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CLIMATE CHANGE ADAPTATION IN THE FISHERIES OF ANGUILLA AND MONTSERRAT

Report on the assessment of vulnerability to climate change in the Anguilla and Montserrat fisheries sector:

Anguilla country report

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Photographs were taken by CANARI.

Acronyms and Abbreviations

AFMP	Anguilla Fisheries Management Plan
CANARI	Caribbean Natural Resources Institute
CARICOM	Caribbean Community
CC4FISH	Climate Change Adaptation in the Eastern Caribbean Fisheries Sector Project
CCA	Climate Change Adaptation
CCCCC – 5Cs	Caribbean Community Climate Change Centre
CDM	Comprehensive Disaster Management
CDEMA	Caribbean Disaster Emergency Management Agency
CIMH	Caribbean Institute for Meteorology and Hydrology
CLME	The Caribbean Large Marine Ecosystem (GEF project)
CNFO	Caribbean Network of Fisherfolk Organisations
CERMES	Centre for Resource Management and Environmental Studies – University of the West Indies
CRFM	Caribbean Regional Fisheries Mechanism
CSO	Civil Society Organisation
DFMR	Department of Fisheries and Marine Resources (Anguilla)
DOE	Department of the Environment
DMCA	Disaster Management Coordination Agency (Montserrat)
DRM	Disaster Risk Management
EAF	Ecosystem Approach to Fisheries
EBA	Ecosystem-based approaches
FAO	Food and Agricultural Organization of the United Nations
FD	Fisheries Division
FFO	Fisherfolk Organisation
IPCC	Intergovernmental Panel on Climate Change
MATLHE	Ministry of Agriculture, Trade, Lands, Housing and the Environment (Montserrat)
NGO	Non-governmental organization
OECS	Organisation of Eastern Caribbean States
OT's	Overseas Territories
P3DM	Participatory Three-Dimensional Modelling
SIDS	Small Island Developing States
SME	Small and micro-enterprises
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
UWI	University of the West Indies
VCA	Vulnerability and Capacity Assessment
VA	Vulnerability Assessment

Executive Summary

The Caribbean Natural Resources Institute (CANARI), Department of Fisheries and Marine Resources (DFMR) – Anguilla, Fisheries and Ocean Resources Unit - Montserrat and the Centre for Resource Management and Environmental Studies (CERMES) of the University of the West Indies (UWI) are jointly implementing the project ***Climate change adaptation in the fisheries of Anguilla and Montserrat***. The project aims to mainstream climate change adaptation (CCA) into fisheries governance and management in Anguilla and Monserrat, using an ecosystem approach to fisheries (EAF). It is being implemented from April 2017 to March 2020, with total funding of £260,925 from the Darwin Plus: Overseas Territories Environment and Climate Fund.

This report presents the main findings and recommendations from an assessment of the vulnerability of the fisheries sector in Anguilla to climate change and natural disasters. The vulnerability assessment complements the institutional assessment of readiness for CCA in Anguilla that identifies priorities for institutional strengthening under the project. These assessments serve as a key first step towards mainstreaming CCA in the fisheries sector in Anguilla to deliver enhanced stewardship of fisheries and coastal and marine resources and livelihood benefits.

The vulnerability assessment was based on a comprehensive desk review and participatory three-dimensional modelling (P3DM). P3DM served as a participatory mapping tool to capture local knowledge and experiences related to climate change impacts and vulnerabilities and, identify potential adaptation actions for the fisheries sector. It involved building physical representations of the entire island of Anguilla that were to scale and geo-referenced, focusing on areas critical to the fisheries sector (e.g. fishing communities, landing sites, fishing grounds and supporting ecosystems such as coral reefs and mangroves). Since the 3D models were produced to scale, the local knowledge captured on the models was also digitised and placed within a geographic information system (GIS) for integration with scientific knowledge and improved land use planning and decision-making. A wide range of stakeholders were actively engaged in the P3DM, such as key resources users like fisherfolk, community residents, civil society organisations (CSOs), government agencies and the private sector, to assess key vulnerabilities and priorities for action in the areas where they live and work. P3DM also supported EAF, taking into account biophysical, cultural and socioeconomic dimensions of vulnerability within ecologically meaningful boundaries (e.g. 'ridge to reef' area or entire island and its marine zone).

The P3DM in Anguilla highlighted a range of climate change hazards that have affected the fisheries sector, or will pose a significant risk in the future, including:

- Coastal erosion and flooding due to sea level rise which poses a critical challenge to this low lying island, especially beaches and coastal cliffs, and results in groundwater salinization;
- More extreme weather, including hurricanes, tropical storms and storm surge. Stakeholders noted that the Category 5 Hurricane Irma in 2017 was much stronger than other previous major hurricanes (e.g. Category 4 Hurricane Luis in 1995 and Category 4 Hurricane Donna in 1960), with maximum sustained winds of 180 mph and storm surge reaching 200 feet (61 m) inland;
- Sargassum influx that has inundated beaches and coves, affects boat engines and limits access to nesting sites by sea turtles;
- Coral bleaching with warmer sea temperatures that affects reef-based fisheries, marine biodiversity and dive tourism;
- Ocean acidification which will result in reduced health of coral reefs and shellfish and affect reef-based fisheries and dive tourism;

- Erratic rainfall and more dry periods that affects access to rainwater, which is the main source of safe, drinking water on the island;
- Inland flooding that affects agricultural lands, increases sedimentation in the coastal zone and damages infrastructure including in the capital, The Valley.

These climate change hazards have begun to trigger a range of biophysical and socio-economic impacts on fisheries in Anguilla, which are compounded by existing pressures. These include coastal development, sand mining and beach nourishment that alters coastal dynamics, pollution and sedimentation from land-based sources, spread of diseases and invasive species such as the lionfish and non-native sea grasses, and overfishing in nearshore reef fisheries and declines in species such as parrotfish and surgeonfish. These impacts are negative, such as loss of coastal areas, as well as positive, such as opportunities to diversify the economy and fisheries sector.

Priorities for CCA in Anguilla's fisheries included:

1. organisational strengthening of key government agencies, in particular the DFMR;
2. building the adaptive capacity of fisherfolk through enhancing knowledge, skills and resources related to safety at sea, insurance, sustainable fishing practices and technologies and alternative livelihoods like aquaculture and seamoss cultivation;
3. strengthening the system of marine protected areas (MPAs);
4. identifying sustainable financing options to encourage entrepreneurship and small business development as well as effective management in the fisheries sector;
5. improving knowledge management and sharing to inform adaptation planning and decision-making; and
6. strengthening legislation, policies and plans to climate proof coastal infrastructure and enable integrated coastal zone management (ICZM) and EAF.

Key recommendations for moving forward under the project and ensuring effective mainstreaming of CCA into fisheries governance and management in Anguilla include:

- Presenting and validating the findings from the P3DM and the priorities for CCA in the fisheries sector through a series of community meetings with fisherfolk and other key community stakeholders in Anguilla in order to gain additional input and finalise action plans for CCA to guide next steps under the project.
- Ensuring that the final action plans for CCA not only reflect stakeholder priorities but make linkages to, and are aligned with, strategic priorities and commitments at the national, regional and international levels related to CCA, DRM and sustainable fisheries management.
- Enabling public access and use of the P3DM outputs, including public display of the 3D model of Anguilla for awareness raising and communication of the impacts of climate change and natural disasters and key vulnerabilities and use of GIS maps and datasets for further spatial planning and analysis in the fisheries sector and other sectors.
- Utilising participatory video[1] and other information and communication technologies (ICTs) to further document and share local and traditional knowledge, best practices and innovations in the fisheries sector that are relevant to CCA. There is particular need for documentation of traditional knowledge of fisherfolk, which may be at risk of being lost, related to fishing practices and navigational skills such as dead reckoning for CCA and other sociocultural aspects.
- Empowering fisherfolk and coastal communities to address identified vulnerabilities to climate change and related hazards from P3DM and promote local stewardship of fisheries and coastal and marine resources through capacity building, including training, mentoring and access to grants to support implementation.

[1] For further details, see http://www.canari.org/cm1

- Engaging and strengthening of national fisherfolk organisations (e.g. fishing associations and co-operatives) to improve dialogue and knowledge exchange between different generations of fishers, amongst fishers' representatives and with other key stakeholders, such as fisheries authorities and other government agencies and national CSOs. This will enable sharing of best practices and innovations (e.g. related to selection of gear and fish species and value added products in the context of changing climate). Active fisherfolk organisations can also improve representation of fisherfolk in sectoral and national decision-making processes and enable collective voice and action on key issues affecting fisherfolk and the fisheries sector.
- Promoting ecosystem based management, including EAF, to enable an integrated, multi-hazard and cross-sectoral approach and build resilience to climate change within the fisheries sector recognising that climate change is one of many challenges affecting the sector. Other key challenges include habitat degradation, pollution, resource overuse, invasive species and impacts from other natural hazards such as volcanic and seismic activity. Adaptation actions that offer co-benefits through addressing climate change and other key non-climatic stresses should be given particular consideration.
- Mainstreaming CCA as well as DRM considerations into fisheries management plans and policies in Anguilla to effectively address extreme climate events and reduce losses from climate-related hazards. This includes taking into account the comprehensive disaster management approach within any sectoral adaptation strategy, investments in early warning systems, safety at sea and insurance, and development of disaster preparedness plans as part of national fisheries management plans.
- Supporting sustainable and resilient livelihoods within fishing and coastal communities in Anguilla through development of value added fish products and SMEs related to aquaculture, aquaponics and seamoss cultivation. This could provide opportunities for increased income generation and livelihood diversification as well as incentives for sustainable utilisation of fisheries and coastal and marine resources.
- Strengthening regional cooperation and partnerships to improve management of shared resources and exchange knowledge and experiences on climate change impacts, vulnerabilities and potential adaptation options for fisheries and coastal and marine resources more broadly. Synergies with other relevant regional projects need to be explored, such as the Climate Change Adaptation in the Eastern Caribbean Fisheries Sector project (CC4FISH) that seeks to improve vulnerability assessments in the fisheries sector, build adaptive capacity among fisherfolk and aquaculturists and mainstream CCA into fisheries policies and plans using EAF. The Joint Nature Conservation Committee (JNCC) is also conducting a number of initiatives that support ICZM and marine spatial planning in UK OT's.

1. Introduction

The fisheries sector in Anguilla and Montserrat makes significant contributions to livelihoods and food security. In Anguilla, fish production in 2014 was 752 metric tonnes (mt), valued at US$9.4 million, with approximately 130 fishers operating 84 fishing vessels[2]. In Montserrat, fish production in 2015 was approximately 36 mt, valued at US$0.3 million, with 110 fishers operating 27 fishing vessels[3]. The contribution of the fisheries sector to Gross Domestic Product (GDP) for Anguilla in 2014 was 2.26%[4], while it was 0.38%[5] for Montserrat in 2015.

Both Overseas Territories (OTs) are particularly vulnerable to the impacts of climate change and variability. Increased sea surface temperature, intensity of storms and sea level rise are expected to trigger a complex series of biophysical and socio-economic impacts on fisheries. Needs assessments for Anguilla and Montserrat, commissioned by the Department for International Development (DFID) in 2012[6,7], showed that resilience activities are hampered by inadequate planning and adaptive capacity. Mainstreaming climate change adaptation (CCA) in the fisheries sector is therefore crucial.

In an effort to mainstream CCA into fisheries governance and management in Anguilla and Monserrat, using an ecosystem approach to fisheries (EAF), the Caribbean Natural Resources Institute (CANARI), Department of Fisheries and Marine Resources (DFMR) – Anguilla, Fisheries and Ocean Resources Unit - Montserrat and the Centre for Resource Management and Environmental Studies (CERMES) of the University of the West Indies (UWI) are jointly implementing the project ***Climate change adaptation in the fisheries of Anguilla and Montserrat***. It is being implemented from April 2017 to March 2020, with total funding of £260,925 from the Darwin Plus: Overseas Territories Environment and Climate Fund.

The project is employing innovative and participatory tools to support stakeholders in the fisheries sector, including fisheries authorities and fisherfolk and their organisations, to achieve the following key outputs:

1. Local and scientific knowledge combined to assess vulnerabilities and potential adaptation actions for the fisheries sector, including priorities for institutional strengthening.
2. Knowledge mobilisation and exchange strengthened among key policy makers, resource managers and resource users to catalyse change in policy and practice for enhanced stewardship.
3. Actions taken to mainstream adaptation to climate change and variability in fisheries-related policies and plans using EAF.
4. Capacity of fisherfolk and their organisations in coastal communities strengthened to undertake practical actions for CCA for improved ecosystem stewardship and livelihoods.

[2] DFMR. 2015. Anguilla Fisheries Development Plan 2015-2025. Government of Anguilla, The Valley, Anguilla.
[3] Ponteen, A. 2016. Presentation - Training workshop on Value Chain Approach in Fisheries, CRFM/UNU-FTP PROJECT, 18 –22 July 2016, Suriname.
[4] DFMR. 2015. Anguilla Fisheries Development Plan 2015-2025. Government of Anguilla, The Valley, Anguilla.
[5] Ponteen, A. 2016. Presentation - Training workshop on Value Chain Approach in Fisheries, CRFM/UNU-FTP PROJECT, 18 –22 July 2016, Suriname.
[6] DFID. 2012a. Addressing Climate Change by Promoting Low Carbon Climate Resilient Development in the UK Overseas Territories. Needs Assessment: Anguilla. DFID, London, UK. July 2012. http://jncc.defra.gov.uk/pdf/2012-07-23%20Anguilla.pdf
[7] DFID. 2012b. Addressing Climate Change by Promoting Low Carbon Climate Resilient Development in the UK Overseas Territories. Needs Assessment: Montserrat. DFID, London, UK. July 2012. http://jncc.defra.gov.uk/pdf/2012-07-23%20Montserrat.pdf

This report presents the main findings and recommendations from an assessment of the vulnerability of Anguilla's fisheries to climate change and natural disasters using participatory three-dimensional modelling (P3DM). This vulnerability assessment, along with the institutional assessment of readiness for CCA in the fisheries sector, serves as a key step in achieving output 1 of the project and supporting mainstreaming of CCA in the fisheries sector to deliver enhanced stewardship of fisheries and coastal and marine resources and livelihood benefits.

2. Climate Change and Its Impacts on the Caribbean Fisheries Sector

It is becoming increasingly clear that the fisheries sector in the Caribbean is highly vulnerable to climate change and variability due to high levels of exposure of local fisheries and coastal and marine resources to climate hazards, economic dependence on the fishing industry, and low adaptive capacity. A recent global vulnerability assessment of the fisheries sector by Monnereau et al. (2015)[8] highlighted Caribbean small island developing states (SIDS) as the most vulnerable country group to the impacts of climate change and variability and, its fisheries sector as particularly vulnerable. The sector is highly exposed to a number of climate change hazards such as rising sea levels, rising sea surface temperatures, ocean acidification and extreme weather events.

Current climate change projections for the Caribbean region, which are based on the recent Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report[9] and supported by the Caribbean Community Climate Change Centre (CCCCC), indicate that:

1. Sea levels in the Caribbean Sea are likely to continue to rise on average during the century. However, projections are not precise as there are few long-term sea level records available for the Caribbean small island developing states (SIDS). Also, detecting variability caused by climate change, rather than temporary conditions such as storm waves and surges, deep ocean swells and tidal cycles, is very difficult.
2. Average surface air and sea temperatures in Caribbean SIDS are very likely to increase during this century. This warming is likely to be somewhat smaller than the global annual mean warming in all seasons. Downscaled projections for the Caribbean region indicate an increase in temperature of 1–4 °C up to 2100.[10] Warmer sea temperatures will likely result in more frequent and intense coral bleaching events and more intense hurricanes.
3. Short-term variability in rainfall patterns (e.g. as caused by El Niño Southern Oscillation events) will likely continue with an increase during the latter part of the wet season in the northern Caribbean and drier conditions in the southern Caribbean. The prevailing warmer conditions may make the convection associated with the short-lived rainfall events more intense. In general, climate change will produce a drier (in the mean) region. Lengthening of seasonal dry periods and increasing frequency of drought are expected to increase demand for freshwater across the region.
4. It is likely that tropical cyclone activity will increase in intensity (but tracks and the global distribution are uncertain).
5. Ocean acidification is projected to continue as carbon dioxide emissions are absorbed by the ocean, reducing pH, carbonate ion concentration and the availability of biologically important calcium carbonate minerals.

Effects from these are compounded by inherent vulnerabilities of SIDS related to factors such as remoteness, small size, limited human resources and high dependency on foreign aid and investment. In addition, the fisheries sector is already prone to various challenges such as overexploitation, pollution, and illegal, unreported and unregulated (IUU) fishing. The link between

[8] Monnereau, I., Mahon, R., McConney, P., Nurse, L., Turner, R., and Vallès, H. 2015. Vulnerability of the fisheries sector to climate change impacts in small island developing states and the wider Caribbean. Centre for Resource Management and Environmental Studies (CERMES), Barbados. CERMES Technical Report No 77.

[9] Climate and Development Knowledge Network (CDKN). 2015. The IPCC's Fifth Assessment Report: What is in it for Small Island Developing States? CDKN, London, UK. https://cdkn.org/wp-content/uploads/2014/08/IPCC-AR5-Whats-in-it-for-SIDS_WEB.pdf

[10] These projections are made under the emissions scenarios used in the previous IPCC *Fourth Assessment Report* (SRES A2 and B2, which are respectively relatively high- and low- emissions scenarios)

climate change, disasters and other environmental issues also adds to the complexity of impacts on the fisheries sector. As outlined in the IPCC Special Report on Extreme Events, climate change is already influencing weather-related hazards, leading to more intense extreme events, and will only further exacerbate natural hazards in the coming decades.[11]

The biophysical and socio-economic impacts of climate change on the fisheries sector in the Caribbean are expected to be significant with changes in fish size, fish redistribution, fish production and eroding reef habitats. Negative climate change impacts on the fisheries sector are already obvious across the Caribbean region, including coral bleaching, increasing levels of damage from more intense storms and hurricanes, coastal erosion and flooding with sea level rise and sargassum influxes, disrupting fishing operations and communities, damaging critical fish habitats and impacting the sustainability of the resource[12]. OTs, including Anguilla, have already begun to experience these impacts and future impacts from climate change are likely to be significant.

Anguilla's draft *National Climate Change Policy (2011)* notes the potential for considerable impacts from climate change on fisheries and coastal and marine resources including:

- destruction of coral reefs as a result of bleaching from higher sea surface temperatures and ocean acidification;
- salinisation of groundwater due to sea level rise;
- loss of mangroves and wetlands, sea grass beds and sand dunes in areas where coastal topography, mangrove systems, and coastal infrastructure do not allow sedimentation to keep pace with rising sea levels;
- increased coastal erosion, including the loss of beaches, due to sea level rise and storm surge and increased costs of sea defence mechanisms;
- increased run off and pollution in coastal and marine areas from land based sources as a result of a changing precipitation patterns;
- increased demand and competition for coastal lands as a result of land lost to sea level rise;
- decrease in nearshore fish stocks, due to loss of important nourishing systems like coral reefs, mangroves and sea grass beds; and
- decrease in deep water fish stocks as a result of changes in sea temperature and currents.

In particular, rising sea surface temperatures and sea levels are a significant cause for concern for Anguilla, which is a low lying island fringed by temperature-sensitive coral reefs upon which its tourism and fisheries sectors depend and future economic growth relies.

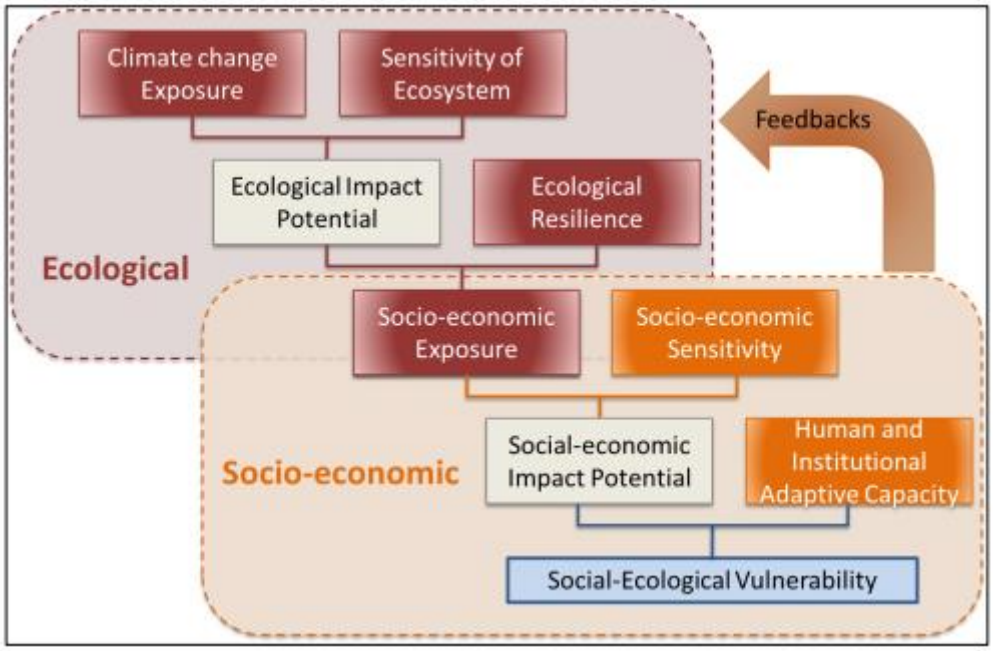
[11] IPCC. 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation.

[12] Monnereau, I., Oxenford, H.A. 2017. 'Impacts of climate change on fisheries in the coastal and marine environments of Caribbean Small Island Developing States (SIDS)'. Caribbean Marine Climate Change Report Card: Science Review 2017, pp. 124-154.

3. Assessing Vulnerability to Climate Change in the Fisheries of Anguilla

Recognising that fisheries are linked social-ecological systems, it is important to understand both the ecological vulnerability and socio-economic vulnerability of fisheries in relation to climate change and their linkages[13]. Vulnerability to climate change is defined as "the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change, including climate variability and extremes"[14]. As shown in Figure 1, it is a function of potential impacts due to exposure to climate hazards and sensitivity of the system to these hazards, and the capacity of the system to adapt and address the potential impacts of climate change. Ecological vulnerability relates to impacts on fish populations and wider coastal and marine ecosystems due to climate change and existing threats related to pollution, overharvesting and coastal development that climate change compounds. Socio-economic vulnerability relates to changes in fish abundance which affect food security and livelihoods dependent on the fisheries and aquaculture sector.

Figure 1: Framework linking ecological and socio-economic vulnerability to climate change



Source: FAO. 2013. Report of the FAO/PaCFA Expert Workshop on Assessing Climate Change Vulnerability in Fisheries and Aquaculture

[13] FAO. 2013. Report of the FAO/PaCFA Expert Workshop on Assessing Climate Change Vulnerability in Fisheries and Aquaculture. Rome: FAO.

[14] IPCC. 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and A. Reisenger (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

Although a number of vulnerability assessments have been carried out across Caribbean SIDS[15,16,17], including Anguilla, these often do not specifically cover climate change or the fisheries sector. Vulnerability assessments need to be adapted to meet the specific needs of the fisheries sector and enhance understanding of local level situations to enable the design of appropriate, location-specific CCA strategies. This includes modifying assessments to integrate both ecological and socio-economic dimensions, including national and regional fisheries policies, plans and priorities and consideration of fisheries-based livelihoods in a more comprehensive manner.

Given limited data on socio-economic aspects of fisheries, the use of participatory approaches and incorporation of local knowledge of fisherfolk and other community stakeholders is also key. Such participatory approaches and tools need to be designed recognising the unique characteristics and capacities of fisherfolk and their organisations (e.g. fisherfolk may have varying levels of literacy and are engaged in a wide variety of activities within geographical sites ranging from the deep sea to fish markets and processing plants on land). Stakeholder buy-in and engagement also promotes uptake of the vulnerability assessment findings and catalyse partnerships that bring benefits beyond completion of the assessment (e.g. opportunities for promoting co-management and community stewardship of fisheries).

Under the project, participatory three-dimensional modelling (P3DM) was used as a tool to assess the vulnerability of Anguilla to climate change and natural hazards, focusing on impacts on areas critical to the fisheries sector (e.g. fishing communities, landing sites, fishing grounds, supporting ecosystems such as coral reefs and mangroves), and identify potential adaptation actions. The vulnerability assessment complements the institutional assessment of readiness for CCA in Anguilla that has been undertaken to identify priorities for institutional strengthening to inform mainstreaming of CCA into fisheries governance and management[18].

3.1 Assessing the vulnerability of fisheries to climate change using P3DM

P3DM is a participatory mapping tool which seeks to capture and share local knowledge and experiences around an identified issue of interest, such as vulnerability to climate change, via building a physical representation of an area that is to scale and geo-referenced. Based on recollections from memory, key landmarks, land and resource use and other features of importance can be depicted by informants on the 3D model. Both quantitative information (e.g. length of beaches or size of fishing grounds) and qualitative information (e.g. areas prone to erosion or perceptions of risk) can be captured on the 3D model. The 3D model can be further used to depict the past, present and future conditions and is therefore a valuable tool to show the potential impacts of climate change and plan for adaptation and resilience building. Since the model is produced to scale, the local knowledge collected can be digitised and placed within a geographic information system (GIS) for integration with scientific knowledge for land use planning and decision-making.

[15] The Nature Conservancy (TNC). 2016. At the Water's Edge Project: https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/Caribbean/science/adaptation/Pages/awe.aspx

[16] IFRC. 2010. Regional Evaluation. Review of the implementation of the vulnerability and capacity assessment (VCA) methodology in the Caribbean region. Geneva, Switzerland: IFRC.

[17] CARIBSAVE. 2014. Vulnerability impact and adaptation analysis in the Caribbean (VIAAC). Prepared by the CARIBSAVE Partnership with funding from the United Nations Environment Programme: Regional Office for Latin America and the Caribbean (UNEP-ROLAC).

[18] CANARI. 2018. Summary report of the assessment to determine institutional readiness for climate change adaptation in the fisheries sector of Anguilla and Montserrat. Prepared for the Darwin+ project, Climate change adaptation in the fisheries of Anguilla and Montserrat. Laventille: CANARI.

The key steps in the process of implementing P3DM are outlined in Table 1.

Table 1: Key steps in P3DM process

P3DM PROCESS		
	PRE-P3DM (Preparatory work) ▶ Define purpose and objectives ▶ Conduct stakeholder analysis ▶ Acquire resources and mobilise stakeholders	• Think about what is the problem you are trying to solve and what you are trying to achieve – Will P3DM help? • Identify who should be involved e.g. for logistics, mobilising participants, building model, inputting information on model, etc. • Identify materials, equipment and supplies and human resources needed to build the model and facilitate the process • Mobilise - Get stakeholders aware and ready to engage in the process e.g. via community meetings, invitations, TV or radio interviews and announcements, press releases, etc.
	DURING (P3DM implementation) ▶ Construct blank model & develop legend ▶ Model population ▶ Analysis of model results ▶ Evaluations ▶ Handover to the local community/ government	• Construct the blank model with layers of cardboard representing various elevations of the land. • Develop a legend to guide what information should be put on the model and to help persons interpret it correctly. • Work with stakeholders to input information on the model; ask probing questions to help them focus and think about what is relevant to include. • Analyse the final model results with key stakeholders e.g. discuss the full picture of what was shared and use the information to think about future scenarios and solutions needed or decisions to be made • Evaluate the process – e.g. can be qualitative assessment of how people felt, what they learnt, noticed, or would like to suggest • Have a ceremony to officially hand over model to the community or other relevant key stakeholder/s, showcase the final model results and share recommendations
	POST ▶ Digitising the model to create GIS outputs- data and maps ▶ Storage of the model ▶ Identifying & planning for further use	• Take photographs of the model and use these to digitise the model in a GIS; create GIS datasets of the various features that were placed on the model and a map representing all the features • Identify a suitable space where the model will be stored • Think about what else the model can be used for

P3DM enables local knowledge to be incorporated into the decision-making process to identify key vulnerabilities and priorities for CCA[19]. It facilitates the engagement of a wide range of stakeholders, such as community residents, resource users, government staff, civil society organisations (CSOs) and academia, in the process of assessing vulnerabilities in the areas where they live and work. Its ability to engage youth, elderly, low literacy and other marginalised groups, who are not often targeted in planning and decision-making processes, is notable. Use of simple means of communication like colours, shapes and dimensions makes for ease of communication and does not require participants to be highly educated or literate to participate. The P3DM process and 3D models developed can be further used to support multi-stakeholder communication for awareness raising and advocacy at the community and national levels.

P3DM is particularly useful in examining geographical or spatial relationships (e.g. between an area's resources and its inhabitants, users and/or customary custodians) and enabling EAF, as it takes into account and allows for examination of biophysical, cultural and socioeconomic factors within ecologically meaningful boundaries (e.g. a watershed, 'ridge to reef' area or entire island and its marine zone). The process not only allow spatial features to be depicted but intangible features like values, tenure, local names and resource uses -, sacred areas and culturally significant boundaries which are not on typical maps-.

However, there are limitations to the application of P3DM. P3DM is time and labour intensive. Typically, it takes between four to twelve weeks to complete the entire process, and requires skilled facilitation and GIS expertise. It therefore can be very expensive. Also, there is a need to identify a place to house the final 3D model for public display and GIS outputs, such as a GIS map and datasets.

[19] CANARI. 2017. Implementing climate change action: A toolkit for Caribbean civil society organisations. Laventille: CANARI.

4. Findings of the P3DM Vulnerability Assessment in Anguilla

4.1 Overview

Anguilla is a British Overseas Territory in the Eastern Caribbean comprised of a small island and several offshore cays and islets. The island is about 26 km long and 5.5 km at its widest, with an area of about 91 km^2 (see the map in Figure 2). It is relatively flat and undulating with its highest point at Crocus Hill recorded at about 65 m above sea level. Coastal cliffs are common on the northern side of the island, and flatter areas are found towards the south and southeast. There are several uninhabited offshore cays and islets, the largest of which are Anguillita, Dog Island, Prickly Pear East, Prickly Pear West, Scrub Island and Sombrero Island. Most of the island and offshore cays are composed of hard crystalline limestone, non-crystalline limestone and clay marls[20].

Anguilla has an exclusive economic zone (EEZ) of over 92,000 km^2, which includes a common submarine shelf with St. Martin to the south. There are extensive reefs off the north coast and fringing reefs along most of the south coast. The 17 km long reef along the north east coast is considered to be one of the most important largely unbroken reefs in the Eastern Caribbean[20]. There are over 40 white sandy beaches around the island, which are comprised mainly of calcareous algal sands, coral and shell fragments, and small areas of mangroves.

Anguilla has an estimated population of 13,534 (est. December 2011). It is a middle income island with a gross domestic product (GDP) of about US$ 319.75 million in 2015[21]. The economy depends heavily on tourism, offshore banking, fishing, construction and remittances from emigrants. Tourism, which has spurred the growth of the construction sector, is the main contributor to economic growth and is also the main source of employment. The fisheries sector is also an important contributor to livelihoods and the economy. It is valued at US$ 9.4 million, contributing about 2.26% to Anguilla's GDP in 2014[22].

4.2 Anguilla Fisheries Profile

A fisheries sector profile for Anguilla is provided below, including a brief overview of the fisheries sector, governance arrangements, key stakeholders, and opportunities and challenges for the sector of relevance to climate change.

[20] DFMR. 2017. Management Plan for Anguilla's Marine Park System and Associated Shallow Water Habitats and Fisheries (2015-2025). The Valley: DFMR, Government of Anguilla.
[21] Government of Anguilla. 2016. 2017 Budget Address. Anguilla at 50: "Celebration and Realignment". December 5, 2016. http://www.gov.ai/documents/finance/2017%20Budget%20Address.pdf
[22] DFMR. 2015. Anguilla Fisheries Development Plan 2015- 2025. Government of Anguilla, The Valley, Anguilla. http://www.gov.ai/documents/fisheries/2015%20fisheries%20development%20plan.pdf

Sector overview:

The fisheries sector contributes significantly to food security and local livelihoods in Anguilla. It includes coastal and offshore pelagic, demersal and deep slope and reef-based fisheries. It is comprised of largely artisanal small-scale fisheries. There is no large-scale industrial fishing and aquaculture is very limited. For the 2016 licensing period, there were 141 licensed seasonal fishers and 96 licensed vessels. While there has not been a significant growth in the number of fishers entering the industry, Anguilla is unique in that its fisheries sector is dominated by many young fishers under 30 years.

The most economically valuable species are conch, lobster such as Caribbean spiny lobster and spotted spiny lobster, reef fish such as hinds, grunts, parrotfish and surgeonfish, demersals such as snappers and pelagics such as sharks, tunas, wahoo and mahi mahi. Of these, the Caribbean spiny lobster is the most valuable species financially. The queen conch is also an important commercial species. Some fisheries with potential commercial value include: the invasive lionfish, sea cucumber, sea urchins, flyingfish and eels. Fish production in 2014 was 752 metric tonnes, valued at US$ 9.4 million. It contributed about 2.26% to Anguilla's gross domestic product in 2015.

There are eight main fishing villages and landing sites, including Crocus Bay, Cove Bay, Forest Bay, Island Harbour, Sandy Ground/Road Bay, Sand Hill Bay, Shoal Bay and Sile Bay. The largest proportion of the catch is landed at Island Harbour, Cove Bay and Sandy Ground/Road Bay. The fishing methods employed includes: purse seines, handline fishing, Antillean or Z designed fish and lobster traps, spear guns, vertical longlines and fish aggregating devices (FADs). SCUBA and skin diving is employed for fishing conch and cray fish respectively. There are currently three, ~14m operational trawlers on the island which are powered by inboard diesel engines. Besides those, the majority of the boats are primarily wood and fiberglass, open hull vessels which are constructed locally, powered by outboard engines and ranging in size from 5m – 15m. Less than an estimated 30% of fishers utilise GPS and electronic safety devices such as E-pubs/SPOT. There is one small-scale fish market on the island that engages only in scaling and gutting of fish.

While a number of fishery resources are underutilised and boast no processing plants or value added products, the rising demand for fish products within Anguilla's tourism sector is placing pressure on the nearshore coral reef fishery. The nearshore fishery is heavily fished and currently diminishing and in poor health. It is hoped that by providing training in new fishing techniques, fishers will increasingly shift from the coral reef fisheries and into the underutilised offshore pelagic and deep slope fisheries. The sector faces further governance challenges due to antiquated legislation and the inability of fishers to mobilise and enable collective voice and action through the Anguilla Fishing Association and Anguilla Fishing Co-operative.

Relevant governance/institutional arrangements:

- The national fisheries authority is the Department of Fisheries and Marine Resources (DFMR). The DFMR currently, falls under the Ministry of Infrastructure, Communications, Utilities, Housing, Agriculture, and Fisheries. DFMR is mandated to manage Anguilla's fisheries resources and to safeguard the functional integrity of the critical marine habitats upon which fish species depend. It currently operates within the legislative boundaries of the revised Fisheries Protection Act of 2000 and Regulations of 2010 and a revised Marine Parks Act of 2000 and Regulations of 2010. The core functions of the DFMR include fisheries management, coastal and marine resources management and conservation through marine protected areas (MPAs).

- A number of other government agencies, such as the Departments of Environment, Physical Planning, Disaster Management, and CSOs, such as the Anguilla Fishing Association and Anguilla National Trust, play an important role in managing the impacts of climate change on Anguilla's fisheries and coastal and marine resources.
- Anguilla has a Fisheries Development Plan (2015-2025)[23]developed by the DFMR. The main objective of the plan is to diversify Anguilla's economy through the optimal and sustainable utilisation of the fisheries resources in Anguilla's EEZ and the creation of specific management plans for existing and potential fisheries. The development plan lays out the steps for developing the fisheries sector; aid in influencing Government decisions; and serve as a guide for fishers wanting to enter the industry or develop their trade. However, CCA considerations need to be mainstreamed into the plan, and the plan should be formalised.
- Anguilla has a draft Climate Change Policy 2011 - Transforming to a Climate-Resilient, Energy Efficient and Low Carbon Economy[24,25]. The draft policy was a key outcome for Anguilla from the ECACC[26] project and is informed by the technical and scientific analysis afforded by a vulnerability and capacity assessment (VCA) conducted under this project. Relevant policy goals and objectives for the fisheries sector include education of key stakeholders on climate change impacts on coastal and marine resources and need to protect and enhance the resilience of these resources, conservation of biodiversity and addressing climate change impacts on community livelihoods, health and wellbeing.
- Several other pieces of legislation and policies have been adopted within the past few years that provide a broad institutional framework for addressing climate change in Anguilla. These include the Disaster Management Act of 2007 and a Comprehensive Disaster Management Strategy, Land Development Control Act of 2000, Anguilla Environment Charter and National Environmental Management Strategy and Action Plan (2005-2009)[27].

Opportunities:

- The draft Climate Change Policy 2011 includes guiding principles, goals and objectives and directives relevant to coastal and marine resources and identifies a number of adaptation actions.
- The Government of Anguilla is supportive of multi-sectoral approaches, including the establishment of a Fisheries Advisory Committee to implement multi-sectoral measures for risk assessment and mainstreaming CCA planning and implementation.
- The fisheries sector is noted as having potential to contribute more to the economy through supplying the growing tourism sector. This may provide incentives for improvements and investments in the sector and motivation for building resilience to climate change impacts.

[23] DFMR. 2015. Anguilla Fisheries Development Plan 2015- 2025. Government of Anguilla, The Valley, Anguilla. http://www.gov.ai/documents/fisheries/2015%20fisheries%20development%20plan.pdf

[24] Government of Anguilla. 2011a: Green paper: a working document to assist with the formulation of a Climate Change Strategy for Anguilla. Caribbean Community Climate Change Centre, Belmopan, Belize.

[25] Government of Anguilla. 2011b: Transforming to a climate-resilient, energy, efficient and low carbon Economy: Anguilla`s Climate Change Policy (draft). Caribbean Community Climate Change Centre, Belmopan, Belize.

[26] For details on the ECCAC project, see http://www.caribbeanclimate.bz/closed-projects/2007-2011-enhancing-capacity-for-adaptation-to-climate-change-ecacc-in-uk-caribbean.html

[27] Government of Anguilla. 2005. Anguilla National Environmental Management Strategy and Action Plan 2005-2009. http://www.gov.ai/documents/Final%20NEMS%20January%2028th%202005.pdf

Challenges:

- Limited research, data collection and monitoring concerning the island's coastal and marine biodiversity, including specific fish species, invertebrates and marine plants.
- Vulnerability assessment work in Anguilla is not fisheries specific or relevant to climate change[28]. In addition, there needs to be a better understanding of the interactive effects between climate and non-climate effects, such as changes in land use, on fish abundance and availability.
- Poor planning and response systems for climate change and disasters, compounded by inadequate skilled human resources and funding, that do not incorporate best practices related to ecosystem-based and multi-hazard approaches to build resilience[29].
- Lack of key legislation in Anguilla, including comprehensive environmental legislation, and a national development plan to inform planning and development of the fisheries sector[30].
- Limited political will and stakeholder buy in to ensure adequate investment in fisheries sector, including capacity building and funding for DFMR and fishers, and effective management and sustainable utilisation of fisheries and coastal and marine resources.
- Limited effective communication and knowledge sharing between government and fishers, and no legal basis for co-management of fisheries and MPAs.
- Low levels of trust and co-operation among fishers.

Key stakeholders:

Public sector

- Key administrative offices - Premier's Office/Ministry of Finance, Attorney General's Chambers, Governor's Office
- Key climate and environment-related ministries – Ministry of Information, Communication, Utilities and Housing, Agriculture and Fisheries, including the DFMR and Department of Environment, Ministry of Social Development and Ministry of Finance
- Other relevant government agencies - Physical Planning Department, Maritime Affairs Department, Port Authority Department, Land and Surveys Department, Department of Agriculture – Policy and Planning, Financial Services Agency, Department of Disaster Management

Civil society and private sector

[28] Under the ECCAC project, a vulnerability assessment was undertaken for the tourism sector in 2009. Two studies, the Anguilla Drainage Study and the Anguilla Slope Study, had vulnerability assessment components but are not relevant to climate change or the fisheries sector. Hazard maps have been produced for Anguilla, including a national disaster preparedness map identifying flood-prone areas and a hazard vulnerability map of Sandy Ground identifying areas prone to flooding, coastal erosion and landslides from 1992.

[29] DFID. 2012a. Addressing Climate Change by Promoting Low Carbon Climate Resilient Development in the UK Overseas Territories. Needs Assessment: Anguilla. DFID, London, UK. July 2012. http://jncc.defra.gov.uk/pdf/2012-07-23%20Anguilla.pdf

[30] Newcastle University. 2013. Future of reefs for: Anguilla. Anguilla National Consultation Meeting, 27 February 2013. Prepared for the Future of Reefs in a Changing Environment (FORCE) project. http://jncc.defra.gov.uk/pdf/ot_FutureforAnguillareefs.pdf

- Civil society - Anguilla Fishing Association, Anguilla Fishing Co-operative, Anguilla National Trust, Anguilla Red Cross, Anguilla Hotel & Tourism Association, fisherfolk, farmers and coastal communities
- Private sector - Dive operators, gear supply stores, small boat operators/water taxis, cruise ship operators and agents, hoteliers, supermarkets (fish importers) and insurance companies
- Academic institutions - Primary level (Omololu International School and seven government schools); Secondary level (Albena Lake Hodge Comprehensive school); Tertiary level (Anguilla Community College, St James Medical School and UWI Open Campus)
- Media - The Anguilla Newspaper, Anguilla News (online news), ATV and Kool FM Radio

4.3 P3DM process

P3DM was used to conduct a vulnerability assessment of Anguilla to climate change and natural hazards, focusing on collection of knowledge on areas critical to the fisheries sector (e.g. fishing communities, landing sites, fishing grounds, supporting ecosystems such as coral reefs and mangroves, and to identify potential adaptation actions. The goal was to develop a scaled, geo-referenced 3D model of the island of Anguilla with spatial information and local knowledge from key stakeholders, including fisheries authorities and fisherfolk and their organisations.

An eight-day P3DM workshop was facilitated by CANARI and the DFMR at the Anguilla Community College from March 1-7, 2018 (see Appendix 1 for the workshop agenda). The target participants for the P3DM workshop included key government, civil society and private sector organisations involved in CCA, disaster risk management and fisheries and natural resource management in Anguilla (see Appendix 2 for the full list of participants). A local mobiliser/administrative assistant was also engaged to support logistics and stakeholder mobilisation for the workshop.

The specific objectives of the P3DM workshop were to work with stakeholders to:

- capture and incorporate their local and scientific knowledge to assess the vulnerability of Anguilla, especially the fisheries sector, to climate change and natural disasters through engagement in building the model;
- analyse the potential impacts of various climate change scenarios for Anguilla's fisheries and coastal communities and their livelihoods;
- identify priorities for action for CCA in the fisheries sector in Anguilla, including priority policy interventions as well as specific actions needed on-the-ground to address the impacts of climate change;
- improve their understanding of and appreciation for the value of local knowledge in decision-making about climate change; and
- enhance their capacity to use P3DM as a tool for vulnerability assessment, spatial planning and resource management to adapt and build resilience to climate change and natural disasters.

The P3DM workshop was conducted in a highly participatory and interactive manner, using a combination of facilitation techniques including plenary presentations and discussions, informal interviews with specific target audiences (e.g. fisherfolk, aquaculture farmers and dive operators) and small group work (see Appendix 5 for slide presentations). The entire exercise was conducted over eight days from start to completion, including approximately three days to build the blank model, one day for drying, two days to input information unto the model and a half day for participatory analysis of key vulnerability and priorities for CCA in the fisheries sector using the completed model (see Figures 3-13 depicting the different steps of the P3DM process). A handover

ceremony was also held on completion of the workshop to showcase the final model results and present key recommendations and lessons identified during the process.

While the workshop successfully engaged a wide range of stakeholders, including six individual fishers, there were limitations to the process due to lack of active participation from leaders of the two key national fisherfolk organisations, the Anguilla Fishing Association and Anguilla Fishing Co-operative. The Anguilla National Trust, Anguilla Tourist Board, the Anguilla Hotel and Tourism Association and the Governor's Office were also not able to participate in the process. The Anguilla National Trust plays a key role in conservation, education and research and monitoring of coastal and marine resources and have a vested interest in CCA and building ecological resilience. Given that tourism is a central focus for future economic growth, the participation of stakeholders from this sector is also important to identify features potentially vulnerable to climate change, especially those which may affect or be affected by the fisheries sector, such as beaches and other scenic coastal and marine landscapes.

The local knowledge captured through the P3DM exercise was further digitised and placed within a GIS for integration with scientific knowledge and other data. The GIS datasets and a map were provided to the Government of Anguilla to facilitate effective spatial and land use planning and decision-making related to fisheries and other sectors. See Figure 12 for the GIS map developed through digitisation of the 3D model.

Figures 3 and 4: Participants setting out the base map and tracing contours unto cardboard sheets

Figures 5-7: Participants gluing the contour layers out of cardboard sheets to develop the blank 3D model

Figures 8-11: Inputting information on the blank model and finalisation of the 3D model

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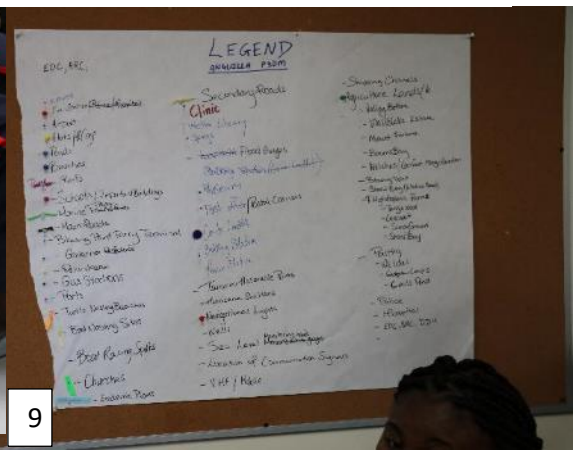

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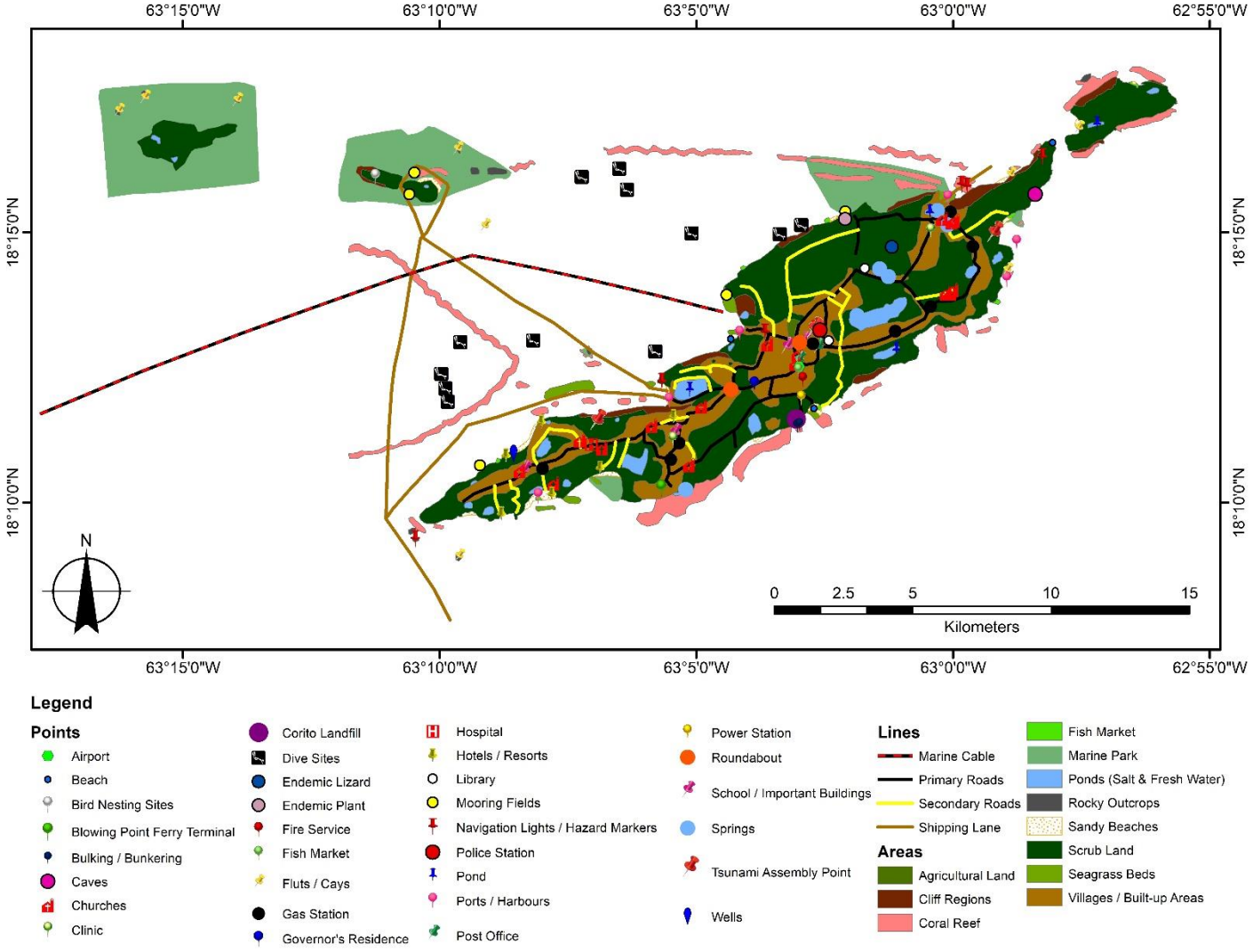
Figure 12. GIS map of Anguilla developed through digitisation of the completed 3D model



4.4 Identification of key climate change impacts and vulnerabilities for Anguilla's fisheries

Stakeholders identified a range of climate change hazards that they had experienced or which will pose a significant risk to Anguilla's fisheries sector, including coastal communities, fishing grounds, landing sites and important coastal and marine ecosystems that support fisheries, during the P3DM exercise. These hazards include:

- Coastal erosion and flooding due to sea level rise, which especially affects beaches and coastal cliffs and results in groundwater salinization
- More extreme weather, including hurricanes, tropical storms and storm surge. Stakeholders noted that the Category 5 Hurricane Irma in 2017 was much stronger than other previous major hurricanes (e.g. Category 4 Hurricane Luis in 1995 and Category 4 Hurricane Donna in 1960), with maximum sustained winds of 180 mph and storm surge reaching 200 feet (61 m) inland.
- Sargassum influx that inundates beaches and coves, affects boat engines and limits access to nesting sites by sea turtles
- Coral bleaching with warmer sea temperatures that affects reef-based fisheries, marine biodiversity and dive tourism
- Ocean acidification that will result in reduced health of coral reefs and shellfish and affect reef-based fisheries and dive tourism
- Erratic rainfall and more dry periods that affects access to rainwater, which is main source of safe, drinking water on the island
- Inland flooding that affects agricultural lands, increases sedimentation in the coastal zone and damages infrastructure including in the capital, The Valley.

These identified climate change hazards have begun to trigger a range of biophysical and socio-economic impacts on fisheries in Anguilla, which are compounded by existing pressures. These pressures include coastal development, sand mining and beach nourishment that alters coastal dynamics, pollution and sedimentation from land-based sources, spread of diseases and invasive species such as the lionfish and non-native sea grasses, and overfishing in nearshore reef fisheries leading to declines in species such as parrotfish and surgeonfish. These impacts are both negative, such as loss of coastal areas, and positive, such as opportunities to diversify the economy and fisheries sector.

Stakeholders identified specific impacts and vulnerabilities to climate change hazards within a number of key areas, which are outlined below in Table 2.

Table 2: Key climate change impacts and vulnerabilities identified by stakeholders using P3DM

Climate change hazards	Key climate change impacts	Vulnerable groups and areas
Coastal and marine biodiversity and ecosystems		
• Sea level rise • Warmer sea temperatures • More extreme hurricanes/ storms and storm surge • Sargassum influx • Ocean acidification • Inland flooding leading to increased siltation and polluted runoff	• Erosion of beaches and cliffs and flooding of low-lying coastal areas, including mangroves • Coral bleaching and die-off • Shifts in fish distribution from warmer to cooler waters in temperate latitudes • Increase in alien invasive species, such as non-native sea grass (*Halophila stipulacea*) displacing native "Turtle grass" (*Thalassia testudinum*) • Damage to and loss of coral reefs, seagrass beds and mangroves that are critical fish habitats and provide coastal defence and other key ecosystem services • Beaches, including turtle nesting sites, clogged by sargassum and coastal and marine species entangled and impaired • Increase in toxic algal blooms leading to fish kills and adverse impacts on coral reefs and associated species • Loss of biodiversity	• Coral reefs off the north and south coasts, and associated reef-based fisheries • Seagrass beds and mangroves which are nurseries for inshore fish and critical habitat for Green sea turtles and other marine species • Offshore cays and islets, where all current marine parks are located, which range in height from 1-30m above sea level • Nesting beaches for endangered sea turtles, including Leatherback, green and hawksbill turtles, that are prone to erosion and affected by sargassum influxes • Coastal cliffs of clay marls prone to erosion, such as Katouche Bay • Low-lying areas in the west and south of the island and Sandy Ground which are less than 30m above sea level, including fresh and salt water ponds that are important bird habitats
Cultural heritage, values and social networks		
• Sea level rise • More extreme hurricanes/ storms and storm surge • Erratic rainfall resulting in increased drought and flash flooding • Sargassum influx • Warmer sea temperatures and increased coral bleaching • Ocean acidification	• Loss of coastal lands and displacement of population (inland or abroad) • Damage and possible loss of important cultural and natural heritage, including old heritage buildings like the Bethel Church, popular beaches like Rendezvous Bay, coral reefs, offshore	• Low-lying coastal communities and other areas in the west and south of the island and Sandy Ground on the north coast which are less than 30m above sea level • Coral reefs off the north and south coasts, and associated reef-based fisheries and dive sites

Climate change hazards	Key climate change impacts	Vulnerable groups and areas
	cays and shipwrecks like The Oosterdiep • Decline in traditional livelihoods and associated knowledge and values, such as agriculture, fishing and beach-based tourism that are climate-sensitive sectors • Increased conflicts over resource use in terrestrial, coastal and marine areas and access to freshwater • Psychological stress and impacts from loss and damage, conflicts and uncertainty within economy, environment and society	• Offshore cays and islets, which are important traditional fishing, diving and recreational sites like Dog, Sandy and Scrub islands, which range in height from 1-30m above sea level • Old heritage buildings like churches, including the Bethel Church that is a key landmark and approach marker for boats • Shipwrecks and related dive sites
Livelihoods and socio-economic practices		
• Sea level rise • Warmer sea temperatures and increased coral bleaching • Warmer air temperatures and increased heat stress • More extreme hurricanes/ storms and storm surge • Erratic rainfall resulting in increased drought and flash flooding • Sargassum influx • Ocean acidification	• Increased impact and frequency of damage to fishing boats and gear, pots, FADs and facilities (e.g. landing sites, wharfs, fueling stations) due to more extreme hurricanes/ storms and storm surge, sargassum influx and sea level rise and lack of proper insurance coverage • Reduced ability to fish and earn income due to storminess, rough seas and sargassum influx • Reduced employment and income earning opportunities due to damage and decline in visitors at hotels and tour operations due to beach erosion, more extreme hurricanes/storms and storm surge and sargassum influx • Decline in reef-based fisheries and dive tourism	• Coastal communities that are heavily dependent on fisheries sector, including Island Harbour, Cove Bay and Sandy Ground/Road Bay • Fisherfolk particularly dependent on reef-based fisheries for their livelihoods and income, and limited access to credit and financing to shift to demersal and deep slope fisheries • Fisherfolk that work part-time in fisheries and tourism sectors (approximately 60% of seasonal fishers) and have limited education and skills to work in other sectors • Small-scale farmers with limited access to credit, land and equipment/ technologies to diversify

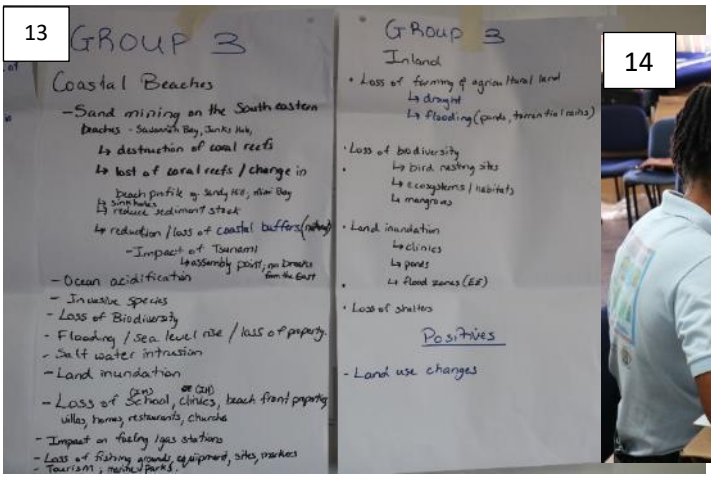
Climate change hazards	Key climate change impacts	Vulnerable groups and areas
	due to coral bleaching and ocean acidification • Possible decline in pelagics due to shifting fish distribution from warmer to cooler waters in temperate latitudes • Water shortages due to more dry spells and groundwater salinisation affecting tourism, agriculture and aquaculture • Increased public health risks and decline in productivity due to rising incidence of mosquito-borne diseases (e.g. dengue, zika and chikungunya) and heat stress • Increased incidence of disease and pests, including alien invasive species like the Giant African snail, and heat stress affecting agricultural crops and livestock Positives: • Growing investment in alternative livelihoods and practices (e.g. climate-smart agriculture and aquaculture/aquaponics) and new sectors (e.g. arts)	
Settlements and infrastructure		
• Sea level rise • More extreme hurricanes/ storms and storm surge • Erratic rainfall resulting in increased drought and flash flooding • Warmer air temperatures and increased heat stress • Sargassum influx	• Damage to and loss of coastal settlements, hotels and infrastructure, including roads, ports, wharfs and fueling stations, due to sea level rise and more extreme hurricanes/storms and storm surge • Damage to and disruption of inland settlements,	• Low-lying coastal communities, particularly in the west and south of the island and Sandy Ground on the north coast which are less than 30m above sea level • Hotels and businesses (e.g. bars, restaurants and shops) built right on the beachfront

Climate change hazards	Key climate change impacts	Vulnerable groups and areas
	public services and infrastructure, including schools, hospitals and health centres, fire and police station and communication towers, due to inland flooding and high winds from more extreme hurricanes/storms • Damage to septic tanks and soakways due to coastal and inland flooding resulting in increased health risks from poor sanitation and water quality • Heat stress and heatwaves leading to increased demand for air conditioning and water • Reduced access to coastal facilities and infrastructure, and increased clean up and maintenance costs, due to sargassum influx Positives: • Growing investment in high quality, resilient and green buildings and infrastructure	• Buildings not built to code, and that do not conform to style where one-storey with concrete walls and roof and underground cistern that can withstand up to Category 4-5 hurricane (e.g. recent immigrants tend to build out of wood with galvanised roofs, while Anguillans shifted to one-storey, concrete houses after Hurricane Donna) • The Valley, which is capital and has bulk of public services, is prone to inland flooding • Corito Bay area with landfill, bulk station that receives and distributes national gas from tankers, and power station that is low-lying and exposed to multiple climate change hazards
Safety at sea and emergency response		
• More extreme weather, including high winds, rough seas, hurricanes/ storms and storm surge • Sargassum influx	• Increased difficulties with navigation and damage to boats at sea, resulting in increased incidence of fisherfolk and boats lost at sea • Increased need and associated costs for search and rescue efforts at sea • Reduced ability to fish and earn income due to safety concerns with increased storminess and rough seas • Damage and disruption to telecommunication infrastructure and signals (e.g. cell phone and radio	• Fisherfolk that are dependent on offshore pelagics, demersals and deep slope fisheries for livelihoods and income and travel on average 25-35 nautical miles (45-65 km) into open sea to fishing grounds • Lower income fisherfolk, who do not have access to or use GPS and other telecommunication devices for navigation, early warning and emergency alerts

Climate change hazards	Key climate change impacts	Vulnerable groups and areas
	towers) that support communications for navigation and early warning systems and increased costs for repair and maintenance • Damage to and loss of navigational lights and lanes (e.g. shipping lanes, approach lanes and markers for ports and landing sites) and increased costs for repair and maintenance Positives: • Increased appreciation of, and need to utilise/ revitalise, traditional knowledge and skills of dead reckoning for navigation and not rely totally on telecommunications and other technologies	• Dive operators and divers, yachtsmen and sport fishers engaged in recreational activities in open sea • Government agencies, including the DFMR and marine police in Anguilla, and Dutch and French coast guard from St. Maarten engaged in search and rescue efforts at sea • Telecommunications businesses and government agencies, such as DFMR, Disaster Management Department and Port Authority, that establish and maintain telecommunications infrastructure and navigational lights and lanes for shipping/fishing
Water resources		
• Erratic rainfall resulting in increased drought and flash flooding • Sea level rise • More extreme hurricanes/ storms and storm surge • Warmer air temperatures and increased heat stress	• Reduced access to freshwater through rainwater harvesting due to more dry spells • Reduced access to freshwater through groundwater aquifers due to sea level rise and groundwater salinization • Damage to and disruption to water supply and infrastructure, including desalination plant, piped system, water bottling plant and rainwater harvesting systems) due to more extreme hurricanes/storms and storm surge • Reduced water quality in groundwater aquifers due	• Communities, including a number of fishing communities, where there is no piped water system and heavy reliance on groundwater wells or rainwater harvesting and cisterns • Small-scale crop and aquaculture farmers that rely on rainwater harvesting or groundwater wells for irrigation or water supply for ponds • Water-intensive sectors, including tourism and construction, that will have added difficulties and costs to access water for drinking and other uses

Climate change hazards	Key climate change impacts	Vulnerable groups and areas
	to increased flooding, siltation and contamination with sewage and other pollutants • Increased demand for freshwater in tourism, agriculture and potential aquaculture farms with heat stress • Increased conflicts over water use and allocation with decreased supply and increased demand	

Figures 13 and 14: Participants working in small groups to identify key climate change impacts and vulnerabilities for specific areas of the island of Anguilla



4.5 Priorities for CCA in Anguilla's fisheries

Priorities and specific adaptation actions for the fisheries sector were jointly identified by stakeholders based on the P3DM exercise and participatory analysis of the key impacts and vulnerabilities from climate change. In particular, stakeholders highlighted the need for a multi-hazard approach that takes into account not only the multiple impacts from climate change, but existing pressures on fisheries and coastal and marine resources from adhoc coastal development, resource overuse, pollution and invasive species and other natural hazards including earthquakes and tsunamis. They also noted the need for adaptation actions to both address negative impacts and take advantage of positive impacts and opportunities that may be derived from climate change.

Key priorities for CCA in the fisheries sector included:

- Organisational strengthening of key government agencies, in particular the DFMR, for effective fisheries management and conservation and sustainable use of coastal and marine resources through:
    - Capacity building for staff to integrate new approaches, such as EAF and marine spatial planning, and technologies for sustainable fisheries management, such as smart FADs[31], aquaculture and aquaponics;
    - Provision of adequate resources, including manpower, boat and equipment for research, monitoring and enforcement as well as for early warning and emergency response; and
    - Strengthening the legal and policy framework, including integrating CCA and disaster management into the Anguilla Fisheries Development Plan and finalising it and addressing gaps in other relevant legislation and regulations;
- Building the adaptive capacity of fisherfolk through:
    - Training on safety at sea and use of GPS, VHF radio and other telecommunication technologies to assist with navigation, access to early warnings and emergency response;
    - Training and support to adopt sustainable fishing practices and technologies to develop sector, including smart FADs, use of underutilised species and alien invasive species (e.g. lionfish), and development of value added products (e.g. smoked tuna);
    - Promotion of alternative livelihoods, including aquaculture, aquaponics and seamoss cultivation, through training and mentoring on technical skills and development of small and micro-enterprises (SMEs); and
    - Improved access to insurance to cover costs of damage and loss of boats, gear and other equipment;
- Strengthening the system of MPAs, including raising public awareness of MPAs and improving monitoring and enforcement of regulations, to protect critical coastal and marine habitats, including coral reefs, mangroves and seagrass beds, to conserve biodiversity and sustain fisheries;
- Ensuring sustainable financing through mobilization of resources via budgetary allocations, grants, public-private partnerships and corporate investment to adequately manage fishing and other marine uses spanning Anguilla's EEZ;
- Improved management and sharing of data from Anguilla Marine Monitoring Programme (AMMP), Beach Monitoring Programme (BMP) and other relevant research and monitoring initiatives to inform adaptation planning and decision-making by the DFMR, fisherfolk and other key stakeholders through web-based applications (e.g. DFMR website, knowledge

[31] FADs, which are temporary or permanent structures used to lure primarily pelagic fish such as tuna, marlin and mahi mahi, can be equipped with geographic positioning system (GPS) and sonar capabilities to allow fisherfolk to contact it remotely to determine fish abundance and track its location and other biophysical conditions. These are known as smart FADs.

platforms, online databases, social media) and effective public awareness and outreach programmes;

- Revising building codes, as well as legislation and regulations related to coastal setbacks and physical planning, to climate proof existing and future coastal infrastructure, including fishing facilities, slipways, landing sites, and telecommunications infrastructure and ensure these can withstand more extreme weather, including Category 3 to 5 hurricanes and associated storm surges; and
- Developing and implementing an Integrated Coastal Zone Management (ICZM) plan to address in particular adhoc coastal development and land-based sources of pollution, including untreated sewage, industrial waste and sediments, that degrade coastal and marine ecosystems and associated fisheries and increase their vulnerability to climate change.

Additionally, these priorities for CCA are consistent with strategic directives outlined in the draft Climate Change Policy (2011) and Anguilla Fisheries Development Plan (2015-2025), and will facilitate implementation of specific actions identified in these national policies and plans.

5. Lessons Learned in Applying P3DM for Climate Change Vulnerability Assessments

Overall, P3DM served as a valuable tool for conducting a climate change vulnerability assessment for the fisheries in Anguilla. It allowed for:

- integration of local knowledge, including traditional knowledge of fisherfolk;
- capture of varying stakeholder perspectives (i.e. it allowed for inclusion of inputs from fisherfolk and other stakeholders with different roles, levels of interest, knowledge and experiences, and with differing capacities and capabilities to engage and contribute information to the process);
- capture of quantitative and qualitative data relevant to EAF (e.g. data within ecologically relevant boundaries and considering multiple and integrated factors including biophysical, cultural, political and socioeconomic);
- identification of useful locations and spatial relationships, including where specific on the ground vulnerabilities exist and actions are needed; and
- engagement of stakeholders in the process to improve knowledge and use opportunities for negotiation and development of consensus on climate change issues.

Specific lessons learned and best practices in the application of P3DM to conduct vulnerability assessments to climate change include:

- Comprehensive stakeholder identification and analysis and effective mobilisation of target audiences are key. The breadth and usefulness of local knowledge captured as part of P3DM is highly influenced by the participation of stakeholders.
- The local context and culture must be factored in as important elements in design and planning of P3DM vulnerability assessments. As such, engaging a local community mobiliser who was familiar with the local participants, but also the local context and culture, was instrumental in helping to shape a locally and culturally relevant process. Community mobilisers can help advise on local needs and cultural preferences so facilitation of the process could be adapted to suit.
- Noting budget implications, field visits prior to and during the P3DM could have assisted with the mobilisation of stakeholders and ensured more meaningful participation of key target audiences.
- Participants' perception of who was responsible for or in charge of the P3DM exercise, as well as who would have eventual control on access and use of data generated, has the potential to influence the level and quality of participation and can even derail the process.
- The process of developing the legend is critical in ensuring relevant information is captured for the vulnerability assessment – this should be used as an opportunity to structure and focus the P3DM exercise to obtain the information required. For example, participants can be asked to directly identify features related to hazards/hazard impacts, exposure, sensitivity and adaptive capacity or other useful categories that should be captured on the model.
- Capacity building and coaching elements can be enhanced by including hands-on training with stakeholders in digitising the P3DM model after its completion and creating GIS outputs (e.g. datasets and maps) themselves. This could be part of the initial process or follow up exercise and could be extended to cover wider understanding of GIS requirements of the P3DM process on the whole, including steps to identify and effectively communicate GIS needs in the case where GIS expertise must be contracted externally.

- Follow up sessions using the model – presenting the final results to various target audiences can support, for example, further inputs and provide the necessary feedback to help validate the model and opportunity to solidify action plans if needed.
- P3DMs need to be scheduled with sufficient time that would allow for key steps, including model construction, inputting information on to the model and analysis of the final results with key stakeholders, to be completed comfortably. At least 8 days is required, but this will also be dependent on factors such as availability of materials to start work, the size of the model being constructed and the overall level of participation that is received.
- Locating the model close to key target audiences and in a highly accessible area to the public in general helped to garner participation, even on the fly. Depending on the key target audiences, location in a government office for example, has implications for perceived locus of control on the process and could have affected level and quality of participation.
- Informal interviews and meetings in the evenings in places where fishers usually congregated was useful in allowing them to access information on what was happening in a more relaxed manner and get comfortable with facilitators outside of formal settings.
- Specific focus group sessions with fisherfolk were useful in capturing fisheries specific needs and information to be included on the model. Focused sessions with these stakeholders helped increase their comfort level and willingness to share information that was not otherwise captured when wider audiences were in the room.

In general, there is need to consider what target audiences get out of theP3DM process that may encourage mobilisation and participation (e.g. knowledge sharing, capacity building, etc.). Depending on the key target audience, such as a government department or national CSO, P3DM vulnerability assessments can be embedded as part of a wider training and capacity building context to encourage participation, uptake and sustainability of the process.

6. Conclusions and Recommendations

Climate change poses a significant, long term threat to the fisheries of Anguilla. Assessing vulnerability to the impacts of climate change is fundamental to guide decision-making and ensure that efforts to mainstream CCA into fisheries governance and management reflect local conditions and needs.

Using P3DM, key impacts and vulnerabilities to climate change and related hazards on the fisheries of Anguilla and priorities for CCA were identified using a participatory, multi-stakeholder process. This process ensured active participation from fisherfolk and other resource users, community residents and other CSOs that may not typically be engaged in decision-making, and enabled local and scientific knowledge to be incorporated into the assessment to identify key vulnerabilities and priorities for CCA. Building a 3D model of the island of Anguilla and the surrounding marine areas also allowed for EAF, examining the biophysical, cultural and socioeconomic dimensions of vulnerability from 'ridge to reef' and, recognising land-sea connections and relationships critical for fisheries in a small island context.

Key recommendations based on the P3DM for moving forward and ensuring effective mainstreaming of CCA into fisheries governance and management in Anguilla using EAF include:

- Presenting and validating the findings from the P3DM and the priorities for CCA in the fisheries sector through a series of community meetings with fisherfolk and other key community stakeholders in Anguilla in order to gain additional input and finalise action plans for CCA to guide next steps under the project.
- Ensuring that the final action plans for CCA not only reflect stakeholder priorities but make linkages to, and are aligned with, strategic priorities and commitments at the national, regional and international levels related to CCA, DRM and sustainable fisheries management.
- Enabling public access and use of the P3DM outputs, including public display of the 3D model of Anguilla for awareness raising and communication of the impacts of climate change and natural disasters and key vulnerabilities and use of GIS maps and datasets for further spatial planning and analysis in the fisheries sector and other sectors.
- Utilising participatory video[32] and other information and communication technologies (ICTs) to further document and share local and traditional knowledge, best practices and innovations in the fisheries sector that are relevant to CCA. There is particular need for documentation of traditional knowledge of fisherfolk, which may be at risk of being lost, related to fishing practices and navigational skills such as dead reckoning for CCA and other sociocultural aspects.
- Empowering fisherfolk and coastal communities to address identified vulnerabilities to climate change and related hazards from P3DM and promote local stewardship of fisheries and coastal and marine resources through capacity building, including training, mentoring and access to grants to support implementation.
- Engaging and strengthening of national fisherfolk organisations (e.g. fishing associations and co-operatives) to improve dialogue and knowledge exchange between different generations of fishers, amongst fishers' representatives and with other key stakeholders, such as fisheries authorities and other government agencies and national CSOs. This will enable sharing of best practices and innovations (e.g. related to selection of gear and fish species and value added products in the context of changing climate). Active fisherfolk organisations can also improve representation of fisherfolk in sectoral and national decision-making

[32] For further details, see http://www.canari.org/cm1

processes and enable collective voice and action on key issues affecting fisherfolk and the fisheries sector.

- Promoting ecosystem based management, including EAF, to enable an integrated, multi-hazard and cross-sectoral approach and build resilience to climate change within the fisheries sector recognising that climate change is one of many challenges affecting the sector. Other key challenges include habitat degradation, pollution, resource overuse, invasive species and impacts from other natural hazards such as volcanic and seismic activity. Adaptation actions that offer co-benefits through addressing climate change and other key non-climatic stresses should be given particular consideration.
- Mainstreaming CCA as well as DRM considerations into fisheries management plans and policies in Anguilla to effectively address extreme climate events and reduce losses from climate-related hazards. This includes taking into account the comprehensive disaster management approach within any sectoral adaptation strategy, investments in early warning systems, safety at sea and insurance, and development of disaster preparedness plans as part of national fisheries management plans.
- Supporting sustainable and resilient livelihoods within fishing and coastal communities in Anguilla through development of value added fish products and SMEs related to aquaculture, aquaponics and seamoss cultivation. This could provide opportunities for increased income generation and livelihood diversification as well as incentives for sustainable utilisation of fisheries and coastal and marine resources.
- Strengthening regional cooperation and partnerships to improve management of shared resources and exchange knowledge and experiences on climate change impacts, vulnerabilities and potential adaptation options for fisheries and coastal and marine resources more broadly. Synergies with other relevant regional projects need to be explored, such as the Climate Change Adaptation in the Eastern Caribbean Fisheries Sector project (CC4FISH) that seeks to improve vulnerability assessments in the fisheries sector, build adaptive capacity among fisherfolk and aquaculturists and mainstream CCA into fisheries policies and plans using EAF. The Joint Nature Conservation Committee (JNCC) is also conducting a number of initiatives that support ICZM and marine spatial planning in OT's.

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Appendix 1

CLIMATE CHANGE ADAPTATION IN THE FISHERIES OF ANGUILLA AND MONTSERRAT

Vulnerability assessment of Anguilla's fisheries sector using participatory three-dimensional modelling (P3DM)

March 1-7, 2018

Anguilla Community College, George Hill, Anguilla

Agenda

Workshop objectives

The Caribbean Natural Resources Institute (CANARI), Department of Fisheries and Marine Resources – Anguilla, the Fisheries and Ocean Resources Unit - Montserrat and the Centre for Resource Management and Environmental Studies (CERMES) of the University of the West Indies are implementing the three year Darwin Plus funded project ***Climate change adaptation in the fisheries of Anguilla and Montserrat*** to mainstream climate change adaption (CCA) into fisheries governance and management in Anguilla and Monserrat using an ecosystem approach to fisheries (EAF).

Under the project, participatory three-dimensional modelling (P3DM) will be used in this workshop to conduct a vulnerability assessment of Anguilla to climate change and natural disasters and identify potential adaptation actions, focusing on areas critical to the fisheries sector (e.g. fishing communities, landing sites, fishing grounds and supporting ecosystems such as coral reefs and mangroves). This P3DM workshop will be a key step in supporting mainstreaming of CCA in the fisheries sector and improving livelihoods at the community level.

By the end of the P3DM workshop, participants would have:

- captured and incorporated their local and scientific knowledge to assess the vulnerability of Anguilla, especially the fisheries sector, to climate change and natural disasters through engagement in building the model;
- analyzed the potential impacts of various climate scenarios for Anguilla's fisheries and coastal communities and their livelihoods;
- identified priorities for action for CCA in the fisheries sector in Anguilla, including policy priorities as well as specific actions needed on-the-ground to address the impacts of climate change;
- improved their understanding of and appreciation for the value of local knowledge in decision-making about climate change; and

- enhanced their capacity to use P3DM as a tool for vulnerability assessment and spatial planning and resource management to adapt and build resilience to climate change and natural disasters.

Target group

The target audience for the P3DM workshop are government, civil society and private sector stakeholders, including fisheries authorities, fisherfolk and their organisations and local communities, involved in CCA, disaster risk management and sustainable utilization of fisheries and related natural resources in Anguilla.

Workshop Agenda

Model Building (Days 1-3)	
Thursday March 1st, 2018	
8:30 am	Registration
9:00 am	Welcome and introductions Overview of the ***CLIMATE CHANGE ADAPTATION IN THE FISHERIES OF ANGUILLA AND MONTSERRAT*** project and P3DM Workshop Objectives
9:30 am	Model building starts
12:00 pm	**Lunch**
1pm	Model building continues Drafting of the legend
3:30 pm	**Snack break**
5:30 pm	End of Day 1
Friday March 2nd, 2018	
8:30 am	Registration
9:00 am	Model building continues
12:00 pm	**Lunch**
1:00 pm	Model building continues
4:00 pm	End of Day 2
Saturday March 3rd, 2018	
8:30 am	Registration
9:00 am	Model building continues
12:30 pm	**Lunch**
1:30 pm	Model building continues
4:30 pm	End of Day 3
Sunday March 4th, 2018 Day 4 - Model drying (No activity/workshop)	
Model Population (Days 5-6)	
Monday March 5th, 2018	
9:00 am	Orientation of participants (session 1) Inputting information on the 3-D model
12:00 pm	**Lunch**
1:00 pm	Orientation of participants (session 2) Inputting information on the 3-D model

3:30 pm	**Snack Break**
4:00 pm	Orientation of participants (session 3) Inputting information on the 3-D model
7:00 pm	End of Day 5
Tuesday March 6th, 2018	
9:00 am	Orientation of participants (session 4) Inputting information on the P3DM model
12:00 pm	**Lunch**
1:00 pm	Orientation of participants (session 5) Inputting information on the P3DM model
4:00 pm	**Snack break**
4:30 pm	Finalisation of 3-D model (painting in features)
7:00 pm	End of Day 6
Analysis of Model Results (Day 7)	
Wednesday March 7th, 2018	
8:00 am	Registration
8:30 am	Overview of P3DM objectives and completed model
9:00 am	Participatory analysis of key climate change vulnerabilities and potential adaptation actions for the fisheries sector
12:00 am	**Lunch**
Handover Ceremony	
1:00 pm	Welcome and introductions
1:10 pm	Opening remarks
1:20 pm	Presentation of key findings and stakeholder recommendations from P3DM
1:45 pm	Showcase of completed 3-D model and media interviews
2:30 pm	Closing remarks (End of workshop)

Appendix 2: List of Participants for Anguilla P3DM Workshop

#	First and Last Name	Organisation	Position/Title	Email/Phone
Thursday 1st March 2018 - Model Construction				
1	Javed Woods	Anguilla Air and Sea Port Authority (AASPA)	Port Officer	Javed.Woods@gov.ai 581-8858
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Appendix 3: Slide Presentations for
P3DM Exercise in Anguilla

1. Overview of the vulnerability assessment under the Darwin Plus Climate Change Adaptation in the Fisheries of Anguilla and Montserrat Project
2. Participatory three-dimensional modelling (P3DM) process and key steps
3. Creating a legend for the three-dimensional model