Anguilla Natural Capital Accounting

Final Report

Joint Nature Conservation Committee

May 2019

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Document evolution

Draft Report	03/2019	Reviewed by Ian Dickie
Draft Final Report	03/2019	Reviewed by Amanda Gregory
Final Report	05/2019	Reviewed by Rob Tinch

Executive Summary

The island nation of Anguilla is fundamentally dependent on its wealth of natural resources to support its economy. The attraction of some of the world's most beautiful beaches provides the basis of a tourism industry which contributes significantly to Anguilla's economy. Often ignored in traditional national accounts, however, are the wide range of less tangible benefits which the environment can provide. These include coastal and terrestrial protection from adverse weather, striking visible links with cultural heritage, and the biodiversity that makes life richer to local inhabitants and enhances the tourist experience. National accounts can lack complete information on these benefits

One approach to provide this information is based on the concept of "natural capital", which views the environment as an asset which provides us with goods and services, including "ecosystem services". The aim of this study is to initiate a process to establish a national "natural capital account" for Anguilla. Natural capital accounting is a structured way to measure, monitor and present in physical and monetary metrics the benefits provided by the natural environment. The accounts can be used, alongside other national accounts, and indicators derived from them such as GDP, as a basis for understanding human dependence on the environment to inform policy and planning decisions.

JNCC, in partnership with the Anguilla Department of Environment, is implementing a programme of work to identify, map and value the ecosystem goods and services associated with terrestrial, coastal and marine environments. The purpose of this initial report is to summarise work on the physical and monetary flows of natural capital on Anguilla. It describes the data identified and accessed in order to provide a preliminary assessment of these values, and identify options and data needs for a subsequent phase of work. This initial report links to wider JNCC work to build up preliminary national natural capital accounts for other UK Overseas Territories.

These initial accounts provide a baseline and structure that can be built upon in future iterations. Due to data limitations, described in more detail in **Section 4.4**, the results are incomplete and only offer an indication as to the scale of values. The uncertainty associated with each measure is indicated by colour coding in **Table ES1.1**, and the uncertainties in several key values means that the total estimated values have a moderate to high degree of uncertainty. Over time, more robust data to input to the process and further development of the methodological approaches will enhance future iterations of the account, while comparison with previous accounts will allow the ability to track change over time.

The results in **Table ES1.1** give an indication of the scale of the value that natural capital contributes to Anguilla. It is estimated that a significant annual value of **EC$248 million** is

provided, feeding into an estimate of the 25-year assessment period value of natural capital on Anguilla of **EC$4.2 billion**, in 2018 prices. The value natural capital contributes to tourism is the largest, followed by fisheries. This reflects the overall importance of the tourism sector to Anguilla, and the dependence of the sector on the natural environment. It gives a strong justification for investment in preserving and/or enhancing the natural environment as an asset that supports the tourism sector.

Several important points to note on the interpretation of this account are as follows;

- The initial account is intended to provide a baseline and structure upon which future iterations can be built, rather than provide accurate and robust valuations at this stage.
- Due to the data limitations and significant uncertainties as a result, the account should be interpreted as providing an indication to the scale of value that natural capital contributes to Anguilla, rather than a definitive value.
- This initial account is partial, and therefore does not estimate the total value of all natural capital benefits gained from each habitat type.
- Although in principle the natural capital benefits assessed in this account are infinitely renewable, a 25-year value has calculated rather than a full asset value in order to align with the Government's 25-year Environment Plan. Following HM Treasury's discounting guidance, the value calculated over 25 years therefore equates to slightly over half of the value of an indefinitely sustainable flow that the asset value would usually be calculated as. Although an underestimation, this is in line with the scope of the account and the wider work for the UK Overseas Territories.
- On the concept of natural capital more generally, this work accounts for the value of a specific subset of natural capital benefits, which represents only a proportion of the total value of natural capital as a healthy, functioning and interconnected system. Furthermore, the account focuses on expenditure measures rather than welfare, so aspects such as consumer surplus and well-being are omitted, again meaning that the account does not produce a total value. Finally, the value of the environment to other species, and in terms of the inherent value of its "existence", are not captured in this anthropocentric accounting framework.

Table ES1.1: Overview of Anguilla's natural capital account

Annual Overview	Physical		Monetary		Present Value
	Measure/ year	Units	Baseline (2017/18)	Uncertainty & valuation method	25 years
At May 2019	Annual Value		Annual Value (EC$)		PV (EC$)
Benefits					
Fisheries	2,418,933	lb caught per year	39,342,000	Average price received for total fish caught each year	671,110,000
Agriculture	85,824	lb of agrcultural yields each year	444,000	Average price received for total agricultural yield each year	7,573,000
Tourism	602,575	Total visitor nights	194,359,000	Total visitor expenditure attributed to natural capital	3,315,441,000
Local cultural services					
	867	Anguilla National Trust tour attendees	89,000	Value of Anguilla National Trust tours	1,523,000
	15,045	Local Anguilla resident population	2,829,000	Value of cultural services to local population	50,136,000
Heritage salt pond	575	Number of people living within 200m of heritage ponds			
Carbon sequestration	7,538	Tonnes of carbon equivalent sequestered each year	834,000	Value of carbon sequestered	19,648,000
Coastal hazard protection					
Hotel closures	1,124	Number of avoided lost room days	556,000	Avoided hotel revenue lost in a year due to water damage	9,476,000
			56,000	Avoided accommodation tax revenue lost due to water damage	948,000
Infrastructure damage	96,298	Square feet avoided damage in storm surge zones	9,806,000	Total avoided infrastructure damage cost	167,276,000
Terrestrial hazard protection					
Total Annual Value			248,170,000		4,240,660,000

Level of Uncertaint	Description of Uncertainty
High	Evidence is partial and significant assumptions are made that require further research.
Moderate	Based on assumptions grounded in science and using published data but with some uncertainty regarding the combination of assumptions.
Low	Evidence is peer reviewed or based on published gudiance.

Table note: Low uncertainty reflects confidence that the evidence can support decisions. High uncertainty reflects results that may be inaccurate by more than an order of magnitude. Note that some data may be marked as 'moderate' uncertainty where the data used are themselves accurate, but do not provide a full measure of the services' value (e.g. for hazard regulation).

Contents

Tables

Figures

Boxes

1. Introduction

1.1 Background

1.1.1 Anguilla

At 35 square miles (Government of Anguilla, 2019a) with a population of 13,500 (BBC, 2019), the island nation of Anguilla (**Figure 1.1**) is largely dependent on its wealth of natural capital assets. These assets provide a wide variety of benefits, including: habitats for local fisheries that support the fishing industry; coastal protection from adverse weather; the attraction of some of the world's most beautiful beaches; and the biodiversity that makes life richer to local inhabitants and visitors. The tourism industry, for example, in 2017 was estimated to contribute to 62% of total GDP (EC$ 551mn) and 64% of total employment (5,000 jobs) (World Travel and Tourism Council, 2018). Looking to the future, the wellbeing of the island and its inhabitants are fundamentally linked to the safeguarding of these natural capital assets.

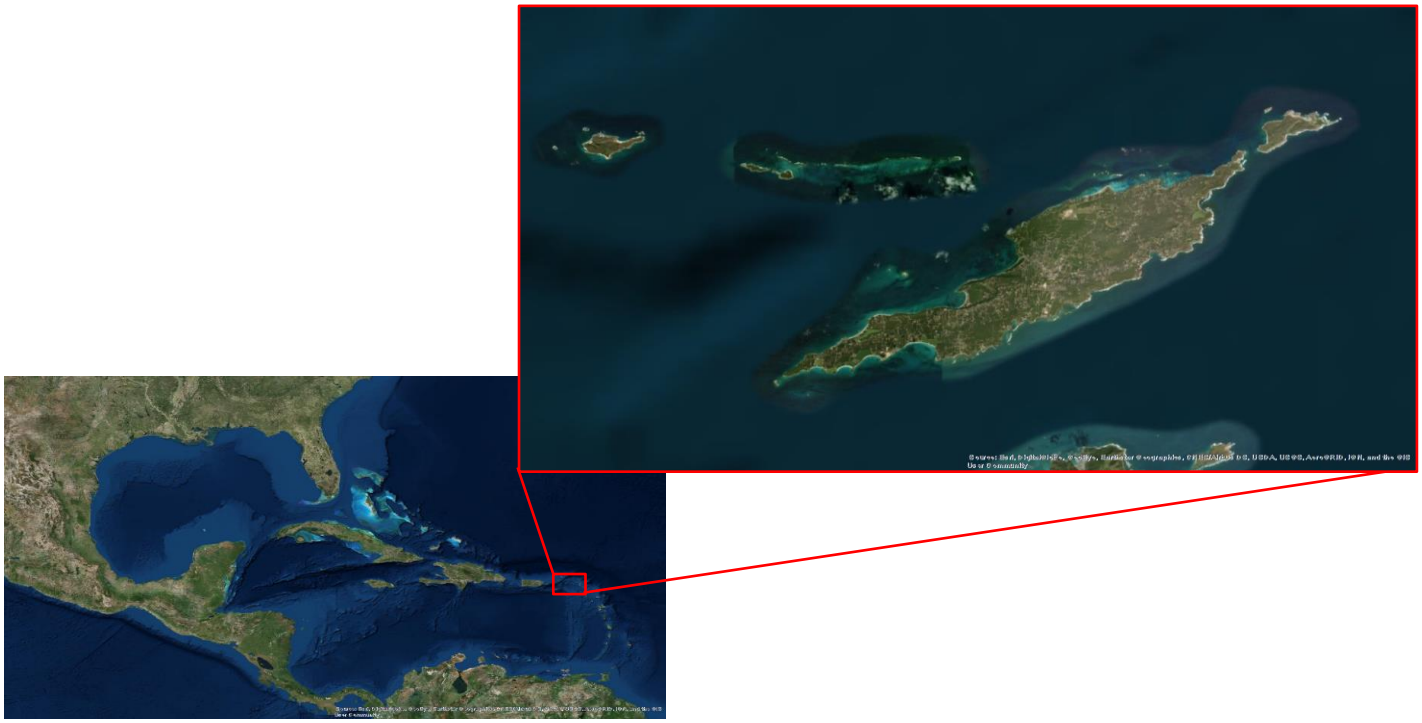

Figure 1.1: Location of Anguilla within the Caribbean (Esri, 2019)

Anguilla faces many challenges in supporting its small but growing local population and developing economy. While economic growth may increase the monetary wealth of Anguilla's population, it can also put immense pressure on the local environment, especially when coupled with unchecked built development. Increased demand on resources by both local residents and tourists, such as for clean water, raw materials and seafood, has implications for the state of the environment and the environment's capacity to sustain the supply of these resources in the long term. The severe hurricanes of 2017 demonstrated how extreme weather events can damage natural assets, but also provided clear evidence that these assets play an important role in mitigating the impacts on infrastructure and human life and livelihood.

Human activity on land or in the sea may also have unintended consequences as impacts on the environment are often linked from one ecosystem to another. Therefore, changes in one part of the environment can

fundamentally alter other environmental assets which help support Anguilla's ability to develop and prosper. This drives a need to better understand the linkages between human activity and the environment, and the numerous ways that the environment contributes to people's wellbeing in Anguilla. This study begins to address this need by drawing together different evidence to begin to build a system to better understand and monitor the benefits provided by the environment to people, presented in both physical and monetary terms.

1.1.2 The Natural Capital Accounting Process

The concept of "natural capital" is an approach that helps frame the interconnection between humans and the environment in economic terms. Viewing the environment through the lens of natural capital is an effective means to draw it into decision-making alongside other human-centric interests. It is a useful way to align the language and data on the environment with other economic factors when making decisions that impact the environment. In this context, natural capital can be considered as the following:

> "the elements of nature that directly and indirectly produce value or benefits to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions"
>
> - Natural Capital Committee (2014)

National natural capital accounting is a process which produces a set of component accounts, collectively named the Natural Capital Account (NCA), that record the value that is provided by a nations' environmental assets. In order to create these accounts, data must be collected and collated in to a number of components. These are:

- **Natural capital asset register** - an inventory that holds details on the state of all the natural capital, or environmental assets, that are present, including their extent and condition (quality and other relevant factors). For example, the spatial area of a reef system, and its health in terms of suitable indicators (for example live coral coverage) .
- **Physical flow account** – contains the flow of goods and services which are dependent on the natural capital assets stocks that are identified in the asset register. This includes benefits related to the provisioning, regulating and cultural goods and services provided by natural capital (relating to the concept of ecosystem services, described in Box 1.1).
- **Monetary flow account** – calculates the annual value of the estimated flow of goods and services that are captured in the physical flow account. The overall asset value is estimated based on assumptions about the values of the monetary flows into the future. The account looks forward over a 25 year assessment period. Future values are discounted to 2018 prices and summed.

The combined accounts therefore monitor the presence and state of different habitats, the benefits these provide, and the value that humans receive from them. When updated year on year they provide a useful means to monitor and evaluate growth or decline in any of these elements, while also helping to understand the relationship between the environment, the services it provides, and how humans use and value them.

Box 1.1: Natural capital accounting - types of ecosystem services

The most widely used definition of ecosystem services is from the Millennium Ecosystem Assessment: "the benefits people obtain from ecosystems". It further categorized ecosystem services into four categories:

- **Provisioning: Material outputs from nature (e.g., seafood, water, fibre, genetic material).**
- **Regulating: Indirect benefits from nature generated through regulation of ecosystem processes (e.g., mitigation of climate change through carbon sequestration, water filtration by wetlands, erosion control and protection from storm surges by vegetation, crop pollination by insects).**
- **Cultural: Non-material benefits from nature (e.g. spiritual, aesthetic, recreational, and others).**
- **Supporting: Fundamental ecological processes that support the delivery of other ecosystem services (e.g. nutrient cycling, primary production, soil formation).**

Analysis of benefits from natural capital also includes abiotic services: the benefits arising from fundamental geological processes (e.g., the supply of minerals, metals, oil and gas, geothermal heat, wind, and tides).

Source: Based on Natural Capital Coalition (2016) Natural Capital Protocol, and Millennium Ecosystem Assessment (2005) Ecosystems and human wellbeing. Biodiversity Synthesis.

1.2 Aims

Forming part of JNCC's 'Natural Capital in the Caribbean and South Atlantic Overseas Territories' project[1], the aim of this study is to create an NCA for the island of Anguilla. The accounts are a structured way to measure and monitor the benefits provided by the natural environment. They can be produced, alongside other national accounts, as a basis for understanding human dependence on the environment and to inform policy and planning decisions. Without an understanding of the contributions that the environment makes to society, it will be undervalued in decision making, and policy and planning decisions may be misaligned or misallocated in ways that harm the environment and reduce its capacity to deliver benefits to society.

The JNCC project is making some of the first applications of natural capital accounting in the UK Overseas Territories (OTs). Therefore, use of the approach is still at a relatively early stage in the region, particularly in terms of disseminating findings and wider engagement. As such, a secondary aim of this study is to engage with relevant sectors of Anguillan society, including governmental departments and the insurance sector, to demonstrate how the natural capital approach can be beneficial. Benefits include the management and mitigation of natural hazard risks, which can reduce government expenditure for rebuilding, and directly impact the financial standings of insurers when claims are made. The intention is to highlight to government planners and the insurance industry how investment in natural capital can reduce risk and build resilience, allowing rebuilding and compensation payments to go further.

The specific outputs for this project are both an initial NCA for Anguilla, and on-island capacity building to produce and use future iterations of the account. The initial account is the first attempt at drawing together currently available data, with the intention of showing how existing data can be manipulated in new ways to inform policy and planning decisions. To facilitate capacity building, a workshop was held on-island with key members of local governance in June 2018 to define the scope of the NCA and NCA training. This was followed up by a workshop in March 2019 to demonstrate how to reproduce and build on the account in years to come, and how the key results and findings can be integrated into the policy and planning processes. It is intended that

1 For more information on the project, see: http://jncc.defra.gov.uk/page-7443-theme=default

in future reporting periods the results from the NCA will be reported alongside other national accounts and indicators (such as GDP), and be used as a measure not only of the value of Anguilla's natural capital, but of its overall national wealth.

1.3 This report

This document reports on the development of the initial NCA for Anguilla, which lays the foundation from which to build future iterations. As the project is establishing a new tool, in practice it also acts as a feasibility study and baseline, and much of the value of the work is in identifying current limitations and ways to address them. Subsequent phases of work will be able to develop Anguilla's NCA further through the recommendations outlined within this report.

The report summarises the approach and findings of the study. It is not meant as a comprehensive technical review of the approach, but rather as an accompanying document to the NCA workbook. It is written to be an accessible and practical report, to aid the ongoing NCA process on Anguilla.

Subsequent sections of this report describe in more detail the natural capital assets of Anguilla (**Section** Error! R eference source not found.). The report then outlines in more detail the specific benefits which are included in the initial account, giving an overview of the approach to their economic valuation (**Section 3**)[2].

Findings from the NCA process are reported, including gaps and limitations, with commentary focusing on issues around data requirements and sources (**Section 4**). Importantly, the report also makes recommendations on how to evolve the accounts for Anguilla, including incorporating additional benefits and developing the data collection systems with which to update relevant aspects of the accounts on an annual basis (**Section 5**). The report concludes with the overall values derived in the accounts and discussion regarding the NCA (**Section 6**).

1.4 Anguilla's Natural Capital Assets

In broad terms the natural capital of Anguilla incorporates all the habitats and sub-soil assets present on the island and the adjacent marine ecosystems, which provide (or could in future provide) ecosystem services[3]. Observations from desk-based study, stakeholder consultation and previous work conducted on Anguilla were used to identify different natural capital assets on the islands, and the ways people benefit from these assets. This information acted as a basis from which to prioritise specific benefits for inclusion in the initial account.

1.4.1 Extent

Geographic Information Systems (GIS)[4] were used to identify the presence of broad habitats on the island. The data indicate which habitats are present, and what their total land coverage is, feeding in to the natural capital asset register for Anguilla. The terrestrial habitat and marine habitat extents of Anguilla are shown in **Figure 1.2** and **Figure 1.3** respectively. The breakdown of habitat areas is provided in the Anguilla NCA workbook[5].

2 More details on the data reported, and calculations can be found in the accompanying Excel workbook.
3 As defined in Box 1.1.
4 Analysis undertaken by Viridian.
5 Extent account.

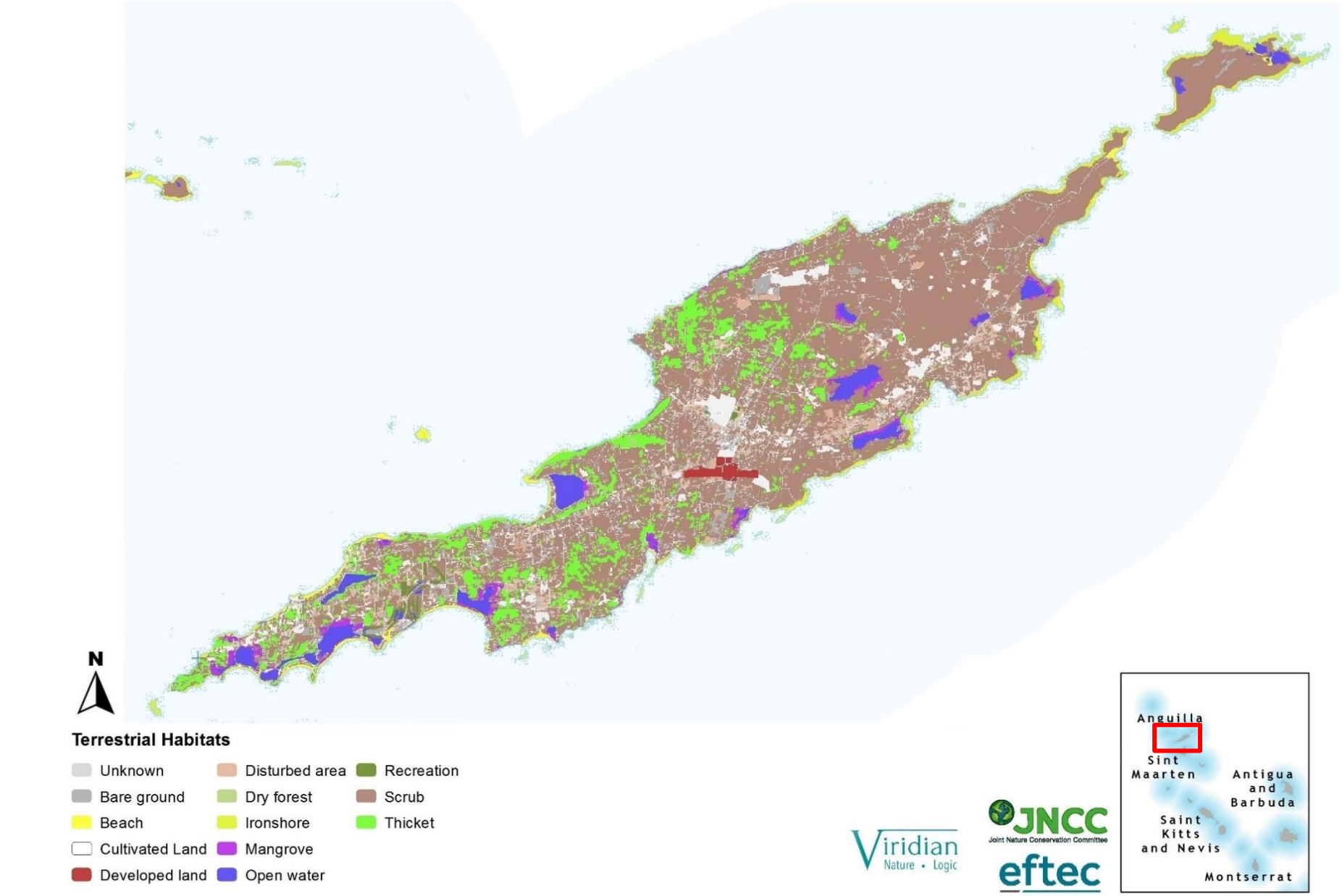

Figure 1.2: Anguilla terrestrial habitat extents.

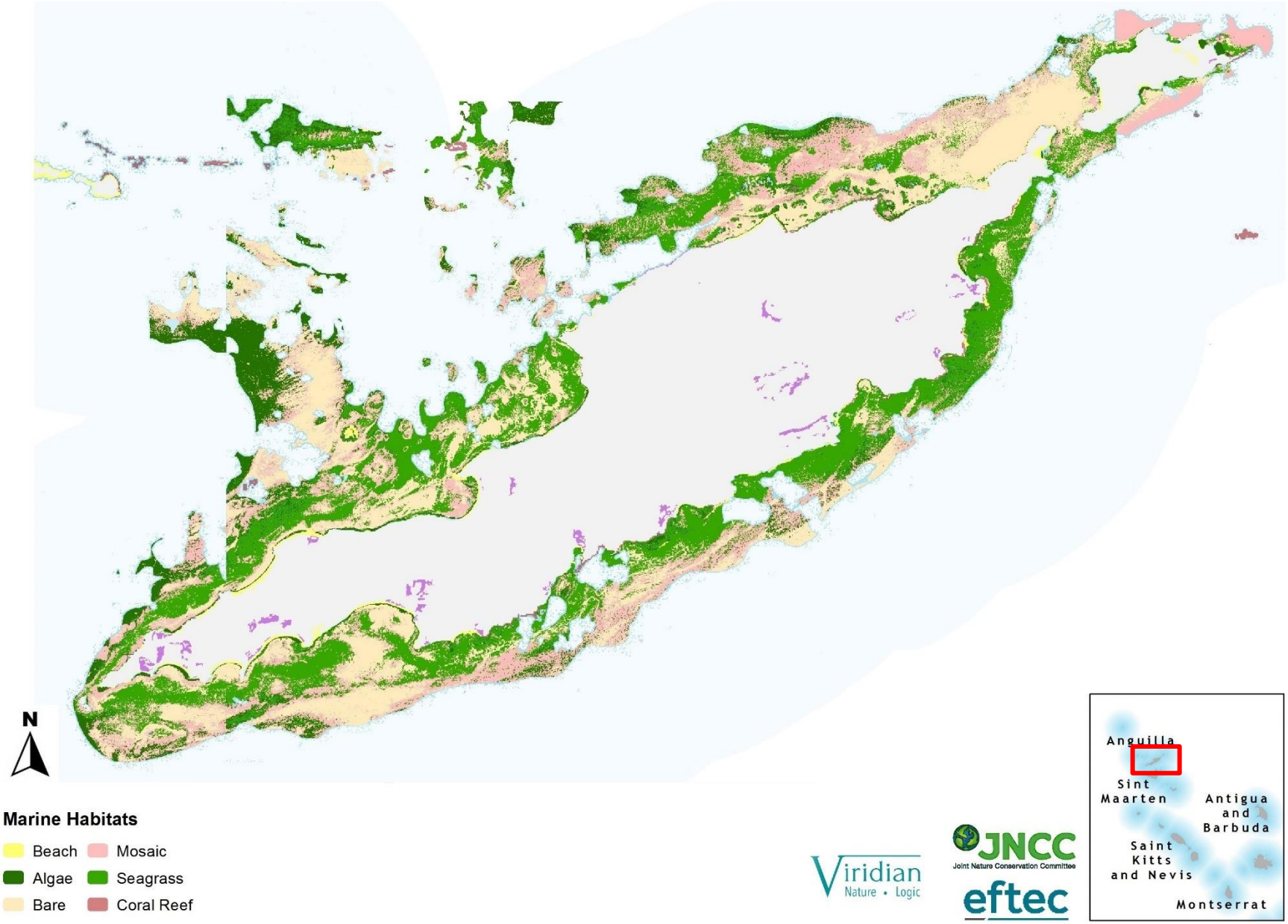

Figure 1.3: Anguilla marine habitat extents.

1.4.2 Condition

It is important to consider the condition of habitats, as this is a fundamental component of their ability to provide benefits to people. Habitat condition data were not available for this initial phase of work but are a priority for future work. As such, the presence of natural capital stock in this iteration, such as of carbon storage and species discussed below, serves as the beginnings of understanding the condition of natural capital on Anguilla. JNCC is aware of other projects in progress or planned for Anguilla which include work to assess habitat condition. These will provide an important contribution to future natural capital assessments.

Carbon retention

Carbon retention refers to the ability of natural capital to store carbon within its biomass or soil, as is of importance due to its regulation of global climate. Quantities of carbon stored indicate the condition of natural capital as a stronger and healthier ecosystem is able to store more carbon. Furthermore, the ability of the natural environment to sequester carbon from the atmosphere and contribute to global climate change mitigation is intrinsically dependent on the ability of natural capital to store carbon, such that once sequestered it is not released back into the environment. Moreover, measuring quantities of carbon stored in this way provide an indicator through which the condition of natural capital on Anguilla can be monitored over time. The steps employed to estimate the quantities of carbon stored by habitat type are outlined below.

Despite significant literature review, it was difficult to identify appropriate carbon storage values for the habitat types of Anguilla. A methodology employed in an Environment Systems[6] workshop for the British Virgin Island (BVI) was applied. This first involved ranking the biomass of each habitat type. It is assumed the habitats on Anguilla are comparable to those on the BVI, so the same rankings were applied. This ranking was then used as a means to loosely calibrate with carbon storage values adopted from the South Atlantic Environmental Research Institute (SAERI) for the island of St Helena. The ecosystems of St Helena are not comparable to those of Anguilla, and as such use of these placeholder values are intended only as a way to demonstrate the method. Carbon storage values were then applied to each habitat type, to produce proxy carbon storage value by each habitat type. This approach would need to be improved upon in reporting of any future results.

Species

Similarly, the presence and populations of species can also provide an indication as to the condition of natural capital. Some species in particular act as indicator species, providing a way of not only measuring the changes over time but also providing an insight into how and why natural capital condition is changing. Birds often act as these indicator species, due their distribution ecology and lifecycle being well understood, generally being easy to identify, requiring habitats that are typically fairly specialised, and due to their high trophic level, their population trends often mirror those of other species[7]. The populations of individuals and breeding pairs of a range of bird species was identified through literature review (Johnson et al., 2014).

Population estimates of other species were more difficult to identify. However, several threatened species were identified as inhabiting or nesting on the island, even if population counts were not provided. This includes the Green sea turtle (*Chelonia mydas* – endangered), the Hawksbill sea turtle (*Eretmochelys imbricate* – listed as critically endangered on the International Union for Conservation of Nature (IUCN) Red List), the Leatherback sea turtle (*Dermochelys coriacea* - listed as critically endangered on the IUCN Red List) (Johnson et al., 2014; BEST Initiative, 2016), and the Lesser Antillean iguana (*Iguana delicatissima* – endangered).

6 Environment Systems are an environmental and agricultural data consultancy.
7 See: http://datazone.birdlife.org/sowb/casestudy/birds-are-very-useful-indicators-for-other-kinds-of-biodiversity

1.4.3 Prioritisation

To develop an initial set of accounts with the available project resources, it was important to determine priority benefits so that a significant proportion of the environment's value to Anguilla would be captured. A prioritisation exercise was conducted in consultation with members of Anguilla's government Department of Environment (DoE) to develop a refined list of benefits for inclusion. The prioritisation is summarised in **Table 1.1** (see **Section 5** for recommendations on extending coverage). The Anguilla NCA workbook provides an asset-service matrix for the prioritised benefits, which helps to define the scope of the account (Scope Tab).

Table 1.1: Prioritisation of benefits for inclusion in the initial natural capital account

Category of service	Ecosystem service	Inclusion	Justification
Provisioning	Food – Subsistence fisheries	Yes	Combined and included as 'Fisheries'. An important source of nutrition and revenue for Anguillan fishermen.
	Food – Commercial fisheries	Yes	
	Food – Crops/agriculture	Yes	Included as 'Agriculture', as there is a large opportunity for increased value from this service.
	Raw materials	No	Scoped out due to lack of available data and uncertainties surrounding the property rights for extraction activities that occur.
	Medicinal values	No	Was not considered for the account due to lack of data.
Regulating	Coastal protection – Storm surge prevention	Yes	Included as 'Coastal hazard' protection'. An important benefit as much of Anguilla is vulnerable to impact from the ocean during storm events.
	Terrestrial protection – surface flooding reduction	Yes	Included as 'Terrestrial hazard protection'. An important benefit as much of Anguilla is vulnerable to impact from heavy rainfall during storm events.
	Erosion control	No	Was not considered for the account due to lack of data.
	Carbon sequestration	Yes	Included as 'Carbon sequestration'. An important benefit supported by Anguilla's habitats.
	Cooling	No	Scoped out due to lack of comprehensive data, but benefit (e.g. finding respite from the sun on hot days under a tree canopy, and the effects of evapotranspiration) could potentially be valuable.
	Water quality regulation	No	Scoped out as water is extracted from the underground water lens, with uncertain interaction with natural capital and limited data.
	Windbreak	No	Scoped out due to lack of data, and uncertainty around the scale of the impacts at the national level.
	Buffer – noise, dust	No	
	Air quality – filtering of air by trees/plants	No	
Cultural	Tourism	Yes	A major economic sector for Anguilla which is

			heavily dependent on the natural environment.
	Existence/spiritual values	Yes	Included in the broadly defined benefit of 'Local cultural services' to reflect the benefit deriving from the inherent value placed on the environment by local residents.
	Heritage values	Yes	'Heritage Salt Ponds', as an important aspect of the heritage of Anguilla, and are included as demonstrating the historic interaction with the environment for economic wellbeing.
	Iconic species	Yes	Iconic species are included in the asset register as an important part of the character of Anguilla that indicates the condition of the ecosystem.
	Education and research	No	Scoped out due to lack of data, and uncertainty around the scale of the impact at the national level.
	Historical and archaeological values	No	
Supporting	Primary production	No	Supporting services scoped out as they indirectly provide value through the provision of other benefits which are measured directly; however, they could provide important information if tracked through other formats.
	Nutrient cycling	No	
	Ecosystem protection	No	
	Habitat provisioning	No	

2. Engagement and Capacity Building

2.1 Availability of data on Anguilla

In order to build accounts and estimate the value of Anguilla's natural capital, the assessment must move from a qualitative understanding of the presence and use of the natural environment and ecosystem services, to a quantification of these values. This may require the collection of primary data (i.e. generating new data for the purpose at hand) or secondary data (i.e. already existing data collected for some other purpose), or both. The scope of this project was to build the initial set of accounts with existing secondary data sources, which has the advantage of being much less resource intensive. Through this process natural capital accounts can add value by leading to better collation and organisation of existing data. However, the accounts will also be subject to gaps in available data, a significant challenge in their production. The data collection process was initiated through contact with the Department for Environment, who undertook significant work to identify sources and compiling secondary data for the accounts. The following government bodies contributed to the data collection process:

- Anguilla Department of Environment;
- Anguilla Department of Statistics;
- Anguilla Department of Fisheries and Marine Resources;
- Anguilla Tourist Board; and
- Anguilla National Trust.

A long term aim of the project is to embed natural capital accounting in government data collection and reporting, and furthermore in the policy and planning process. This makes it critical to engage people who will work with these tools early in the process to find the most appropriate government body to eventually have responsibility over the process (i.e. the statistics departmental with support from other departments for data provision).

By drawing on the resources provided and conducting additional desk-based research, as well as making use of GIS and Earth Observation analysis to supplement the data available, a sufficient data set was built with which to develop the initial account. This data set can be improved with more direct sources and regular updates, as discussed in greater detail in **Section 5**.

2.2 Data collection for the natural capital accounts

As previously indicated, natural capital accounting should be viewed as a process as well as a product. Data collection activities are an important part of this process, and should aim to:

- Collate all relevant data that are collected for a location into a single data set;
- Suggest additional areas where data collection would be valuable;
- Report collected data in a consistent format;
- Ensure data are regularly updated; and
- Embed data analysis directly into policy and planning (i.e. through natural capital accounting).

Some of these elements are already present in data collection activities that occur for a number of purposes across Anguilla. However, data are often separately stored resulting in a lack of overall understanding of what other government departments' or organisations' data collection activities are addressing. This could be addressed through widespread adoption of the recently developed metadata catalogue and cross governmental data portal.

The initial account, as described in greater detail in **Section 3**, is a first attempt at drawing together a number of different data sources into a national natural capital accounting framework. In doing so they provide an outline as to how a number of benefits can be measured and valued with currently available data. This demonstrates a process by which different data sources can be used to produce a consistent set of accounts. It also demonstrates current limitations of the process, which should be addressed to improve future iterations of the accounts.

2.3 Engagement with the insurance industry on Anguilla

For Anguilla, natural capital benefits include resilience to natural disasters and extreme weather events, like storm surges and surface flooding. The value of this benefit can be measured through protection from damage to buildings and other physical infrastructure on the island. Better measurement of this benefit in the NCA provides an evidence base to support investment in natural capital. By investing in natural capital and encouraging its appropriate management, Anguilla's vulnerability to extreme weather events can be reduced, avoiding some future damage by reducing risk and building resilience.

In 2017 Anguilla and its inhabitants sustained EC$ 880 million in total damage costs from Hurricane Irma, which had a direct impact on the insurance industry (ECLAC, 2018), which may then be passed on to consumers through increased premiums. A better understanding of the financial cost of this damage, as brought together through the NCA process, can help provide evidence to support a case for investments to reduce damages in the future.

Engagement with the insurance industry on Anguilla is vital to develop a greater understanding of the impacts of Hurricane Irma through insurance industry data. Doing so can also introduce natural capital accounting to the insurance industry and demonstrate how they can benefit from the evidence provided and future investment in natural capital as a means of avoiding damage. Natural capital accounting can facilitate the better management of risk and inform the development of more accurate premiums.

With help from Anguilla's DoE, insurers on Anguilla were identified and contacted via e-mail to provide a briefing note explaining what natural capital accounting is, how it can help the insurance industry and how the insurance industry can contribute to the project. Where receptive, further engagement with stakeholders from the insurance industry was conducted. Of 12 insurers originally contacted, three were interested in taking part in the project, whereby eftec conducted telecon calls with relevant members to discuss the impacts of Hurricane Irma on Anguilla and the scale of damages. Follow-up questions were sent via e-mail after the calls, along with an invitation to have a face-to-face meeting with the project team in March 2019. A key finding from the engagement was that the main cause of damage on Anguilla was from wind and debris, which resulted in structural damage such as torn roofs and broken windows, and not necessarily sea surge and surface flooding.

Five meetings were also held with representatives of the insurance industry in Anguilla. These were conducted as face to face meetings with branch managers or other employees from five different insurance providers. There was a good degree of engagement from most of those met, though there was some scepticism on the relevance

of NCA to the insurance industry expressed by a minority. There appeared to be an intuitive understanding of the benefits from natural capital, but the ability to quantify these benefits to provide evidence for the insurance industry was largely a new concept.

Three potential uses of the evidence provided by NCA were raised, with supporting points:

Adjustments:

- The evidence generated could be used to adjust premiums and deductibles. This is currently done with factors such as the presence of beachfront and other physical characteristics. Adjusters have experience adjusting for risk, but do not necessarily have expertise in environmental factors, such as natural capital, and therefore could use a better understanding of the impact that they have informed by the data provided in an NCA.
- Potentially, it could be made a pre-condition at the point of development application that environmental assets must be protected to maintain insurance coverage but would require a high degree of confidence in the data.
- Data would need to be understood and adopted by head underwriters and re-insurers which are generally based off-island, either in regional headquarters or head offices in cities such as New York and London. While risk is assessed locally, it is done in consultation with underwriters who may determine what does or does not constitute a risk adjustment factor.

Uptake:

- The evidence provided by NCA could also help demonstrate to people where insurance could be beneficial, as even after recent hurricanes, many people still feel that insuring their property was not necessarily relative to the cost. This is seemingly due to a combination of 'overconfidence' that they are not at risk, but also because the rates are set too high to be realistic for many. This is driven by high re-insurance rates, which are based on regional risk perceptions, rather than being island specific. This ignores local nuance, for example the building code in Anguilla is stronger than many islands, in part because more concrete is used, and so damage is reduced, but as Anguilla is a relatively small market to re-insurers, this does not factor in to the re-insurance rates. Likewise, if a hurricane hits another island in the region, it will likely affect Anguilla's rates, regardless of the actual impact.

Re-insurers:

- Rates are largely determined by re-insurers; however, they don't look at geographical locations at a refined scale, so it is often the case that all of Caribbean is treated as one geographical location in terms of risk and rates. Premiums are also adjusted based on events that happen in other parts of the region, or even other regions globally, such as trends in weather patterns, by re-insurers, while retail insurers consider local context and information.
- This potentially points to there being an opportunity to influence re-insurers, and therefor rates, with evidence from NCA. Focus could be placed not only 'downward' to influence customers, but also 'upwards' to influence re-insurers. This would require being able to go to insurers and re-insurers able to demonstrate the use of NCA supported evidence to reduce risk, such as in the better development location decision-making, and natural capital maintenance for protection. If this led to adjusted rates which more accurately reflected risk, it could act as a financial incentive for better environmental management and decision making.

Independent of NCA, several people expressed the sentiment that the government needs to make appropriate environmental legislation and strongly enforce it, rather than being influenced by the requests of the tourism sector which brings in considerable money. The general consensus seemed to be that NCA could be a good thing for Anguilla, and potentially for the insurance industry specifically, and there was a willingness to participate further if or when more information, or useable data, were available.

3. Benefits from Natural Capital in Anguilla

This section provides a general overview of each benefit, and the available data and approach used to quantify their physical flow and monetary value. The accounting spreadsheet[2] presents the methodologies employed to derive the physical and monetary value for each benefit in detail transparently. The total volume and value of each ecosystem service, estimated using methods described below, are shown in **Table 4.1**. Monetary values were converted from US$ to EC$ using a rate of 2.70[8], from EUR to EC$ using a rate of 3.06[9], and from GBP to EC$ using a rate of 3.63[10], and adjustments for gross domestic product (GDP) or purchasing power parity (PPP) where necessary.

In general, the methodologies adopted are designed to make use of existing data and be straightforward to replicate to ensure that data are generated consistently over time. While they should be revisited and revised as better data becomes available, the approaches adopted can act as a baseline to build from year on year. For each service, data needs to improve on the assessment are also noted.

3.1 Fisheries

The natural capital resources of Anguilla's marine ecosystems provide habitat, feeding grounds, and nursery sites for a wide variety of marine life. This, in turn, provides the residents of Anguilla with sustenance as well as economic opportunities through commercial fisheries. Once caught, fish (assumed in this report to refer to all edible sea life) are sold for the export market, sold and traded domestically both formally and informally, and consumed by both the tourism sector and for subsistence. The inclusion of fisheries in the accounts helps to track the annual value that marine natural capital contributes through this benefit.

Fish catch data, provided by the Anguilla DoE, outlined the total annual catch (in pounds and tonnes), the price per pound (EC $/lb) and total value of annual catch (EC $) in 2017, broken down as follows:

- Caribbean Spiny Lobster (*Panulirus argus*);
- Caribbean Spotted Lobster (*Panulirus guttatus*) – no catch data provided;
- Conchs - although the species of conch was not stated, catches of conch were designated as queen conch (*Strombus gigas*), as this is the only species of conch considered to be commercially important (Department of Fisheries and Marine Resources, 2015), and due to the predominance of this species in Caribbean catches (Ramdeen et al., 2014);
- Reef Fish (mix species);
- Snappers;
- Other small coastal pelagics – no catch data provided;
- Small Pelagics (mixed species) – no catch data provided; and
- Large Pelagics (mixed species).

Note that the fish annual catch data for 2017 were the most up-to-date data available and were considered a

8 See: https://www.xe.com/
9 See: https://www.google.com/search?rlz=1C1GCEU_en-GBGB821GB821&ei=p4GbXMThLqC81fAPyKWAuAs&q=eur+to+ecd&oq=eur+to+ecd&gs_l=psy-ab.3..0i7i30j0i7i5i30j0i7i5i10i30l3.172782.173868..174046...0.0..0.79.417.6.....0....1..gws-wiz.....0i71j0i7i10i30j0i10j0i8i7i10i30j0i8i7i30j0i5i30j0i8i30j35i304i39j0i13i5i30.MwgxLwgIfOc
10 See: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/768556/average-year-to-december-2018.csv/preview

satisfactory proxy for the 2018 account. Data were not provided on how, once landed, fish is distributed, traded, and consumed. As such, the estimations of Ramdeen *et al.* (2014) were employed as follows:

- Total reported catch only represents 40% of actual catches made within the Anguilla EEZ, with the remaining 60% likely caught for subsistence and shadow market activity;
- Of total reported catch, 10% of finfish was exported; and
- Of total reported catch, 10% of lobster was exported.

It was also assumed that queen conch is not caught for export, due to the species protection under Appendix II of CITES legislation (CITES, 2017), for which only two merchants have the appropriate permits and are known to not utilize their full quota (Department of Fisheries and Marine Resources, 2015).

These assumptions were applied to the total catches by species to calculate the total domestic, export and subsistence quantities by species. The price per species, uplifted to 2018 values, were then applied to calculate the total annual value per species.

Data needs: Further data requirements include the breakdown of how fish is traded and consumed once landed (for example, what proportion is exported, what proportion is sold domestically to households and the tourism sector). Furthermore, prices in line with these shares would be beneficial, as this would improve the assumption that all fish, whether traded internationally or domestically, receive the same price. An estimate of catches made by foreign fleets within the Anguilla EEZ (such as St Martin) would also more accurately reflect the real value of fish catches that can be attributed to Anguilla's natural capital resources; likewise, an understanding of whether any fish reported by Anguillan fishers are actually coming from other waters would help to more accurately reflect this benefit.

3.2 Agriculture

Natural capital stock encompasses healthy, fertile soils and hydrological systems which form the basis of agriculture, which in turn provides for sustenance as well as commercial opportunity. Initial desk-based research suggested that the agricultural sector of Anguilla represents 3% of GDP – generated through small quantities of tobacco, vegetables and cattle raising (Central Intelligence Agency, 2019). However, there is potential for its growth, and it could become an important factor for the future self-sufficiently of the currently import-dependent island, dependent on other limiting factors such as water availability and encroachment on other natural capital assets. It therefore merits inclusion in the national natural capital accounts to help track growth in the contribution natural capital makes through agricultural year on year.

Agricultural produce data on total annual yield (tonnes) and price per pound (EC $/lb) was provided by the Anguilla DoE for 2017, and again is considered a satisfactory proxy for the 2018 account. 28 key types of produce are identified:

- Beets
- Broad beans
- Cabbage
- Carrots
- Corn (maize)
- Cucumber
- Egg plants
- Limes
- Mangoes
- Onions
- Papaw
- Pigeon peas

- Pumpkin
- Sorghum
- Sweet ground
- Sweet peppers
- Sweet potatoes
- Tomatoes
- Yams
- Lettuce
- Kale, thyme, parsley, celery
- Chives
- Watermelon
- Cassava
- Broccoli
- String beans
- Others

The annual yields of individual produce were first converted to pounds (lb), and then valued at the market prices per lb, by category, to be consistent with locally used metrics as reported in provided data. Prices were then uplifted to 2018 values and summed to calculate the total annual flows.

Data needs: Although this method is relatively robust and there is confidence in the results, the methodology can always be improved with more refined data. These could include total annual yields and prices projections, or trends from which averages can be calculated or trends identified. Data on subsistence agriculture, such as from private gardens, could also be added in to the calculation for this benefit.

3.3 Tourism

Data on the arrivals by visitor type (overnight tourist, excursionist and cruise passenger), tourist length of stay, expenditure by visitor type and main activities undertaken by visitors on Anguilla were provided by the Anguilla DoE. On interpretation, it was assumed that 'cruise passenger' referred to cruise participants who arrive at Anguilla but do not alight from the ship, and as such were excluded from analysis. 'Excursionist' was assumed to refer to cruise participants who do alight from the ship and interact with the island, and 'overnight tourist' was understood to refer to the more conventional visitor, not associated with a cruise visit.

To calculate, the number of tourist arrivals was applied to the average length of stay to produce total tourist nights. The number of participants in individual activities was divided by the total number of participants in all activities, to estimate the proportion of total activity participation accounted for by each activity. This proportion was then applied to the total tourist nights, to derive an estimate of the total tourist nights by each activity[11]. Total tourism expenditure was divided by total tourist nights to produce an average expenditure by night. This was then applied to the tourism nights by activity, to estimate the tourism expenditure attributable to each activity[12].

To determine the value that the natural environment contributes to this wealth creation, a 'factor of ecosystem dependence' score was applied for each activity, based on the following scale as applied by the Wolfs Company (2016):

- **25%** - These activities are slightly dependent on local ecosystems, but degradation of the local ecosystem

11 This approach is an approximation for the sake of deriving an estimate of the overall importance of each activity in motivating the visit. The approach implicitly assumes that the proportion of visitors that participated in an activity is equivalent to the overall importance of that activity in motivating the visits. Despite the limitations of the approach, it was considered the best way to use the available data.

12 Note that there may be some overlap between the approach to this benefit, and that of other benefits where expenditure includes elements that might appear in the data for those benefits, resulting in double counting. For example, if tourists consume fish sourced from local fisheries, this could appear both as tourist expenditure and fisheries revenue. This could be further assessed with additional data and research but is not thought to be material relative to the overall value of tourism.

would not affect the experience of these activities very much.

- **50%** - These activities are partly dependent on local ecosystem, degradation of the local ecosystem would have a moderate effect on the experience of these activities.
- **75%** - These activities have a very high level of interaction with the natural environment and the experience of the activity is almost fully dependent on the local ecosystem. Degradation of the local ecosystem would have a great effect on the experience of these activities.
- **100%** - These activities are 100% dependent on the local ecosystem, for example: diving and snorkelling are totally dependent on the local coral ecosystem, without a healthy coral ecosystem the activity will not take place.

For each of the main tourist activities, **Table 3.1** factor of ecosystem dependence was identified from the definitions above and applied to the respective expenditure:

Table 3.1: Factor of ecosystem dependence of tourist activities

Activity	Factor of ecosystem dependence
Swimming/other activities	75%
Sunbathing / relaxing on beach	50%
Boating / Sailing / Watercraft	75%
Scuba diving	100%
Snorkelling	100%
Fishing	100%
Golfing	50%
Visits to offshore cays	100%
Horseback riding	50%
Art galleries / studio	0%
Museums	0%
Archaeological sites or ruins	50%
Bird sanctuaries / ponds	100%
Hiking / Nature trail	100%
Garden / botanic displays	50%
Carnival / boat racing	50%
Music festival (moonsplash / reggae)	0%
Bars / nightlife	50%
Festival del Mar	50%
Anguilla Lit Fest	0%

Data needs: The approach undertaken in this account has several limitations that would be improved with more accurate and robust data. The value of 'cruise passengers' has not been explicitly included in the account, primarily due to data limitations and a lack of understanding on how much is actually spent on island by ship-

based visitors. Further research is required to identify the type and value of utility that these visitors receive from the cruise ship experience including excursions, and the proportion of this value that can be attributed to Anguilla's natural capital. There is also indirect expenditure that can be attributed to cruise visitors, for example through replenishing supplies, but it was not possible to include this aspect within the account due to data limitations. A portion of these values should be accounted for already where they fall under other benefit categories such as agriculture and fisheries.

In addition, although some excursionist expenditure data were provided, they have not been included in the account due to uncertainty in representation, and relatively small values compared to overnight tourists. Future iterations would benefit from an understanding of the activities undertaken by these visitors, and a more detailed breakdown of expenditure. Relating to overnight tourists, more detailed and robust data would improve the accuracy and reliability of the account, for example as collected through a more detailed tourism departure survey.

3.4 Local cultural services

'Local cultural services' is a relatively broad term and encompasses a wide variety of cultural benefits that natural capital provides to local residents. This can include opportunities for physical interaction with the natural environment such as recreation, as well as the non-use value Anguilla residents gain from knowledge of the existence of the variety and health of habitats on the island. However, while the tourism sectors' dependence on the environment is well acknowledged, local cultural and recreational use of the environment is less understood.

Initial research and anecdotal evidence suggested that cycling, sailing and beach cricket are popular recreational activities on Anguilla, from which clear links with natural capital can be observed. As such, several organisations (including the Caribbean Sailing Association, Anguilla Sailing Association, Anguilla Youth Sailing Club, Leeward Islands Cricket Board, and the Anguilla Cycling association) were contacted with requests to share data. Unfortunately, no responses were received. Furthermore, the informal nature of beach cricket makes it a difficult activity to quantify through appropriate boards and organisations. As such, we were unable to value the local cultural services in terms of these activities.

Instead, the approach to valuing this benefit applies a transfer value for the general Willingness to Pay (WTP) for cultural and passive use values taken from a meta-analysis of coastal and estuarine ecosystems (Ghermandi *et al.*, 2009). The value was adjusted to reflect the relative income per capita at Purchasing Power Parity (PPP) in Anguilla (IndexMundi 2019a, 2019b), and applied to the total resident population of the island.

The valuation of this benefit also draws on data provided by the Anguilla National Trust, on local resident attendees of two tours operated by the trust. Prices for these tours, which were found online[13], were applied to the number of tour attendees to produce total annual revenue. A proportion of the total value of the tours that can be attributed to natural capital, referred to as the factor of ecosystem dependence, had to be assumed, and was based on the number of natural capital sites visited per tour as a proportion of the total sites visited. These values were applied to the total annual revenue, to produce the total annual revenue attributable to natural capital.

Data needs: Although transfer values are a widely accepted method of non-monetary valuation in the academic literature, the value applied in this study is a generalised value. As such, the study would be improved through

13 See: http://www.axanationaltrust.com/tour/

use of data more specific to Anguilla, and the habitat types and cultural preferences of local residents. In future iterations it may also be possible to value cycling, sailing and beach cricket as important cultural activities. This will involve retrieval of data from the respective associations, or the undertaking of surveys to identify and count the participants of these activities.

3.5 Heritage (Salt ponds)

The salt industry was once one of the most prominent industries in Anguilla, made possible by several salt ponds[14] on the island into which sea water would percolate and evaporate[15]. The heritage of this industry remains very visible on the island, with some of the ponds forming prominent features of the landscape.

A simple mapping exercise was undertaken by Viridian Logic, to identify whether historical features existed around the salt ponds, to establish which ponds were likely to accrue heritage benefits. Due to the limited data available, this was qualitatively broken down into 'many' features, expected to produce heritage value benefits, or 'few' features, expected to produce very little heritage benefits. Of the five ponds examined, Road Salt Pond and West End Pond were identified as having 'many' features.

A buffer was applied to each pond to identify the number of buildings within 200m[16], to estimate the number of households for which the heritage benefit accrues as a result of being able to appreciate the heritage quality of the salt ponds from homes or by easily interacting with the ponds on a day-to-day basis. This is a broad approximation to account for the population mostly like to interact with, and therefore be aware of, these heritage features on a regular basis, although in reality the heritage value could be appreciated by all residents, or visitors, of Anguilla to some degree. **Figure 3.1** shows the output from the mapping exercise. Note that, as well as the heritage benefit discussed here, the salt ponds also lead to other natural capital benefits, including resilience to storm surge (discussed in **Section 3.7)**, and as a tourist attraction, (discussed in **Section 3.3)**.

Data needs: It is recognised that, to date, the historic environment has been poorly represented in natural capital accounts (Fluck and Holyoak, 2017). A short literature review was not able to identify an applicable WTP value which could be transferred into the account as an indicative value. It was therefore not possible to estimate the monetary flows associated with this ecosystem service within the scope of the project. If a per person unit value could be identified, possibly through transferring an appropriate WTP value or through conducting a bespoke survey with local residents, this value could be applied to the physical data on the flow of benefit heritage received by people through use or proximity.

14 Note that 'salt pond' refers to ponds manipulated and exploited for salt, rather than natural saline lagoons also found on Anguilla.
15 See: http://www.aahsanguilla.com/uploads/7/3/7/1/7371196/salt.pdf
16 Although identified as 'buildings' in the mapping exercise, due to lack of data to indicate otherwise it is assumed these are local resident households.

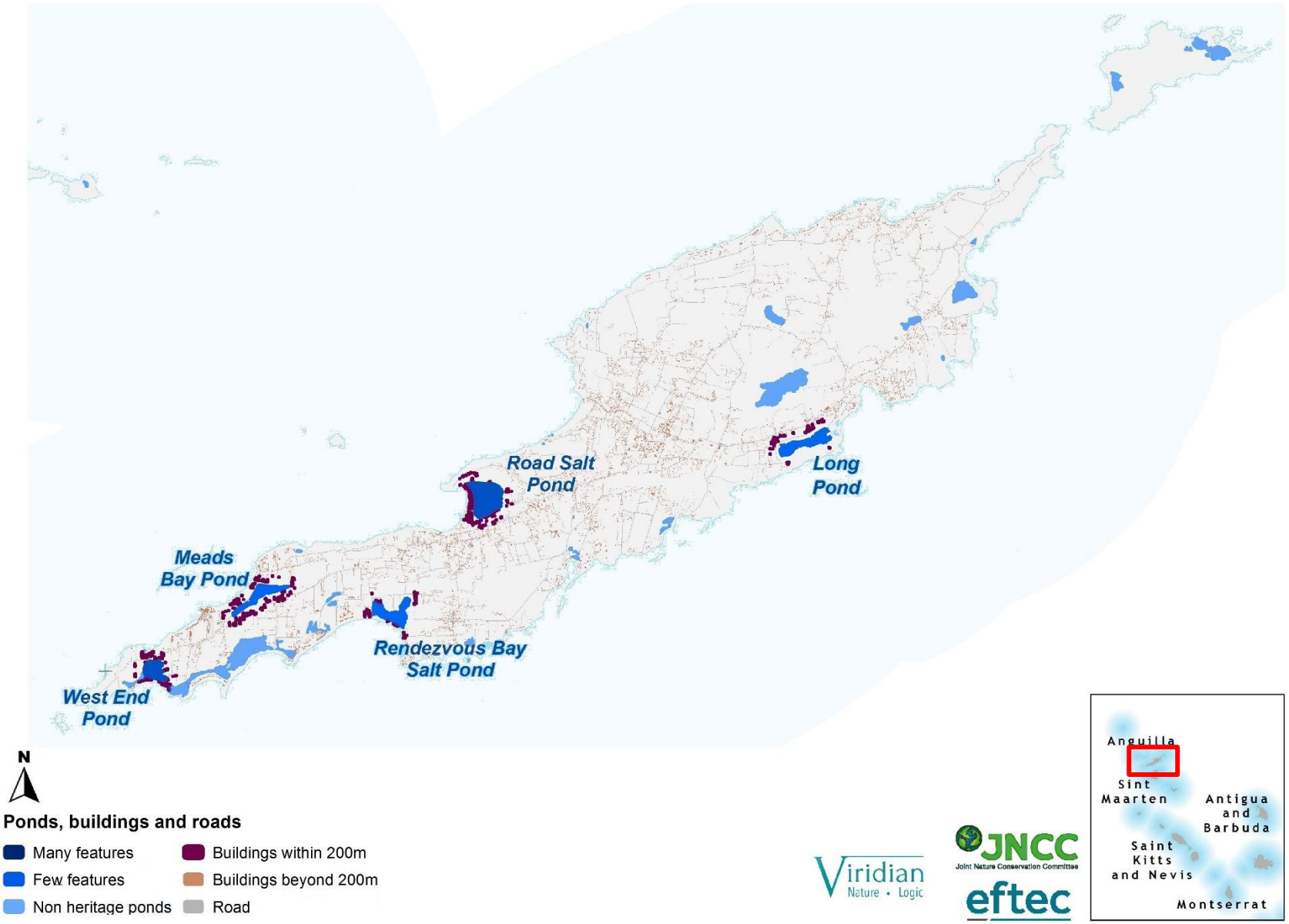

Figure 3.1: Location and grade of salt ponds

3.6 Carbon sequestration and retention

Carbon sequestration refers to the ability of the natural environment to remove carbon from the atmosphere. The flow of this benefit, and its ability to successfully contribute towards the global priority of climate change mitigation, is intrinsically linked with the natural capital stock of stored carbon (**Section 1.4.2**), such that it is not released back into the environment once sequestered.

A literature review was undertaken to identify appropriate carbon sequestration rates by habitat type. Data for many of the Anguillan habitat types were often conflicting. Sequestration rates that were considered robust enough to be applied in the account were identified for three habitats. These rates were multiplied by their respective habitat areas; 5.5tC/ha/yr sequestered from dry forest habitats (Soepadmo, 1993), 54 gC/m^2/yr for seagrass and 174 gC/m^2/yr from mangrove habitats (Alongi, 2012). The annual volume of sequestered carbon was then valued following the BEIS (2018) guidance, by applying the central, non-traded value for carbon, adjusted for GDP per capita. The central non-traded value is applied because the EU Emissions Trading Scheme does not include carbon sequestration from ecosystems. This carbon value increases over time, in line with the expected increasing risks of climate change.

Data needs: This approach identified a gap within the academic literature of appropriate and applicable carbon sequestration rates for the habitats present in Anguilla. As research and literature improves and provides greater understanding into the capacity of differing habitats to sequester carbon, it is hoped more accurate rates can be applied, both to improve the certainty in the habitat types that have been calculated, and to expand to the calculation to cover other habitat types.

3.7 Coastal hazard

The natural capital of Anguilla's marine coastal habitats provides protection to the island from sea surge from storms and other adverse weather events which can cause damage and flooding. Reefs, sand bars, mangrove stands, dunes and even seagrass beds all help to absorb energy and mitigate the impact of waves and rising waters. This can have the significant effect of defending tourism infrastructure, including vulnerable hotels and 33 beaches. These assets are at risk from major storm events if the existing natural capital is not managed properly. The damages Anguilla and its inhabitants sustained from Hurricane Irma in 2017 amounted to EC$ 880 million in total damage costs (ECLAC, 2018).

3.7.1 Hotel closures

The tourism industry was heavily impacted by the landfall of Hurricane Irma, with many of Anguilla's top resorts remaining closed for the remainder of the tourism high season[17]. This was confirmed during the discussions with insurers on the island, one of which identified that the major hotels[18] on the island did not re-open until November 2018. Based on this and further desk-based research, a list of hotels and villas was identified, and cross-checked with those listed as members of the Anguilla Hotel and Tourism Association (AHTA, 2019). The AHTA was also used to determine the total number of rooms of each member, which totalled roughly 940 rooms[19,20].

17 Tourism high season begins in October and continues until mid-April of the following year.
18 Major hotels identified include Belmond Cap Juluca, CuisinArt Resort Golf Course, Four Seasons Resort and Residence, Malliouhana Resort, The Reef by Cuisinart Anguilla and Zemi Beach.
19 940 rooms across 15 hotels.
20 Exact room numbers were not able to be identified for two AHTA members: Shoal Bay Villas and Quintessence Hotel. The AHTA website did not provide the number of rooms for Malliouhana Resort.

Consultation was conducted with the DoE to determine the length of closure of the hotels and villas following Hurricane Irma, from which a list of 13 hotels and villas, accounting for 904 rooms, were identified as having been closed from 1 to 15 months, with three hotels identified as still closed to date. It is estimated that Anguilla has a total of 1,200 rooms, indicating that this sample accounts for roughly 75% of Anguilla's total room stock (TravelWeekly, 2018). In the year following the landfall of Hurricane Irma in September 2017, the hotels on Anguilla lost roughly 4,014 days of business[21]. The results from the mapping exercise completed by the DoE are shown in **Figure 3.2**, where the blue shading represents the severity of ocean storm surge (i.e. the waves). This qualitatively illustrates how the greater amount of coral in the east of the island reduces the amount of damage in higher storm surge zones.

To estimate the avoided hotel closures due to natural capital, for the physical values (i.e. number of lost room days), GIS modelling suggests that damages would be approximately 28% worse if natural capital degraded[22]. These are both one-off values rather than annual values to demonstrate the effect of a singular high impact storm event. An estimate of avoided number of lost room days is produced by comparing the two estimates, which indicates that the existing natural capital on Anguilla prevented the loss of an additional 1,000 days of business. The estimate is presented for one year only as further modelling of frequency of similar hurricane events across the 25-year period has not been undertaken.

The hotel closure impacted not only hotel revenues, but also the Anguillan government through lost accommodation tax revenue[23]. Revenue losses has been estimated as both the total loss of revenue associated with hurricane damages (i.e. including both wind and water damage), as well as the revenue loss associated with water damage specifically. The analysis was undertaken on a hotel-by-hotel basis to reflect room numbers and closure days, and then aggregated. The assessment makes use of hotel performance data published by STR for the Caribbean, specifically the revenue per available room (RevPAR)[24]. In the Caribbean in 2018, revenue per available room was estimated as EC$ 366 (Hotelnewsnow.com, 2019)[25].

Hotel revenue lost per day was estimated as the product of RevPAR and the number of rooms described above. This was expanded to estimate the total hotel revenue lost in the year following the hurricanes by multiplying the per day value by the number of days closed during this time period. The government tax revenue loss then simply represents 10% of the hotel revenue lost during this year due to closure. Water damage proportions were attributed on a hotel-by-hotel basis, after grouping the hotels as having on-shore or near-shore locations. On-shore hotels are assumed to have sustained a higher level of water damage (20% of total damage) than near-shore locations (5% of total damage). These proportions are thought to be reasonable assumptions based on stakeholder feedback, but are unverified and should be verified in future iterations. The proportions are applied to the estimates produced, resulting in estimated revenue loss due to water damage on hotel revenue (in a year) and government tax revenue.

To estimate the avoided revenue loss resulting from the protection offered by reefs, mangroves, and ponds, the

21 It is assumed that closure started after Hurricane Irma made landfall on 6 September 2017. As the natural capital account is an annual account, it looks at a 12-month period, therefore closures are only accounted for until 6 September 2019. Hotels or villas identified as being closed for more than 12 months or 'Still closed' have been capped at 12 months.

22 This is based on Viridian GIS modelling of storm surge zones. It is estimated as the total damage costs in the degraded scenario, divided by the total damage costs in the baseline (with natural capital) scenario. This percentage can be adjusted in future iterations to reflect better information and data. This is subject to change over time but will depend on having confidence in the underlying model. The change in damage costs between the two scenarios has been used as it captures the change in both the depth and extent of the modelled hurricane damages.

23 Anguilla has an accommodation tax rate of 10% (Government of Anguilla, 2019b).

24 RevPAR is estimated as the product of average daily rates and occupancy rates (HotelNewsNow, 2019).

25 Note that this is a regional figure that is being applied to Anguilla. The estimate is based on a survey of 1,900 hotels in the region accounting for 250,000 rooms. The full STR report is accessible for hotel and tourism association members only, therefore Anguilla specific rates were not accessible to the study team.

monetary values (i.e. hotel revenue lost in a year and accommodation tax revenue lost)[26] are annualised based on an assumption of storm frequency. The underlying GIS analysis has modelled a low-probability event, similar to the scale of Hurricane Irma and Maria (i.e. Category 4 or 5 at point of contact with Anguilla. How often storms of this scale will occur in the future is still not known, so an assumption of once every 10 years has been made. This can be adjusted in to future to reflect better modelling and information, along with taking into consideration the impacts of climate change.

To estimate the expected revenue loss due to water damage that arises if natural capital degrades the same 28% proportion is applied to the annualised values. In doing so, the avoided revenue loss is estimated by comparing the monetary values with the current state of natural capital and the values produced assuming damages are 28% worse, resulting in an expected avoided loss of hotel revenue, due to water damage, of roughly EC$ 555,500. This estimate reflects risk and is contingent upon the assumed storm frequency (i.e. probability of occurrence). The estimated avoided loss of hotel revenue due to water damage is equivalent to approximately an avoided loss of 339 full-time equivalent (FTE) employees in the tourism and travel sector on Anguilla. The estimated avoided loss in FTEs is based on estimates of the direct employment contribution in travel and tourism on Anguilla in 2018 (World Travel & Tourism Council, 2018) and the ratio between direct employment and direct FTEs from the UK tourism satellite account (ONS, 2018). Estimates will be more representative if the ratio were based on either the Caribbean region or a similar Island economy in the region (e.g. Cuba, Jamaica) rather than the UK.

26 Note that there is potential overlap in the application of this approach and the approach to tourism, whereby a portion of hotel revenue may be double counted both as tourism-based expenditure and avoided loss due to protection from coastal hazard. This could be further assessed with additional data and research, but is not thought to be material relative to the overall value of tourism.

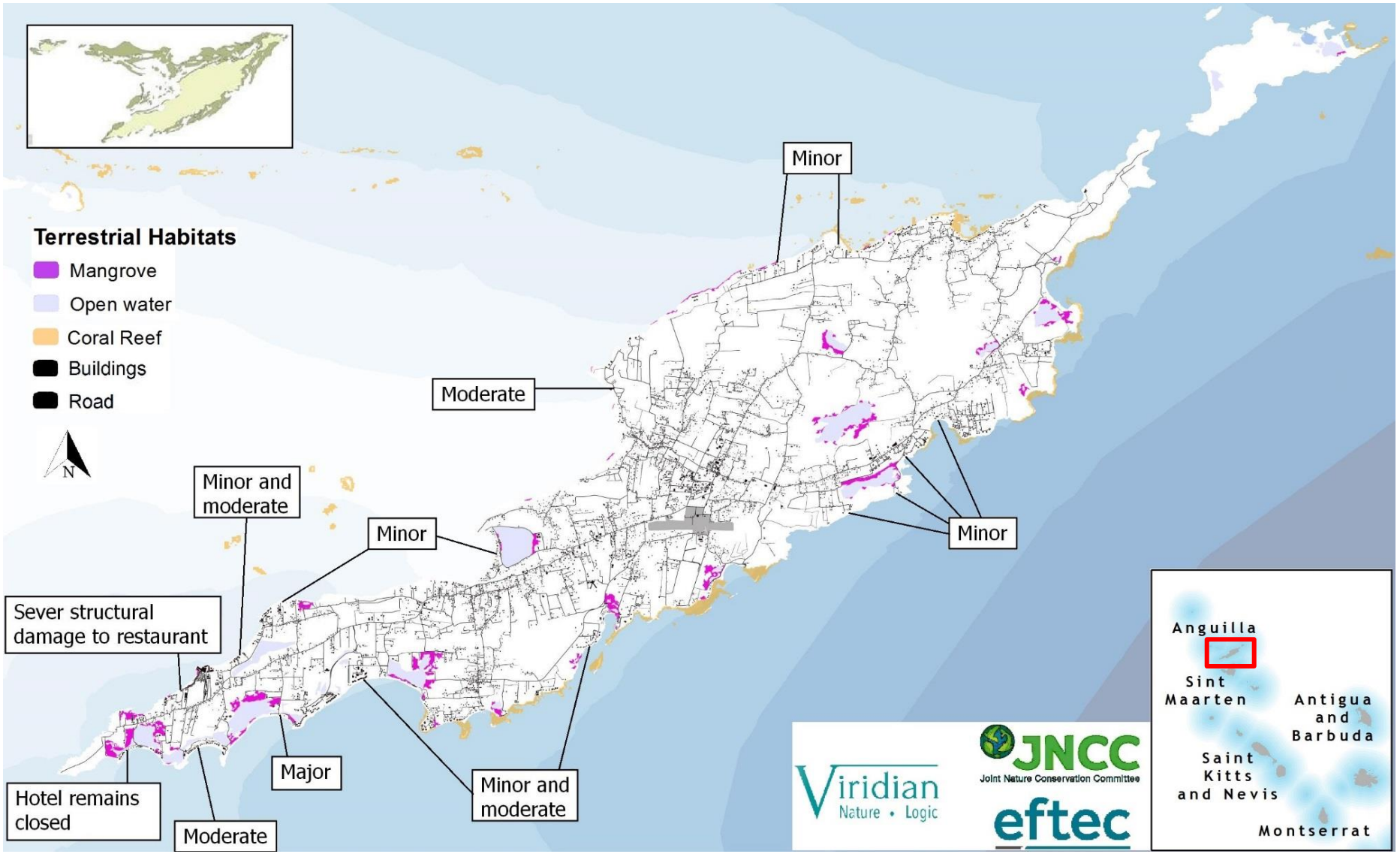

Figure 3.2: Observed damage after Hurricane Irma.

Figure note: Inset map in the top left shows the alternative coral map from Environment Systems which was used in their original modelling. The GIS files have been requested. Changes to the GIS layers used in the modelling will result in changes to estimated physical and monetary values throughout.

3.7.2 Avoided damage to buildings

To assess the value of this benefit in the current accounts, a methodology was adopted from Environment Systems (2017). They developed a generalised model to indicate relative risk using the Spatial Evidence for Natural Capital Evaluation (SENCE) methodology. It focuses on the path of least resistance of storm waves based on conditions on the seafloor, and average annual fetch indicating prevailing winds. GIS is used to score layers on their resistance to surge waves, and a hypothetical weather event is then fed in to the model to indicate the relative risk potential at the coastline. An analysis of terrestrial resistance to movement can then be conducted with data on the risk at the coastline, topography and land cover to produce a terrestrial relative risk potential map.

This data set is then used to model the footprint and inundation level of areas vulnerable to flooding. The vulnerability areas are overlaid with infrastructure maps, to produce a count of buildings impacted by different flood inundation levels, with data on height, size and type of building also inputted if available. This is used to estimate relative damage costs as a function of depth and velocity. Overall risk across Anguilla is displayed in **Figure 3.3**.

The mapping of these modelling results produced storm surge zones, from which the number of buildings and sum of square feet in each zone was extracted[27]. This produces a baseline value of the total square feet of buildings on Anguilla at risk from storm surge. The model is re-run to reflect the impact of natural capital degrading, providing the total amount of square feet at risk from storm surge under this scenario. These are modelled as per-event values rather than annualised values[28]. The avoided damage is estimated by comparing the two measures, which indicates that the existing natural capital on Anguilla protected roughly 96,000 (4%) square feet of buildings at risk from storm surge[29].

To estimate the damage costs, costs of rebuilding and repair were sourced through engagement with insurers and contractors on Anguilla. Through these discussions it was concluded that, in general the cost to Anguillans to rebuild and repair ranges between US$ 90 and US$ 200, per square foot. This range reflects the costs of rebuilding following Hurricane Irma, at which point prices were fluctuating and increased after the hurricane as there was higher demand for contractors (per comms). It was also noted that on average, the cost of repairing cosmetic damage ranges between US$ 5.25 and US$ 11.2 per square foot[30,31]. These prices were used to create a damage cost per square foot for each storm surge zone. The ranges depending on risk level are shown in **Table 3.2**.

Table 3.2: Damage costs per square foot by risk level

27 Storm surge zones were originally provided on a scale from 01-10, which reflected the risk of storm where 0 represents no risk and 10 represents high risk. The zones were grouped into low (Zones 1-3), medium (Zones 4-7) and high (Zones 8-10) classification by the eftec team.
28 To reach an annual estimate further hurricane modelling would be required to estimate storm frequency and thus, damage per event. In this instance, the physical flow represents the damages caused by a large-scale, low frequency, event similar to recent major storms, rather than damages sustained following a range of strengths and frequencies of large-scale storm events which may occur.
29 This, and subsequent figures, should be interpreted with caution as there are discrepancies in the underlying data.
30 Costs will vary greatly, and will depend on market conditions, site conditions, government concessions on imported materials, level of design complexity, season, project requirements, funding and schedule.
31 All costs have been converted into East Caribbean dollars using a conversion rate of 2.7.

Risk level	Damage costs per square foot (US$)	Damage costs per square foot (EC$)
Low	$5.25	$14.2
Medium	$80 - $140	$216 - $378
High	$160 - $200	$432 - $540

The damage cost per square foot is then applied to the total square feet at risk from storm surge, to produce total damage cost estimates at each risk level. The baseline results are shown in **Figure 3.4**. The calculation is repeated using the square feet at risk if natural capital degrades. The total avoided infrastructure damage cost is then estimated as the difference between the baseline natural capital estimates and the degraded natural capital estimates. These estimates are not annual values as they based on the costs associated with Hurricane Irma. The monetary values are annualised based on an assumption of storm frequency, which can be interpreted as expected damage costs. The underlying GIS model has modelled a low-probability event, similar to the scale of Hurricane Irma and Maria (i.e. Category 4 or 5 at point of contact with Anguilla. How often storms of this scale will occur in the future is still not known, so a conservative assumption of once every 10 years has been made. This can be adjusted in to future to reflect better modelling and information, along with taking into consideration the impacts of climate change.

In doing so, the avoided damage costs are estimated by comparing the monetary values of the current state of natural capital to the degraded natural capital estimates at each risk level. Total avoided damage costs across all risks levels amounts to EC$ 9.8 million. This estimate reflects risk and is contingent upon the assumed storm frequency (i.e. probability of occurrence).

Data needs: For hotel closures, the approach relies heavily on engagement with the insurance industry on Anguilla, as well as the assistance from the DoE to provide insight into hotel locations and closures. The estimates can be updated with more information on length of closures (i.e. days) as well as updating hotel room prices. The method is contingent on the role that natural capital plays in protecting coastal areas from storm surge damage. The 28% assumption requires refinement and will depend on further GIS modelling. The valuation approach for building damage requires GIS analysis and the specified data inputs with which to model the impact. The modelling can be updated with the most up to date infrastructure and habitat maps as they are produced. Doing so on a regular basis will track changes in development, coral reefs and habitat cover which can help monitor the change in the risk of damage due to storm surge with changing land use, as well as to identify high risk storm surge areas for future development planning. Property value and damage cost estimates due to sea surge damage should also be updated as available. For both hotel closures and building damage, the assumption on storm frequency can be adjusted when more information becomes available. In doing so, the physical flows can be updated to account for frequency of events of this magnitude. This approach does not take into account the time needed for repairs, the natural capital recovery time and whether storms of this scale will increase in frequency and severity in the future as a result of climate change.

The methodology described in this section are thought to be the best approach available given current data limitations. In future iterations of the account it is possible to overlap the map of risk zones with the hotels damaged, and also the potential tourism values to identify the key areas at risk from damages of similar hurricane events, and where natural capital is able to provide protection.

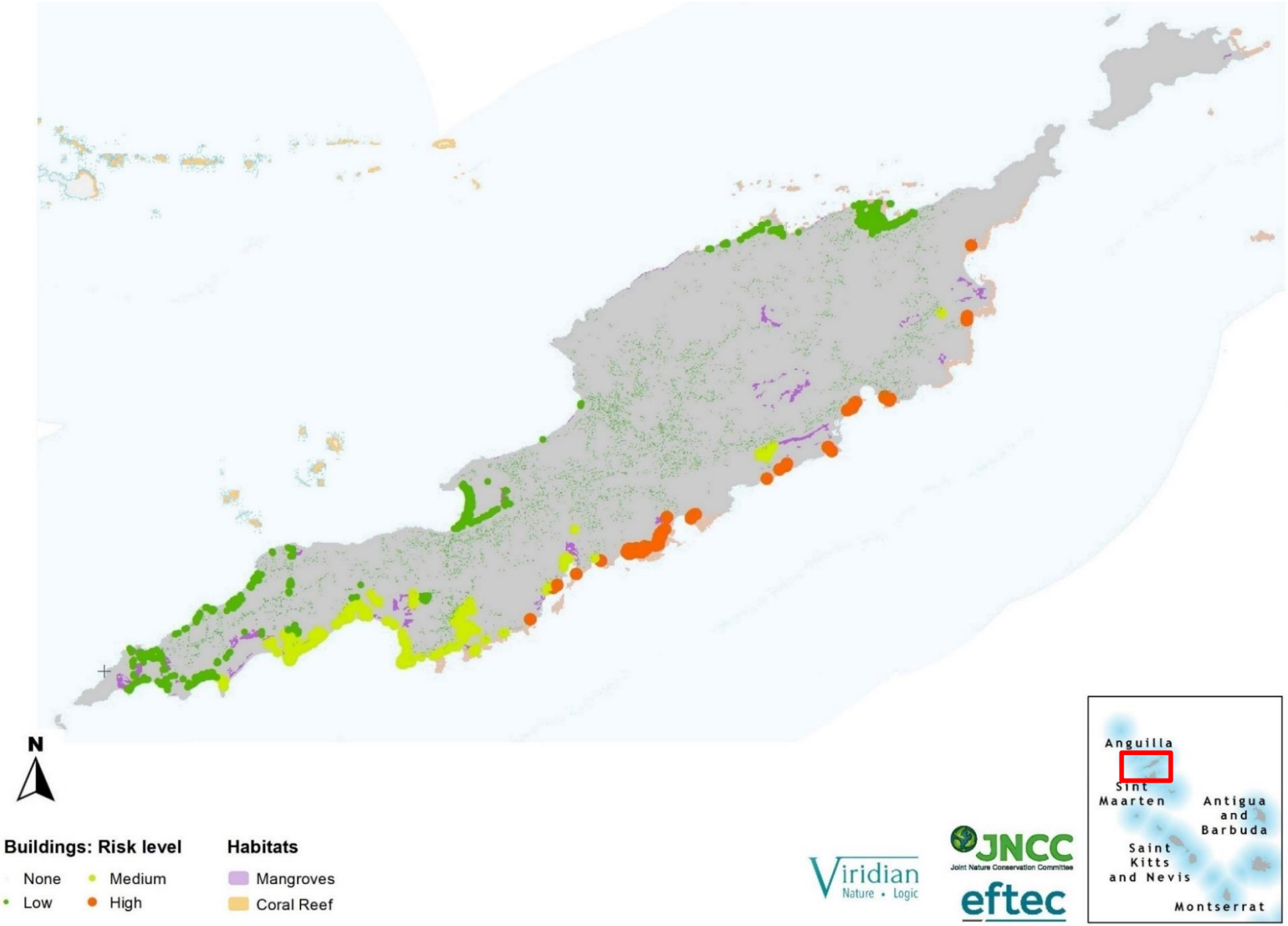

Figure 3.3: Buildings affected by storm surge.

Figure note: Whereas Figure 3.2 shows damages specifically caused by Hurricane Irma, this map shows a more generalised storm surge risk from major storms based on EnvSys SENSE mapping.

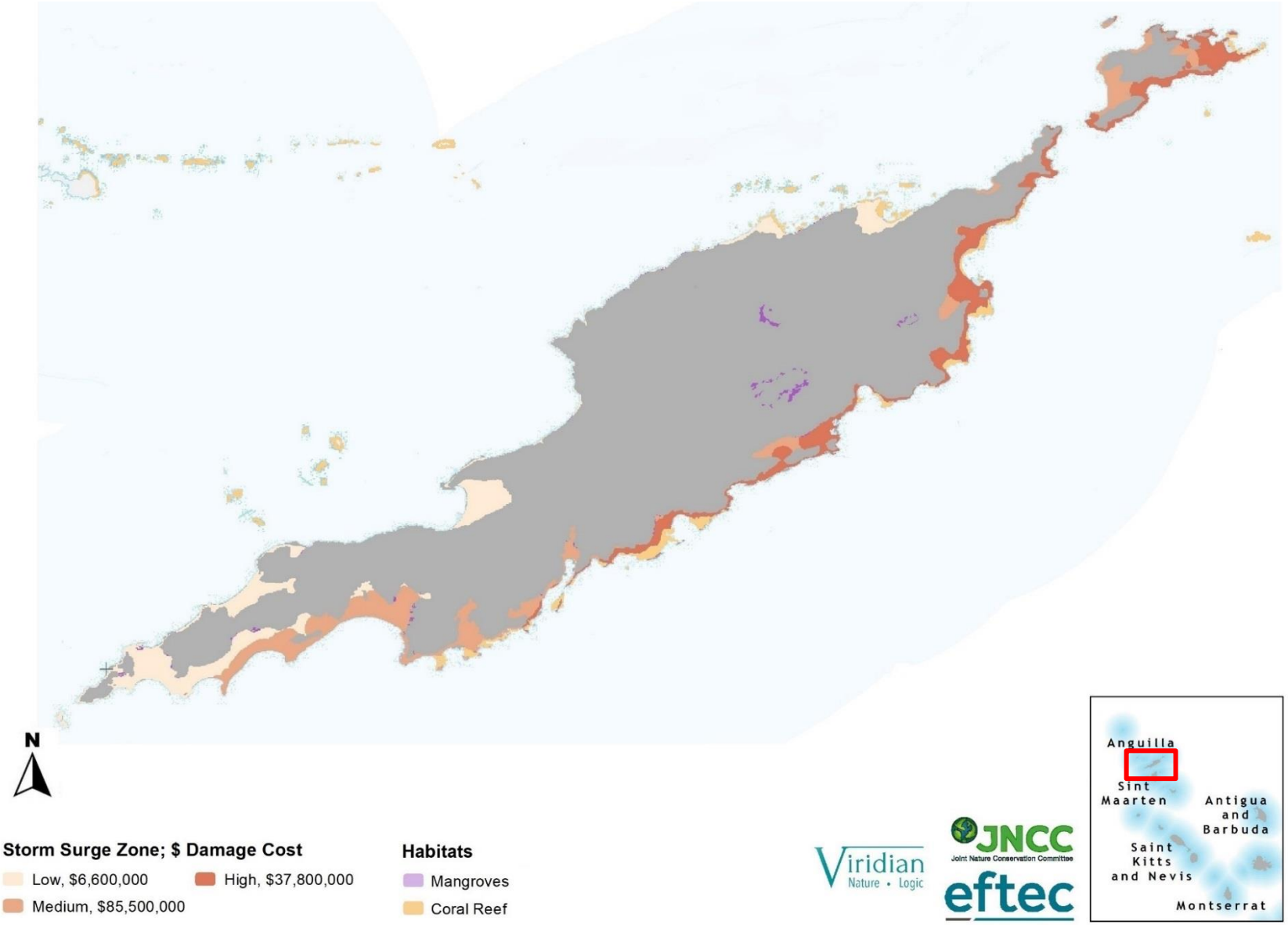

Figure 3.4: Total cost of property damage by storm surge zone.

Figure note: Total costs displayed in map legend is in US$.

Whereas Figure 3.2 shows damages specifically caused by Hurricane Irma, this map shows a more generalised storm surge risk from major storms based on EnvSys SENSE mapping.

3.8 Terrestrial hazards

Terrestrial natural capital can help regulate surface hydrology, reducing erosion and surface flooding during high precipitation weather events. The prevention of erosion contributes to benefits in marine ecosystems by preventing run-off which protects habitats valuable to fisheries and maintaining the aesthetic quality of coastal habitats that attract tourists and recreational users. However, the fisheries and tourism aspects of this service are captured in the assessments of those respective benefits[32]. Additionally, increased erosion may lead to release more carbon into the atmosphere Therefore, the assessment of this benefit is focused more specifically on the avoidance of flood damage from surface flooding.

To assess the value of this benefit in the account, a methodology was adopted from Environment Systems (2017). A vulnerability assessment is conducted using terrain mapping and other available data sets, employing Remote Sensing (RS) and open source data, analysed with GIS and Earth Observation techniques. Contour maps are used to identify areas potentially at risk of flooding with WorldDEM DTM, by effectively 'filling in' areas of low elevation from the bottom up, with land cover data from habitat maps inputted to model the impact of vegetation on the movement of water and propensity to flood. The approach estimates the potential footprint and depth of vulnerable zones in a flooding event. **Figure 3.5** shows the location and depths of these low-lying areas at risk of inundation during heavy rainfall. The modelling produced analysis on the current level of flood mitigation and erosion control provided by the Anguillan landscape, and is also capable of indicating the placement of habitats to increase flood mitigation and erosion control on Anguilla. The outputs of this analysis can be a useful input to land use planning.

This vulnerability mapping can then be overlaid with infrastructure maps, to produce a count of buildings impacted by different flood inundation levels, with data on height, size and type of building also inputted if available, to estimate relative damage costs as a function of depth and velocity. The monetary flow associated with this ecosystem service have not been estimated within this account, however an example of the approach is illustrated in in the 2018 ecosystem services assessment for Montserrat (produced by eftec and Viridian for JNCC and the Government of Montserrat). The mitigation of erosion risk to infrastructure by the natural environment can be measured using erosion flow accumulation data. The mapping of this erosion risk allows it to be compared to the location of infrastructure, such as roads, to measure the exposure of that infrastructure to the erosion risk. This modelling can provide data such as the percentage of infrastructure with an elevated risk level. For this modelling, the extent of infrastructure can be quantified through the number of pixels containing the infrastructure. An elevated level of erosion risk can be quantified based on the number of pixels where erosion risk is a certain factor higher than the average level of flow accumulation in the base year. Consistent measurement of this exposure can provide an indicator of whether erosion risk is changing over time.

Data needs: The approach requires GIS analysis and the specified data inputs with which to model the impact. The modelling can be updated with the most up to date infrastructure and habitat maps as they are produced. Doing so on a regular basis will track changes in development and vegetative cover which can help monitor the change in the risk of damage due to flooding with changing land use, as well as to identify high risk flooding areas for future development planning. Property value and damage cost estimates should also be updated as available. Changing weather patterns should also be incorporated in to the model.

32 Note that there is potential overlap between this benefit and the benefits of agriculture and fishing, whereby a portion of the value of agricultural and fisheries produce may be double counted as avoided losses to these sectors due to protection from terrestrial hazard (i.e. erosion run-off which may negatively impact these sectors). This could be further assessed with additional data and research but is not material in this iteration of the accounts as terrestrial hazard protection is not valued.

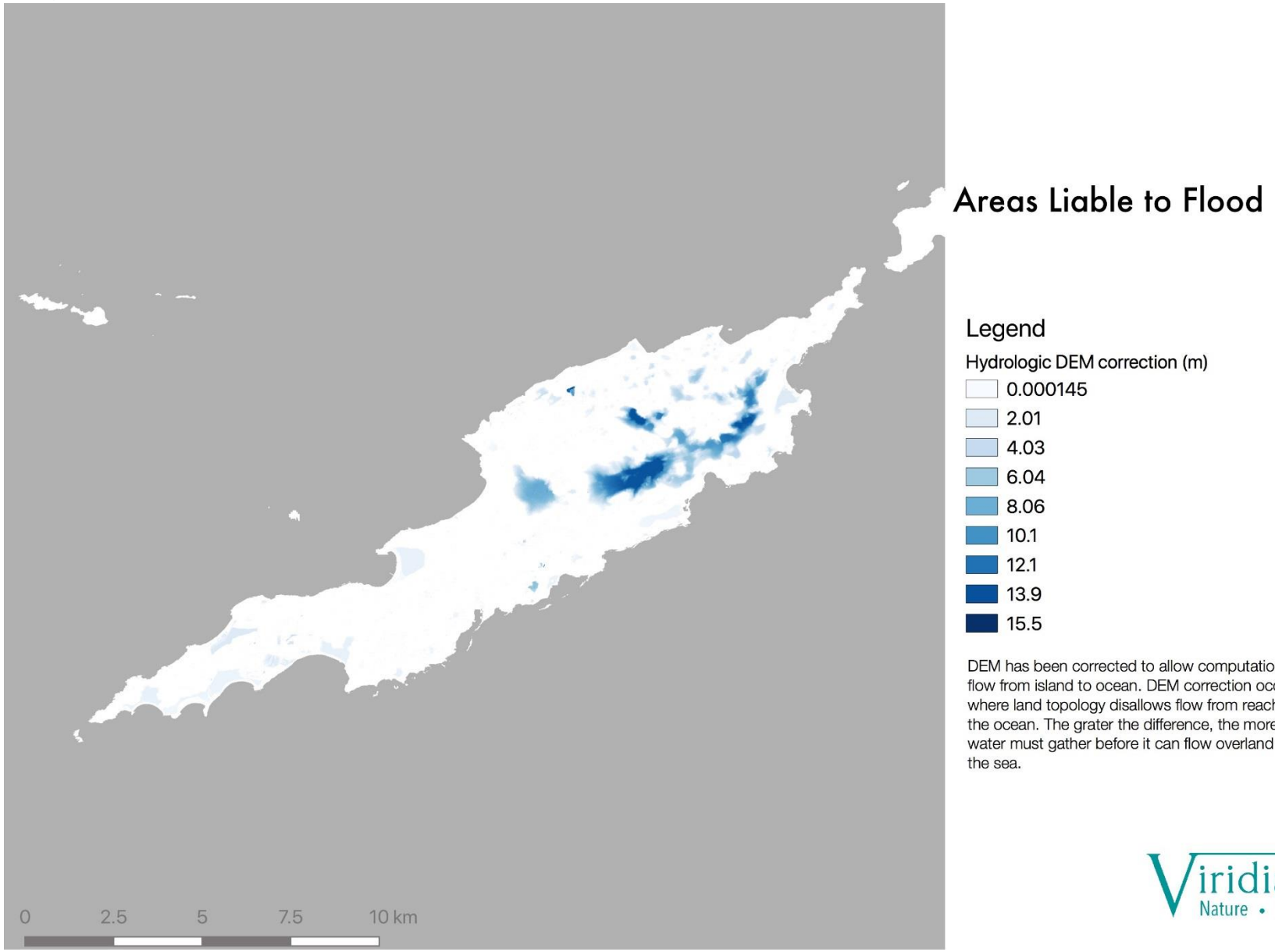

Figure 3.5: Areas liable to flood.

4. Results

4.1 Measurement and Valuation of Benefits

The initial national natural capital accounts demonstrate the considerable value that Anguilla receives from its natural environment. The results from the accounts also give an indication of the scale of the value that natural capital contributes to Anguilla. It is estimated that a significant annual value of EC$248 million is provided by the modelled benefits. A break down for each benefit is shown in **Table 4.1**: the cells are colour-coded to show the robustness of the data as an accurate measure of the full value of each service. This value must be interpreted with the understanding that they are partial results and subject to refinement over time. This represents just a proportion of the total ecosystem services that natural capital provides, as part of an interconnected, interdependent system.

The data in **Table 4.1** are shown in **Figure 4.1** and **Figure 4.2**. Where possible, these associate the services measured and valued with the approximate areas of the environment most important for production. The value natural capital contributes to tourism is the largest, followed by fisheries. This reflects the overall importance of the tourism sector to Anguilla, and the dependence of the sector on the natural environment, serving as justification for investment in preserving and/or enhancing the natural environment as an asset that supports the tourism sector.

A 25-year assessment was also conducted to estimate the asset value of natural capital from each of these benefits. In this account, a time period of 25 years has been applied, in alignment with HM Governments 25-year environment plan. It should be noted that, when following HM Treasury's discounting guidance (2019a), the 25-year asset value equates to slightly over half of the total indefinite stream value. Although an underestimation of the total sustainable asset value, this is in line with the scope of the account and with the wider work for the UK Overseas Territories. To calculate, the annual value for each benefit was projected forward 25 years. For each benefit a simple projection was applied assuming the stable provision of the benefit and its unit value throughout the assessment period. This implies that, unless stated otherwise in **Section 3**, all the benefits were assumed to continue being provided by the environment for the next 25 years, as all are based on renewable ecosystem processes and functions. Other implicit assumptions are also made for the purposes of modelling about socioeconomic characteristics remaining constant, including aspects such as population, visitor numbers, income, and real prices. The results of the 25-year assessment are an overall asset value of natural on Anguilla of around EC$4.2 billion, in 2018 prices.

In reality, both the provision of the benefit and the associated value are likely to vary year on year, based on a variety of factors including internal and external trends in human populations, markets, climate change and the natural environment. However, there is a lack of evidence on these trends, especially over longer time periods, and so in the absence of strong evidence to the contrary, it is reasonable to assume a stable provision and value for the purposes of modelling and producing a value stream. In doing so, it is inherently assumed that the condition of natural capital on Anguilla will remain (at least) at the current level, such that the capacity to provide benefits to society is not eroded. However, this does not mean the benefits are resilient to changes, such as sea level rise or coral bleaching, which may reduce their future value; conversely, it is also possible that provision of benefits, or the unit value of those benefits, will increase over time. As such, the accounts should be updated regularly in order to track change in Anguilla's natural environment over time.
As a result of the limitations discussed, as well as the partial nature of the account, the sum of the annual values and asset values at this stage should be interpreted as providing a broad indication of the total values of individual

services, rather than focusing on the single figure for the overall value of natural capital.

Table 4.1: Overview of Anguilla's natural capital account

Annual Overview	Physical		Monetary		Present Value
	Measure/ year	Units	Baseline (2017/18)	Uncertainty & valuation method	25 years
At May 2019	Annual Value		Annual Value (EC$)		PV (EC$)
Benefits					
Fisheries	2,418,933	lb caught per year	39,342,000	Average price received for total fish caught each year	671,110,000
Agriculture	85,824	lb of agrcultural yields each year	444,000	Average price received for total agricultural yield each year	7,573,000
Tourism	602,575	Total visitor nights	194,359,000	Total visitor expenditure attributed to natural capital	3,315,441,000
Local cultural services					
	867	Anguilla National Trust tour attendees	89,000	Value of Anguilla National Trust tours	1,523,000
	15,045	Local Anguilla resident population	2,829,000	Value of cultural services to local population	50,136,000
Heritage salt pond	575	Number of people living within 200m of heritage ponds			
Carbon sequestration	7,538	Tonnes of carbon equivalent sequestered each year	834,000	Value of carbon sequestered	19,648,000
Coastal hazard protection					
Hotel closures	1,124	Number of avoided lost room days	556,000	Avoided hotel revenue lost in a year due to water damage	9,476,000
			56,000	Avoided accommodation tax revenue lost due to water damage	948,000
Infrastructure damage	96,298	Square feet avoided damage in storm surge zones	9,806,000	Total avoided infrastructure damage cost	167,276,000
Terrestrial hazard protection					
Total Annual Value			248,170,000		4,240,660,000

Level of Uncertaint	Description of Uncertainty
High	Evidence is partial and significant assumptions are made that require further research.
Moderate	Based on assumptions grounded in science and using published data but with some uncertainty regarding the combination of assumptions.
Low	Evidence is peer reviewed or based on published gudiance.

Table note: Low uncertainty reflects confidence that the evidence can support decisions. High uncertainty reflects results that may be inaccurate by more than an order of magnitude. Note that some data may be marked as 'moderate' uncertainty where the data used are themselves accurate, but do not provide a full measure of the services' value (e.g. for hazard regulation).

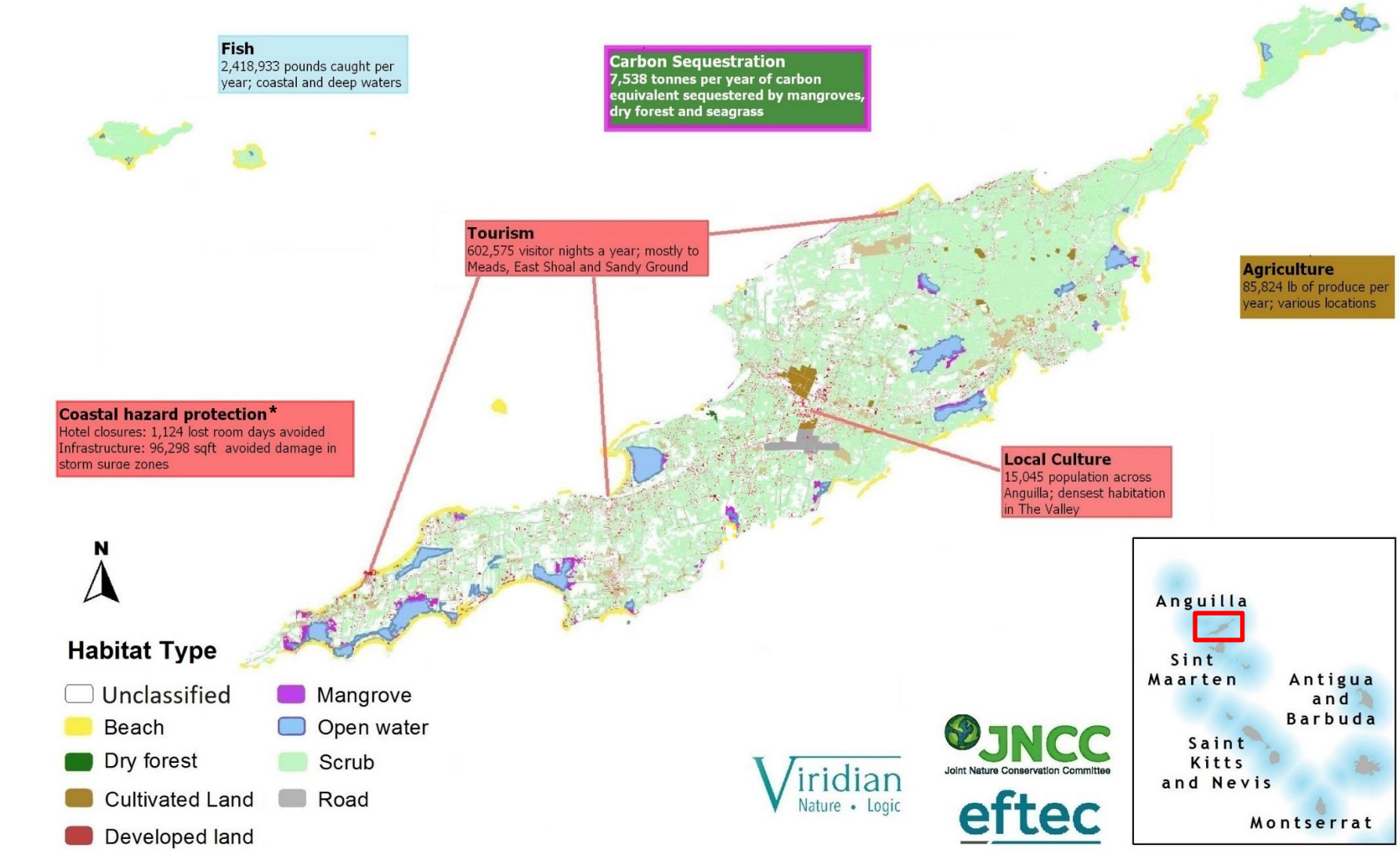

Figure 4.1: Anguilla natural capital account – annual physical flows

Figure note: White text refers to seagrass,

** indicates values are one-off values and are not annual.*

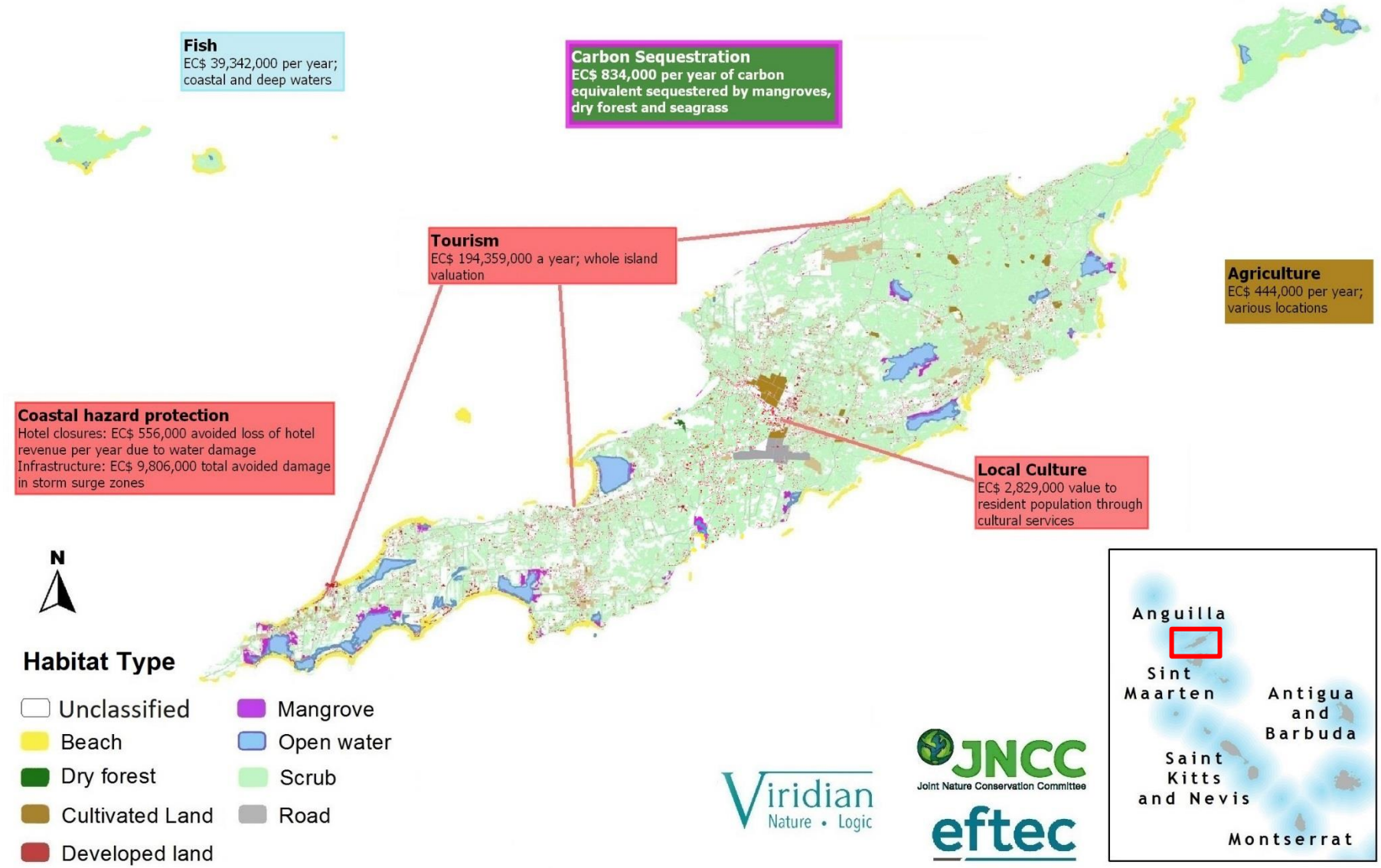

Figure 4.2: Anguilla natural capital account – annual monetary flows

Figure notes: White text refers to seagrass.

** indicates values are one-off values and are not annual.*

4.2 Sources of data

Many potential sources of data and information were identified with which to build the accounts, this study alone draws from the following:

- Government departments and other governmental/quasi-governmental bodies
- Anguilla Department of Environment;
- Anguilla Department of Statistics;
- Anguilla Department of Fisheries and Marine Resources;
- Anguilla Tourist Board;
- Anguilla National Trust;
- GIS
- Surveys (the tourism departure survey)
- Published Anguilla studies
- Published Caribbean-wide studies
- Published meta-analysis
- Insurance industry data

In general, the most direct and easily updateable sources are preferable. It may not be possible, or cost-effective, to update all data every year, but efforts should prioritise data that supports the ability of the accounts to accurately track trends. Much of the data requirements have overlapping uses with other government bodies or organisations. Establishing these links avoids duplication and may create opportunities for joint responsibility.

Furthermore, creating an understanding of how different bodies use data may also build awareness of the types of challenges being faced by different government departments and in different sectors, helping to identify ways to exploit data for different decision-making purposes. For example:

- Fisheries data are collected as economic data for national economic accounts but can also be used by natural capital accounts to demonstrate the value of marine habitats, and by environmental departments to manage fishing effort and monitor pressures on habitats.
- Data collected by the tourism board to assist hotels in planning for and managing the hospitality sector can also be used to track the benefit that natural capital contributes to the tourism.
- Infrastructure maps used for spatial planning can also be used with GIS to help model the protective benefits natural capital provides from sea surge and surface flooding. The subsequent vulnerability maps generated can then feedback into the development planning process and for insurance.

Ideally, as the natural capital accounting process develops much of the data collection can become streamlined or even semi-automated. One potential area of development is increased familiarity and use of GIS tools and Earth Observation. Methods of analysis with remote sensing allow for processing of data reducing the resource requirement for intensive surveying methods. This does not replace the need for people 'on the ground,' but

helps support their efforts and improve the efficiency and quality of the data produced. Linking up GIS/EO specialists with people or organisations capable of supporting, and using, the work would contribute to the natural capital accounts, and likely benefit other potential users as well.

4.3 Use of the natural capital accounts

An aim of this initial natural capital account is to provide a foundation on which to build future iterations. The accounts act as a structure for systematic understanding of the value of the environment and can accommodate and be improved as better data becomes available, and new methods made possible. Establishing the initial accounts initiates a process by which data are collected, shared, and analysed to produce a centralised register of environmental value.

In its first iteration, the account can contribute to the following:

- Provide a foundation for improvements to the Anguilla natural capital accounts, discussed above;
- Demonstrate the significant value of natural capital in supporting Anguilla's economy and society;
- Give planners a clearer picture of how a loss of habitat might impact these benefits, helping them to manage development and preserve the value of the natural environment;
- Make clear to policy makers that decisions which impact the environment can have significant economic and social implications; and
- Justify investing in environmental protection and/or enhancement to secure and/or increase values of ecosystem services.

Although the accounts will develop over time, they can begin to feed in to the policy and planning process and become a regularly consulted source of information in their current format. Specifically, this could include highlighting the scale of value that land-use and development decisions need to take in to consideration. This can be enhanced with increasingly robust and accurate monetary values that could be used alongside other decision support tools such as cost-benefit analysis. Once the accounts have been through several iterations and people become confident updating and using them, they should naturally integrate with, and sit alongside, other national accounts, and become a measure of the value of Anguilla's natural capital's contribution to its overall national wealth. This process can commence with the initial NCA developed by this study, eventually becoming part of a suite of indicators of Anguilla's national well-being.

4.4 Limitations

Specific limitations with each natural capital benefit are discussed in depth **Section 3**, many of which primarily stem from issues around the availability and quality of data. These data limitations mean the results offer an indication as to the scale of values. The uncertainty associated with each measure is indicated by colour coding in **Table 4.1**, and the uncertainties in several key values means that the total estimated values have a moderate degree of uncertainty. Over time, with more robust and additional data, the accuracy and comprehensiveness of the account can be improved. Ideally, the relevant raw data would be collected directly and on an annual basis through consistent processes by the national statistical authority, as is the case for other national accounts and associated indicators such as GDP.

This iteration of the accounts identified nine benefits for consideration, and initial efforts should be aimed at

improving the data and methodologies applied to these benefits. This should focus on those with a large estimated values and/or degree of uncertainty, including:

- **Tourism**, due to the exclusion of cruise passengers, the exclusion of indirect benefits, and a limited understanding of tourist activities and expenditure;
- **Coastal hazard and terrestrial hazard protection**, through further modelling of damage, analysis of damage costs to the tourism sector and insurance implications;
- **Carbon sequestration and retention**, due to gaps within the academic literature of appropriate rates according to Anguilla's habitat characteristics, resulting in a degree of uncertainty as well as an incomplete assessment of the benefit; and

Another limitation is the comprehensiveness of the accounts. While a set of nine benefits is a good starting point, they do not capture the overall value of natural capital to Anguilla. It is expected that some key benefits have been omitted, such as regulation of water supplies and cooling from tree shading. This may be a particular concern if trying to disaggregate or make comparisons between particular habitats or locations, as doing so will be based on an incomplete understanding of value, and so this is not a recommended use of the current accounts. Used on its own, the results will only give a partial view of the value of the Anguillan environment and so are open to misinterpretation, and therefore should be used in combination with other components of the account. Likewise, the accounts are most valuable when used together with other sources of information.

5. Recommendations for Future Iterations

The current national natural capital account lays the groundwork for further development to build upon, so that over time they will evolve and become more refined in regard to how they are built up, and what they are able to do. This section makes recommendations to feed in to this process.

Natural capital extent and condition should be monitored on a regular ongoing basis, and the asset register reproduced annually:

- **Extent** – the extent of ecosystems can be measured through mapping and analysis tools such as GIS and EO, and ecological surveying. These should be updated regularly to measure changes in the footprint of various habitats.
- **Condition** – there is currently a lack of up to date data on the condition of Anguilla's ecosystems, this includes their quality, functionality, presence of species, and overall biodiversity. The health of an ecosystem influences its ability to provide ecosystem services, and thus how much humans are able to benefit from them. Ecological surveying focused on key indicators of condition, aided by GIS and EO analysis, conducted on an intermittent basis to monitor trends in ecosystem health, would help to estimate and track natural capital's capacity to provide ecosystem services.

The nine benefits currently assessed can be updated and improved with better data, specific recommendations for each benefit has been outlined in **Section 3**. These suggested improvements will take time, and therefore need to be prioritised. Based on the values in **Table 4.1**, high priority areas include tourism, fisheries and marine health, and hazard protection which are high value benefits. Improvements to lower value benefits, such as carbon sequestration and agriculture, are of a lower priority to update.

Most improvements are dependent on data collection, therefore some general steps to establishing and improving data collection processes are indicated below. Note that, due to time and cost constraints, it is not necessary that all data must be collected and updated at the same frequency. Rather, this should be dependent such factors as the cost of collecting the data, the speed of underlying changes to be monitored, and the ability to detect these changes through regular monitoring.

- **Conducting regular surveys –** once a survey has been trialled and proven that it is able to deliver quality data, it can be reused regularly. By collecting data in a consistent format, valuable information can be produced demonstrating trends over time. Surveys can be administered in several different formats as feasible, such as online, at point of interest, or by volunteer or student surveyors. Once a survey has been conducted a few times, the knowledge of how to do so will become embedded and it should become easier and less resource intensive.
- **Developing remote sensing capabilities –**Earth Observation offers an innovative new source of data generated in a consistent manner and over repeated time periods. It can provide Anguilla with new information and reduce the resource requirements for collecting existing data. The skillsets required to operate these tools should be maintained and developed for regular data collection and analysis.
- **Creating a register of where data are held –** identifying who holds various datasets is one of the most challenging aspects of developing the accounts. Many different bodies, including various governmental departments, hold valuable data but it is often hard to know where they are located. A central, easily

searchable register of what data exist, what they contain, when they were produced, and how they may be obtained would greatly facilitate the data collection process and help to remove barriers between the various bodies which hold data. Note that all sources used in the accounting process are listed within the account, which could form the beginnings of meeting this recommendation. It is important that collected data are stored in a consistent format and location to facilitate retrieval and use, for example the Government of Anguilla Data Portal[33] which has been agreed to be adopted by the Executive Council is March 2018.

- **Placing authority in one government body –** a single body and authority in Government with the power and responsibility to collect and hold data from across government departments, and from other sources, should produce the accounts in a consistent manner over time. This provides a first point of contact for conducting all types of research that can support the accounts. There work can make us of the online data portal that is easily accessible to everyone.
- **Forming pathways for data transfer** – As these processes are used repeatedly, they become embedded and there should be automated pathways for transferring data through the various tools and networks that are established. If supported, this can become a self-reinforcing system for the collection and dissemination of information. As mentioned above, the creation of the Data Portal[34] has initiated the process of establishing a centralised government data storage system.

Along with continual updates and improvements in data, there are a few other areas of focus that could be improved on over time. These include recommendations to Government and for further research. Recommendations to the Government of Anguilla include:

- **Monitor trends** – one of the most useful aspects of natural capital accounting is its ability to compare results between relevant time periods, such as year on year, and thereby monitor trends. These trends can reflect changes in the extent of Anguilla's natural capital, improvement or degradation in its condition, changes in the uses of the goods and services provided, changes in the characteristics of users and the appreciation or depreciation in the value placed upon them. When taken together, these trends will emerge as the overall trend in the wealth provided by Anguilla's natural environment, and importantly, also indicate what is driving the trend.
- **Integrate with policy and planning –** over time, natural capital accounting should become an integral part of the policy and planning process. As robustness and confidence in the accounts grow, they should become embedded tools to be consulted regularly to inform decision making, and to measure the progress and accountability of specific policy and planning decisions.

Recommendations on further research include:

- **Refine methodologies** – natural capital accounting is an emerging field, and environmental economic approaches to valuation are subject to testing, reflection, and revision. As the practice evolves, the methodological approaches to valuing the benefits in the Anguilla accounts can evolve with them, ensuring the most rigorous assessment possible and building increasing confidence in the results.
- **Investment and enhancement of the natural environment –** natural capital accounting can not only measure value and monitor trends, but also be used as one input to strategies to investment to maintain

[33] See: https://anguilla-portal.envsys.co.uk/
[34] See: https://anguilla-portal.envsys.co.uk/

or restore natural capital to increase future benefits. Investing in natural capital can yield future increases in the provision of essential environmental goods and services. Natural capital accounting is a tool to inform those investment decisions.

The accounts could also be improved by including additional benefits in future iterations. Some suggestions on the types of data that would be needed to build physical or monetary accounts for additional benefits are presented in Error! Reference source not found.[35].

Table 5.1: Data types for additional benefits

Benefit	Data for physical account[36]	Data for monetary account
Building material	• Quantity of material by use.	• Market price of material bought for specific use
Arts and crafts material	• Quantity of material by use.	• Market price of material bought for specific use
Medicinal value	• Frequency of use, perceived effectiveness of medicine.	• Cost of equivalent pharmaceutical medicine
Aggregates and mineral extraction	• Types and quantities of aggregates and minerals extracted	• Market price of aggregates and minerals
Local climate regulation	• Level of shade provided Cooling impact of shade on productivity and comfort (e.g. mature trees around the valley)	• Value of improved productivity
Erosion control	• Incidents of mudslides • Modelled level of sedimentation reaching property or coastal waters	• Cost of cleaning property • Cost of marine dredging
Noise buffer	• dB reduction capacity of vegetation in residential area.	• Impact on health and well-being of noise
Air quality	• Capacity of local vegetation to filter air pollution • Level of air pollution •	• Health impacts from air pollution on Anguilla
Education and research	• Presence of sites used for education or research	• Cost of education or research programmes

Potential areas for further research include:

Spatial disaggregation:

A potential opportunity for evolving natural capital accounts lays in disaggregating benefits spatially. Currently this can be done at a high level; however, for the more localised information needed for land use decision making, site-specific ecosystem services assessments can draw on the approaches developed in national natural capital accounts to produce more spatially precise estimates.

The benefits assessed in the current accounts could be spatially disaggregated with additional data:

- Fisheries: include the location of origin of catch or the areas of fishing effort, as well as breeding and nursery areas;

35 A prioritisation exercise could identify which benefits are most valuable and feasible to include in future iterations of the account.
36 An additional challenge to data collection occurs due to the subsistence use of many environmental goods and services.

- Agricultural produce: include farm location;
- Tourism data: include where activities occur;
- Local cultural services data: include how and where residents use the natural environment for recreation, and which habitats they place value on;
- Iconic species: include location of sightings or location of breeding areas, and other ecological important sites for the species;
- Carbon retention and sequestration: could improve with greater understanding of respective rates by habitat type.

The GIS analysis conducted for coastal defence and terrestrial hazard has location data built in to the assessment through the identification of vulnerable areas, and therefore demonstrates where natural capital is providing value through avoided damage. This will be a function of two important factors: firstly, where the service is being provided, such as by specific reefs, mangroves, or pine forests; and secondly, where the benefit is being realised, meaning where infrastructure is at lower risk.

However, it should be noted that there is some risk in disaggregating estimates of value if used without a clear understanding of what the information does and does not include, and whether this increases the uncertainty in site-specific results. Partial accounts, as produced in this study, by definition, do not estimate the total value of every given habitat and as such should be used in combination with other sources of information. These limitations of accounting can be increased when disaggregating to local levels. High level assumptions may not translate well to the context of specific landscapes at a finer resolution, meaning that what works in aggregate at the macro level may not be appropriate to apply at a finer scale.

There are additional factors to consider when applying spatially disaggregated values of natural capital. Ultimately what is being valued is the benefit provided to people, but it must be remembered that natural capital and the ecosystem services it provides are an interconnected functional whole, and value should be considered as resulting from the overall system. Measures of the spatial distribution of value of services can be heavily dependent on the spatial distribution of human activity, rather than reflecting the assets that provide the services. This may have a distorting effect where the disaggregated value tracks population and access to benefits, rather than natural capital extent and condition, and so must be carefully interpreted for policy and planning purposes.

Tourism on Anguilla provides a good example of the difference between mapping natural capital assets that provide benefits and the locations where benefits are realised. It contributes a very large component of the national economy, and the natural environment contributes significantly to this sector. However, the majority of the activity is highly spatially concentrated on the most popular beaches (e.g. Meads Bay, East Shoal and Sandy Ground - where many of the most popular resort developments are). Spatially disaggregating the benefit to these locations, would overlook the contribution from other natural capital assets (e.g. reefs and other marine ecosystems) in supporting the quality and attractiveness of these hotspots. This could result in partial, and potentially misleading, data being fed into policy and planning decisions.

Value layers:

Spatial disaggregation, as discussed above, could result in the production of GIS layers of value for each habitat, overlaid with other types of data such as human and economic activity. This may allow for site-specific information to be drawn from the national level accounts. However, for the reasons noted above regarding

spatial disaggregation this should be done only with a degree of caution. Alternatively, where information is needed for decision making at the local level, a site-specific ecosystem services assessment or cost-benefit analysis may be more applicable, which can be supported by the methods and data produced in the national accounts.

Another factor that could emerge from value layers is in regard to ecological thresholds. Spatial disaggregation would require some degree of smoothing of value spatially in order to map (i.e. at some resolution, an average value per spatial unit would be applied). This would imply an equal marginal impact from a loss or gain of a spatial unit of a given habitat; however, in reality some spatial areas will be more functionally important than others, and at some point, an ecological threshold can be crossed creating a non-linear, or disproportional, impact on value. These thresholds are rarely well understood until they are crossed.

There is risks when mapping does not link on to underlying assets. Disaggregation can be done but should be generally done on a bespoke site by site basis. This is a potential area of research but would need verification and testing of results before considered reliable enough to link to decision-making. If these and other issues are well understood there may be some benefit in spatial disaggregation of the accounts. However, if the issues are not well understood, it may do more harm than good. As such, it is not generally recommended as part of the accounts, instead it is better to use the accounts to interpret the total value that the natural environment contributes to Anguilla at the national scale, and to use this understanding to inform policy and planning that seeks to maximise

Option values:

Another factor in interpreting a natural capital account regards the potential future use (rather than the actual current use), of ecosystem services. This potential future use of natural capital is referred to as option value. In some cases, the potential capacity of ecosystem services provision may be large, but under-exploited as a flow of benefits by human activity, and so not valued highly within the national accounts.

In theory, option value may be incorporated into future periods within the assessment, and therefore reflected in the overall asset value of natural capital. However, in practice option value can be hard to measure, as future use can be hard to anticipate and therefore value, and there may be uncertainty in the difference between the potential value of the benefit that could be sustainably realised, and the actual value that is likely to be appreciated in the future. A good example of this is agriculture on Anguilla, where there is a lot of potential value in the capacity to grow food, even though little value is currently realised as the agricultural sector is very small at present.

6. Conclusion

The primary purpose of this project was to develop an initial natural capital account for the island of Anguilla. In doing so the benefits provided by the existing natural capital was investigated, available data was collected with which to build the initial accounts, and the processes by which natural capital accounting can develop in Anguilla were established. The project has acted as a 'proof of concept' for natural capital accounting in Anguilla, demonstrating its potential as an approach, and creating a guideline for how the accounts can be built and developed over time. Although the accounts are partial and with several key limitations, they demonstrate the scale of value of natural capital on Anguilla in monetary terms and can contribute to better decision making and support policy development. Future phases of work can further develop the Anguilla natural capital accounts.

The methods employed to investigate these values help to create an understanding of how the natural environment provides benefits to people through goods and services. It shows how these benefits can be consistently measured, valued and monitored to assist better management of the environment. Several limitations were noted with the current study. Recommendations were made as to how these limitations can be addressed to improve confidence in the accounts, and further develop them over time. There are also limits to how natural capital accounts should be interpreted; as such they should be used alongside other information in decision-making. This version of the accounts, though not complete, can be used to support decision-making. If the advantages of natural capital accounting are recognised at an early stage, support will grow for the adoption of the natural capital accounting process, leading to further integration in the policy and planning process as the accounts develop.

An established natural capital accounting framework will bring all of the different sources of data together in one place, in a coherent format that links to economic value, and develop a consistent procedure for updating data and filling in gaps. In order to accomplish this, the overall responsibility for gathering data for the natural capital accounts will need to be held by one team or government department. While the process may initially be supported by different bodies involved with environmental management, as a set of national statistics, responsibility for the accounts should eventually be held by the national statistics department to sit alongside other national accounts and associated indicators such as GDP.

A fully developed set of national natural capital accounts will measure and monitor the benefits Anguilla receives from the natural environment and provide valuable information to decision makers. This will allow policy makers and planners to better manage the human social-political-economic relationship with natural capital to support real and sustainable prosperity for Anguilla through a flourishing natural environment.

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Final Report | May 2019