Annex – TCI 2018 NCA

An update to the initial Natural Capital Accounts for TCI

eftec/JNCC

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Disclaimer

Document evolution

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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 considerably 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 work is to establish a national "natural capital account" (NCA) for TCI, which is a structured way to measure and monitor these benefits provided by the natural environment. The accounting framework can be used alongside other national accounts and associated indicators (such as GDP), as a basis for understanding the environment to inform policy and planning decisions.

The purpose of the second iteration of the account is to build upon the data and methods developed for the initial 2017 NCA for TCI (eftec and JNCC, 2018). The update applies 2018 data where available and adopts some of the recommendations made in the original report in regard to incorporating additional benefits, and improving methodologies. The aim of this annex to the initial report is to highlight the work done to update the 2018 NCA and to discuss the results; notably it is not meant to be a comprehensive description of the NCA as further details can be found in the main report.

The initial accounts provide a baseline and structure to enable future iterations to be built upon. Due to data limitations, described in more detail in Section 4, the results primarily offer an indication as to the scale of values. The uncertainty associated with each measure is indicated by colour coding in **Table ES1**, and the uncertainties in several key values mean that the total estimated values have a moderate to high degree of uncertainty. Over

time, with more robust and additional data, the accuracy and comprehensiveness of the account can be improved.

Benefit	2018 account			Notes on approach for 2018 NCA
	Physical flow (Annual)	Monetary value (Annual)	Asset value (25yr)	
Fisheries	3,000 tonnes	$19.7 million	$336.7 million	Updated price for spiny lobster and queen conch
Agriculture	45,000 pounds	$0.1 million	$2.3 million	Updated values not available (assumed same quantities as 2017)
Coastal defence	1,137 total infrastructure	*Not available*	*Not available*	GIS analysis for road and building damage conducted
Surface hydrology	*Not available*	*Not available*	*Not available*	GIS analysis for road and building damage not possible at this time
Carbon sequestration and retention	950,000 tCO2e/yr	$31.3 million	$740.6 million	Assessed physical and monetary values for carbon sequestration, but little confidence in results
Tourism	3.3 million visitor-days	$75.7 million	$1,291.1 million	Updated land based arrivals and stay overs, removed measure of consumer surplus, changed GDP deflator to be more accurate
Local cultural services	36,000 local users	$4 million	$77.3 million	No data updates, changed GDP deflator to be more accurate
Local recreation	2.0 million visits	$3.5 million	$68.7 million	Modified approach, included data from preliminary recreational use survey
Additional benefits	*Not available*	*Not available*	*Not available*	Gaps remain
TOTAL		**$134.4 million**	**$2,516.7 million**	

Table ES.1 Headline results from 2018 updated accounts

Note: Due to a high degree of uncertainty, carbon sequestration values are not included in the total

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 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.

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1. Introduction

1.1 Context

This document sets out the updates made to the 2018 natural capital account. It builds upon data and methods used in the initial natural capital account for TCI produced in 2018 for data year 2017 (eftec and JNCC, 2018). The update applies 2018 data where available and adopts some of the recommendations made in the report in regard to incorporating additional benefits, and changing valuation approaches. The aim of this Annex to the original report[1] (eftec and JNCC, 2018) is to highlight the work done in updating the 2018 NCA and to discuss the results; notably it is not meant to be a comprehensive description of the NCA process, as details can be found in the initial report. The accounts provide a baseline and structure to enable future iterations to be built upon, but due to data limitations the results are incomplete and offer only an indication as to the scale of values. Over time, with more robust and additional data, the accuracy and comprehensiveness of the account can be improved.

The following items have been added, or the approaches amended, to improve the account:

- **Asset register** – The extent of TCI's habitats was updated.
- **Carbon sequestration and retention** – Benefit added because carbon sequestration and carbon storage are important for global climate regulation.
- **Coastal defence** – Data on the number of buildings, schools, and roads at risk of damage from a storm surge was added.
- **Tourism** – Measure of consumer surplus for valuation removed from monetary accounts to focus more explicitly on tourism expenditure to be more in line with other benefits.
- **Local cultural benefit** – Data was collected on local recreation and included for this benefit.
- **GDP deflator** - Updated to align with TCI's GDP.

1.2 General approach

This study reviewed the list of priority benefits from the previous year and scoped in three additional benefits to this iteration of the account. The benefit prioritisation is summarised in **Table 1.1**.

Table 1.1 Prioritisation of benefits for inclusion in the second 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 low expectation around the scale of the impact at the national level.
	Raw materials – Craft materials extraction	No	

[1] Retrievable from http://jncc.defra.gov.uk/pdf/ot_nca_sup_cbn_19_tci_nca_Nov2018.pdf

	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.
	Carbon sequestration and retention	**New**	**Included as 'carbon sequestration and retention'. An important benefit supported by TCI's habitats which plays a role in global climate regulation**
	Water quality regulation	No	Scoped out due to lack of data and understanding of the connection between natural capital and the provision of water extracted from the underground water lens; need for further research and potential future inclusion.
	Windbreak	No	Scoped out due to lack of data, and low expectation 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	**New**	**Included as 'local recreation'. Local resident use of natural capital for recreational activities.**
	Existence / spiritual values	Yes	Included within a general catch-all 'Local cultural services' category.
	Historical and archaeological values	No	Scoped out due to lack of data and difficulty in valuing the benefit.
	Iconic species	No	
	Education and Research	No	Educational opportunities, such as a field school for study abroad university students, as well as academic research, derive value from natural capital; however, this benefit is not currently included due to a lack of data.

Once the benefits have been scoped for inclusion in the account, an asset-service matrix is used to consider which ecosystem service is dependent on which habitat type. **Figure 1.1** sets out the asset-service matrix for the prioritised benefits.

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						
	Carbon sequestration						
Cultural	Tourism						
	Recreation						
	Local cultural services						

Figure 1.1 Asset-service matrix with prioritised benefits

In order to update the account, collecting primary and secondary data is required. For the first account, a 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 existing data with which to conduct the assessment. For this account, the same government departments were contacted to request the most up to date data where available.

The School for Field Studies (SFS) provided an additional source of data. Based on South Caicos, students at the school conduct guided field research as part of their studies. In partnership with SFS, data were collected on local recreational use and incorporated in to the NCA.

Sources of data drawn on to update the account are as follows:

- Government departments and other government/quasi-governmental bodies
  - Environment
  - Planning
  - Tourist Board
  - Agriculture
  - Economics and statistics
- GIS / Earth Observation
- Field school survey
- Online sources

1.3 Structure of document

The remainder of this document has the following structure:

- Section 2: Sets out the benefits included in the account, the methodology, and data updates.
- Section 3: Sets out the findings from the 2018 account.
- Section 4: Provides a discussion of the findings and outlines the limitations of the approaches and includes recommendations for future accounts.
- Appendix A: Contains the recommendations from the initial NCA report.

2. Benefits

This section sets out the benefits included in the 2018 account. It highlights the methods used to value each benefit and outlines where data has been updated on the previous account. For more detail regarding the methodology, refer to the main report (eftec and JNCC, 2018).

2.1 Asset Register

The asset register is an inventory of natural assets, including information regarding their extent and condition. The total habitat extent on TCI is approximately 100,000 ha, see **Table 2.1** which compares habitat extent by individual habitat type from 2017 to 2018, demonstrating relatively minor changes across habitats, with the overall modest gains mostly driven by increases in forest.

Table 2.1 Habitat extent in total on TCI

Habitat	2017 area (ha)	2018 area (ha)
Dwarf Shrubland	16,770	16,769
Forest	5,000	5,024
Herbaceous	7,413	7,412
Human Altered	5,679	5,678
Non-Vascular	23,021	23,020
Shrubland	22,488	22,487
Woodland	19,384	19,383
Grand Total	**99,753**	**99,773**

Source: Environment Systems, 2018

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.

There is currently a lack of up to date data on the condition of TCI's ecosystems, including 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 humans are able to benefit from them.

The following data were updated: Habitat extent

2.2 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, including for 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 fish 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.

Data needs: To reproduce these figures, data are needed on quantity of landings (currently only recorded for fish destined for the export market), consumption patterns (to estimate domestic consumption), and prices. 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 following data were updated: TCI population and tourism land-based arrivals were updated, as well as the price paid at landing for spiny lobster and queen conch. Once available, landings data for 2018 should be added.

2.3 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 it could be an important factor for the self-sufficiently of the currently import-dependent island. 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

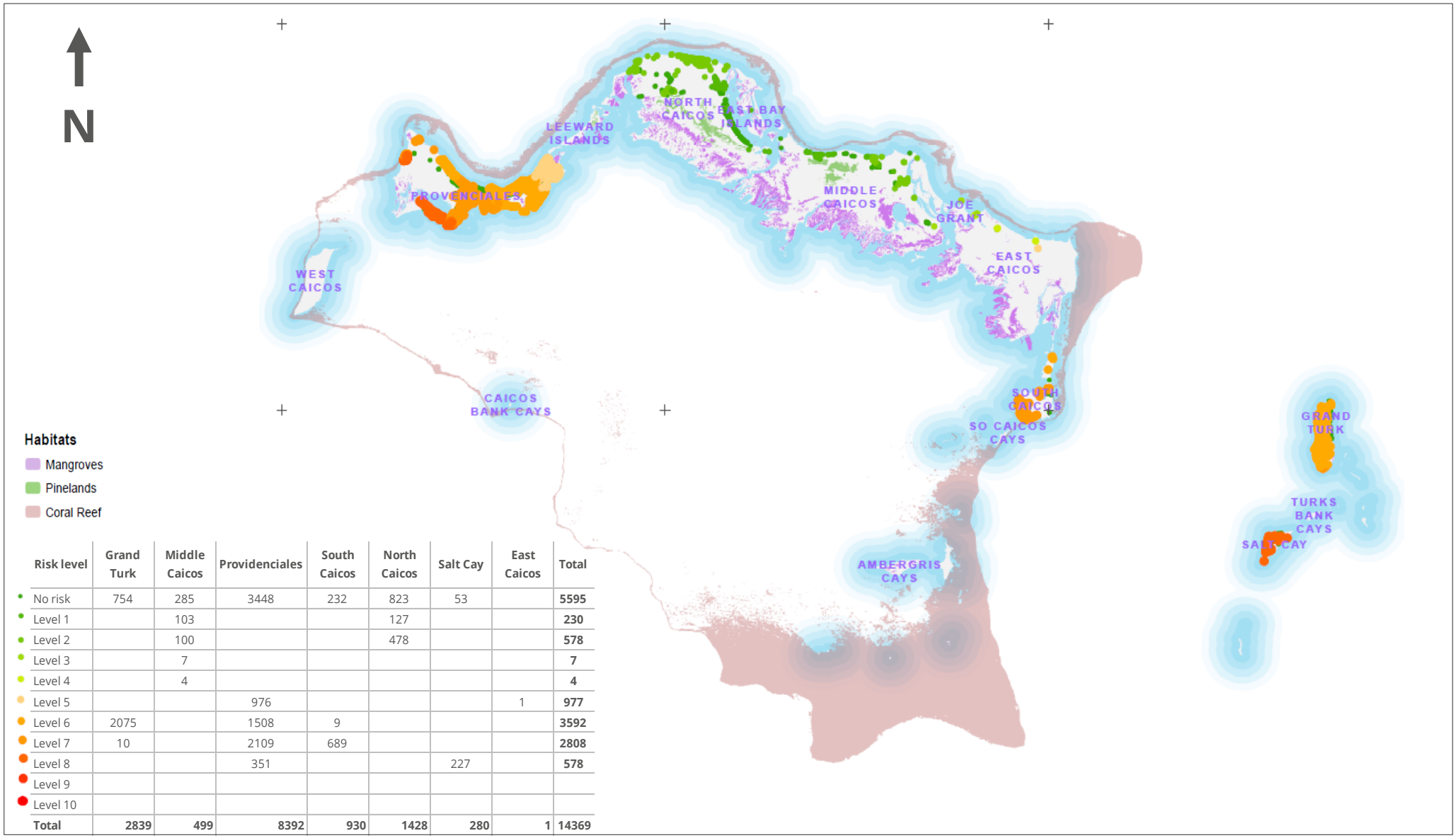
Data needs: The quantities sold for each item and the price paid to farmers (or alternatively the price paid by consumers as quoted in a local grocery store, adjusted to remove the retail mark-up). The data for this straightforward approach, quantity of good multiplied by price per good, should be updated annually.

The following data were updated: The agricultural survey report has not been published at the time of reporting, but this benefit should be updated with these data when available.

2.4 Coastal Defence

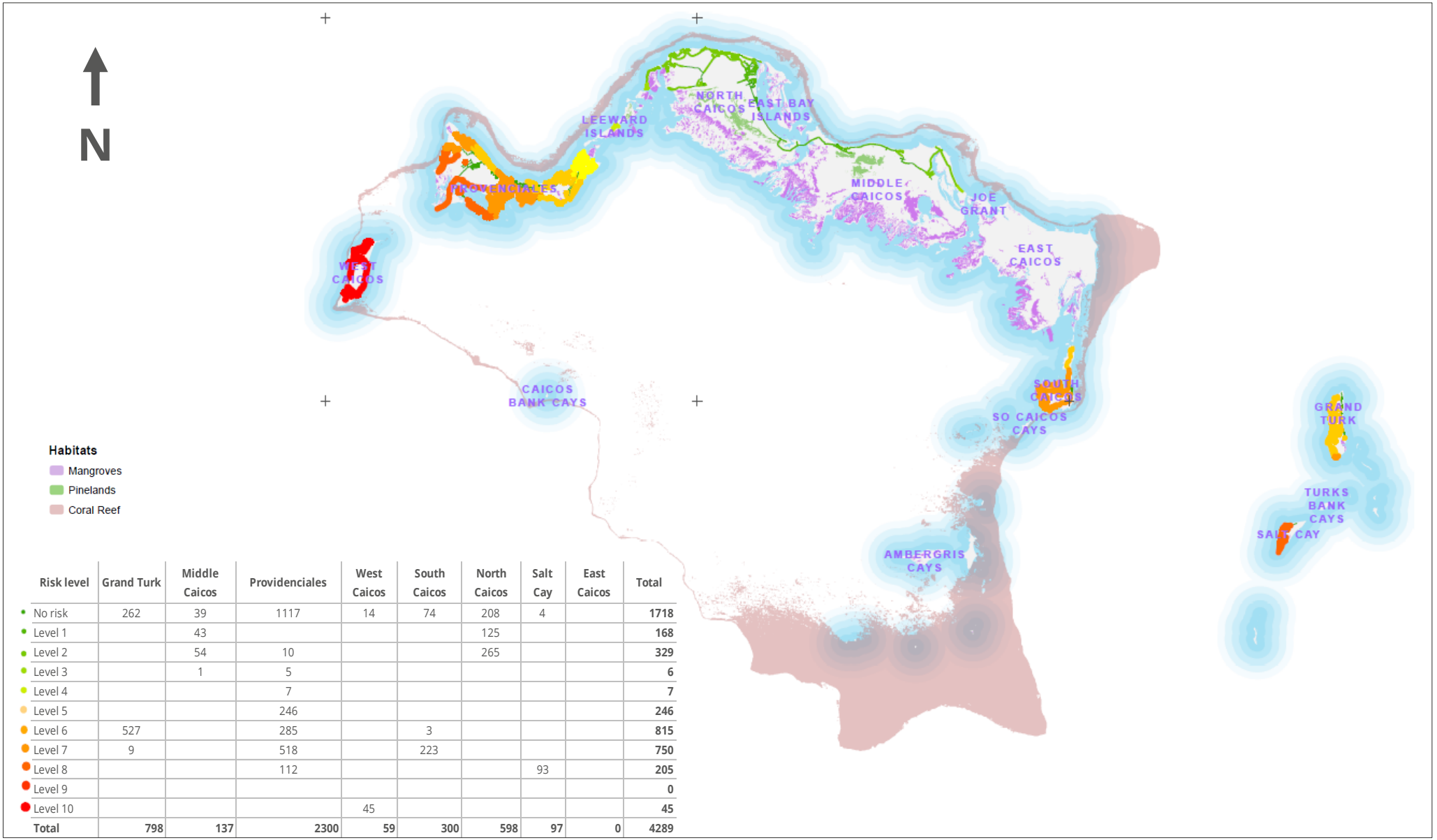
The natural capital of TCI's marine coastal habitats provides protection to the islands from damage and flooding due to sea surge from storms and other adverse weather events. Reefs, sand bars, mangrove stands, dunes and even seagrass beds all help to absorb energy and mitigate the impact of waves and rising waters. This can have the effect of defending vulnerable built infrastructure on the islands.

The vulnerability areas are overlaid with infrastructure maps, to produce a count of buildings impacted by different flood inundation levels. The potential damage to roads on TCI is displayed in **Figure 2.1**, the damage to buildings in **Figure 2.2,** and the damage to schools in **Figure 2.3**. Each map illustrates the level of risk for each infrastructure type and the habitat types.



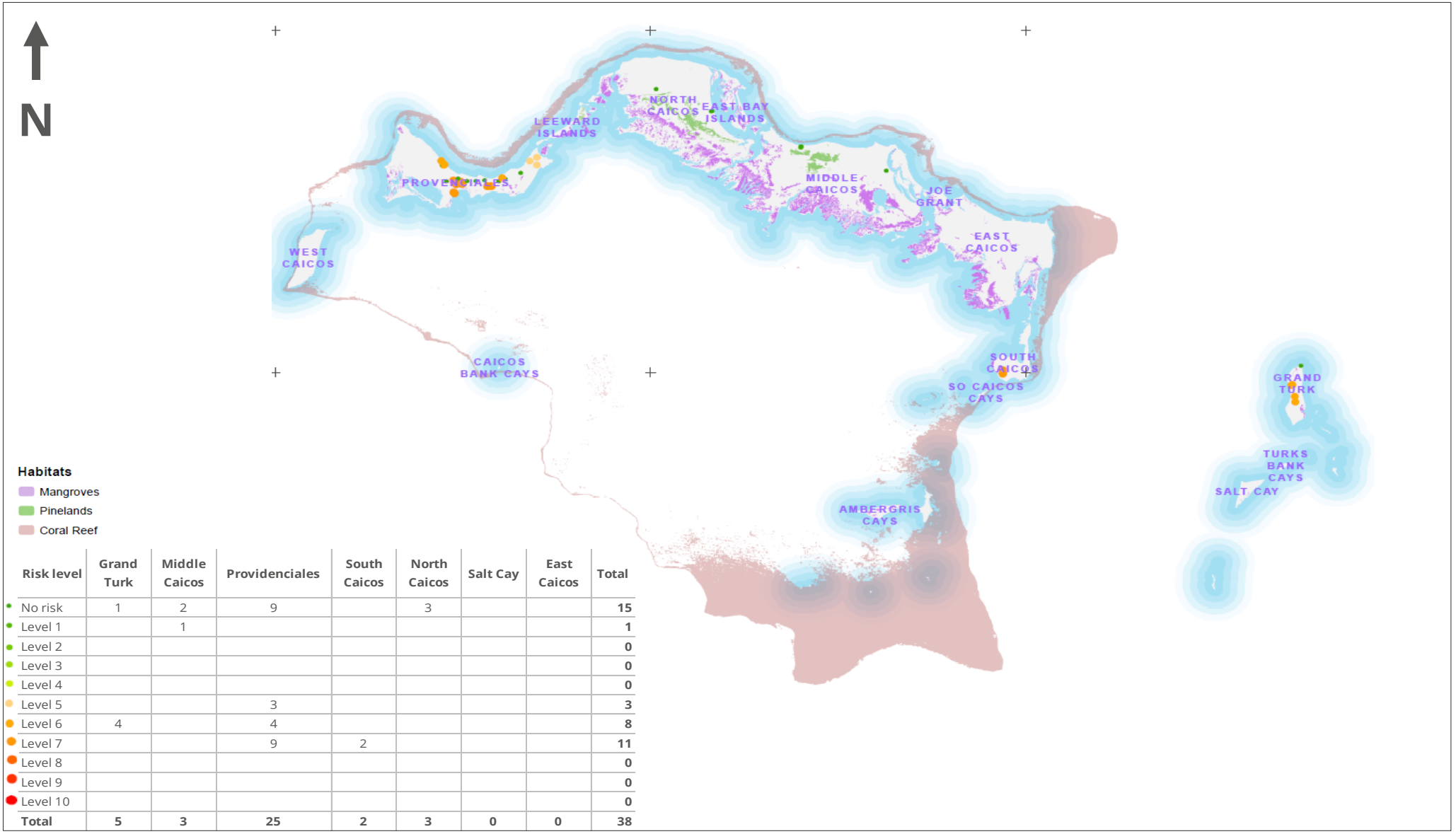
Risk level	Grand Turk	Middle Caicos	Providenciales	South Caicos	North Caicos	Salt Cay	East Caicos	Total
No risk	754	285	3448	232	823	53		**5595**
Level 1		103			127			**230**
Level 2		100			478			**578**
Level 3		7						**7**
Level 4		4						**4**
Level 5			976				1	**977**
Level 6	2075		1508	9				**3592**
Level 7	10		2109	689				**2808**
Level 8			351			227		**578**
Level 9								
Level 10								
Total	**2839**	**499**	**8392**	**930**	**1428**	**280**	**1**	**14369**

Figure 2.1 Roads on TCI affected by storm surge



Risk level	Grand Turk	Middle Caicos	Providenciales	West Caicos	South Caicos	North Caicos	Salt Cay	East Caicos	Total
No risk	262	39	1117	14	74	208	4		**1718**
Level 1		43				125			**168**
Level 2		54	10			265			**329**
Level 3		1	5						**6**
Level 4			7						**7**
Level 5			246						**246**
Level 6	527		285		3				**815**
Level 7	9		518		223				**750**
Level 8			112				93		**205**
Level 9									**0**
Level 10				45					**45**
Total	**798**	**137**	**2300**	**59**	**300**	**598**	**97**	**0**	**4289**

Figure 2.2 Buildings on TCI affected by storm surge



Risk level	Grand Turk	Middle Caicos	Providenciales	South Caicos	North Caicos	Salt Cay	East Caicos	Total
No risk	1	2	9		3			**15**
Level 1		1						**1**
Level 2								**0**
Level 3								**0**
Level 4								**0**
Level 5			3					**3**
Level 6	4		4					**8**
Level 7			9	2				**11**
Level 8								**0**
Level 9								**0**
Level 10								**0**
Total	**5**	**3**	**25**	**2**	**3**	**0**	**0**	**38**

Figure 2.3 Schools in TCI affected by storm surge

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 from sea surge due to 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.

The following data were updated: habitat data, GIS analysis was conducted to produce number of buildings, schools and roads damaged as a result of sea surge.

2.5 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 damage from surface flooding.

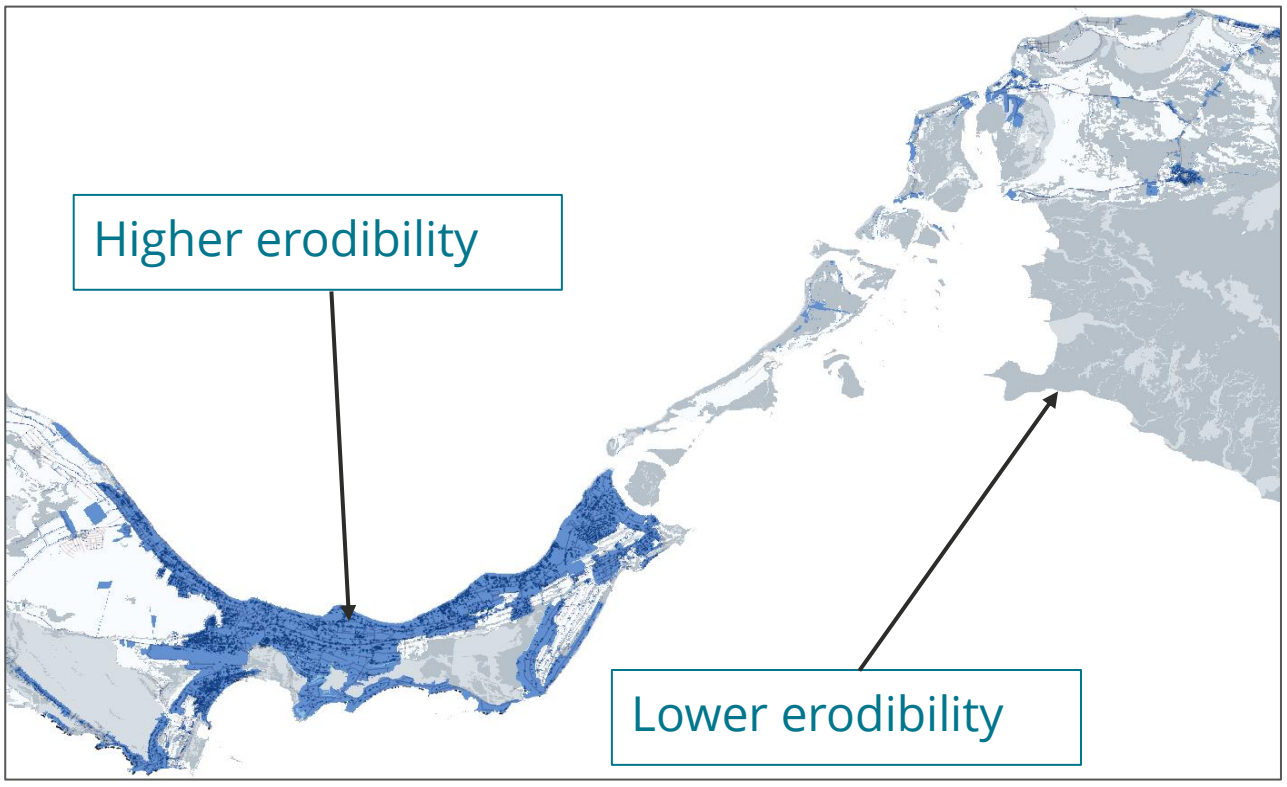


Figure 2.4 Demonstration of erosion risk mapping with GIS analysis

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 from surface flooding due to 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.

The following data were updated: Due to data and resources constraints, this benefit was not able to be modelled at this time.

2.6 Carbon sequestration and retention

Carbon sequestration is the process of capturing carbon dioxide from the atmosphere. The carbon sequestration rate is highly dependent on a variety of TCI's habitats. This benefit contributes to global climate regulation.

To assess the value of this benefit, a unit value of carbon sequestration rates in tropical forests was adopted (Soepadmo,1993). This study estimated 5.5 tonnes of carbon are sequestered per hectare per year in trees in sub-tropical dry forests of Costa Rica. This habitat type is similar to what is found in TCI, and so this value is transferred to this study. This estimate was applied to the forest and woodland habitats on TCI by multiplying the carbon sequestration rate by the area of each habitat

The values were converted to tCO2e in order to apply the UK non-traded price of carbon (HM Treasury, 2018). The UK carbon prices were converted to US dollars, and then multiplied by the UK and TCI GDP per capita ratio.

There was insufficient carbon sequestration data to value the remaining habitats (shrubland, dwarf shrubland, herbaceous, non-vascular, human-altered). The value estimated by this approach should be considered a placeholder value, the data applied is not specific enough to TCI to give an accurate indication of value and needs to be updated with more accurate carbon sequestration estimates.

Data needs: There is a significant data gap on the carbon sequestration rate for each TCI habitat, and so the approach requires data on the carbon sequestration rate for TCI's specific habitat types to be more accurate. Habitat extent and carbon price data are also needed to estimate this value.

Carbon storage is an indicator of condition. Carbon storage capacity on TCI contributes to global climate regulation. An approach to estimate the condition was applied by ranking the biomass of habitats on TCI, and a study by the South Atlantic Environmental Research Institute (SAERI) (St Helena Government, 2019), which measured absolute carbon stored in soil organic stocks.

The method applied is experimental and offers only a broad estimate of the level of carbon stored. It is adopted from work conducted in a workshop in the British Virgin Islands (BVI) in December 2018 which required stakeholders to rank habitats based on how much biomass they were likely to store, considering both above and below ground organic material. The ranking from this approach was applied to equivalent TCI habitats. For example, forest and woodland habitats were scored 15 (out of 15), while scrubs were scored 10, see **Table 2.2** for the habitat matching and ranking for TCI.

Table 2.2 BVI and TCI Habitat ranking based on carbon storage of each habitat

BVI Habitat equivalent	TCI Habitat	Ranking
Evergreen Forest	Forest	15
Evergreen Forest	Woodland	15
Scrub	Shrubland	10
Scrub	Dwarf Shrubland	10
Grassland	Herbaceous	8
Salt Pond	Non-Vascular	6
Urban	Human Altered	4

This ranking was then applied to the soil carbon scale provided by SAERI, where values ranged from less than 20 Mg C per ha to over 65 Mg C per ha. For example, forests and woodlands are at the top of the carbon storage scale, therefore, a measure of 65 Mg C per ha was applied to these habitats. The carbon storage capacity estimate was then multiplied by the area of each habitat type.

Although carbon storage was not valued in this account, it is possible to value the carbon released from different land use to determine the ability of the present natural capital to maintain the storage capacity (i.e. avoid the release of stored carbon) with additional research and data.

Data needs: Better data on carbon storage of TCI's habitats, as well as the carbon release rate from different land management regimes, is needed. The approach outlined above illustrates a potential format to be developed in the future with more accurate data. Habitat extent and carbon price data is also needed are also needed to estimate this value.

This benefit is a new addition to the 2018 accounts.

2.7 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.

Several types of data and estimates are required to assess the value of this benefit, such as visitor numbers, expenditure, and time spent at destination. Data were drawn from different sources to estimate the number of visitor-nights per year for categories of visits[2]. For each category of overnight visitor, expenditure was broken down by visitor type and applied a factor of ecosystem dependence score. 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. 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).

[2] Data was drawn from: Turks & Caicos Islands Tourist Board 2009 – 2017, National Tourism Policy (KPMG, 2015), and TCI Departing visitors survey - March 2017 (Turks and Caicos Department of Statistics, 2017).

Data need: Tourism data should be updated annually in regard to tourist numbers for each type of visit, while average expenditure data 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 following data were updated: tourism numbers for land-based arrivals and cruise arrivals.

2.8 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 cultural 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 are 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.

Data needs: 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 (Ghermandi, 2009). The value was adjusted to reflect the relative Purchasing Power Parity[3] (PPP) in TCI and applied to the total resident population of the islands. This value could be updated with a more direct study on TCI residents' value of the local environment for cultural purposes. Although the accounting framework generally prefers the use of exchange values for valuation, due to a lack of appropriate data, the use of WTP, a welfare value, is useful to indicate value for this benefit.

The following data were updated: number of residents in TCI.

2.9 Local Recreational use

The natural environmental is important for recreational use by local residents in TCI, and so this benefit has been added in to the 2018 NCA. The value of this benefit was assessed using survey data collected by the SFS over a period of a week. The survey was conducted in South Caicos with information gathered on the frequency, expenditure and time spent on the following activities:

- Boating
- Kayaking
- Swimming
- Walking
- Hiking
- Snorkelling
- Fishing
- 'Other'

The value of recreation is estimated by multiplying the average number of visits by the average expenditure on accessing and participating in recreation, for each activity. To calculate the average number of visits per year per activity, the total number of visits was divided by the total number of participants in the study. The average number of visits per year was aggregated to the total resident population of the islands, by multiplying the average visits by the total population. To value the recreational benefit, the average number of visits per activity was multiplied by the average spend per visit in the survey sample group. This gave the total estimated value of recreation for each activity.

Data needs: The local recreation data can be improved by conducting a survey throughout the whole of TCI as the survey was only conducted in South Caicos, and therefore does not accurately represent the population of TCI. Data updates are needed on the population of TCI annually, as well as the rate of participation in various activities and the average expenditure associated with the activities through surveying or other data collection activities conducted intermittently.

This benefit is a new addition to the 2018 accounts.

2.10 Other benefits

Numerous other benefits are provided by TCI's natural capital. The current accounts focus on the value of nine prioritised benefits, and so do not provide an exhaustive coverage of the benefits the natural environment provides to TCI. See **Table 1.1** in Section 1.2 for a list of potential additional benefits. The benefit from educational opportunities, subsistence agriculture (i.e. from backyard gardens) and use of materials from the environment for building, arts and crafts and medicinal purposes, have been identified for potential inclusion in the next iteration of the account.

[3] Purchasing power parity show the ratio of prices in national currencies of the same good or service in different countries. See https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm

3. Findings

The national natural capital accounts demonstrate the considerable value that TCI receives from its natural environment on an annual basis. A total annual value of $134 million was estimated for the modelled benefits for 2018. 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, as all are based on renewable ecosystem processes and functions. The total 25 year value stream[4], based on the modelled benefits, is estimated at $2,516.7 million.

For the provisioning services, the monetary value of fisheries decreased from the 2017 due to updated prices of spiny lobster and queen conch. This was due to the source of the data changing - prices for 2018 were gathered directly from the TCI Department of Environment and Coastal Resources. This source provides a more robust value compared to 2017, where average fish prices between 2012-2015 was applied.The agriculture benefit remained unchanged as data were not available to update the accounts. The approach was updated for the regulating benefit of coastal defence, with the number of buildings that avoided damage estimated to be 900 in 2018. This differs from previous approach whereby the total number of buildings at risk of damage was reported, rather than an estimate of the avoided damage due to natural capital. Carbon sequestration and retention had an estimated annual value of $31.3 million (one-off value). . The annual value of tourism fell from $80.2 million to $75.7 million, as a result of the removing the measure of consumer surplus for valuation from monetary accounts to explicitly focus on tourism expenditure, while the value from local cultural use and local recreational use is estimated at $4.4 million and $3.6 million respectively.

The headline results from the 2018 NCA, along with the results from the 2017 NCA, can be found in **Table 3.1**.

[4] *A 25 year assessment period is chosen to align with the UK Government 25 Year Environment Plan, retrievable from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/693158/25-year-environment-plan.pdf*

Table 3.1 Headline results from 2017 and 2018 accounts

Benefit	2017 account			2018 account			Notes on approach for 2018 NCA
	Physical flow (Annual)	Monetary value (Annual)	Asset value (25yr)	Physical flow (Annual)	Monetary value (Annual)	Asset value (25yr)	
Fisheries	3,000 tonnes	$21.7 million	$369.5 million	3,000 tonnes	$19.7 million	$336.7 million	Updated price for spiny lobster and queen conch
Agriculture	45,000 pounds	$0.1 million	$2.3 million	45,000 pounds	$0.1 million	$2.3 million	No updated data available yet
Coastal defence	7,000 buildings at risk	*Not available*	*Not available*	1,137 total infrastructure	*Not available*	*Not available*	GIS analysis for road and building damage conducted
Surface hydrology	*Not available*	*Not available*	*Not available*	*Not available*	*Not available*	*Not available*	GIS analysis for road and building damage not feasible as of March 2019 at time of analysis
Carbon sequestration	*Not included*	*Not included*	*Not included*	950,000 tCO2e/yr	$31.3 million	$740.6 million	Included unit values for carbon sequestration, but no confidence in results
Tourism	3.1 million visitor-days	$80.2 million	$1,336.2 million	3.3 million visitor-days	$75.7 million	$1,291.1 million	Updated land-based arrivals and stay overs, removed consumer surplus measure, changed GDP deflator to be more accurate
Local cultural services	35,000 local users	$4.3 million	$83.4 million	36,000 local users	$4 million	$77.3 million	No data updates, changed GDP deflator to be more accurate
Local recreation	*Not included*	*Not included*	*Not included*	2.0 million visits	$3.5 million	$68.7 million	Included data from preliminary recreational use survey
Additional benefits	*Not available*	*Not available*	*Not available*	*Not available*	*Not available*	*Not available*	Gaps remain
TOTAL		**$106.4 million**	**$1,791.4 million**		**$134.4 million**	**$2,516.7 million**	

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.

4. Discussion

4.1 Data availability and limitations

As discussed in the main report, the initial accounts are a starting point from which to set up the structure that future iterations will build upon, therefore the overall results presented should be interpreted with caution. Although an improvement on the initial accounts, this holds true for the results presented in this report for the second iteration of the accounts. The first two accounts offer an indication as to the scale of value, but improved robustness in input data and methodological approach will enhance future updates.

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 will not always be feasible under current conditions in terms of resources and practical restrictions, but these processes do exist for other national accounts and should be the benchmark to aim for. The type of data required dictates the frequency of collection, whether it's annual where change is expected, or less frequently where underlying variables move only slowly. Further, some data might be ideal to know, but too expensive or impractical to gather. In some cases, data for 2018 were still being produced (as of the time of the analysis), and data can be added to update the 2018 NCA when available (e.g. from the updated agricultural survey and tourism survey).

This iteration of the accounts identified two new benefits to include; carbon sequestration and retention, and local recreation. As initial estimates, these values are not yet considered robust, and efforts should be aimed at improving the data and methodologies applied to these benefits. In the case for the carbon sequestration and retention benefit, transfer values were applied as carbon sequestration and storage values were limited for Caribbean island habitats, and non-existent for TCI; therefore, the carbon sequestration and storage values might not accurately represent the specific TCI climate regulation capacity. The approach to estimating the storage capacity as an indicator of condition in the asset register leads to very high estimate especially, and there is a high degree of uncertainty in these values. For the other added benefit, local recreational use, the estimated relies on applying primary research on South Caicos to the total population of TCI, this approach implicitly assumes that local recreational use on South Caicos is representative of the rest of TCI; however, this may not accurately reflect the level of recreational use on the other islands.

While progress was made in the physical accounts for the coastal defence benefit, there is still a notable gap in the current account regarding the value of the coastal defence and surface hydrology benefits. This is 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, including training in March 2019. This aspect of the account should be further advanced as a priority and fed in to future iterations. This will help direct efforts to build resilience to future adverse weather events.

4.2 Recommendations

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 specific recommendations following from the 2018 NCA, with a more detailed list of recommendations presented in Appendix A.

- **Asset Register -** 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. Prioritisation should be to collect up to date information on the condition of TCI's ecosystem as the benefits generated from the natural assets are largely dependent on their quality.
- **Fishing –** The updated 2018 landings data should be input in to the model once available to update the catch for export. Future iterations could try to use more accurate estimates of domestic consumption based on surveying.
- **Agriculture –** Data from the agricultural survey should be updated in the report to reflect 2018 quantities. Data on prices paid to farmers would be a better estimate of the value provided by natural capital than the currently used retail prices.
- **Coastal defence –** Further GIS analysis is required to refine the assessment of this benefit. While the current analysis indicates the amount of infrastructure at risk, to determine the value that natural capital has in preventing damage from coastal defence, GIS models need to be run with and without natural capital (or make use of alternative scenarios with regard to the condition of natural capital) to determine the difference in at risk properties. Avoided damage costs values can then be placed on this difference by estimating the cost to repair the damage.
- **Surface hydrology -** Further GIS analysis is required to conduct the assessment of this benefit. GIS analysis and fill modelling needs to be conducted to determine the vulnerability of infrastructure to surface flooding and erosion, and then run with and without natural capital (or make use of alternative scenarios with regard to the condition of natural capital) to determine the difference in at risk properties. Avoided damage costs values can then be placed on this difference by estimating the cost to repair the damage.
- **Carbon sequestration –** The approach to valuing carbon sequestration draws on the value of carbon sequestration rates in tropical forests. The values were converted to tCO2e in order to apply the UK non-traded price of carbon. These values were then exchanged from pounds (£) to US dollars. While this is a transferable method, it should be updated with more accurate carbon sequestration data for the specific habitats found in TCI (or other Caribbean territories with similar ecosystems), including scrubs and non-vascular plants, and other habitat types. The approach to measure carbon storage draws on two components – a habitat ranking of carbon storage in BVI habitats, and a scale of soil organic carbon from St Helena. Carbon storage was only estimated quantitively in woodland, forest and scrubland and dwarf shrubland and used to indicate the condition of those habitats. More localised or in-depth studies could be used to improve these estimates.

- **Tourism –** The approach to tourism relies on survey data that are regularly updated, specifically in regard to tourist numbers and expenditure values. These should be incorporated in to the accounts annually. The current version as reported here has updated tourist numbers, but not updated expenditure data; this should be updated for 2018 once published.
- **Local cultural services –** There are limited data in regard to local residents' perception of the environment and its value in regard to cultural use and appreciation (including existence and spiritual values). Surveying should be conducted to examine these values, potentially using various stated preference methods to determine a WTP value specific to TCI, to be applied across the total local population.
- **Local recreational use -** 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 were collected. However, the robustness of the data used could be improved. The survey was only conducted in South Caicos with results assumed to be representative across TCI as a whole, this may or may not be an accurate assumption. More widespread surveys could be conducted to understand how recreational use occurs across all residents of the island, and how much value they place on them.
- **Other - Education –** The environmental on TCI provides an educational opportunity for students of all ages, research, and anyone else who is interested. The SFS hosts students from abroad to come and learn and conduct guided research related to the environment. The value the environment provides through educational opportunities could be estimated by applying the total number of students over the course of a year by the value the receive from it, with tuition and travel fees being used to approximate monetary value. A similar approach could be applied to other beneficiaries of educational opportunities from the environment, including scientific researchers who both contribute to the local economy and draw scientific benefit from the environment.
- **Other - Material use –** Material use from the environment includes use of plant fibres and extracts for building material, art and crafts, and medicinal purposes. Data can be collected on the quantities used, and then valued using market data for alternative building materials, a portion of the selling price for arts and crafts, and the value of medicine to treat similar ailments as treated by medicinal plant material.

4.3 Conclusion

The 2018 NCA has built on the processes initiated with the 2017 NCA. Where available, 2018 data have been updated to the accounts which helps to demonstrate change over time. This iteration of the accounts also represents progress in the approaches applied through the improvement of the methodology for the coastal defence benefit, and expansion by including carbon sequestration and retention, and local recreation. Although further work is needed to refine the benefits to a stage where the results can be confidently reported within the NCA, these amendments and inclusions represent progress.

The development of a robust account with the inclusion of a comprehensive range of benefits will take several iterations, and a degree of experimentation and innovation. It will also take improvement in the availability and quality of relevant data. However, even as largely preliminary results, the 2018 NCA does provide an indication of the significant value that the environment contributes to TCI.

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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Appendix: Recommendations from initial report

The current national natural capital accounts build on the initial accounts and together they lay the groundwork for continued refinement. This section restates the recommendations made in the initial report 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. These estimates should be verified on the ground with ecological surveying. This will enable the accurate monitoring of changes in land use of time.
- **Condition –**data on the condition of TCI's ecosystems is lacking. 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 by using consumption data. The accuracy would be improved by measuring all landings directly, either at point of landing or by surveying fishermen and spot checking. Alternatively, 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 will 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 A.1**[5].

Table A.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
Local climate regulation	• Level of shade provided	• Value of improved productivity

[5] 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.

	• Cooling impact of shade on productivity and comfort	• WTP for relief from heat
Water quality regulation	• Quantity of water extracted • Capacity of environment to purify water and regulate flow	• Cost of alternative sources of water • Cost of treatment
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.

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