGRAMS/OUTPUTS

Climate Change and Biodiversity in the Insular Caribbean (2008)

STATUS:	ASSESSMENT COMPLETED (2008)
APPROACH:	IMPACT AND VULNERABILITY BASED
MOTIVATION:	RESEARCH-DRIVEN

In September, 2008 then-UVI President Dr. LaVerne E. Ragster played a key role at a workshop in Trinidad to develop priorities for a research agenda that was presented to the MacArthur Foundation for further funding consideration and distribution throughout the region. The two-year project, *Climate Change and Biodiversity in the Insular Caribbean Project (CCBIC)*,[292] was implemented by the Caribbean Natural Resources Institute (CANARI).

"The important thing that we accomplished was identification of areas that need to be assessed in order to respond to climate change," Dr. Ragster said at the time. For example, an area that project participants are looking at is greater use of high resolution modeling in assessing climate change, she said.

The CCBIC conference drew professionals from various Caribbean institutions to the Normandie Hotel in Port of Spain. The CCBIC project focuses on increasing understanding of what is known - and, perhaps more importantly, what is not known - about the predicted climate change trends and their impact on the biodiversity in Caribbean small-island developing states.

"It's aim is to develop a regional research agenda and capacity needs assessment to address identified gaps and to consider how protected area management, biodiversity protection, and conservation policy can best address climate change in the region," Dr. Ragster said.

Sea Grant: Potential Future Land Loss of Small Islands of Puerto Rico and the United States Virgin Islands

STATUS:	ASSESSMENT COMPLETED (2014)
APPROACH:	IMPACT AND VULNERABILITY BASED
MOTIVATION:	RESEARCH-DRIVEN

Coastal vulnerability was analyzed for 20 small islands around Puerto Rico and the U.S. Virgin Islands. One island out of the twenty was in the U.S. Virgin Islands – Buck Island. A coastal vulnerability index (CVI) was utilized based on shoreline composition, sea-level change, offshore slope, and shoreline change rate. Shoreline position rate of change and CVI were calculated using models called AMBUR and AMBUR-HVA. The research was conducted to generate a scientifically-sound shoreline change and land loss data on which to base coastal management decisions in the territory that allows managers to easily identify critical coastal areas efficiently in terms of personnel and fiscal assets and to gain a better understanding of potential shoreline retreat on small islands and a quantifiable method of comparing island coastal vulnerability.

[292] For more information about the Climate Change and Biodiversity in the Caribbean Project, visit www.canari.org.

The results for Buck Island found that the island is eroding at a rate of 0.12 meters per year. Across the 430 transects on the island they found 56% are eroding. Based on this study, a series of management recommendations were developed to aid in developing land use and management plans for Puerto Rico and USVI cays. A number of research impacts resulted from this investigation. The number one impact of the project, no doubt, is the new method of assessing the vulnerability of different shoreline types to sea-level rise. There now exists a relatively easy and cost-effective method of assessing the islands. The remaining several small islands associated with Puerto Rico and the U.S. Virgin Islands can now be evaluated very quickly and easily. Much of the data collected for the islands in the study is contained within large data sets that include other islands not in the study. The evaluation of other islands will be a simple operation with the new method of assessing the vulnerability of different shoreline types to sea-level rise developed in this project.

Sea Grant: Assessment of the Impact of Watershed Development and Restoration on Marine Sediment Dynamics, St. John, USVI

A new project by the Sea Grant College Program will be starting in 2016 in Coral Bay, St. John: *Assessment of the Impact of Watershed Development and Restoration on Marine Sediment Dynamics, St. John, USVI.* The project may study climate-related impacts.

STATUS:	ASSESSMENT STARTING IN 2016
APPROACH:	RISK MANAGEMENT
MOTIVATION:	DECISION-DRIVEN

UVI-Center for Marine and Environmental Studies

Scientists at UVI's Center for Marine and Environmental Studies (CMES) routinely collect information about the conditions of the waters surrounding the Virgin Islands and those of the broader Caribbean region. In 2011, some of this data was used to create new, state-of-the-art computer-generated models of our oceans. These models are designed to help to determine patterns in the ocean, in the sky, and where the two interconnect.

STATUS:	ASSESSMENT (2011)
APPROACH:	INTEGRATED ASSESSMENT
MOTIVATION:	RESEARCH-DRIVEN

Co-principal investigators for the project were CMES Director Dr. Richard Nemeth, UVI Assistant Research Professor Dr. Nasseer Idrisi, a biological oceanographer, and Dr. Laurent Chérubin, a visiting research oceanographer who is based at the University of Miami. In September 2011, an article describing their study was published in the prestigious international journal Ecological Modeling. This specific study is titled: "Flow

and transport characteristics at an *Epinephelus guttatus* (red hind grouper) spawning aggregation site in St. Thomas (US Virgin Islands)".[293]
Based on the UVI model's predictions, the article describes how larval fish - very tiny, young fish that float or swim in ocean currents - might spread out from an important reef fish spawning aggregation site. Such aggregation sites are areas where many fish gather to reproduce. The UVI ocean model also makes predictions about where the tiny red hind might end up - on St. Thomas reefs or elsewhere down current.

This spawning site where the study was conducted is within a large marine protected area in the USVI known as the Red Hind Bank. Results from this research indicate an important relationship exists between the timing of a spawning event and the phase of the tidal cycle, according to Dr. Idrisi. The spawning fish need to coordinate or synchronize with this timing so that they can successfully produce the next generation.
Although the authors have not yet looked into how climate change affects the ocean's delicate balance, it is possible to model different climatic scenarios with the programming system developed at UVI. One goal would be to better understand how populations of commercially important fish species in the Caribbean region will be affected.

Researchers, natural resource managers, and others can also use these models to better predict climatic events such as hurricanes, changes in oceanic and coastal currents, and changes in rainfall patterns, according to Dr. Idrisi.

Understanding how these events unfold in the context of global climate change will be extremely valuable. It is expected that the success of this research will improve the ability to anticipate and plan for catastrophic events such as hurricanes, storm surges, and droughts.

A major portion of the funding for UVI's ocean modeling research came from the federally funded Virgin Islands Experimental Program to Stimulate Competitive Research (VI-EPSCoR). VI-EPSCoR supported the purchase of hardware and software as well as the funding of personnel who conducted the research. Along with the U.S. Geological Survey, VI-EPSCoR has also recently funded a collaborative study between the University of Miami and the University of the Virgin Islands, in which researchers used the ocean model that UVI developed.[294]

Water Resources Research Institute

[293] Cherubin, L.M., R.S. Nemeth, N. Idrisi (2011) Flow and transport characteristics at an Epinephelus guttatus (red hind grouper) spawning aggregation site in St. Thomas (US Virgin Islands), Ecological Modelling, Volume 222, Issue 17, 10 September 2011, Pages 3132-3148, ISSN 0304-3800, http://dx.doi.org/10.1016/j.ecolmodel.2011.05.031.
(http://www.sciencedirect.com/science/article/pii/S0304380011003115)
[294] Information on this research came from UVI article: http://www.uvi.edu/news/articles/2011/Spotlight_News_Showe963.aspx

Ghuts are some of the most diverse habitats in the U.S. Virgin Islands, containing distinct forest types (Gallery Moist Forest and Gallery Shrubland) and one of the two types of freshwater habitats in the Territory. Ghuts provide critical ecological functions, but moreover they provide sources of freshwater for agricultural purposes and other services to communities such as recreational and educational opportunities. In 2008, "A Strategy for Management of Ghuts in the U.S. Virgin Islands"[295] was developed. Management strategies such as this, that don't explicitly mention climate change, are important as climate change exacerbates pre-existing vulnerabilities. This strategy recommended a variety of ghut restoration and hazard mitigation actions that can be taken to continue to provide important benefits to the U.S. Virgin Islands.

AGENCY: *U.S. FISH AND WILDLIFE SERVICE*

The U.S. Fish & Wildlife Service (USFWS) in the Caribbean offers diverse habitat and services in the region. They provide Ecological Services and operate nine refuges throughout Puerto Rico and the Virgin Islands. In the U.S. Virgin Islands they are focused on recovery of listed species and habitat restoration. They do not have any studies on climate change, except one habitat vulnerability project (described below) that covers two cays in in USVI[296]

PROGRAMS/OUTPUTS

Sandy Point National Wildlife Refuge Leatherback Project

STATUS:	Monitoring and Implementation
APPROACH:	Risk Management
MOTIVATION:	Research, Decision and Stakeholder-driven

Since 1981 leatherback sea turtle nesting has been monitored at Sandy Point National Wildlife Refuge in St. Croix using saturation tagging protocols. Nests in danger of erosion are relocated to low-risk beach zones, which has resulted in increased hatch success and an increasing nesting population. Other sea turtle species are monitored by project staff, as well.[297]

Cay Systems Habitat Vulnerability Assessment.

[295] http://www.uvi.edu/files/documents/Research_and_Public_Service/WRRI/strategy_management.pdf
[296] Rivera, Marelisa (U.S. FWS). Personal communication with Kasey R. Jacobs. 25 Feb 2016.
[297] WIDECAST U.S. Virgin Islands Projects. http://www.widecast.org/What/Country/USVI/usvi.html

STATUS:	Assessment and Planning
APPROACH:	Integrated Assessment
MOTIVATION:	Research, Decision and Stakeholder-driven

The U.S. Fish and Wildlife Service Caribbean Ecological Services program and HJR Reefscaping are working to assess habitat vulnerability of the small islands (cays) of Puerto Rico and the U.S. Virgin Islands. Ten cays were selected and two are located in USVI. The results are slated to be available in 2016. Additionally, USFWS Ecological Services and the Director of the Refuges Program are members of a new Cay Systems Conservation Action Team,[298] a collaboration facilitated by the Caribbean Landscape Conservation Cooperative. Using a Structured Decision Making approach partners from NOAA, FWS, USGS, NPS, VI Department of Planning and Natural Resources, Puerto Rico Department of Natural and Environmental Resources, Island Conservation, HJR Reefscaping, Jost van Dykes Preservation Society, and the University of the Virgin Islands are working to define what stakeholders want the cay land-seascape to look like in 50 years. They are identifying indicators, surrogate species, targets and metrics to develop a spatially-explicit strategy that will be used to work together towards the desired future conditions.

AGENCY: *UNITED STATES NATIONAL PARK SERVICE*

NPS operates in the Virgin Islands through their national monument, national parks (historical parks and ecological preserves) and Buck Island Reef National Monument Buck Island Reef National Monument is part of the U.S. National Park Service. The park is one of a few fully marine protected areas in the National Park System. The 176-acre island and surrounding coral reef ecosystem support a large variety of native flora and fauna. Salt River Bay National Historical Park and Ecological Preserve 340-773-1460 Salt River Bay National Historical Park and Ecological Preserve on the Virgin Island of St. Croix, contains the only known site where members of a Columbus expedition set foot on what is now United States territory. It also preserves upland watersheds, mangrove forests, and estuarine and marine environments that support threatened and endangered species. Virgin Islands National Park (VINP) covers approximately 3/5 of St. John, and nearly all of Hassel Island in the Charlotte Amalie harbor on St. Thomas. In addition to the nearly 7,000 acres on land, the VINP also manages over 5,600 acres of submerged lands surrounding the Park. Managed by the National Park Service, the VINP is dedicated to the protection and preservation of its natural and cultural resources and promotes the responsible enjoyment of this unique national treasure. Virgin Islands Coral Reef National Monument (STJ) Seeking to provide greater protection to the sensitive coral reef resources, President Clinton established the Virgin Islands Coral Reef National Monument in 2001. The monument

[298] http://caribbeanlcc.databasin.org/

includes 12,708 acres of federal submerged lands within the 3 mile belt off of Saint John, including Hurricane Hole and areas north and south of Saint John. The U.S. Virgin Islands National Coral Reef National Monument is managed by the VI National Park.

PROGRAMS/OUTPUTS

STATUS:	Monitoring
APPROACH:	Risk Management
MOTIVATION:	Research and Decision

Since 1988, hawksbill sea turtle (*Eretmochelys imbricate*) nesting has been monitored by National Park Service staff at Buck Island, St. Croix using saturation tagging protocols. Since 1994, in-water capture of juvenile hawksbill sea turtles has provided information on growth rates, movement patterns, habitat use, sex ratios and general ecology. Similar efforts have occurred intermittently on St. John by NPS staff since 1980 for all species of sea turtle.

AGENCY: *U.S. GEOLOGICAL SURVEY*

The mission of U.S. Department of the Interior's (DOI) United States Geological Survey (USGS) is to provide reliable scientific information to describe and understand the geological processes of the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect the nation's quality of life. USGS has eight interdisciplinary program areas: 1) water resources; 2) climate and land use change; 3) energy and minerals and environmental health; 4) natural hazards; 5) core science systems; 6) ecosystems; 7) administrative and enterprise information, and 8) facilities. Much of the work relevant to climate change adaptation is done through the climate and land use change program area; portions of several other program areas also relate to climate change adaptation. USGS is primarily a science agency. Unlike other DOI agencies, USGS does not manage large tracts of lands, or construct infrastructure or modify waterways or habitat. Further, the agency does not have regulatory authority under any laws. Consequently, USGS addresses climate change adaptation through conducting scientific studies; collecting and analyzing data related to climatic variables; modeling and predicting the effects of climate variability on natural resources, natural processes (e.g., natural hazards), wildlife, and ecosystems; and monitoring resources such as water flows, habitat changes, and wildlife. For example, USGS provides data on natural resources and scientific analysis to support adaptive management strategies implemented by DOI land management agencies (as well as for other federal agencies, state and local governments, and others) that address climate change adaptation. U.S. Department of the Interior's agencies rely on USGS for scientific data and interpretations to inform their land management decisions. Memorandums of understanding (MOUs) and scientific agreements between USGS and other federal and

state agencies allow USGS to provide research results on climate change processes and impacts, as well as data for making decisions on specific geographic areas.

The USGS supports the Water Resource Research Institute (WRRI) at the University of the Virgin Islands. WRRI is one of 54 such research institutes located at land-grant universities throughout the United States. The institute supports research projects that promote the efficient use and resilience of the islands' limited water supply.[299]

PROGRAMS/OUTPUTS

Groundwater Resources of the Kingshill aquifer, St. Croix, U.S. Virgin Islands

STATUS:	ASSESSMENT STILL NOT FUNDED (2016)
APPROACH:	IMPACT AND VULNERABILITY-BASED
MOTIVATION:	RESEARCH AND DECISION-DRIVEN

St. Croix, the largest of the U.S. Virgin Islands, lies about 60 miles east-southeast of Puerto Rico and has an area of 82 mi^2 (square miles). Christiansted and Frederiksted are the principal population centers, but a number of small communities are scattered throughout the island. The population in St. Croix is approximately 55,000, of which about 60 percent is served by the public-water supply system. This system derives water primarily from groundwater sources, and the desalination plants. Groundwater furnishes about 10 percent of the freshwater for public supply throughout the island. Total groundwater pumpage in 1990 was estimated at 1.13 million gallons per day. The most productive groundwater system in St. Croix is the Kingshill Limestone aquifer, which is susceptible to saline water encroachment and contamination from anthropogenic activities. At coastal aquifers like the Kingshill aquifer, saline water encroachment is induced by over pumping, and land-use changes that reduce aquifer recharge. This reduction in recharge promotes up-coning of the saline waters as a result of the existing groundwater withdrawals. Another water quality problem is the migration of possible hydrocarbon contaminants from areas located near industrial facilities in south-central St. Croix. These contaminants may threaten the public water-supply wells in the south-central portions of the Kingshill aquifer.

In July 1987, the USGS conducted an assessment of the groundwater resources of St. Croix, U.S. Virgin Islands. The investigation included development of a well inventory, collection of borehole geophysical data, mapping of permeability, development of a meteoric water-line obtained from isotopic analyses, and mapping the potentiometric surface. These data and information acquired during the investigation were integrated into a groundwater flow model, which was for used to simulate the hydrologic conditions prevailing at that time. Simulation results indicated; 1) the aquifer was recharged substantially by numerous

[299] UVI WRRI: http://uvi.edu/research/water-resources-research-institute/default.aspx

artificial ponds: 2) actual pumping from the aquifer may have been 30 percent greater than reported, and 3) at least 20,000 gallons per day of seawater were entering the aquifer.[300]
In 1982 a local industry notified the U.S. Environmental Protection Agency (USEPA) Region II of the discovery of a large quantity of petroleum hydrocarbons floating in the groundwater beneath its facility. According to USEPA officials, the recovery activities during this time produced 42 million gallons of free-product petroleum (letter of July 17, 2009, U.S. Virgin Island's Department of Planning and Natural Resources, VIDPNR).
The potential continued degradation of the Kingshill aquifer may limit even more of the water-supply resources of the island. Therefore, continued monitoring and evaluation of the health of the aquifer system will promote the effective use and management of this resource. In 2009 and in 2015, the VIDPNR expressed interest in evaluating the groundwater resources of St. Croix, with particular interest in water quantity and quality.

Coastal Vulnerability Assessment of Virgin Islands National Park (VIIS) to Sea-Level Rise

STATUS:	ASSESSMENT COMPLETED (2004)
APPROACH:	IMPACT AND VULNERABILITY BASED
MOTIVATION:	RESEARCH AND DECISION-DRIVEN

In 2004, a coastal vulnerability index (CVI) was used to map the relative vulnerability of the coast to future sea level rise within Virgin Islands National Park on St. John in the U.S. Virgin Islands.[301] The CVI ranks the following in terms of their physical contribution to sea-level rise-related coastal change: geomorphology, regional coastal slope, rate of relative sea-level rise, historical shoreline change rates, mean tidal range and mean significant wave height. The rankings for each input variable were combined and an index value calculated for 500-meter grid cells covering coastal areas of the park. The CVI highlights those regions where the physical effects of sea-level rise might be the greatest. This approach combines the coastal system's susceptibility to change with its natural ability to adapt to changing environmental conditions, yielding a quantitative, although relative, measure of the park's natural vulnerability to the effects of sea-level rise. The CVI provides an objective technique for evaluation and long-term planning by scientists and park managers. Virgin Islands National Park coast consists of carbonate sand beaches, rock cliffs, fringing reefs, and mangrove wetlands. The areas within Virgin Islands National Park that are likely to be most vulnerable to sea-level rise are areas of unconsolidated sediment where coastal slope is low, and wave energy is high.

[300] Torres-González, Sigfredo, 1991, Steady-state simulation of ground-water flow conditions in the Kingshill aquifer, St. Croix, U.S. Virgin Islands, July 1987, in Gómez-Gómez, Fernando, Quiñones-Aponte, Vicente, and Johnson, A.I., eds., Aquifers of the Caribbean Islands, Proceedings of the International Symposium on Tropical Hydrology, San Juan, Puerto Rico, July 23-27, 1990, AWRA Monograph Series no. 15, p. 93-98.
[301] Pendleton, E., E.R. Thieler, and S. J. Williams. 2004. Coastal Vulnerability Assessment of Virgin Islands National Park (VIIS) to Sea-Level Rise. U.S. Department of the Interior U.S. Geological Survey Open-File Report 2004-1398. http://pubs.usgs.gov/of/2004/1398/images/pdf/report.pdf

Assessment of Dark Spot Syndrome in Starlet Corals

STATUS:	ASSESSMENT COMPLETED (2004)
APPROACH:	IMPACT BASED
MOTIVATION:	RESEARCH AND DECISION-DRIVEN

Coral disease is one of the major causes of reef degradation. Dark Spot Syndrome (DSS) was described in the early 1990's as brown or purple amorphous areas of tissue on a coral and has since become one of the most prevalent diseases reported on Caribbean reefs. It has been identified in a number of coral species, but there is debate as to whether it is in fact the same disease in different corals. An article published October 7, 2014, by USGS microbiologists Christina Kellogg and Michael Gray, examines this prevalent coral disease in collaboration with scientists from Lawrence Berkeley National Laboratories. DNA microarrays, a technology that measures a large numbers of genes simultaneously, were used to compare bacterial communities between healthy and dark-spot coral colonies in Virgin Islands National Park in St. John. Overall, the findings do not support the hypothesis that dark spot in the massive starlet coral (*Siderastrea siderea*) is linked to a bacterial pathogen. The dataset does provide the most comprehensive overview to date of the bacterial community associated with this coral species.

AGENCY: U.S. ENVIRONMENTAL PROTECTION AGENCY

Land-based sources of sediment and pollution are a major threat to the health of coral reefs and severely degrade coral reef capacity to be resilient to climate stressors. Protection and restoration of coral reef ecosystems in a changing climate require resource managers to identify watersheds where human activities and modifications to the landscape contribute to reef decline in order to design and implement interventions. US EPA has partnered with a number of federal and non-governmental entities in the Territory to address land-based sources of pollution and thus increase coral reef resilience.

Programs/Outputs

U.S. EPA, Office of Research and Development, National Health and Environmental Effects Research Laboratory

The U.S. Environmental Protection Agency used NOAA Coastal Change Analysis Program (C-CAP) land cover data and coral survey data to explore the relationship between landscape and coral reef condition in the watersheds of St. Croix, U.S. Virgin Islands.[302] The coral survey followed techniques described in the EPA's "Stony Coral Rapid Bio-Assessment Protocol" to measure coral condition indicators. Landscape data were derived

[302] https://coast.noaa.gov/digitalcoast/stories/coralreef-vi

STATUS:	Completed Assessment
APPROACH:	Impact Based
MOTIVATION:	Decision

from 2007 high-resolution (2.4 meter) C-CAP land cover data. A landscape development intensity (LDI) coefficient that relates sources of land-based sediments and contaminants to land cover types in a watershed was applied to each land cover class. The resulting LDI maps highlight watersheds with elevated amounts of human disturbance. The LDI data are used to inform coastal management and land use decision making.

AGENCY: *U.S. FOREST SERVICE INTERNATIONAL INSTITUTE OF TROPICAL FORESTRY*

The U.S. Forest Service International Institute of Tropical Forestry[303] (the Institute) is a tropical forestry research and technology transfer institute located in Río Piedras, Puerto Rico. Created in 1939, the Institute has a long history of climate-related research and outreach programs delivering tropical forestry research, technology transfer and technical assistance throughout the world. In the Virgin Islands, the Institute maintains the Estate Thomas Experimental Forest on the island of St. Croix and has active research and monitoring programs associated with the FS Research and Development deputy area, and programs in Forest Health, Legacy, Stewardship, Urban and Community Forestry, Conservation Education, and Wildland Fire associated with the FS State and Private Forestry Deputy Area. The Institute leads or participates in a number of collaborative programs that conduct research or otherwise provide information relevant to assessing and addressing climate change. These include the Forest Service Forest Inventory and Analysis Program[304] (FIA), Caribbean Foresters,[305] National Ecological Observatory Network[306] (NEON), Long term Ecological Research Network[307] (LTER) which includes the Canopy Trimming Experiment[308] (CTE) of hurricane effects, the Urban Long term Research Area[309] (ULTRA), Luquillo Critical Zone Observatory[310] (LCZO), Caribbean Landscape Conservation Cooperative (CLCC), U.S. Virgin Islands Terrestrial and Aquatic Gap Analysis Projects[311] (GAP), USDA Caribbean Climate Sub Hub for Agriculture and Tropical Forestry[312] (CCH), Department of Energy Next Generation Ecological Experiment[313] (NGEE Tropics), the Tropical Warming Experiment[314] (TRACE), and many

[303] http://www.fs.usda.gov/iitf
[304] http://www.fia.fs.fed.us/
[305] http://caribbeanforesters.org/
[306] http://www.neonscience.org/
[307] https://www.lternet.edu/
[308] http://luq.lternet.edu/research/project/canopy-trimming-experiment-cte
[309] http://sanjuanultra.org/
[310] http://criticalzone.org/luquillo/
[311] http://caribbeanlcc.org/interactive-map/
[312] http://caribbeanclimatehub.org/
[313] http://esd.lbl.gov/ngee-tropics/
[314] http://forestwarming.org/

cooperative agreements with universities, governmental and non-governmental agencies. Of these collaborative programs related to climate change, the FIA, Caribbean Foresters, CLCC, CCH, and the GAP programs apply directly to USVI.

The USDA Forest Service has a strategic plan for the fiscal years 2015–2020[315] which includes three strategic goals: 1) Sustaining the Nation's forests and grasslands; 2) Delivering benefits to the public, and 3) Applying knowledge globally. All of the strategic objectives to achieve these are either directly or indirectly connected to climate change:

- Fostering resilient, adaptive ecosystems to mitigate climate change,
- Mitigating wildfire risk,
- Conserving open space,
- Providing abundant clean water,
- Strengthening communities,
- Connecting people to the outdoors,
- Advancing knowledge,
- Transferring technology and applications,
- Exchanging natural resource expertise.

The International Institute of Tropical Forestry program areas of Research and Development and State and Private Forestry are active in the U.S. Virgin Islands and work to address the strategic goals of the Forest Service and the Institute mission to develop and disseminate scientifically based knowledge that contributes to the conservation of forests, wildlife, and watersheds of the American tropics in the context of environmental change.

USDA Forest Service International Institute of Tropical Forestry Programs/Outputs

Research and Development

The Institute's initial research focused on reforestation, plantation forestry, tropical species identification, forest inventory methods, endangered species, carbon sequestration and the establishment of long-term permanent plot studies. Biomass and climate change research, watershed and biogeochemical studies began in the 1980s. Today, the Institute builds on

[315] USDA Forest Service Strategic Plan: FY 2015–2020 http://www.fs.fed.us/strategicplan

past research with a focus on forest ecology, disturbance ecology, ecosystem functions and services, urban ecology, watershed dynamics, migratory species, climate change, and policy science to better understand the effects of natural and human-induced pressures on tropical forests and the surrounding landscapes. New research includes understanding structure and function of tropical wildlands at watershed and landscape scales, assessing the effects of climate and land use/land cover change on tropical ecosystems and biodiversity, and quantifying ecosystem goods and services from working lands where human and ecological systems interact.

The Institute publishes 50-70 publications annually, many dealing with climate change and of value to local decision makers. Over 13,000 Institute publications are available on the FS Treesearch[316] website. Some have been conducted in the U.S. Virgin Islands that could be used to assist the Territory adapt to climate changes. Stein et al. (2014)[317] provides an overview of expected housing density changes and related impacts to private forests on America's islands in the Pacific and Caribbean and covers the U.S. Virgin Islands specifically. They discuss the vulnerability of island forests to conversion for housing development, introduction and spread of invasive species, and risk of uncharacteristic wildfire, among other concerns. For USVI they found that about 12 percent (~5,400 acres) of USVI's private forest land is projected to undergo a substantial increase in housing density from 2000 to 2030, such that the category will shift from very rural to less rural or to urban-exurban. Substantial housing increases are projected to occur in localized areas across the Virgin Islands, most notably in much of the remaining rural private forest across inland areas of northern St. Thomas. Increases are also expected in smaller patches of St. Thomas' coastal forests, including those located on Neltjeberg Bay on the northeastern area of the island, as well as forests along Bovani Bay and the northeastern tip of Western Island. Projected change for St. John is minimal. The authors stress that, "It is critical that resource managers, developers, community leaders, and landowners consider the unique and sensitive ecologies of island forests when planning for future development. This is especially important in light of the added stressors that climate change will bring. Careful planning will help sustain and protect native species, water, and forest ecosystems—along with the people and cultures that depend on them."

Another U.S. Virgin Islands -specific study was Gould et al. (2010)[318] from the GAP project. Four useful products are available: land stewardship (protected areas) information, landcover maps, species range maps, and modeled distributions of 153 species of terrestrial vertebrates that occur in the U.S. Virgin Islands. Species geographic distributions were

[316] http://www.treesearch.fs.fed.us/
[317] Stein, S. M.; Carr, M.A.; Liknes, G.C.; Comas, S.J. (2014). Islands on the edge: housing development and other threats to America's Pacific and Caribbean Island forests: a Forests on the Edge report. Gen. Tech. Rep. NRS-137. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 55 pp. http://www.treesearch.fs.fed.us/pubs/47119
[318] Gould, W.A., Solórzano, M. and Potts, G. (2010). U.S. Virgin Islands GAP Analysis Project. Gap Analysis Bulletin. 17: 35-36 http://www.treesearch.fs.fed.us/pubs/36881

mapped using a network of 2 km^2 hexagons that cover the U.S. Virgin Islands. Species probability of occurrence information is derived from published literature, unpublished datasets, museum records, and expert opinion. Species habitats were predicted using models developed from the literature and expert review. Species distributions were mapped by identifying predicted habitat within the species geographic range. The resulting 153 maps of species predicted distribution are based on the integration of information from a database of vertebrate occurrences and land cover mapping. Predicted distributions are in raster format with a resolution of 10 m^2. They modeled the habitat distribution of 118 bird species, 21 reptiles, 6 amphibians, and 8 mammal species that occur in the USVI. All information is available through the CLCC Data Center interactive map.[319] Building on this work, Nytch et al. (2015)[320] analyzed information combined from the Puerto Rico and the USVI Gap analysis projects with other conservation planning efforts to develop a set of bird conservation planning priorities for the area. Two suggested actions that refer to climate change include:

- Investigate and monitor localized effects of climate change and rising sea levels on coastal zones, mangrove habitats, and upper elevation forests.

- Engage citizen scientists in monitoring programs to obtain information on population trends and habitat requirements of high priority species, and to study the effects of habitat management actions and climate change on species distribution across the landscape.

The report includes many resource specific planning recommendations. There are also a few recent climate studies published by the Institute that were conducted for Puerto Rico but could be relevant to the U.S. Virgin Islands. A literature synthesis, Jennings et al. (2014),[321] summarizes climate change effects for El Yunque National Forest. The report provides an overview of key findings on climate trends, extreme weather, terrestrial ecosystems, aquatic ecosystems, wildlife, and recreation as well as on the effects on ecological and physical resources, including biodiversity, plant and animal communities, freshwater systems, water resources, soils, and vegetation management. Additionally, the study discusses the effects on social and economic resources, including recreation and tourism, land use and planning, and coastal resources. The information presented in this report demonstrates for natural resource managers, planners, and stakeholders the starting point to assess the vulnerability of local resources to climate change as part of a broader

[319] http://caribbeanlcc.org/interactive-map/
[320] Nytch, C.J., Hunter, W.C., Núñez-Garcíá, F., Fury, C., and Quiñones. M. (2015). Avian Conservation Planning Priorities for Puerto Rico and the U.S. Virgin Islands (BCR 69). U.S. Fish and Wildlife Service, Atlantic Coast Joint Venture, and the Caribbean Landscape Conservation Cooperative: http://acjv.org/documents/PRUSVI_plan.pdf.
[321] Jennings, Lisa NicoleL.N.; Douglas, J.amison; Treasure, EmrysTreasure, E.; González, Grizelle. (2014). Climate change effects in El Yunque National Forest, Puerto Rico, and the Caribbean region. Tech. Rep. SRS-GTR-193. Asheville, NC: USDA-Forest Service, Southern Research Station. http://www.treesearch.fs.fed.us/pubs/45918

decision-making framework. Subsequent to the Jennings et al. (2014) compilation, new information based on hydrologic modeling and statistically downscaled climate data has become available for Puerto Rico, and may be useful for the US Virgin Islands as well - particularly as the Puerto Rican islands of Culebra and Vieques share many similarities in climate and vegetation with the USVI. As a basis for this modeling, Stoner et al. (2013)[322] describe a statistical downscaling method used for the region, Ryu and Hayhoe (2014)[323] describe some of the sources of uncertainty in simulating Caribbean precipitation patterns, and Hayhoe (2014) describes the key drivers of climate variability and change for Puerto Rico and the Caribbean. Hayhoe (2013) provides data on precipitation and daily minimum and maximum temperatures downscaled to several weather stations through the year 2100 and available via the CLCC data center.[324] Van Beusekom et al. (2014)[325] looked at the effects of changing land cover on streamflow simulation in Puerto Rico and calibrated a streamflow model for the region that provides information on surface, subsurface, and groundwater flow. The group then assessed future scenarios of streamflow based on the Hayhoe (2013) statistically downscaled data (Van Beusekom et al. 2015). Henareh et al. (2015) used the same Hayhoe (2013) downscaled data to map the projections to Puerto Rico and to look at the potential ecological and economic effects of climate change for tropical islands.

The Institute's Forest Inventory and Analysis Program[326] (FIA) collects, analyzes, reports, and distributes data about the forests in the U.S. Virgin Islands: how much forest exists, who owns it, what condition it's in, where it's located, and how it's changed. The FIA is managed by USFS Research and Development in cooperation with State and Private Forestry and National Forest Systems. Brandeis et al. (2013)[327] report that from 2004 to 2009 forest area on the U.S. Virgin Islands held steady, or decreased slightly (46,564 acres to 45,163 acres). The authors estimate there to be 85.1 million trees in the U.S. Virgin Islands holding 1.2 million tons of aboveground woody biomass. On average, an acre of subtropical moist forest held 17.2 tons per acre of carbon and an acre of subtropical dry forest held 11.4 tons per acre. A total of 118 species were encountered on the forest inventory plots measured in 2009. West Indian mahogany (*Swietenia mahagoni*) replaced black mampoo (*Guapira fragrans*) as the tree with the highest importance value. Authors continue to see the prevalence of smaller white leadtrees, or tan-tan (*Leucaena*

[322] Stoner, A. M. K., K. Hayhoe, X. Yang, and D. J. Wuebbles, (2013): An asynchronous regional regression model for statistical downscaling of daily climate variables. Int. J. Climatol., 33, 2473–2494, doi:10.1002/joc.3603.

[323] Ryu, J.-H. and Hayhoe, K. (2014). Understanding the sources of Caribbean precipitation biases in CMIP3 and CMIP5 simulations. Climate Dynamics 42: 3233-3252.

[324] http://caribbeanlcc.org/climatedata-download/

[325] Van Beusekom, A.E.,Hay, L.E., Viger, R.J., Gould, W.A., Collazo, J.A., Henareh Khalyani, A. (2014). The Effects of Changing Land Cover on Streamflow Simulation in Puerto Rico. Journal of the American Water Resources Association., 50(6).

[326] http://www.fs.usda.gov/detail/iitf/research/?cid=stelprd3853524

[327] Brandeis, T.J. and J.A. Turner. 2013. U.S. Virgin Islands, 2009 - forest inventory and analysis factsheet. e-Science Update SRS-SU-077. Asheville, NC: USDA-Forest Service, Southern Research Station. 5p. http://www.treesearch.fs.fed.us/pubs/45105

leucocephala) in both the subtropical dry and moist forests. This repeated monitoring of permanent plots is an excellent tool for assessing climate change effects and understanding forest responses to change. Institute researcher Peter Weaver has described the Estate Thomas Experimental Forest as well as results of long term forest plot monitoring (Weaver 2006,[328] 2009[329]) which serves to better understand the relationships of climate and forest ecosystem services.

State and Private Forestry

The U.S. Forest Service State and Private Forestry Program provides professional, technical, and financial assistance to local communities and private landowners in the U.S. Virgin Islands. Federal resources are leveraged to protect and support sustainable natural resource management of the U.S. Virgin Islands' forests and ecosystems to produce goods and services that are important to many communities. Assistance is focused on cooperative programs including: Urban and Community Forestry, Forest Legacy, Forest Stewardship, Cooperative Fire Protection, Forest Health and Conservation Education. State and Private Forestry programs work in partnership with the Virgin Islands Department of Agriculture (VIDOA), the U.S. Virgin Islands Fire Service (USVIFS), and various other state, local, and non-profit organizations and universities throughout the Caribbean. While many programs do not explicitly address climate change, the conservation actions promoted are aligned with the best adaptation and mitigation practices in order to address the Institute's mission.

The State and Private Forestry Program works with the VIDOA Forestry Division to periodically produce the U.S. Virgin Islands Forest Resources Assessment and Strategies. The most recent was produced in 2010 (Chakroff 2010[330]) and 11 specific climate change threats to forest and coastal ecosystem services are articulated and documented. They include deteriorating coastal conditions; floods, storm surge, and erosion; reduction in freshwater resources; increased invasion by non-native species; economic loss from reduced agricultural yields; loss of mangroves due to sea level rise; ocean acidification effects on corals; storm damage; reduction in aquifers due to saltwater intrusion; coastal inundation; and reduction in tourism due to increased storm activity.

The Urban and Community Forestry Program promotes the conservation of urban forests. It supports educational initiatives and provides technical assistance, including the development of urban forest management plans, tree planting, managing existing urban

[328] Weaver, P. L. 2006. Estate Thomas Experimental Forest, St. Croix, U.S. Virgin Islands: research history and potential. General Technical Report GTR-IITF-30. Río Piedras, PR: U.S.

[329] Weaver, P.L. 2009. Long-term diameter growth for trees in the Cinnamon Bay Watershed. Acta Cientifica. 23 (1-3): 23-34. http://www.treesearch.fs.fed.us/pubs/42001

[330] Chakroff, Marilyn.2010. U.S. Virgin Islands Forest Resources Assessment and Strategies. A comprehensive analysis of forest-related conditions, trends, threats and opportunities.VI Department of Agriculture. http://geographicconsulting.com/wp-content/uploads/2011/05/USVI-Forest-Resources-Assessment-and-Strategies-2-sideds-printing-VIDOA.pdf

forests, and reducing hazardous conditions. Each year the program provides technical and financial assistance to communities, non-profit organizations, educational institutions, and State governments. The Virgin Islands Department of Agriculture (VIDOA), with the advice of the Virgin Islands Urban and Community Forestry Council, are State-level partners that administer the program in their jurisdiction.

The Forest Legacy Program is a partnership between States and the U.S. Forest Service to identify and help conserve environmentally important forest areas that are threatened by conversion to non-forest uses. To date 179 acres in the U.S. Virgin Islands have been entered in the program.

The Forest Stewardship Program was established in 1991 to encourage forest landowners to actively manage their forests. It is a federal program that provides technical assistance through State forestry agency partners to nonindustrial private forest owners to encourage and enable active long-term forest management. A primary focus of the program is the development of comprehensive, multi-resource management plans that provide landowners with the information they need to manage their forests for a variety of products, and services. These enhanced management practices are vital for forest health and improve the quality of air, water, soil, recreation, and help conserve and sustain the islands' biodiversity and ecological integrity. The Institute partners with the U.S. Virgin Islands Department of Agriculture (VIDOA) and the U.S. Virgin Islands Forest Stewardship Coordinating Committees for program implementation.

The Cooperative Fire Protection Program provides financial and technical assistance to the U.S. Virgin Islands Fire Service (USVIFS) to build capacity and address firefighter safety, initial attack capability, equipment maintenance, technical and professional training, and hazard mitigation activities. It ensures that federal, state, and local agencies can deliver a coordinated response to wildfire through adoption of the National Incident Management System, and common standards of training, equipment, qualifications and other operational functions. It supports fire mitigation activities and prevention programs such as Fire Adapted Communities and Firewise. Other preparedness activities include geospatial data collection and management to support fire planning, decision support, and fuel analysis processes and systems.

The Forest Health Protection Program provides forest insect, disease, and invasive plant survey and monitoring information, and technical and financial assistance to prevent, suppress and control outbreaks threatening forest resources. The FHP program works with natural resource managers, private landowners, and various partners to maintain, enhance, and restore healthy forest conditions. Forest Health specialists provide information to land and nursery managers on integrated pest management, and phytosanitation methods.

Partners and collaborators work with researchers and natural resource managers to look at the relationship between changing climates, invasive plant species, pest conditions, and overall forest health conditions to provide specialized assistance to incorporate disturbance considerations into forest management plans and decisions.

The Conservation Education Program coordinates the development and delivery of high-quality, science-based education about forests, grasslands and related natural resources for pre-kindergarten through 12th grade students and their educators, in both formal and informal settings. IITF works with partners in both the U.S. Virgin Islands and Puerto Rico to promote educational programs that are founded in science, promote the concept of "systems thinking," for students to recognize their role in natural surroundings, and foster a land ethic amongst students and their educators.

NATURAL RESOURCES SECTOR SUMMARY

The natural resources of the USVI are of paramount importance to the islands continued cultural and economic vitality. Territorial authorities are working with federal partners on a number of terrestrial and marine based programs to help adapt to changes already being felt and prepare for future scenarios. Preserving and restoring ecosystem health across the islands will minimize vulnerability and risk in the face of climate change. The territories coral reefs are an invaluable asset that provides a number of critical ecosystem services such as healthy fisheries, protection from storm surges and tourism opportunities. The health of these reefs is tied to management and development practices across the islands.
The Virgin Islands Department of Planning and Natural Resources (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. DPNR is also responsible for oversight and compliance of land survey, land subdivision, development and building permits, code enforcement, earth change permits, zoning administration, boat registration, and mooring and anchoring of vessels within territorial waters. Two DPNR divisions work directly to study and plan for the effects of climate change: the Division of Coastal Zone Management and the Division of Fish and Wildlife. The divisions work in partnership with NOAA's Office of Coastal Management and Coral Reef Conservation Program and the U.S. Fish and Wildlife Service. The mission of the agency and the programs its division implements is critical to maintaining and restoring healthy marine and terrestrial ecosystems that will be resilient to stresses from climate change. A variety of other federal programs such as U.S. Geological Survey, National Park Service, and U.S. Environmental Protection Agency play a strong role working with DPNR and other territorial agencies to protect natural resources. A review shows that all of these federal agencies have climate-explicit programs completed or in-development in USVI. These efforts are complimented by programs currently being administered by the Virgin Islands Department of Agriculture (VIDOA) in partnership with the U.S. Forest Service, the University of the Virgin Islands Cooperative Extension Service, the Natural Resource Conservation Service (NRCS), and various other USDA entities aimed at improving agricultural and land management practices that have a direct impact on biodiversity, water quality, and overall natural resource health. Technical capacities in this sector run the gamut from climate and coastal hazards science, modeling and spatial analysis, ecosystem dynamics, monitoring, strategic planning, and decision support, and many other fields of expertise. Based on this analysis it appears that the institutions in this natural resources sector have greater expertise and capacity to understand climate change vulnerabilities, propose and implement best adaptation and risk reduction practices for natural resources than other sectors.

Notable
Climate Change Research and Program Results in the
U.S. Virgin Islands for Natural Resources

- Stresses from higher sea surface temperatures are believed to contribute to coral bleaching events and possibly to increased susceptibility to diseases. Global climate change is likely to increase these stresses in the Virgin Islands, leading to greater risk for reef related ecosystems.[331]

- Coastal erosion and occasional sediment injections into the coastal waters of the Virgin Islands are a natural condition of island life. Excessive erosion and sediment deposition on coastal marine ecosystems is an effect of the development and over-development of coastal areas which has become commonplace in the insular Caribbean and especially the Virgin Islands. The strong tropical showers typical of the region (and predicted to increase in some Global Climate Change forecasts) can temporarily greatly increase the sediment-related stresses in bays and adjacent waters that are catchment basins for large watersheds. These changes can stress marine organisms attached to the bottom. Salt ponds, lagoons, mangroves, and fringing coral reefs all play a role in helping to stabilize and mitigate the effects of such episodes on nearshore waters.[332]

- Buck Island is eroding at a rate of 0.12 meters per year.[333]

- Precipitation data for St. Croix shows a general decreasing trend of 2.83 inches over the last 100 years as documented by the National Weather Service, and Don Jordan (1974) . The period of record extends from 1852 to 2014

- Virgin Islands National Park coast (St. John) consists of carbonate sand beaches, rock cliffs, fringing reefs, and mangrove wetlands. The areas within Virgin Islands National Park that are likely to be most vulnerable to sea-level rise are areas of unconsolidated sediment where coastal slope is low, and wave energy is high.[334]

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[331] Island Resources Foundation, 2002. Resource Description Report. University of the Virgin Islands and Department of Planning and Natural Resources. USVI, 14 August, 2002.

[332] Island Resources Foundation, 2002. Resource Description Report. University of the Virgin Islands and Department of Planning and Natural Resources. USVI, 14 August, 2002.

[333] Bush, D. et al. 2014. "Potential Future Land Loss of Small Islands of Puerto Rico and the United States Virgin Islands" Final Report to Puerto Rico Sea Grant College Program.

[334] Pendleton, E., E.R. Thieler, and S. J. Williams. 2004. Coastal Vulnerability Assessment of Virgin Islands National Park (VIIS) to Sea-Level Rise. U.S. Department of the Interior U.S. Geological Survey Open-File Report 2004-1398. http://pubs.usgs.gov/of/2004/1398/images/pdf/report.pdf

- An EPA study[335] found that high human land-use activity within a watershed is associated with poor coral condition and that landscape development intensity maps developed from land cover data are a good predictor of the condition of coral reefs in St. Croix. See the link for maps showing low and heavy human disturbance areas in St. Croix.

- In the U.S. Virgin Islands, there are 11 specific climate change threats to forest and coastal ecosystem services are articulated and documented. They include deteriorating coastal conditions; floods, storm surge, and erosion; reduction in freshwater resources; increased invasion by non native species; economic loss from reduced agricultural yields; loss of mangroves due to sea level rise; ocean acidification effects on corals; storm damage; reduction in aquifers due to saltwater intrusion; coastal inundation; and reduction in tourism due to increased storm activity (Chakroff 2010). [336]

- US Virgin Islands could experience the same projected effects for Puerto Rico as described in Henareh et al. 2015. They found that precipitation is predicted to decline in two sets of climate model ensembles investigated. The precipitation declines cause gradual and linear increases in drought intensity and extremes. The warming from the 1960–90 period to the 2071–99 period was between 4.6 to 9 degrees Celsius depending on the global emission scenarios and location. This warming may cause increases in cooling degree days, and consequently increasing energy demands as more residences and businesses increase air conditioning use.

- Recurrent hurricanes and droughts during centuries have had an impact on the understory vegetation within the Cinnamon Bay watershed in St. John. During pre-hurricane visits in 1983 and 1988, the understory was open and easy to traverse; in comparison, after hurricanes Hugo and Marilyn, dense regeneration, broken branches, and fallen trees occupied the understory through 1998, and to a much lesser extent, until 2003. By 2008, tree canopy had recovered completely and the understory was similar to pre-hurricane conditions. The Institute's research in Cinnamon Bay also shows that vegetation on low-lying tropical islands may face dramatic changes in weather from one moment to the next. For example, the drought of 1994 and 1995, the severest of the century, ended with a hurricane.[337]

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[335] https://coast.noaa.gov/digitalcoast/stories/coralreef-vi

[336] Chakroff, Marilyn.2010. U.S. Virgin Islands Forest Resources Assessment and Strategies. A comprehensive analysis of forest-related conditions, trends, threats and opportunities.VI Department of Agriculture. http://geographicconsulting.com/wp-content/uploads/2011/05/USVI-Forest-Resources-Assessment-and-Strategies-2-sideds-printing-VIDOA.pdf

[337] Weaver, P.L. 2009. Long-term diameter growth for trees in the Cinnamon Bay Watershed. Acta Cientifica. 23 (1-3): 23-34. http://www.treesearch.fs.fed.us/pubs/42001

- Hurricane Hugo had different impacts on trees according to species. *Pimenta racemosa* (West Indian Bay Tree) was very resistant to wind damage. Only one tree of the 157 found on the plots in Cinnamon Bay watershed succumbed during the 1988-1993 measurement period that included Hurricane Hugo; moreover, it is uncertain that Hugo was responsible for the loss. Other well known tree species that were highly resistant to damage were *Maytenus elliptica* (white cinnamon)*, Inga laurina* (sackey sac bean), and *Bursera simaruba* (gumbo limbo). In comparison, all of the sampled *Clusia rosea* (scotch attorney) and 23 % of the *Nectandra coriaceae* (lancewood) on the plots died as a result of the storm. An important factor regarding tree damage is their location within the watershed.[338]

CONCLUSION

The information on available data and knowledge, education and training resources, online tools, and implementation projects contained in this report is as known by the project team as of February 29, 2016. One more review period will be conducted with members of the Caribbean Landscape Conservation Cooperative and Virgin Islands Climate Change Council and from this, new institutions, programs and information might be uncovered. A final public version will be designed and distributed subsequent to the final review. As is the case with all institutional analyses, the information will need to be updated periodically for as long as this tool is considered a valuable resource for the users. What follows is a brief summary for each sector included in this institutional synthesis.

Human Health. According to the National Institute of Health, a changing climate affects our health and wellbeing. The major public health organizations of the world agree that climate change is a critical public health problem. Climate change makes many existing diseases and conditions worse, but it may also help introduce new pests and pathogens into new regions or communities. The most vulnerable people—children, the elderly, the poor, and those with underlying health conditions—are at increased risk for health effects from climate change. Climate change also stresses our health care infrastructure and delivery systems.[339] These assertions are consistent with what United States Virgin Islands (USVI) experts from the Virgin Islands (VI) Department of Health and the University of the Virgin Islands (UVI) recently presented in a health panel at the Climate Change in the Caribbean 2015: Puerto Rico & U.S. Virgin Islands Conference.[340]

A review of the USVI health sector indicates that there has been limited published scholarly research that addresses health issues and health disparities in the U.S. Virgin Islands. The

[338] Weaver, P.L. 2009. Long-term diameter growth for trees in the Cinnamon Bay Watershed. Acta Cientifica. 23 (1-3): 23-34. http://www.treesearch.fs.fed.us/pubs/42001

[339] http://www.niehs.nih.gov/research/programs/geh/climatechange/

[340] Ragster, L., Ellis, E.M., L.E. Petersen, Jr., N. Michael. 2015. Public Health Concurrent Session. Responding to Climate Variability and Change – What's been working in climate mitigation and adaptation. Climate Change in the Caribbean 2015 Conference, Inter American School of Law, San Juan, PR. 17 November 2015.

available studies are primarily national surveys such as the Behavioral Risk Factor Surveillance System (BRFSS) that have included participants from the USVI. The USVI has several health programs/outputs but none have addressed the direct impacts of climate change on the health sector, apart from a 2009-2011 UVI public awareness campaign. However, new guidance, national strategies, and web-based resources from the Federal Government for Healthy People 2030 from the U.S. Department of Health and Human Services, the U.S. Centers for Disease Control and Prevention and an assortment of agencies' environmental justice strategies and programs are potential opportunities for the territorial agencies responsible for health and wellbeing services to address challenges presented by climate change. Human Health appears to be the sector with the least amount of existing capacity in the territory to deal with climate adaptation or risk reduction, followed by the tourism sector. This is largely due to the limited amount of programs addressing health concerns poised by climate change, as well as the less direct linkages between health and the other sectors examined in this report.

Critical Infrastructure. The territory's critical infrastructure provides essential services that are vital to public confidence and the islands' safety, prosperity and well-being. There appears to be some amount of inclusion of climate change vulnerability in some programs/ projects related to key infrastructure development, most in the last five years but even as far back as a 2005 study completed by Dr. Aurelio Mercado funded by the Puerto Rico Sea Grant College Program, entitled, *An evaluation of the main ports and bays in Puerto Rico and the U.S. Virgin Islands as to their exposure to hurricane wave attack.*[341] Most of the programs and projects have been assessment and planning focused such as planning climate mitigation actions as part of the VI Department of Public Works Proposed 2030 Master Transportation Plan (goals 5.3 and 5.4) and the Virgin Islands Territorial Emergency Management Agency's Territorial Hazard Mitigation Plan[342] in 2014 that includes the effects of climate change in the assessment (qualitatively) and proposes programmatic and island actions to mitigate climate risks. A non-governmental study led by The Nature Conservancy used funding from the National Oceanic and Atmospheric Administration[343] and input from workshop participants to apply mapping and modeling tools to identify U.S. Virgin Islands' most vulnerable communities. The documented studies, assessments and plans are a good start for the territory, but many more like these are needed that focus on identifying specific critical infrastructure assets vulnerable to multiple climate parameters and viable solutions for mitigating those risks. A few of the institutions synthesized in the critical infrastructure sector have reached implementation, mostly related to energy infrastructure, such as a joint project between the Water and Power Authority (WAPA) and the Federal Emergency Management Agency (FEMA) to transfer overhead lines and pole

[341] Mercado. 2005. Final Report: An evaluation of the main ports and bays in Puerto Rico and the U.S. Virgin Islands as to their exposure to hurricane wave attack. Sea Grant College Program. Available upon request.

[342] VITEMA. United States Virgin Islands Territorial Hazard Mitigation Plan (Final) July, 2014. http://www.vitema.gov/mitigation/mitigation-plan-2014.html

[343] Schill, S., J. Brown, A. Justiniano, A. Hoffman. 2014. US Virgin Islands Climate Change Ecosystem-based Adaptation: Promoting Resilient Coastal and Marine Communities. The Nature Conservancy and NOAA Coral Reef Conservation Program. https://www.conservationgateway.org/ConservationPractices/Marine/crr/library/Documents/USVI%20EBA%20Guidance_Final.pdf

mounted transformers to new underground electric infrastructure in Charlotte Amalie. Each of the critical infrastructure programs and projects also demonstrate a variety of inventorying, modeling and analysis, GIS and mapping, stakeholder engagement, and education and outreach technical capacities available in or for the territory.

Economic Development. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change found that the impacts of climate change will be felt by every sector of the economy and are relevant to all investors, financial services and businesses.[344] The VI Economic Development Authority (VI EDA), a semi-autonomous government organization responsible for the promotion and enhancement of economic development in the United States Virgin Islands, currently does not have a climate change policy or risk and vulnerability assessment publicly available; however, the VI EDA admisters a number of programs that work to build resiliency into the territory's economy. Additionally, the federal programs that provide funding and technical assistance to territorial programs, like the U.S. Department of Commerce, recognizes the importance of factoring climate change impacts into their planning and grant processes. The U.S. Economic Development Administration (US EDA) is helping to build resiliency into communities by providing grant-based investments to communities and regions suffering from economic distress. These investments range from strategic economic development planning to public infrastructure construction.

According to the Bureau of Economic Research (BER) Comprehensive Economic Development Strategy (CEDS 2015),[345] the USVI is at a "critical juncture of economic crisis and change, after three successive years of economic decline..." The strategy recognizes the natural and human resources of the islands as core strengths for economic development as well as identifying the need to invest in "infrastructure, environment and quality of life", but does not make specific mention of climate change. Programs aimed at incorporating climate change vulnerabilities and solutions into existing and emerging development strategies as well as diversifying the economy of the USVI represent important strategic opportunities for this sector. Through the programs described in this report it appears technical capacity is strong in the economic development sector for statistical analysis and research, strategic planning, financial management and advice, loan programs, tax credits and market-based incentives.

Food Security. Many programs exist within the USVI that are ostensibly aimed at increasing production, food security, and overall resilience of the agricultural sector. Unfortunately, these programs have had seemingly little effect in reversing an overall downward trend in agriculture within the islands. According to the last available U.S. Department of Agriculture (USDA) census

[344] IPCC. 2014. Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32. http://www.ipcc-wg2.gov/AR5/

[345] USVI CEDS: http://www.usviber.org/CEDS%20Plan%202015.pdf

of agriculture for the territory (2007), the amount of land in farms declined by 36 percent from 2002 to 2007 with total sales declining by a similar 31 percent over the same period.[346] Feedback from producers and agriculture sector advisors suggest that any intervention geared at reversing these trends need to be tailored to the specific and unique culture and economic needs of Virgin Islands' producers. Training courses in planning, record keeping, and overall business management have been suggested as necessary to help farmers access assistance as well as potential local and tourist retail markets. Increasing participation in any new or existing programs may depend on addressing cultural stigmas surrounding both agricultural work and government services. Fostering more public/private partnerships that seek local input during program planning phases may alleviate some of these barriers by allowing agricultural intervention to be locally driven, placed-based, and in line with local population values, priorities and demands. The relatively small size of the agricultural community within the islands, as well as the small scale of many farms, suggest that even minor investments, if properly planned and guided by a placed-based understanding of local needs, could potentially have profound effects in increasing food production and security in the face of social and climate change related challenges.

Tourism. Tourism is a critical piece of the economy of the U.S. Virgin Islands. In 2015, tourism accounted for 30 percent of GDP and more than 79,000 direct jobs. In 2013, the industry attracted 2.7 million air and cruise ship passengers. A review of the VI Department of Tourism, the VI Economic Development Authority, the VI State Historic Preservation Division within the VI Department of Planning and Natural Resources, the VI Port Authority, the VI Hotel and Tourism Association, and the VI Chambers of Commerce did not result in finding any programs, projects or strategies directly related to climate change. However, as in many of the other sectors, a wide host of tourism projects were found that could indirectly contribute to climate adaptation or mitigation initiatives, such as energy reduction, infrastructure improvements and natural resource protection (the 2015 Comprehensive Economic Development Strategy specifically cites the importance of natural assets to the USVI tourism product).

Since tourism is the flagship industry in the territory, special attention must be given to conducting assessments, planning and implementing climate adaptation projects immediately. Two recent comments from territorial government representatives illustrate that despite the lack of projects, there is awareness: "the VI needs to expand our tourism products to include options away from the coasts to adapt to climate change" and "the climate challenge calls for reimagining our tourism products." Much work remains to determine the specifics of how to achieve that. Three federal agency programs were found to have connections to the VI tourism sector as related to Marine Protected Areas Management and Historic and Cultural Resources. Of all the territorial and federal initiatives found, all but two were still in planning and assessment. The two that were implementing were addressing impacts to historic and cultural resources. Tourism appears to be

[346] USDA USVI Census of Agriculture 2007: http://www.agcensus.usda.gov/Publications/2007/Full_Report/Outlying_Areas/usvi.pdf

one of the sectors with the least amount of existing capacity in the territory to deal with climate adaptation or risk reduction, the first being the Human Health sector.

An important factor in adaptation and resilience building is the ability to collaborate with other sectors. While the tourism institutions in the U.S. Virgin Islands do not have many programs, studies, mandates, policy guidance, educational and training resources available to them for climate-related work, the tourism sector does benefit from the climate work of the economic development, critical infrastructure and natural resources sectors.

Natural Resources. The natural resources of the USVI are of paramount importance to the islands continued cultural and economic vitality. Territorial authorities are working with federal partners on a number of terrestrial and marine based programs to help adapt to changes already being experienced, as well as prepare for future scenarios. Preserving and restoring ecosystem health across the islands will minimize vulnerability and risk in the face of climate change. The territories coral reefs are an invaluable asset that provides a number of critical ecosystem services such as healthy fisheries, protection from storm surges and tourism opportunities. The health and resilience of these reefs in the face of increasing threats from climate change is tied to management and development practices across the islands.

Two divisions of the Virgin Islands Department of Planning and Natural Resources (DPNR) work directly to study and plan for the effects of climate change: the Division of Coastal Zone Management and the Division of Fish and Wildlife. The divisions work in partnership with National Oceanic and Atmospheric Administration's (NOAA) Office of Coastal Management and Coral Reef Conservation Program and the U.S. Fish and Wildlife Service (USFWS). The mission of DPNR and the programs its division implements is critical to maintaining and restoring healthy marine and terrestrial ecosystems that will be resilient to stresses from climate change. A variety of other federal programs such as U.S. Geological Survey (USGS), National Park Service (NPS), and U.S. Environmental Protection Agency (EPA) play a strong role working with DPNR and other territorial agencies to protect natural resources. A review shows that all of these federal agencies have climate-explicit programs completed or in-development in USVI. These efforts are complimented by programs currently being administered by the Virgin Islands Department of Agriculture (VIDOA) in partnership with the U.S. Forest Service, the University of the Virgin Islands Cooperative Extension Service, the Natural Resource Conservation Service (NRCS), and various other USDA entities aimed at improving agricultural and land management practices that have a direct impact on biodiversity, water quality, and overall natural resource health. Technical capacities in this sector run the gamut from climate and coastal hazards science, modeling and spatial analysis, ecosystem dynamics, monitoring, strategic planning, and decision support, and many other fields of expertise. Based on this analysis it appears that the institutions in this natural resources sector have greater expertise and capacity to understand climate change vulnerabilities,

propose and implement best adaptation and risk reduction practices for natural resources than other sectors.

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ACRONYMS

AES	Agricultural Experiment Station
ARRA	American Recovery and Reinvestment Act
BER	Bureau of Economic Research
BRFSS	Behavioral Risk Factor Surveillance System
CaMPAM	Caribbean Marine Protected Area Network and Forum
CANARI	Caribbean Natural Resources Institute
CaRA	Caribbean Regional Association for Coastal Ocean Observing
CariCOF	Caribbean Regional Climate Outlook Forum
CARICOM	Caribbean Community and Common Market
CARICOM	Caribbean Community and Common Market
C-CAP	NOAA's Coastal Change Analysis Program
CCCCC	Caribbean Community Climate Change Centre
CCH	USDA Caribbean Climate Hub for Tropical Forestry and Agriculture
CClimAG	Caribbean Climate and Agriculture Geodatabase
CCZP	Division of Comprehensive and Coastal Zone Planning
CDC	Conservation Data Center
CDC	U.S. Centers for Disease Control and Prevention
CEDS	Comprehensive Economic Development Strategy
CERC	Caribbean Exploratory Research Center
CESL	Comprehensive Evaluation of Projects with Respect to Sea Level Change
CFP	U.S. National Parks Service Climate Friendly Parks Program
CGTC	University of the Virgin Islands Caribbean Green Technology Center
CHAMP	NOAA's Coral Health and Monitoring Program

CLCC	Caribbean Landscape Conservation Cooperative
CMES	Center for Marine and Environmental Studies
COP21 UNFCCC	21st Conference of Parties to the United Nations Framework Convention on Climate Change
CRCP	NOAA's Coral Reef Conservation Program
CSA	Community Supported Agriculture
CSC	U.S. Department of the Interior's Climate Science Centers
CSCRI	Climate Ready States and Cities Initiative
CTMP	U.S. Virgin Islands Comprehensive Transportation Master Plan
CVI	Coastal Vulnerability Index
CZM	DPNR's Division of Coastal Zone Management
CZMA	Coastal Zone Management Act
DEP	DPNR's Division of Environmental Protection
DFID	United Kingdom's Department for International Development
DFW	DPNR's Division of Fish and Wildlife
DOC	U.S. Department of Commerce
DOE	U.S. Department of Energy
DOH	VI Department of Health
DOI	U.S. Department of the Interior
DOT	U.S. Department of Transportation
DPNR	Virgin Islands Department of Planning and Natural Resources
DSS	Dark Spot Syndrome
EBA	Ecosystem-based Adaptation
EDB	Economic Development Bank
EDC	Economic Development Commission

EDPC	Economic Development Park Corporation
ENSO	El Niño Southern Oscillation
EPA	U.S. Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
EZC	Enterprise Zone Commission
FAO	United Nations Food and Agriculture Organization
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIA	Forest Inventory and Analysis Program
FMNP	Farmers Market Nutrition Program
FSA	USDA Farm Service Agency
GAP	U.S. Virgin Islands Terrestrial and Aquatic Gap Analysis Projects
GCRA	Global Change Research Act
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
HAN	Secure Virgin Islands Health Alert Network
HHS	U.S. Department of Health & Human Services
HRSA	Health Resource and Service Administration
IITF	International Institute of Tropical Forestry
LDI	Landscape Development Intensity
LMSL	Local Mean Sea Level
LTER	Long term Ecological Research Network
MAP-21	Moving Ahead for Progress in the 21st Century
MOU	Memorandum of understanding
MPAs	Marine Protected Areas

NAH	North Atlantic Subtropical High
NAP	Noninsured Crop Disaster Assistance Program
NCA	National Climate Assessment
NDRF	National Disaster Recovery Framework
NGO	Non-Governmental Organizations
NGSP	NOAA's Next Generation Strategic Plan
NIH/NCMHD	National Institutes of Health, National Center on Minority Health and Health Disparities
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCS	USDA Natural Resource Conservation Service
NREM	Natural Resource and Environmental Management Program
NWS	National Weather Service
OECS	Organization of Eastern Caribbean States
OIA	Office of Insular Affairs
OIA	Office of Insular Affairs
PHP	Public Health Preparedness Program
PPA	Power Purchase Agreement
PRCCC	Puerto Rico Climate Change Council
PSC	Public Service Commission
PSEP	Pesticide Safety Education Program
RSLR	Relative Sea Level Rise
SARE	U.S. Virgin Islands Sustainable Agriculture Research and Education
SEA	St. Croix Environmental Association

SEIA	Solar Energy Industries Association
SEP	State Energy Program
SLOSH	Sea, Lake and Overland Surges from Hurricanes
SNS	Strategic National Stockpile
SWOT	Strengths, Weaknesses, Opportunities and Threats
TARS	USDA Tropical Agriculture Research Station
TEOP	Territorial Emergency Operations Plan
TIP	U.S. Virgin Islands Transportation Improvement Program
TNC	The Nature Conservancy
UNDP	United Nations Development Program
UPR	University of Puerto Rico Sea Grant College Program
US EDA	U.S. Economic Development Administration
USACE	U.S. Army Corps of Engineers
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
USFS	USDA Forest Service
USFWS	U.S. Fish & Wildlife Service
USGCRP	U.S. Global Change Research Program
USGS	U.S. Geological Survey
USVI	United States Virgin Islands
UVI	University of the Virgin Islands
UVI-CES	University of the Virgin Islands Cooperative Extension Service
UWI	University of the West Indies
VI DOT	U.S. Virgin Islands Department of Tourism
VI DPW	U.S. Virgin Islands Department of Public Works

VI EDA	VI Economic Development Authority
VICCC	Virgin Islands Climate Change Council
VIDOA	Virgin Islands Department of Agriculture
VIEO	U.S. Virgin Islands Energy Office
VI-EPSCoR	Virgin Islands Experimental Program to Stimulate Competitive Research
VIFS	Virgin Islands Fire Service
VIMAS	Virgin Islands Marine Advisory Service
VINP	Virgin Islands National Park
VIPA U.S.	Virgin Islands Port Authority
VISHPO	U.S. Virgin Islands the State Historic Preservation Office
VITEMA	U.S. Virgin Islands Emergency Management Agency
VIWMA	U.S. Virgin Islands Waste Management Authority
VLM	Vertical Land Movement
WAP	Weatherization Assistance Program
WAPA	U.S. Virgin Islands Water and Power Authority
WRRI	Water Resource Research Institute
WVO	Waste Vegetable Oil

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About the Caribbean Landscape Conservation Cooperative:
The CLCC is a partnership of management and research agencies, non-governmental organizations, businesses and individuals working together to achieve a sustainable future for the Caribbean. The CLCC is one of a network of 22 public-private partnerships initiated by the U.S. Department of the Interior to respond to climate change and other large-scale stressors. The mission is to develop and implement coordinated, efficient, and effective landscape-scale conservation design and strategy to conserve, restore and sustain ecological and cultural resources and human well-being in the Caribbean inside and outside of CLCC jurisdictional boundaries. www.caribbeanlcc.org

About the USDA Caribbean Climate Hub for Tropical Forestry and Agriculture:

The Caribbean Climate Hub is one of seven Regional Hubs and three Subsidiary Hubs nationwide. This network of Climate Hubs works with USDA to deliver science based knowledge and practical information to farmers, ranchers, and forest landowners that will help them to adapt to climate change and weather variability by coordinating with local and regional partners in federal and state agencies, universities, and the public. www.climatehubs.oce.usda.gov/caribbean

About the USDA Forest Service International Institute of Tropical Forestry:

The International Institute of Tropical Forestry (the Institute) is a tropical forestry research and technology transfer institute. Located in Río Piedras, Puerto Rico, it has a long and productive history. Created in 1939, in cooperation with the University of Puerto Rico, the Institute has been a leader in tropical forestry research, technology transfer and technical assistance throughout the world. www.fs.usda.gov/iitf

[i] Data are derived from Bureau of Labor Statistics Quarterly Census of Employment and Wages, based on the ENOW framework. For more information on the industries included each ocean sector, visit the "Crosswalk Table for ENOW and NAICS" on Digital Coast.