Turks and Caicos Islands Natural Capital Accounting- Initial Review

eftec/JNCC

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Disclaimer

Document evolution

Draft report	September 2018	Reviewed by Ian Dickie
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Executive summary

As a small island nation, the fortunes of the Turks and Caicos Islands (TCI) are fundamentally linked to its natural environment and associated assets. These environmental assets provide a broad variety of benefits, from habitats for local fisheries, to coastal protection from adverse weather, and from the attraction of some of the world's most beautiful beaches, to the biodiversity that makes life richer to local inhabitants of the islands. However, human activity on land or in the sea have unintended consequences as impacts on the environment can fundamentally alter the very environmental assets which help support TCI'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 on TCI. One approach 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 TCI, which is a structured way to measure and monitor these benefits provided by the natural environment. The account can be used, alongside other national accounts such as GDP, as a basis for understanding the environment to inform policy and planning decisions.

JNCC, in partnership with the TCI Government, 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 on the monetary and cultural value of natural capital in the TCI is to summarise work done in identifying and gaining access to the data necessary to assess these values, use available data to provide a preliminary assessment and identify options and data needs for the next phase of work.

This initial phase of work builds up a preliminary set of national natural capital accounts for the TCI, and establishes the processes by which natural capital accounting can develop in TCI. The initial accounts are developed as a starting point from which to set up the structure that future iterations will build upon. They offer an indication as to the scale of value (see the summary table below). More robust data input to the process and further development of the methodological approach will enhance future iterations of the account. Key limitations in the current set of accounts primarily stem from issues around the availability and quality of data.

Initial natural capital accounting results for TCI

Benefit	Physical flow (Annual)	Monetary value (Annual)	Asset value (25yr)	Note on approach
Fisheries	3,000 tonnes	$21.7 million	$369.5 million	Based on a combination of reported fish for export and domestic consumption patterns, likely overestimates value of domestic consumption.
Agriculture	45,000 pounds	$0.1 million	$2.3 million	Based on farmer reported weights and a spot check of market prices, likely a good approximation of overall value.
Coastal defence	7,000 buildings	*Not available*	*Not available*	Current gaps in data for Geographical Information Systems (GIS) input layers for physical benefit and damage cost estimates for valuation, likely a considerable benefit.
Surface hydrology	*Not available*	*Not available*	*Not available*	Current gaps in data for GIS input layers for physical benefit and damage cost estimates for valuation, likely a moderate benefit.
Tourism	3.1 million visitor-days	$80.2 million	$1,336.2 million	Based on tourism surveys for number of nights, activities, and expenditure, and assumptions for degree of ecosystem dependence, likely a reasonable approximation of overall value.
Local cultural services	35,000 local users	$4.3 million	$83.4 million	Based on total population of TCI and a transfer value for WTP for cultural services, generalised approach likely underestimates the total value.
Additional benefits	*Not available*	*Not available*	*Not available*	Numerous additional benefits from natural capital are not valued in this iteration of the account.
TOTAL		**$106.4 million**	**$1,791.4 million**	Due to data gaps and benefit omissions there is a high level of uncertainty in the overall value. However, it gives an indication as to the scale of the value is likely to be an underestimate.

High uncertainty
Moderate uncertainty
Low uncertainty

Low uncertainty reflects confidence in the evidence to support decisions. High uncertainty reflects results that may be inaccurate by more than an order of magnitude. Some data may be marked as 'moderate' where the data used are themselves accurate, but do not provide a full measure of the services' value. All values in US dollars.

The 2017 hurricanes Irma and Maria inflicted severe damage on the TCI. Work supported by JNCC, and based primarily on use of satellite data, has highlighted the role of natural capital in mitigating the impacts of hurricane generated storm surge. With approximately 7,000 (60%) of buildings on the island of Providenciales at risk from such surges understanding the role and monetary benefits of these natural capital disaster mitigation is essential for economic and disaster planning processes

JNCC currently intends to undertake a second phase of work prior to April 2019, building on the results and recommendations contained in this report.

The methods employed to investigate natural capital values help to create an understanding of how the natural environment provides benefits to people through goods and services, including ecosystem services. It shows how these benefits can be consistently measured, valued and monitored to assist better management of the environment. Recommendations are made as to how current limitations can be addressed to improve confidence in the accounts, and further develop them over time. A fully developed set of national natural capital accounts will measure and monitor the benefits TCI 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 TCI through a flourishing natural environment.

Contents

1. Introduction

1.1 Background

As a small island nation, the fortunes of the Turks and Caicos Islands (TCI) are fundamentally linked to its natural environment and associated assets. These environmental assets provide a broad variety of benefits, from habitats for local fisheries, to coastal protection from adverse weather, and from the attraction of some of the world's most beautiful beaches, to the biodiversity that makes life richer to local inhabitants.

However, TCI also faces many challenges in supporting its small but growing local population and developing economy. While economic growth may increase the wellbeing of TCI'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 material and seafood, has implications for the environment and the environment's capacity to sustain the supply of these resources. The severe hurricanes of 2017 also demonstrated how severe weather events can damage natural assets and provided clear evidence that these assets also play an important role in mitigating these impacts.

Human activity on land or in the sea also may have unintended consequences as impacts on the environment are often linked from one ecosystem to another, which can fundamentally alter the very environmental assets which help support TCI'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 on TCI. 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.

The study draws on the field of environmental economics which focuses on the application of economic tools to environmental challenges. 'Natural capital' is an environmental economics approach that helps understand the interconnection between humans and the environment. Natural capital interprets the environment as an asset which provides us with goods and services, including those called "ecosystem services". For example, in TCI marine ecosystems can be considered a natural capital asset, providing landings from local fisheries that are harvested and consumed on the island, which are an ecosystem service.

The aim of this study is to establish a national "natural capital account" for TCI. These accounts are a structured way to measure and monitor the benefits provided by the natural environment. They can be produced, alongside other national accounts, such as GDP, as a basis for understanding 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 reduces its capacity to deliver benefits to society.

Figure 1.1: Location of Turks and Caicos Islands in the Caribbean (Google Maps, 2018)

1.2 The natural capital accounting process

National natural capital accounting is a process which produces a set of accounts that record the value that is provided by a nations natural capital. In order to create these accounts, data must be collected and collated in to a number of stages, these are:

- **Natural capital asset register** - an inventory that holds details of all the natural capital, or environmental assets, that are present, including their condition, as measured by their extent, quality and other relevant factors. For example, the spatial area of a reef system, and it's health in terms of coral coverage and quality.
- **Physical flow account** – contains the expected 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 (see Box 1.1).
- **Monetary account** – demonstrates the value of the expected flow of goods and services that are captured in the physical flow account. This includes both value derived bon an annual basis, and the overall asset value over the course of the assessment period.

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, tides, and the annual seasons).

1.3 This report

This document reports on development of an initial baseline TCI national natural capital account on which to build from year on year. As the project is setting up a new tool, in practice it also acts as a feasibility or scoping study, and much of the value of the work is in identifying current limitations and setting a direction on which to improve them. Subsequent phases of work will develop the TCI natural capital accounts further.

The first stage of developing the accounts involved a field study to cultivate an initial impression of TCI's natural environment and the types of benefits that it provides. This field work also began to link up to other relevant work and form connections with which to develop the system for natural capital accounting. Specifically, this involved identifying data sources and initiating processes for collecting it. As such, an outcome of the project is also the initiation of a natural capital accounting process and development of capacity on TCI, it to build further national natural capital accounts.

The initial natural capital account lays a basis for continuing natural capital accounting activities. The ultimate aim of the process is the integration of natural capital accounting into TCI's system of national accounts and decision-making. This will aid the continual monitoring of TCI's natural capital, and an understanding of how policy and planning decisions impact, and are impacted by, the benefits that TCI's natural capital provides.

This document 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 natural capital accounts, and a guide outlining how the accounts may be further developed in the future. As such, it is written to be

an accessible and practical report, with the hope that it can aid the ongoing natural capital accounting process on TCI.

Subsequent sections of this report will describe in more detail the natural capital of TCI, and the benefits that it provides. This draws on an understanding of TCI's environment, built on desk-based research, conversations with stakeholders in TCI's environment, and first-hand experience from the field visit to TCI. The report then outlines in more detail the specific benefits which are included in this initial natural capital account, giving an overview of the economic approach to their valuation. Additional benefits that could be valued in future iterations are also discussed.

Findings from the process are reported, including gaps and limitations, with commentary particularly focusing on issues around data requirements and sources. Importantly, the report also makes recommendations on how to evolve the accounts for TCI, focusing on incorporating additional benefits, and developing the data collection systems with which to build the accounts on an annual basis. The report closes with the overall values derived in the accounts, and some general conclusions.

As an initial set of accounts, it was important both to prioritise the most material benefits so that a significant proportion of the environment's value to TCI would be represented, while also limiting the scope of the assessment to be feasible with available resources and data, and an understanding that future iterations of the accounts will be able to include additional benefits. A prioritisation exercise was conducted in consultation with members of TCI's government Department for Environment and Coastal Resources to develop a refined list of benefits for inclusion. The prioritisation is summarised in Table 2.2 (see Section 5 for a discussion on extending the coverage of the accounts).

2. Natural Capital Accounting and the Turks and Caicos Islands

2.1 Context on TCI

Viewing the environment through the lens of Natural Capital is an effective means to draw it in to decision-making alongside other human-centric interests. It is a useful way to align language and data on the environment with other economic factors when making decisions that impact the environment. It is not without controversy, and some people believe it is counter-productive to conceive of the environment in economic terms. Regardless of the terminology used, human societies have significant impact on the environment. While not denying the inherent value of the environment outside of its value to humans, conceptualising it as natural capital allows for better management of the human social-political-economic realm's relationship with the environment.

In broad terms the natural capital of TCI incorporates all of the habitats and sub-soil assets present on the islands and the adjacent marine ecosystems, which provide ecosystem services, usually categorised as provisioning services (e.g. fish habitat), regulating services (e.g. maintenance of the hydrological system), and cultural services (e.g. location for recreation), all of which are underpinned by supporting services (i.e. ecological systems which provide the biodiversity upon which the other services are dependent).

An economic understanding of the value of these services allows for more balanced decision making and supports the case for actions to mitigate against loss, and for investment in their protection and enhancement; without this understanding, uninformed decision-making risks undervaluation of, and therefor sub-optimal provision for, the environment.

2.2 The natural environment of TCI

A field tour of the Turks and Caicos Islands to observe first-hand the natural capital of the islands and investigate the benefits that people receive from it was conducted over one week in late April / early May 2018. The tour demonstrated the rich and diverse habitats of the islands, and the variety of ways people interact with, and benefit from, the environment. This section discusses in broad terms the natural capital of TCI, and the ecosystem services it provides. Observations from the field tour, stakeholder consultation and previous work conducted on TCI, were used to identify different natural capital assets on the islands, and the ways people may benefit from these assets. This acted as a basis from which to prioritise specific benefits for inclusion in the initial set of accounts.

Previous mapping work identified the presence of broad habitats on the island. The data indicates which habitats are present, and what their total land coverage is for each of the islands of TCI, and TCI as a whole. This data contributes to the natural capital asset register for TCI. Figure 2.1 shows the results of this mapping for North Caicos, Middle Caicos and East Caicos, while Table 2.1 gives the associated figure for each broad habitat by the main islands, and in aggregate for TCI.

It is still important to consider not just the presence of habitat, but also its condition as this is a fundamental component of its ability to provide benefits to people. Habitat condition data was not available for this initial phase of work but is a priority for future work. JNCC is aware of other projects in progress or planned for the TCI which include work to assess habitat condition. These will provide an important contribution to future natural capital assessments.

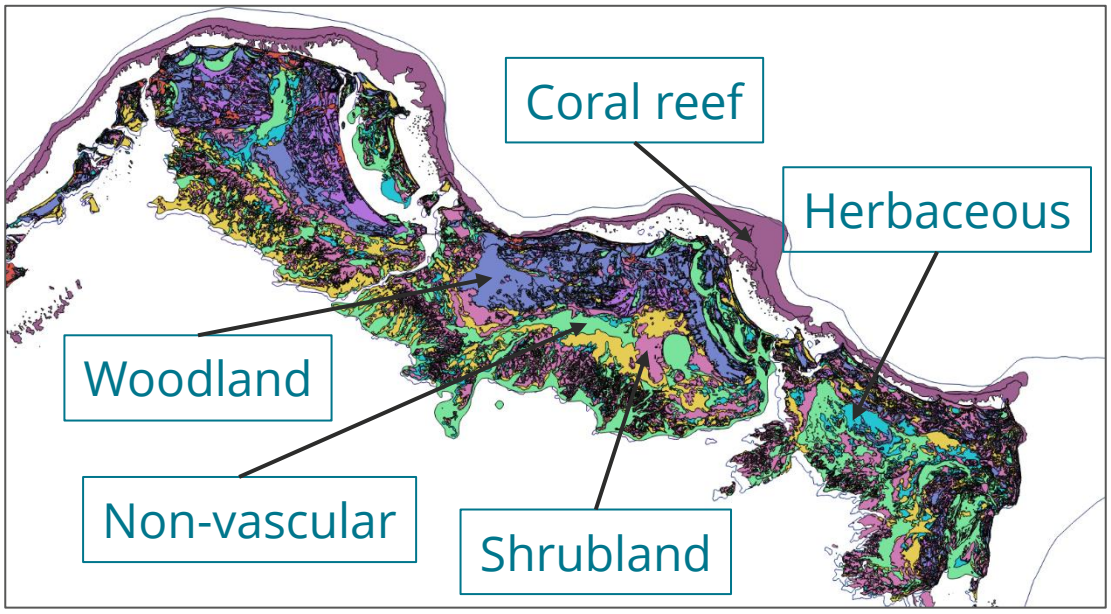


Figure 2.1: Habitat map of North Caicos, Middle Caicos and East Caicos

As can be seen in Figure 2.1, the habitat varies widely across the islands. Table 2.1 indicates that the most prevalent broad habitats TCI are shrubland, woodland and non-vascular plant ecosystems, with different proportions of broad habitat across the islands. As the most populated island, Providenciales as a disproportionately large amount of human-altered landscape and less shrubland.

Table 2.1: Habitat extent by main islands and in total on TCI

	East Caicos	Grand Turk	Middle Caicos	North Caicos	Providenciales	South Caicos	West Caicos	Grand Total TCI
Dwarf Shrubland	3,039	56	5,859	4,380	604	373	458	16,770
Forest	625	52	849	3,218	142	36	2	5,000
Herbaceous	2,387	131	2,353	1,217	195	181	59	7,413
Human Altered	11	663	189	560	3,632	274	57	5,679
Non-Vascular	5,608	377	8,896	3,084	2,559	417	431	23,021
Shrubland	6,564	521	7,835	3,672	1,098	606	769	22,488
Woodland	1,802	24	6,700	5,056	3,987	294	500	19,384
Grand Total	20,036	1,826	32,682	21,186	12,218	2,181	2,277	99,753

Previous work conducted on TCI by the Wolfs Company (2017) sought to use remote sensing and ground verification to map the ecosystems and ecosystems services of the islands in more detail. This work was used as a starting point to identify the priority ecosystem services for inclusion in the accounts. The habitats identified by the Wolfs Company are listed in Figure 2.2, while the full list of ecosystem services identified are listed in Figure 2.3.

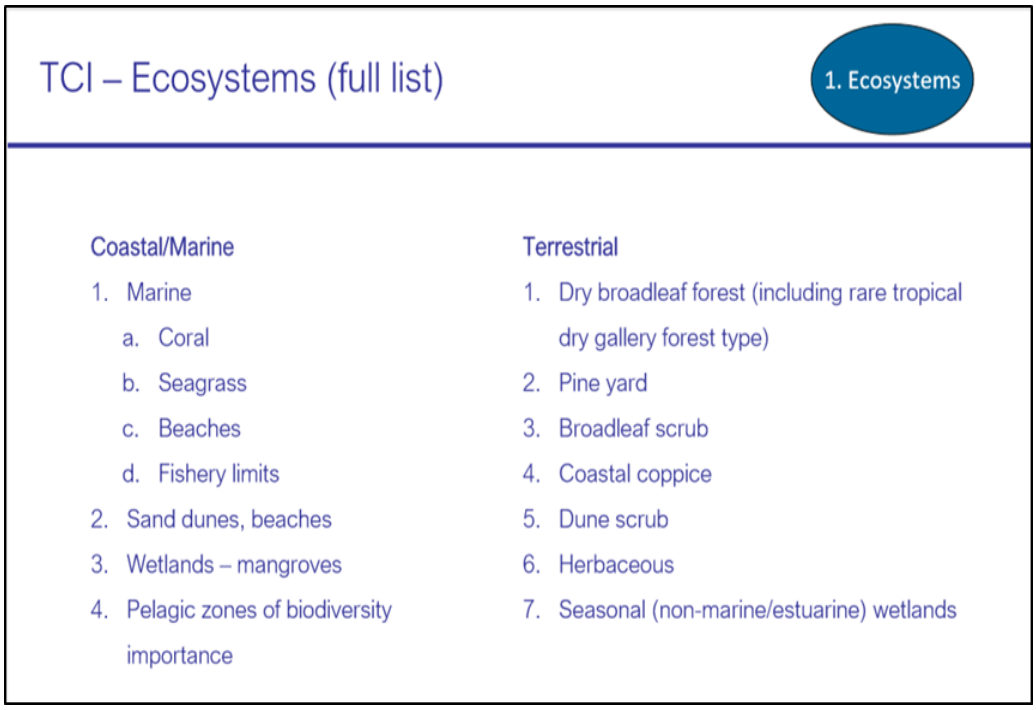


Figure 2.2: Marine and terrestrial habitats of TCI (Wolfs Company, 2016)

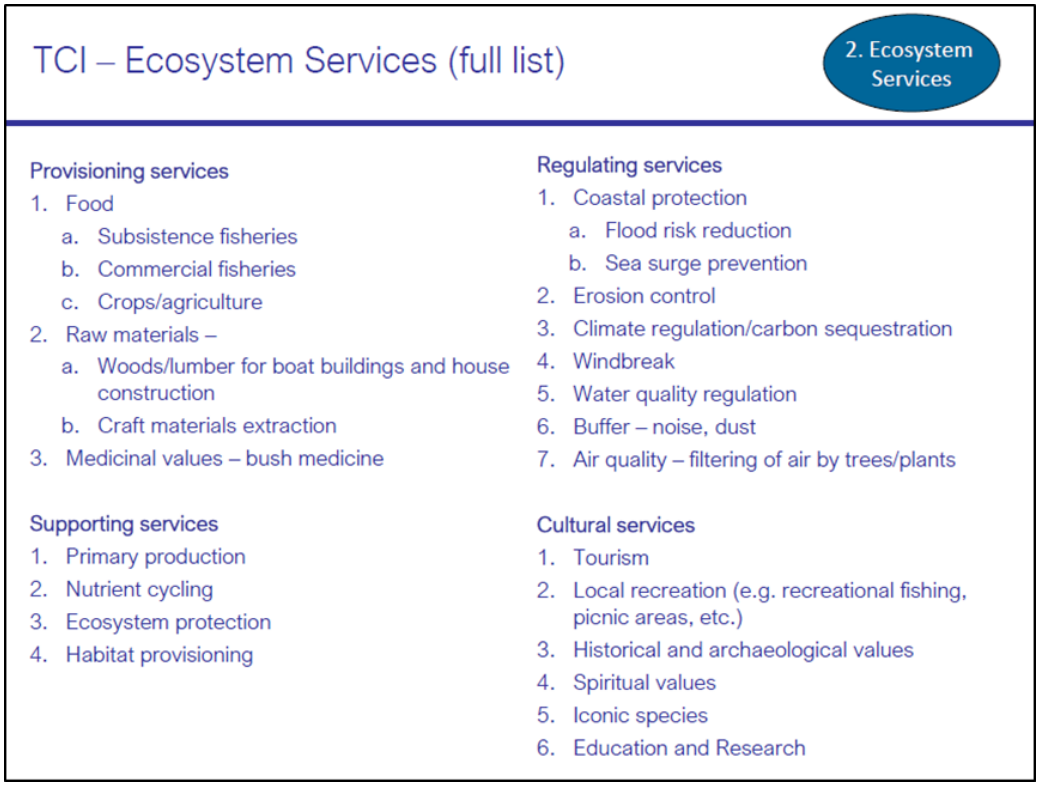


Figure 2.3 Ecosystem services on TCI (Wolfs Company, 2016)

As an initial set of accounts, it was important both to prioritise the most material benefits so that a significant proportion of the environment's value to TCI would be represented, while also limiting the scope of the assessment to be feasible with available resources and data, and an understanding that future iterations of the accounts will be able to include additional benefits. A prioritisation exercise was conducted in consultation with members of TCI's government Department for Environment and Coastal Resources to develop a refined list of benefits for inclusion. The prioritisation is summarised in Table 2.2 (see Section 5 for recommendations on extending coverage). Figure 2.4 shows the asset-service matrix for the prioritised benefits.

Table 2.2: 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 TCI fishermen.
	Food – Commercial fisheries	Yes	
	Food – Crops/agriculture	Yes	Included as 'Agriculture', as although currently a small benefit, there is a large opportunity for increased value from this service.
	Raw materials – Woods/lumber for boat buildings and house construction	No	Scoped out due to lack of data, and uncertainty around the scale of the impact at the national level.
	Raw materials – Craft materials extraction	No	
	Medicinal values – bush medicine	No	
Regulating	Coastal protection – Flood risk reduction from sea rise	Yes	Combined and included as 'Coastal defence'. An important benefit as much of TCI is vulnerable to impact from the ocean during storm events.
	Coastal protection – Sea surge prevention	Yes	
	Erosion control	Yes	Included as 'Surface hydrology', the benefit of regulated surface hydrology is valued as avoidance of flood damage, the avoidance of other impacts from erosion such as sedimentation of coastal waters would be partially captured in tourism and fisheries values.
	Climate regulation/carbon sequestration	No	Scoped out as unlikely to have a significant impact at the global scale at which the benefit is realised.
	Water quality regulation	No	Scoped out as water is extracted from the underground water lens, with uncertain dependency on regulating services from natural capital.
	Windbreak	No	Scoped out due to lack of data, and uncertainty around the scale of the impact at the national level.
	Buffer – noise, dust	No	
	Air quality – filtering of air by trees/plants	No	
Cultural	Tourism	Yes	Included as 'Tourism', as a major economic sector for TCI which is heavily dependent on the natural environment.
	Local recreation	Yes	Included as a general catch-all 'Local cultural services' category.
	Existence / spiritual values	Yes	
	Historical and archaeological values	No	Scoped out due to lack of data, and uncertainty around the scale of the impact at the national level.
	Iconic species	No	
	Education and Research	No	
Supporting	Primary production	No	Supporting services scoped out as they indirectly provide value through the provision of other benefits, but do not provide benefits to humans directly.
	Nutrient cycling	No	
	Ecosystem protection	No	
	Habitat provisioning	No	

Ecosystems		Marine			Terrestrial		
Ecosystem services		Coral reefs	Seagrass	Pelagic zones	Wetlands, mangroves	Beaches, sand dunes	Pine shrub, forest
Provisioning	Fisheries						
	Agriculture						
Regulating	Coastal protection						
	Surface hydrology						
Cultural	Tourism						
	Local cultural services						

Figure 2.4: Asset-service matrix with prioritised benefits

2.3 Availability of data on TCI

In order to build accounts and estimate the value of TCI'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. The field tour initiated the data collection process by making contact with a number of government departments and other organisations, to try to identify and collect relevant data with which to conduct the assessment.

Making use of existing data sources has the advantage of being much less resource intensive by making use of already present data collection processes. 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.

Many contacts that were made expressed a willingness to share data. However, not all were forthcoming with actually providing the data when requested. This could be down to a number of reasons, in some cases the data that people thought existed, or that they thought they were in possession of, may have been lost or not what was expected. In other cases, a simple lack of human resources to track down and send data was likely the cause, as the small size of the government departments and other organisations holding the data meant that staff had many competing requirements on their time.

Another issue with the data that was supplied was that it often did not match expectations in terms of the desired format. In general, recently collected raw data is preferable, while much of what was provided was the processed data found in reports, sometimes several years out of date. The information presented in reports may seem more valuable as it is based on additional work and processing, but in fact it is the underlying raw data which is generally is more valuable for accounting purposes, and which was more often absent. It is also this raw underlying data which is required to be updated on a regular basis in order to build accurate annual accounts.

By drawing on the resources provided and conducting additional desk-based research, as well as making use of Geographical Information Systems (GIS) and Earth Observation (EO) analysis to supplement the data available, a sufficient data set was built with which to develop the initial natural capital accounts. This data

set can be improved with more direct sources and regular updates, as will be discussed in greater detail in Section 5.

2.4 Engagement with natural capital accounting on TCI

A final purpose of the field tour was to assess interest and build engagement with the project, and the concept of natural capital accounting more generally. As 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, it is critical to involve the people who will work with these tools as early as possible.

The following government bodies were consulted with:

- Department of Environment and Coastal Resources
- Department of Planning
- Department of Agriculture
- Department of Economic Planning and Statistics
- Tourism Board
- Ministry of Tourism, Environment, Heritage and Culture

Every civil servant that was met with was generally positive about the potential for natural capital accounting to benefit their respective areas of responsibility. There was much agreement that the environment is critically important to the development of TCI, and that it was often over looked in policy and planning, which could be at least partially addressed by having an economic view on the environment.

Some people were particularly enthusiastic around adopting the language of economics and accounting, and to making reference to environmental accounts in terms of 'withdrawals' of natural capital, 'growth' of natural capital through investment in environmental restoration, and the maintenance of 'sustainable revenues' of ecosystem services.

However, another factor that became clear over the course of the project, was that while in theory natural capital accounting was supported, the subsequent adoption of the practice was less certain. Most government bodies are stretched for resources, both financial and human, and there seemed to be little capacity to take on more responsibility, at either an individual or departmental level. Without political backing and financial support to take advantage of the existing levels of engagement and enthusiasm, motivation may fade along with the support necessary to embed the natural capital accounting process.

Outside of the government, there was some concern around conceptualising the environment in economic terms, and what adopting the terminology and practices of accounting might lead to in practice. The resistance to the approach was focused primarily to how it might be misused to justify development on areas which were not assessed to have a high value, and a concern that the process was incapable of capturing all value of the environment and so undervaluing certain habitats was inevitable.

This is a valid concern, the accounts, especially in their initial iteration, are not fully developed and do not capture all values of all habitats. In fact, there is current discussion around how well even the most developed natural capital accounting processes are able to capture such values as biodiversity. A misunderstanding of the accounts could lead decision makers to base decisions with what is essentially

incomplete information.

However, there are some ways to mitigate this risk by offering training and building knowledge as to what the accounts mean, and ensuring practitioners and users of the accounts understand their limitations, and use them appropriately. Their worth is as a barometer of the overall state of the natural environment, and the value it provides, and understanding the links between impacts on the environment, and its capacity to provide benefits, and thus can inform policy and planning along with the use of other tools and means of understanding value.

2.5 Data collection for the natural capital accounting process on TCI

As previously indicated, natural capital accounting should be viewed as a process rather than a product. Data collection activities are the foundation of natural capital accounting. The goal of natural capital accounting with respect to data collection is in a practice is multi-purpose:

I. to collate all relevant data that is collected for a location into a single data set;
II. to suggest additional areas where data collection would be valuable;
III. to report collected data in a consistent format;
IV. to ensure data is regularly updated; and
V. to embed data analysis directly in to policy and planning (i.e. through natural capital accounting).

Some elements of these items are already present. Valuable data collection activities occur for a number of purposes across TCI. However, it is often disjointed, and there can be a lack of overall understanding of what other government departments' or organisations' data collection activities are addressing. An established natural capital accounting framework would bring all of these 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 such as GDP.

The initial account, as described in greater detail below, are a first attempt at drawing together a number of different data sources into to 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.

3. Benefits from natural capital in the Turks and Caicos Islands

The natural capital accounts present the approach for deriving the physical and monetary value for each benefit transparently. This section provides a general overview of the benefit, available data, and approach to quantifying their provision and value. In general, the methodologies adopted are designed to make use of existing data and be straightforward to replicate to ensure data is generated consistently over time. While they should be revisited and revised as better data becomes available, they provide a means to work with currently available data to estimate the value of natural capital in the initial accounts, which can act as a baseline to compare to year on year.

3.1 Fisheries

The marine ecosystems surrounding TCI provide habitat for a variety of species of fish and other sea life. This in turn provides the people of TCI with sustenance and commercial opportunities through fishing. Fish (defined in this report as all edible sea life) caught by TCI fishermen are sold for the export market, sold and traded domestically both formally and informally, and both to the tourism sector and used for subsistence. The inclusion of fisheries in the accounts helps to track the annual value that marine natural capital contributes through this benefit.

There are three categories of species caught for sale and consumption; Spiny Lobster, Queen Conch, and Scalefish. Direct fish landings are recorded, but only for quantities destined for the export market. Data for quantities caught and sold to the domestic market or used for subsistence either do not exist or are not reliable. Therefore, an alternative method was used to estimate domestic catch quantities based on domestic consumption estimates.

The approach adopts the methodology for the reconstruction of historic fisheries developed by Ullman et al. (2015). Data from a survey investigating fish consumption patterns per capita is used to estimate the quantity of domestic consumption for each of the three categories, aggregated for the resident population of TCI. A similar approach is used to calculate tourist consumption, estimating the quantity consumed per individual over the course of a trip, applied to the annual number of visitors to the TCI.

The estimates of consumed weight have to be converted to live weight to account for the weight removed during processing, as the valuation applied the price paid to fishermen per unprocessed weight of fish. The domestic weight estimate is then combined with the export weight data collected at the fish landings and processing site to get total weight of fish caught. The price data was taken as the average of the three most recent years for which data was available on prices paid to fishermen at the processing plant.

Data needs: To reproduce these figures, data is needed on quantity of landings, consumption patterns, and price. Landings figures and price paid to fishermen should be updated annually, while consumption data should be updated as new survey information is produced, and not more than every five years to account for shifting preferences in sea food consumption.

The baseline weight estimate is 3,067 tonnes per year (Lobster 1,092 tonnes; Conch 1,069 tonnes; Scalefish 906 tonnes) with a value of $21.7 million (Lobster $9.8 million; Conch $3.9 million; Scalefish $7.9 million). The reconstructed domestic catch is approximately four times the size of the reported catch for the export market; there is some uncertainty around this figure, and it should be interpreted with care until further investigation confirms if this is a realistic factor.

3.2 Agriculture

Natural capital in TCI includes the fertile soils and hydrology systems which provide sustenance to plant life. With human input these services provide the benefit of agricultural food production. The practice of agriculture is currently limited in TCI. However, there is considerable potential for its' growth, and as an important factor for the self-sufficiently of the currently import-dependent islands. 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.

A number of types of produce were reported in the 2018 edition of the TCI Farmer's Survey Report as being grown and sold domestically:

- Sweet pepper
- Tomato
- Okra
- Papaya
- Sweet potato
- Hot pepper
- Pumpkin
- Beans
- Naseberry (Sapodilla fruit)
- Callaloo (Taro leaves)
- Cucumber
- Soursop (Guyabano fruit)
- Eggs

Data needs: The quantities reported for each item were annualised individually, and then applied to the price paid by consumers as quoted in a local grocery store[1]. The retail price charged by the market will be greater than that paid to the farmers for the produce to account for storage and other associated retail costs, as such there is uncertainty as to the actual value of the produce in the absence of these mark-ups. To account for this, only half the retail price is applied. This straightforward approach, quantity of good multiplied by price per good, should be updated annually, though it would be preferable to source data on the prices paid directly to farmers for each good.

For each item, weights brought to market per month were estimated. The total weight as reported by the survey for all items, annualised, is 44,500 lbs (20,200 Kgs) and 360 flats of eggs. The total annual value of local agricultural produce was estimated at under $100,000 per year as the baseline.

3.3 Coastal defence

The natural capital of TCI's marine coastal habitats provides protection to the islands from damage and flooding due to sea surge from storms and other adverse weather events. 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 vulnerable built infrastructure on the islands.

[1] *Graceway IGA, September 2018.*

To assess the value of this benefit in the current accounts, a methodology was adopted from EnvSys (2017). A generalised model to indicate relative risk using the Spatial Evidence for Natural Capital Evaluation (SENCE) methodology was developed by EnvSys. 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 TCI is displayed in Figure 3.1, while Figure 3.2 displays a close up of a section of Providenciales with the level of hazard for the present infrastructure indicated.

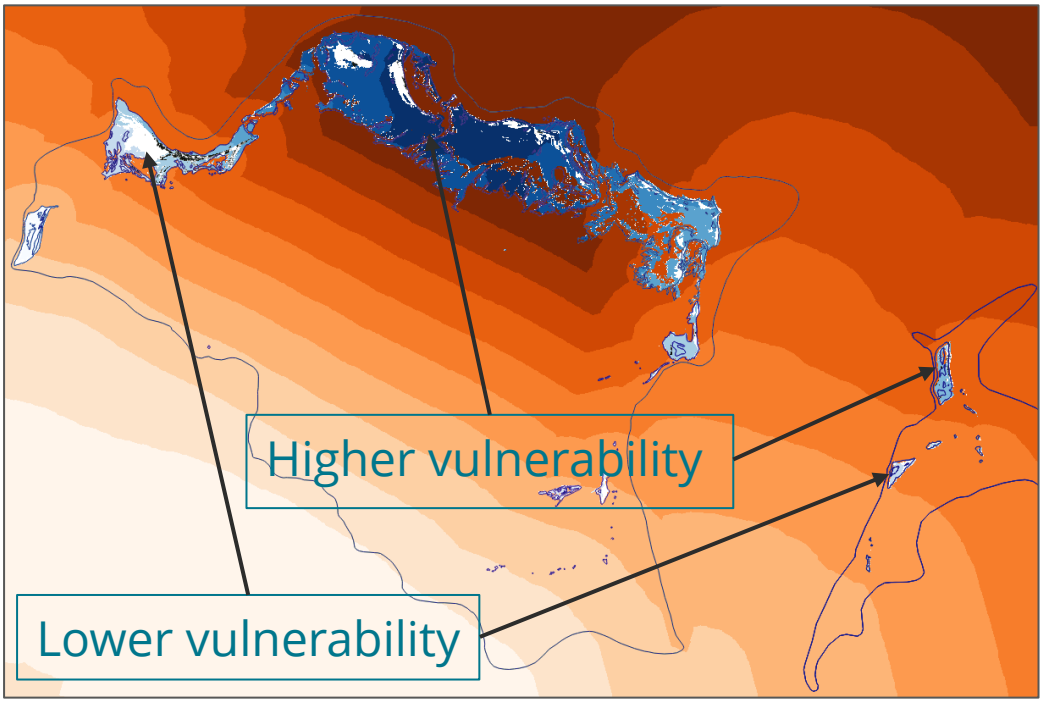
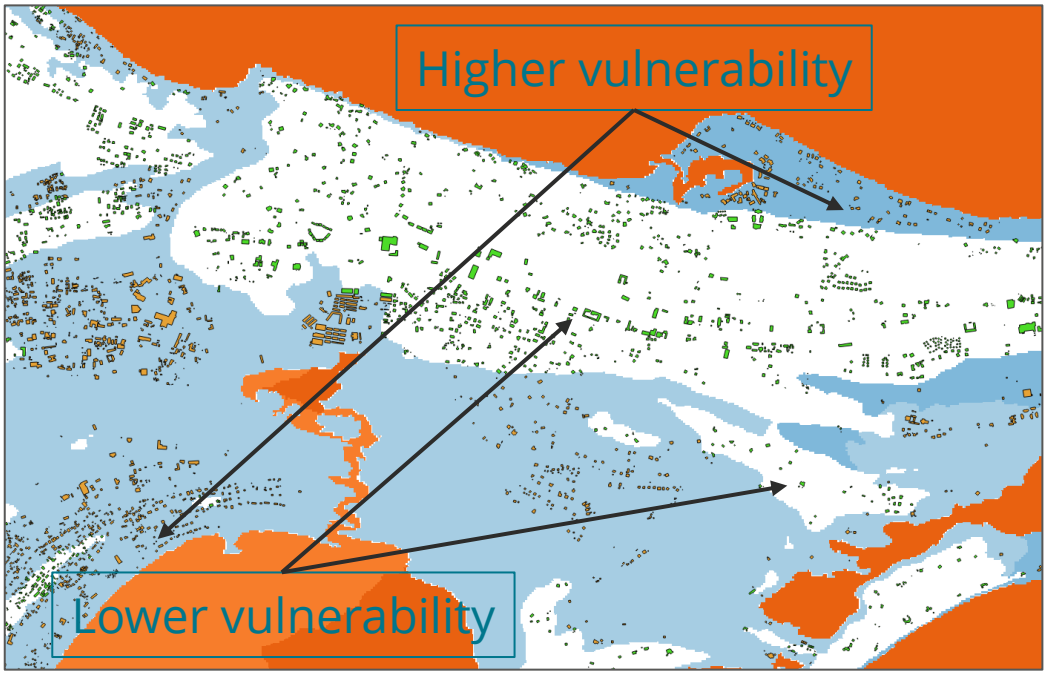


Figure 3.1 Coastal vulnerability map for TCI



3.2 Close up coastal vulnerability may with level of infrastructure hazard for a section of Providenciales

Models can be run with no land cover to model the absence of any habitat. The results are compared to measure the avoided damage due to natural capital and a monetary value is applied to the damage avoided. As data on the value of specific real estate or damage cost estimates are not currently available, costs can be calculated as the proportion of relative damage, applied to the average reconstruction cost per square meter in the UK OTs, estimated as $300/sq.ft. of building surface area (EnvSys, 2017).

In the absence of adequate habitat data only a preliminary, baseline assessment is feasible and indicates that approximately 7,000 (60%) buildings on the island of Providenciales are at risk from sea surge generated from storm events. As an indicative value, a study by Nautilus (2005) estimated that TCI's reefs provide $16.9 million in coastal protection annually applying a replacement cost approach for providing coastal protection of equivalent efficacy to coral reefs per kilometre of coastline.

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.

3.4 Surface hydrology

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 these benefits respectively, the

assessment of this benefit is focused more specifically on the avoidance of flood damage from surface flooding.

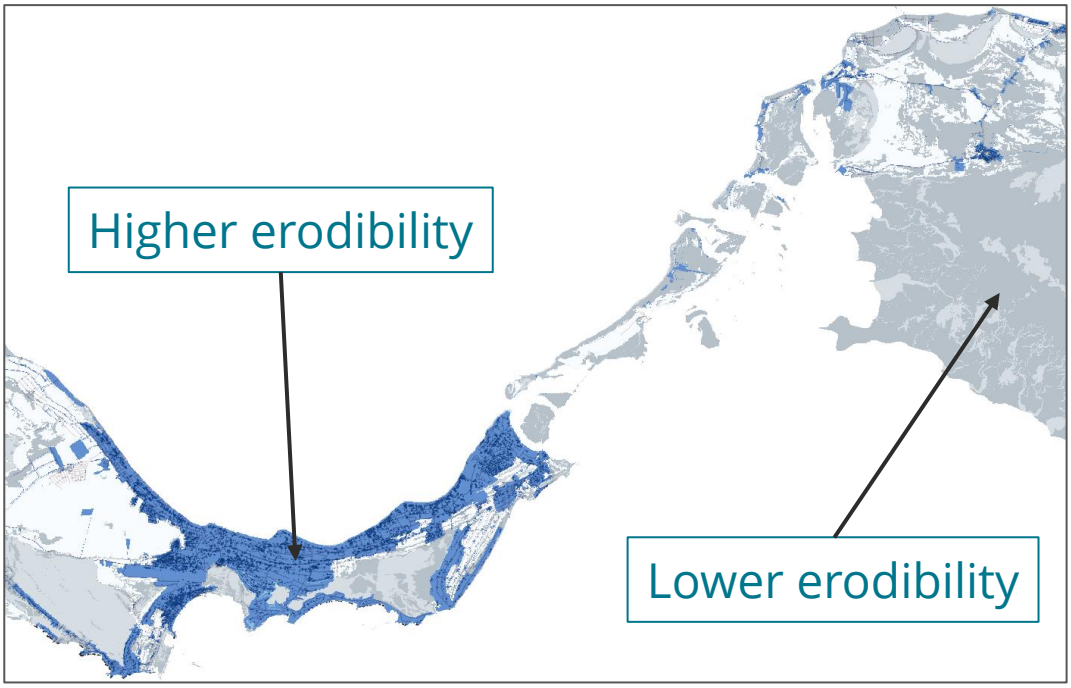


Figure 3.3: Surface erodibility on Providenciales and East Caicos

To assess the value of this benefit in the current accounts, a methodology was adopted from EnvSys (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 EO 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 proneness to flooding. The approach estimates the potential footprint and depth of vulnerable zones in a flooding event. Figure 3.3 demonstrates a data input on areas of erodibility, which can be seen to closely track built-up areas as would be expected due to the removal of vegetation.

This is then 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 model is then run without land cover to model the absence of any habitat. The results are compared to measure the avoided damage due to natural capital. Finally, a monetary value is applied to the damage avoided.

Data on the value of specific real estate or damage cost estimates were not available for this study , costs are calculated as the proportion of relative damage applied to the average reconstruction cost per square meter in the UK OTs, estimated as $300/sq.ft. of building surface area (EnvSys, 2017). It was not possible to value this benefit with available data and resources at this 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.

3.5 Tourism

Tourism is a major contributor to the economic prosperity of TCI, and the major attraction for tourism is TCI's natural environment. In particular, it is TCI's beautiful beaches and coastal marine habitats which attract tourists. The tourism industry has grown over the past decades to become the largest sector in TCI's economy contributing significantly to society through tourist expenditure, employment opportunities, and tax revenue contributions to the country.
A number of data and estimates are required to assess the value of this benefit:

i) Number of visitors by category of visit for overnight visitors
ii) Number of scuba dive trips
iii) Number of passenger and crew day visits for crew arrivals
iv) Average length of stay by category of visit for overnight visitors
v) Average expenditure per activity type, by type of visitor for overnight visitors
vi) Average expenditure on a scuba dive trip
vii) Average expenditure on day visits for cruise arrivals
viii) Total cruise line supplementary expenditure
ix) Value added of the tourism sector
x) % of spend for each activity that is dependent on natural capital
xi) Estimate of consumer surplus

The general approach to overnight tourism estimates the number of visitor-nights per category of visit (i. and iv.), multiplied by the value added of the tourism sector and average expenditure that is dependent on natural capital (v., ix., and x.). Scuba dive trips are also added to this value (ii., ix. and vi.). The general approach to value of cruise line tourism estimates the passengers and crew on shore arrivals by their average expenditure (iii. and vii.), and the supplementary expenditure by the cruise line (viii.), by the value added of the tourism sector and the dependence of that expenditure on natural capital (ix. and x.). Consumer surplus for overnight visitors is also estimated (i. and xi.). This approach is expanded on below.

To place a value on the contribution the natural environment makes to the tourism sector, the assessment uses both a market based producer surplus estimate of value and a welfare based consumer surplus[2] estimate of value. These are additive and represent both the value to local businesses and the value to tourists.

To estimate the market based producer surplus, data is needed on the number of tourists, their length of stay, the main purpose of their visit, the activities they participate in, and how much they spend. Data was drawn from a number of sources to estimate the number of visitor-nights per year for a number of categories of visit, as follows:

- Sun, sea and sand / Vacation

[2] *Producer surplus is the additional benefit (revenue) that a producer receives greater than their cost, this is equivalent to their profit. Consumer surplus is the additional benefit (wellbeing) that a consumer receives greater than their cost (price paid), this is equivalent to their welfare.*

- Honeymoon / wedding
- Scuba diving
- Ocean sports
- Visiting friends and relatives
- Business / Other

The value added by the tourism sector, estimated as 25%, based on previous analysis in the Caribbean region as reported by Wolfs Company (2016). This percentage was applied to expenditure to tourism expenditure to estimate the additional wealth created by the sector over the value of any inputs. To determine the value that the natural environment contributes to this wealth creation, a 'factor of ecosystem dependence' score was applied for each expenditure category, based on the following scale as applied by the Wolfs Company (2016):

- **25%** - These activities are a small part dependent on local ecosystems, but degradation of the local ecosystem would not affect the experience of these activities very much.
- **50%** - These activities are 50% dependent on local ecosystem. For example, a beach visit for relaxation where the sand and the water is enjoyed. The presence of the sand and opportunity to swim is dependent on the local ecosystem but relaxation is also part of the experience, which can also take place on other locations.
- **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 the activity.
- **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 category of overnight visitor, expenditure was broken down into the following categories and applied a factor of ecosystem dependence score from the definitions above:

- Accommodation – 50%
- Meals – 25%
- Taxi / car – 50%
- Tours / excursions – 100%
- Entertainment / recreation – 50%
- Shopping – 25%
- All other spending – 50%

With these figures, an overall value for the natural capital contribution to tourism was estimated for each category of visitor per day. This value was applied to the total number of visitor-days per category of visitor.

A value for the number of scuba dives was also added in separately, as a popular activity that is highly dependent on the marine habitat.

In addition, the value of cruise ship visits was assessed using data on the number of tourist arrivals going onshore and the number of crew visits, as per a regional cruise sector survey conducted by Business Research & Economic Advisors (BREA, 2015). For cruise ship tourist and crew arrivals, the value added by the tourism sector, and a factor of ecosystem dependence, was applied to the total average spend per visit as reported in BREA (2015). Finally, the cruise line expenditure in TCI was also included, applying the value added by the tourism sector and factor of ecosystem dependence estimates, to account for supplementary cruise line spend in TCI to support their operations.

To account for the welfare based consumer surplus, or the additional benefit to the consumer above the price they paid, a transfer value was used based on the Willingness to Pay[3] for nature conservation of visitors from exit surveys from other Caribbean islands. This value was applied to the total number of overnight visitors, and added to the market based producer surplus estimates to determine the overall value natural capital contributes through tourism.

Data needs: Tourism data should be updated annually in regard to tourist numbers for each type of visit, while average expenditure data and WTP figures should be updated when relevant survey data is published in order to capture trends, and no more than every five years to capture changing patterns of use and perceived value.

The number of overnight tourists visits in the baseline year is approximately 400,000 with an additional 600,000 passenger and crew cruise ship visitors. The overall value of natural capital's contribution to tourism is estimated at $80.2 million per year as a baseline value.

3.6 Local cultural services

The benefit of local cultural services on TCI captures a variety of cultural benefits that the natural environment provides to local residents. The primary factors contributing to this value are assumed to be the recreational opportunities available to residents of TCI in the natural environment (such as by the ocean, beaches), and the value residents of TCI gain from knowledge of the existence of the variety of habitats on the islands.

Although data is lacking on the physical flow, or use, of these benefits to residents, anecdotal evidence from the field tour and conversations with stakeholders suggests the presence of both of these benefits to some degree. For example, local residents were seen to be using local beaches and waterways in their free time, and several expressed pride in regard to the variety of habitats found across all of the individual islands of TCI.

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 conducted by Ghermendi et al. (2009). The value

[3] *Willingness to Pay is a valuation technique whereby surveys are used to assess the maximum price an individual would pay for a specified good or service, or the avoidance of a negative impact. In environmental economics the technique is used to place a monetary figure on hard to value ecosystem goods and services. The approach also captures consumer welfare, the additional value a consumer received from a good or service above its' market price.*

was adjusted to reflect the relative Purchasing Power Parity (PPP) in TCI, and applied to the total resident population of the islands.

Data needs: This value is a proxy for the value of local cultural services, but is likely a lower bound value for the annual benefit to residents from recreational opportunities and the existence value of the variety of habitats present in their homeland. The benefit should be updated annually by updating the resident population, and could be improved through a stated preference survey or time cost based analysis (see Section 5).

The total value of this benefit is estimated through this approach as £4.3 million per year as a baseline value.

3.7 Other benefits

Numerous other benefits are provided by TCI's natural capital, so while the current accounts focus on the value of six prioritised benefits, it is not a comprehensive coverage of the benefits the natural environment of TCI provides to people. Future iterations of the account could seek to include additional benefits, such as from: provisioning services, such as raw materials for building and crafts, and plants of medicinal value; regulating services, such as climate regulation, air and water quality, and buffer from wind, noise and dust; and, cultural services, such as heritage values, iconic species, and education and research. Nevertheless, the six included benefits give an indication of the scale of value that natural capital provides to TCI, and the overall importance of the natural environment to people's wellbeing.

4. Findings from natural capital accounting

4.1 Overall findings

The initial national natural capital accounts demonstrate the considerable value that TCI receives from its natural environment on an annual basis. A total annual value of $106.4 million was estimated for the modelled benefits modelled, broken down for each benefit in Table 4.1.

A 25-year assessment was also conducted to determine the asset value of natural capital from each of these benefits. To do so, the annual value for each benefit was projected for 25 years. All the benefits were assumed to continue being provided by the environment for the next 100 years, as all are based on renewable ecosystem processes and functions. For each benefit, with the exception of local cultural services, a simple projection was applied assuming the stable provision of the benefit and its' unit value throughout the assessment period. For local cultural services, which is based on the population of local residents receiving the benefit, population trends were projected over the assessment period. The value stream for each benefit was then discounted appropriately.

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 and the natural environment. However, these are hard to predict, especially in 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. The estimate gives an indication as to the scale of the overall asset value of TCI's natural capital, with a total contribution from the modelled benefits of $1,791.4 million, broken down for each benefit in Table 4.1.

This figure represents the value of the natural environment on TCI to people into the future. It assumes that the extent and condition of the environment is maintained such that its capacity to provide benefits to people is not eroded. However, it should be noted that this does not mean the benefits are invulnerable to changes, such as sea level rise or coral bleaching, reducing their future value.

Table 4.1: Initial natural capital accounting results for TCI

Benefit	Physical flow (Annual)	Monetary value (Annual)	Asset value (100yr)	Note on approach
Fisheries	3,000 tonnes	$21.7 million	$369.5 million	Based on a combination of reported fish for export and domestic consumption patterns, likely overestimates value of domestic consumption.
Agriculture	45,000 pounds	$0.1 million	$2.3 million	Based on farmer reported weights and a spot check of market prices, likely a good approximation of overall value.
Coastal defence	7,000 buildings	*Not available*	*Not available*	Current gaps in data for GIS input layers for physical flow and damage cost estimates for valuation, likely a considerable benefit.
Surface hydrology	*Not available*	*Not available*	*Not available*	Current gaps in data for GIS input layers for physical flow and damage cost estimates for valuation, likely a moderate benefit.
Tourism	3.1 million visitor-days	$80.2 million	$1,336.2 million	Based on tourism surveys for number of nights, activities, and expenditure, and assumptions for degree of ecosystem dependence, likely a

Benefit	Physical flow (Annual)	Monetary value (Annual)	Asset value (100yr)	Note on approach
				reasonable approximation of overall value.
Local cultural services	35,000 local users	$4.3 million	$83.4 million	Based on total population of TCI and a transfer value for WTP for cultural services, generalised approach likely underestimates the total value.
Additional benefits	*Not available*	*Not available*	*Not available*	Numerous additional benefits from natural capital are not valued in this iteration of the account.
TOTAL		**$106.4 million**	**$1,791.4 million**	Due to data gaps and benefit omissions there is a high level of uncertainty in the overall value. However, it gives an indication as to the scale of the value is likely to be an underestimate.

High uncertainty Moderate uncertainty Low uncertainty	Low uncertainty reflects confidence in the evidence to support decisions. High uncertainty reflects results that may be inaccurate by more than an order of magnitude. Some data may be marked as 'moderate' where the data used are themselves accurate, but do not provide a full measure of the services' value

4.2 Limitations

As previously discussed, the initial accounts are a starting point from which to set up the structure that future iterations will build upon, and so the overall results should be taken with a degree of healthy scepticism. They offer an indication as to the scale of value, but improved robustness in input data and methodological approach can enhance future iterations of the account.

Key limitations in the current set of accounts primarily stem from issues around the availability and quality of data. Ideally, the relevant raw data would be collected directly and on an annual basis. This may not be feasible under current conditions in terms of resources and practical restrictions, but these processes do exist for other national accounts such as GDP and should be the benchmark to aim for. As this iteration of the accounts identified and valued six priority benefits, initial efforts should be aimed at improving the data and methodologies applied to these benefits, focusing first those with a large estimated value, and a large degree of uncertainty.

There is a notable gap in the current account in regard to the value of the coastal defence and surface hydrology benefits due to insufficient data, and GIS/EO resources. This can be addressed with data updates and additional GIS/EO capacity, which is currently being developed on island. This aspect of the account should be further advanced as a priority, and feed in to future iterations, as doing so will help direct efforts to build resilience to future adverse weather events.

Another limitation is the comprehensiveness of the accounts, while a set of six priority benefits is a good starting point, they do not capture the overall value of natural capital to TCI and it is expected that some key benefits have been omitted. This may be a particular concern if trying to disaggregate the findings to particular habitats or locations, as doing so will be based on an incomplete understanding of value. Used on its own, the results will only give a partial view of the value of the TCI environment and so are open to misinterpretation and therefore should be used in combination with other components of the account, and other sources of information.

4.3 Sources of data

There are many potential sources of data and information to build the accounts on, this study alone draws from the following:

- Government departments and other governmental/quasi-governmental bodies
  - Environment
  - Planning
  - Tourist Board
  - Agriculture
  - Economics and statistics
- GIS / Earth Observation
- Consumer surveys
- Producer surveys
- Tourism surveys
- Primary market research
- Published TCI studies
- Published Caribbean-wide studies
- Published meta-analysis

In general, the most direct and easily updateable sources are preferable. It may not be possible to update all data every year, but efforts should prioritise accurately tracking 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 also may build awareness of the types of challenges being faced by different government departments and in different sectors, and help identify ways to exploit data for different decision-making purposes. For example:

Fisheries data is 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 track their health.

Data collected by the tourism board to assist hotels in planning for and managing the economically important hospitality sector can also be used to track the benefit that natural capital contributes to the tourism sector, and help justify investment in its maintenance to sustainably provide this benefit.

Infrastructure maps used for spatial planning can be used with GIS to help model the protective benefit natural capital provides in regard to sea surge, and the subsequent vulnerability maps generated can then feed back in to the development planning process.

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/EO tools. Methods of analysis with remote sensing allow for processing of data without relying fully on resource 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 make a contribution to the natural capital accounts, and likely benefit other potential users as well.

4.4 Issues to consider when developing natural capital accounts

4.4.1 Spatial disaggregation

A major 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 could be tagged with location of origin of catch or the areas of fishing effort
- Agricultural produce could be tagged with farm location
- Tourism data could more specifically include where activities occur
- Local cultural services data could include how and where residents use the natural environment for recreation, and which habitats they place value on.

The GIS analysis conducted for coastal defence and surface hydrology, as fundamentally a mapping exercise, does have location data built in to the assessment through the identification of vulnerability areas, and may therefore demonstrate 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 appreciated, meaning where infrastructure is present that is at 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 how confident one should be in the 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. This can be exaggerated 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 appropriately be applied when disaggregated to the micro level.

4.4.1 Location of natural capital assets and beneficiaries

There are other emergent issues with 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 can have a distorting effect where the disaggregated value tracks population rather than

natural capital extent and condition, or the presence and quality of ecosystems.

TCI provides a good example of this case. Tourism is a disproportionately 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 Providenciales. Thus, the benefit assessed, if spatially disaggregated, would apply a very high value to the contribution from natural capital via the beaches, reefs, and coastal ecosystems around Providenciales, and in particular Grace Bay, where many of the most popular resort developments are. Meanwhile, the relatively pristine environment of East Caicos, being largely away from human activity, would seemingly make a relatively small contribution to the total value when disaggregated.

This result can feed in to the policy and planning cycle. While the high value associated with the natural capital around Providenciales and Grace Bay would be noted, and appropriate investment made for its protection and enhancement, if this effect is not understood, the relatively small value assigned to East Caicos, due to a partial measurement of benefits[4], it may mean it's natural environment is undervalued in decision making, leading to suboptimal choices at the local level such as inappropriately placing large scale development in otherwise high worth ecosystems.

4.4.1 Option values

Another emergent issue is regarding not the actual use, but the potential use, of ecosystem services. In some cases, the potential capacity of ecosystem services provision may be large, but unexploited as a flow of benefits by human activity, and so not valued highly within the national accounts. In theory, this potential use value may be incorporated into future periods within the assessment, and therefore reflected in the overall asset value of natural capital.

However, in practice this can be hard to predict, and there may be uncertainty in the difference between the potential value of the benefit that could be realised, and the actual value that is likely to be appreciated in the future. A good example of this is agriculture on TCI, where the ecosystem services provided means that 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.

4.4.2 Value layers

In future iterations of the natural capital accounts, it may be possible to create GIS layers of value for each habitat, spatially disaggregated and 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 this should be done with a degree of caution. Alternately, where information is needed for decision making at the local level, a site-specific ecosystem services assessment may be more applicable, which can draw from 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

[4] *The partial measurement of benefits could take a number of forms in this case, for example: each visit to East Caicos may be of a much higher value, this would be a valuation problem of types of recreational visits not picked up in the data; if East Caicos has high-worth culturally or for some other ecosystem service (e.g. existence value of biodiversity), then it would be a problem of an omission of the benefit; or, if its high-worth is considered as a moral case for nature conservation, then it should be a designated site and conservation measures devised through other means (e.g. cost-effectiveness analysis).*

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 will be crossed creating a non-linear, or disproportional, impact.

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. In either case, it is better to use the accounts to interpret the total value that the natural environment contributes to TCI at the national scale, and to use this understanding to inform policy and planning that seeks to maximise the sustainable provision of these benefits.

4.5 Use of the natural capital accounts

As discussed throughout the text, it is hoped that the initial natural capital account acts as a foundation on which to build future iterations. As better data becomes available, and new methods made possible, as the accounts are a structure for systematic understanding of the value of the environment, and can accommodate and be improved on by improved data. The purpose of these accounts is to initiate a process by which data is collected, shared, and analysed to produce a centralised account of environmental value. The current accounts give an outline of this process, and indication as to what the overall scale of this value might be.

As the accounts develop over time, they should consistently feed in to the policy and planning process, and become a regularly consulted source of information. The data processes that feed in to the accounts should become increasingly streamlined and 'automated' so that updates can happen on an annual basis, without significant resource requirements. Once the accounts have been through a few iterations and people become confident updating and using them, they should naturally integrate with, and sit alongside, other national accounts, such as GDP, and be used as a measure not only of the value of TCI's natural capital, but of its overall national wealth.

5. Recommendations to evolve the TCI accounts

The current national natural capital accounts lay 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.

Ecosystem extent and condition should be monitored on a regular, even ongoing, basis, and the asset register reproduced annually, through the identification and measurement of key natural capital indicators:

- **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. GIS and EO data can be collected relatively easily and analysed to produce estimates for extent, but these estimates should still be verified on the ground with ecological surveying, as they will be based on assumptions of habitat type which need to be confirmed. This will enable the accurate monitoring of changes in land use of time.
- **Condition –** there is currently a lack of up to date data on the condition of TCI's ecosystems, this includes their quality, functionality, presence of species, and overall biodiversity. The health of an ecosystem will greatly determine 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 six benefits currently assessed can be updated and improved with better data, some suggestions as to how to approach:

- **Fisheries –** The current assessment of the fisheries benefit makes use of landings values for export, but estimates domestic landings with consumption data. The accuracy would be improved by measuring domestic landings directly, either at point of landing, which may not be realistic for more informal fishermen, or by surveying fishermen and spot checking. Short of this, the consumption surveying methods should be revisited to ensure they are not leading to an overestimation but instead reflect realistic consumption patterns, and then updated regularly. Price paid to fishermen data should also be updated annually.
- **Agriculture –** The farmer survey report is a good source of data and should be updated annually. As the agricultural sector grows, it may become more complex to collect this data and appropriate measures should be taken to ensure consistency. Spot checks could be used to check the accuracy of estimates. The approach should be updated to reflect prices paid to farmers rather than sticker prices in supermarkets, which will contain the supermarket's value added, or mark up. As prices may fluctuate over the course of the year, an annual average should be used.
- **Coastal defence –** The approach to valuing coastal defence draws on habitat and infrastructure maps. These are good sources of data, but are often out of date. To track changes year on year these should be updated as frequently as possible with EO/GIS data and analysis. Currently the approach models the impact of sea surge in GIS using several assumptions. This methodology should be revisited and updated as the technology improves and sea surge dynamics are able to be modelled more accurately, including with changes to the bathymetry due to changing reef dynamics. A more

immediate improvement can be made with better economic data on the vulnerable infrastructure, in terms of its financial value, and a more nuanced approach to estimating the damage costs from flooding, such as through collection of insurance claim data.

- **Surface hydrology -** The approach to valuing surface hydrology draws on habitat and infrastructure maps. These are good sources of data, but are often out of date. To track changes year on year these should be updated as frequently as possible with EO/GIS data and analysis. Currently the approach models the impact of surface flooding in GIS using several assumptions. This methodology should be revisited and updated as the technology improves and surface flooding dynamics are able to be modelled more accurately. A more immediate improvement can be made with better economic data on the vulnerable infrastructure, in terms of its financial value, and a more nuanced approach to estimating the damage costs from flooding, such as through the collection of insurance claim data.
- **Tourism –** The data available on tourism is relatively comprehensive, and updated regularly. Tourist numbers, types of visits, length of stay and expenditure by activity should all be updated annually. Improvements should focus on the approach to valuation, well-constructed surveying could provide more accurate estimates on the degree of ecosystem dependence of various activities, the value added of the tourism sector, and tourist consumer surplus or willingness to pay for the environment.
- **Local cultural services –** Currently there is limited data in regard to local residents' behaviour and attitude towards the environment. To better understand the cultural values that the people of TCI get from the environment, data on recreational uses, such as frequency and duration of visits to the beach, sight seeing, hiking and other outdoor activities should be collected. Data on the value residents' place on these activities should also be generated, such as actual expenditure, cost-of-time analysis, willingness to pay, and travel costs to participate in these activities. Another local cultural value arises from knowledge of the existence of the natural environment, and pride in the variety of habitats found in TCI. Surveys could be conducted to understand how wide spread these sentiments are across residents of the island, and how much value they place on them.

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 Table 5.1[5].

Table 5.1: Data types for additional benefits

Benefit	Data for physical account[6]	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 • WTP to avoid illness
Aggregates and mineral extraction	• Types and quantities of aggregates and minerals extracted	• Market price of aggregates and minerals
Global climate regulation	• Carbon sequestration capacity of island vegetation	• Social or market price of carbon

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

Local climate regulation	• Level of shade provided • Cooling impact of shade on productivity and comfort	• Value of improved productivity • WTP for relief from heat
Erosion control	• Incidents of mudslides • Modelled level of sedimentation reaching property or coastal waters	• Cost of cleaning property • Cost of marine dredging
Windbreak	• Level of protection from wind in residential and recreational areas	• WTP for absence of nuisance
Noise buffer	• dB reduction capacity of vegetation in residential area	• Impact on health and well-being of noise
Dust and debris screen	• Effectiveness of vegetation at blocking dust and debris	• WTP for absence of nuisance
Air quality	• Capacity of local vegetation to filter air pollution • Level of air pollution	• Health impacts from air pollution on TCI
Historical/heritage value	• Sites of historical / heritage interest on TCI • Frequency of visits to sites	• WTP to preserve sites • Travel cost to visit sites
Iconic species	• Presence of iconic species • Number of occurrences of species	• WTP for protection of iconic species
Education and research	• Presence of sites used for education or research	• Cost of education or research programmes
Biodiversity and habitat provision	• Amount of flora and fauna • Variety of species • Health and functionality of ecosystems	• WTP for biodiversity conservation • A function of all other values to capture supporting services

Most improvements are dependent on data and data collection, some general steps to establishing and improving data collection processes include:

- **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 –** GIS and EO offer a great opportunity to collect data remotely, reducing resource requirements and aiding in consistency and repeatability. The skillsets required to operate these tools could be developed for regular data collection and analysis.
- **Creating a register of where data is 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 it is located. A central, easily searchable register of what data exists, what it contains, when it was produced, and how it may be obtained would greatly facilitate the data collection process and help to remove barriers between the various bodies which hold data.
- **Placing authority in one government body –** a central authority with the power and responsibility to collect and hold data from across government departments, and from other sources, and to produce the accounts, would provide a valuable resource and first point of contact for conducting all types of research. This could take the form of an online portal that is easily accessible to everyone.

The Department of Economic Planning and Statistics currently has a website that collates national statistics; this could be built on with greater authority and resources to do so.

- **Forming pathways for data transfer** – As these processes are used repeatedly, they become embedded and form 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.

Along with continual updates and improvements in data, there are a few other areas of focus that could be improved on over time:

- **Value layer –** as previously discussed, care must be taken in spatially disaggregating value and interpreting the results. That does not negate that it might be valuable in some cases, and that future developments might make valid spatial disaggregation more feasible. A possible route to explore would be in creating value layers for each benefit by habitat type, and then effectively imposing them onto each other to create an overall natural capital value layer.
- **Monitor trends** – one of the most useful aspects of natural capital accounting is its ability to compare results year on year and thereby monitor trends. These trends can reflect changes in the extent of TCI'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 TCI's natural environment, and importantly, also indicate what is driving the trend.
- **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 TCI accounts can evolve with them, ensuring the most rigorous assessment possible and building increasing confidence in the results.
- **Integrate with policy and planning –** over time, natural capital accounting should play not just a supporting role in policy and planning, but 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.
- **Investment and enhancement of the natural environment –** natural capital accounting can not only measure value and monitor trends, but also be used to advise on investment to maintain or restore natural capital to increase future benefits. Much like investing in built capital in the present can increase revenue in the future, investing in natural capital can yield future increases in the provision of essential environmental goods and services. Natural capital accounting is a tool to strategically inform those investment decisions, and where enhancements will be most beneficial.

This version of the accounts can be used to:

- Provide a foundation for improvements to the TCI natural capital accounts, discussed above;
- Demonstrate the significant value of natural capital in supporting TCI's economy and society;
- Give planners a clearer picture of how built development 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.

If these and other advantages 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.

6. Conclusion

The purpose of this project was to investigate natural capital on TCI, collect available data with which to build up an initial national natural capital account, and to begin to establish the processes by which natural capital accounting can develop in TCI. In one regard, the project has acted as a 'proof of concept' for natural capital accounting in TCI, demonstrating its potential worth as an approach, and creating a guideline for how the accounts can be built and developed further. Future phases of work will develop the TCI natural capital accounts further.

The results from the accounts also give an indication of the scale of the value that natural capital contributes to TCI. It is estimated that a significant annual value of $106.4 million is provided, feeding in to an estimate of the asset value of natural capital on TCI of $1,791.4 million over a 25-year assessment period. Perhaps unsurprisingly, the value natural capital contributes to the tourism sector is by far the largest. This reflects the overall importance of the sector to TCI, and the dependence of the sector on the natural environment, and justifies investing significantly in preserving and / or enhancing the natural environment as the asset that support this sector.

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, including ecosystem 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 are 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 and how far their results can be disaggregated (e.g. spatially). They should be used alongside other information in decision-making.

A fully developed set of national natural capital accounts will measure and monitor the benefits TCI 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 TCI through a flourishing natural environment.

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