Seychelles Post Disaster Needs Assessment

Tropical Cyclone Fantala

April 2016

A Report by the Government of Seychelles

With support from the European Union, the United Nations, and the World Bank

A report prepared by the Government of Seychelles, with technical and financial support from the European Union (EU), the World Bank (WB), the Global Facility for Disaster Reduction and Recovery (GFDRR) and the United Nations (UN).

Photos: Courtesy of: Government of Seychelles, Virgine Duvat, Adrian Skerrett, and Doekle Wielinga.

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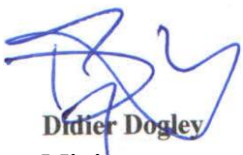
FOREWORD

The tropical cyclone, Fantala, formed over the southwestern Indian Ocean on 11 April, 2016. It passed near Farquhar Atoll on April 17, with maximum sustained wind speeds of 241 km/h. On April 19, it sustained maximum wind speeds of 157 km/h, causing widespread damage. Tropical cyclone Fantala made landfall on the evening of Sunday 17 with winds up to 350 km/h. Significant damage was reported on Farquhar Island's environment, physical infrastructure, and coconut palm tree groves. On April 20, the Government of Seychelles declared the Farquhar group area, including Providence Atoll and St. Pierre a disaster area.

The government is grateful that no one was killed or seriously injured from this disaster, thanks to adequate preparedness measures taken by the Government and the Islands Development Company. This event is another reminder for the entire nation that Seychelles is not safe from disasters and there is an increasing trend in the frequency and intensity of extreme weather events that affect the archipelago, threatening the Seychelles' unique terrestrial and marine ecosystems, exacerbating the limited availability of key natural resources such as water, energy, and agricultural lands that characterize the Seychelles and other small island development states. The challenges related to geography, a small economy—which, in the case of the Seychelles, is dependent on a few highly sensitive sectors and industries, particularly tourism—limited land and freshwater resources, as well as high levels of exposure to natural hazards, compounded by reduced fiscal space to finance disaster preparedness and response capacity, constrain the country's ability to build economic and financial resilience to external shocks.

On April 25, 2016 the Government approached the World Bank, requesting support in conducting a Damage and Loss Assessment and in May, a small team of experts from the World Bank, complemented by the Division of Risk and Disaster Management (DRDM), Islands Development Company (IDC), Island Conservation Society (ICS), and the United Nations conducted a Post Disaster Needs Assessment (PDNA). The report provides a breakdown of key sectors affected, the economic damages and losses, as well as the resources needed to finance the recovery of the areas negatively impacted upon by the passing of Tropical Cyclone Fantala over Farquhar Atoll. The PDNA report also provides recommendations and guidelines to ensure that a risk reduction perspective that incorporates a build-back-better approach guides the recovery process. The aim is to mitigate the underlying drivers of vulnerability. A key outcome of the PDNA assessment is to highlight an enhanced understanding that disaster risk reduction and climate change adaptation considerations shall be the overarching themes that underpin the selection of sustainable recovery interventions, contributing to protect the country's social and economic gains and assets, as well as its natural environment and ecosystem services.

The Government of Seychelles remains committed to ensuring the safety and well-being of its people and the preservation of the country's unique biodiversity. The government works to continuously improve the regulatory and institutional frameworks for disaster risk reduction and preparedness to protect developmental and social gains of our nation.



Minister
Ministry of Environment, Energy and Climate Change

ACKNOWLEDGMENTS

The Government of Seychelles extends its gratitude to its partners for the timely deployment of a team of experts to conduct a Post Disaster Needs Assessment (PDNA) at the request of Honorable Didier Dogley, Minister of Environment, Energy, and Climate Change, in the immediate aftermath of the passing of Tropical Cyclone Fantala over the Farquhar Atoll.

The report is prepared by a joint team under the guidance of Honorable Minister Dogley and consists of representatives of the Government of Seychelles, the World Bank (WB), United Nations, Islands Development Company (IDC) and the Island Conservation Society (ICS).

The PDNA was led by Paul Labaleine, Director General of the Seychelles' Division of Risk and Disaster Management (DRDM); and Glenny Savy, Chief Executive of IDC; supported by a World Bank technical team led by Doekle Geert Wielinga, Senior Disaster Risk Management Specialist; and comprising Isabelle Forge; Hemang Karelia; Alex Sienaert; Keiko Saito; Roberto Jovel; Virginie Duvat; and Luis Corrales. Simon Springett, United Nations Resident Coordinator for Seychelles and Mauritius also participated and Aurélie Duhec, Pierre-André Adam, and Adrian Skerrett from the ICS provided critical information on Farquhar's ecosystems.

We would like to especially thank Habiba Gitay (WB) and Tahir Akbar (GFDRR) for their insightful comments and suggestions to an earlier draft of this report.

The PDNA was produced with contributions from the African, Caribbean, and Pacific (ACP) Group of States and the European Union (EU), which provided financial support for the PDNA through the Global Facility for Disaster Reduction and Recovery (GFDRR), in the framework of the ACP-EU Natural Disaster Risk Reduction Program. IDC and the United Nations provided valuable technical and logistical support.

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ACRONYMS

ACP	African, Caribbean, and Pacific Group of States
AWS	Automatic Weather Station
Cat DDO	Catastrophe Deferred Drawdown Option
CCA	Climate Change Adaptation
DPL	Development Policy Loan
DRDM	Division of Risk and Disaster Management
DRR	Disaster Risk Reduction
EEZ	Exclusive Economic Zone
ENSO	El Niño–Southern Oscillation
EU	European Union
EWS	Early Warning System
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GFDRR	Global Facility for Disaster Risk Reduction and Recovery
GoS	Government of the Seychelles
IBA	Important Bird and Biodiversity Area
ICS	Island Conservation Society
IDC	Islands Development Company
IUCN	International Union for Conservation of Nature and Natural Resources
kmph	Kilometer per hour
O&M	Operations and Maintenance
OIP	Outer Islands Project
PDNA	Post Disaster Needs Assessment
RCO	Resident Coordinator Office
RSMC	Regional Specialized Meteorological Center
SCAA	Seychelles Civil Aviation Authority
SCG	Seychelles Coast Guard
SCR	Seychelles Rupee (currency)
SIDS	Small Island Developing States
SIF	Seychelles Island Foundation
SNMS	Seychelles National Meteorological Services
SOP	Standard Operating Procedures
TC	Tropical cyclone
UN	United Nations
UNDG	United Nations Development Group
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNITAR	United Nations Institute for Training and Research
UNOSAT	United Nations Operational Satellite Applications Programme
US$	United States Dollar

VSAT	Very Small Aperture Terminal
WB	The World Bank

EXECUTIVE SUMMARY

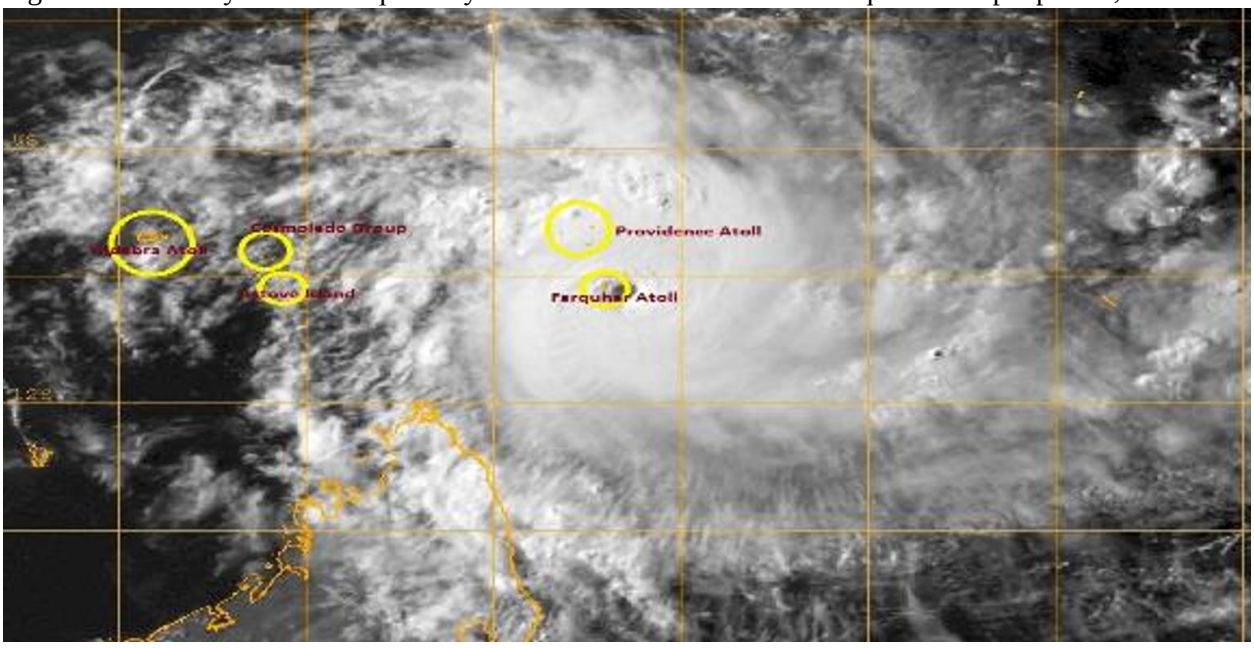
On 17 and 19 April 2016, Farquhar Atoll, located in the Seychelles' Outer Islands, was hit by the strongest tropical cyclone ever recorded to have developed over the Indian Ocean basin. Tropical Cyclone Fantala was the sixth cyclone occurring during the 2015/16 tropical cyclone season, making landfalls twice on Farquhar Atoll, damaging almost all the infrastructure and coconut palm tree groves on the atoll.

As the emergency evolved, the Seychelles National Meteorological Services (SNMS) monitored the situation and issued and updated a total of 21 advisories and warning bulletins to all relevant agencies, including the Division of Risk and Disaster Management (DRDM) and the general public. As a precaution, the IDC and the Seychelles Coast Guard (SCG) evacuated most of their staff and personnel, leaving only essential staff behind for post event clean up, and ensuring the runway was safe and accessible. All essential staff took refuge in the cyclone shelter during the episode.

On 19 April 2016, UNITAR/UNOSAT triggered the International Charter on Space and Major Disasters on behalf of the United Nations Resident Coordinator Office (UN RCO) for Seychelles and& Mauritius to support, with satellite imagery analysis, emergency response operations within the affected areas in the Farquhar Atoll.

On Wednesday 20, the Government of Seychelles, based on initial findings and upon recommendation of the DRDM and in accordance with the Disaster Risk Management Act of 2014, Section 39(3), declared the Farquhar Atoll, a disaster zone.

Figure ES1. A Very Intense Tropical Cyclone "Fantala." Landfall on Farquhar Group April 17, 2016



Source: METEO-7. 04/17/16

From May 8 to 17, 2016 a Post Disaster Needs Assessment (PDNA) was conducted to assess the overall impact of the disaster on key sectors, as well as to define a strategy for recovery, including an estimate of financial resources required for recovery and reconstruction.

Disaster Effects

The effects of Tropical Cyclone Fantala are estimated at SCR 101 million, equivalent to US$7.5 million of which SCR36.5 million (US$2.7 million) are due to physical damages and SCR 64 million (US$4.8 million) are due to changes in economic flows, or losses.

Table ES1: Estimated Value of Disaster Effects from the passing of Tropical Cyclone Fantala over Farquhar Atoll in 2016 (SCR)

	Sectors	Damage (SCR)	Losses/ Change in flows (SCR)	Sector Total (SCR)
Social		**9,080,038**	**390,792**	**9,470,830**
	Housing	9,080,038	390,792	9,470,830
Productive		**8,540,020**	**12,350,370**	**20,890,390**
	Agriculture& Fisheries	582,300	129,500	711,800
	Industry	3,061,985	621,030	3,683,015
	Commerce	780,000	350,000	1,130,000
	Tourism	4,115,735	11,249,840	15,365,575
Infrastructure		**3,305,400**	**2,698,208**	**6,003,608**
	Electricity	1,639,200	14,125	1,653,325
	Transport	97,200	2,669,958	2,767,158
	Telecommunication	774,600	14,125	788,725
	Water & Sanitation	794,400	-	794,400
Cross-cutting		**15,614,792**	**49,023,796**	**64,638,588**
	Government (Coast Guard)	13,640,000	9,300,000	22,940,000
	Disaster risk reduction	600,000	1,613,296	2,213,296
	Environment	1,374,792	38,110,500	39,485,292
Total (SCR)		**36,540,250**	**64,463,166**	**101,003,416**
Total (US$)		**2,706,685**	**4,775,049**	**7,481,735**

Source: PDNA

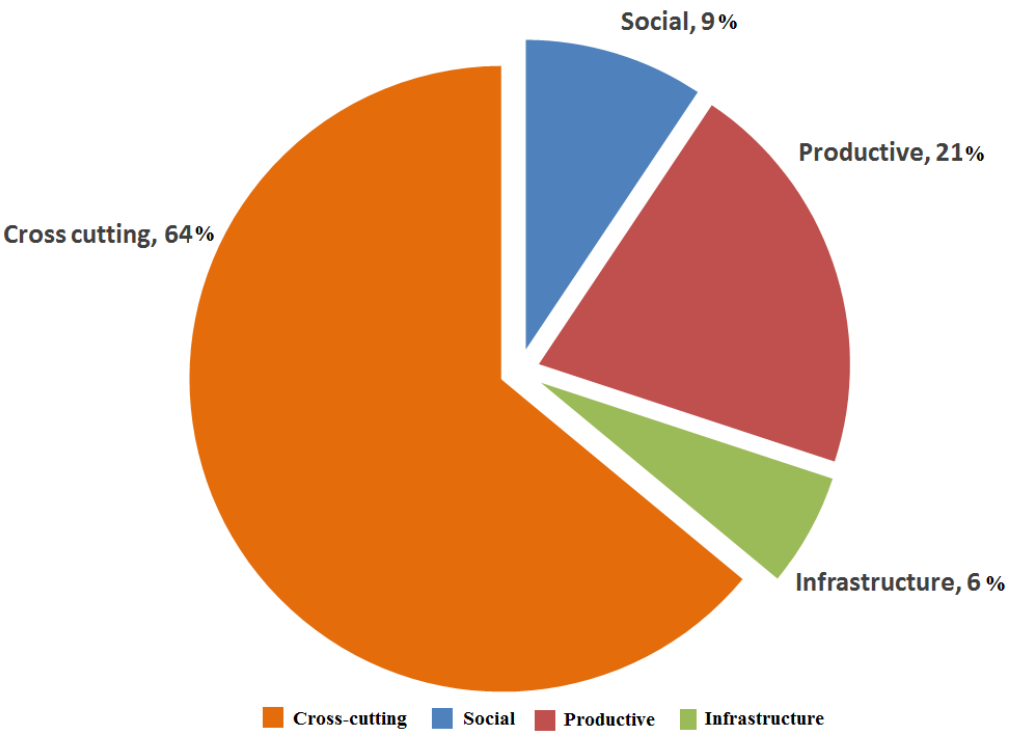
Disaster effects are not evenly distributed when considering the ownership of damage and production losses. The government sector alone, quantified in this assessment as the effects on the SCG's installations in the affected area, along with the increased operational expenses incurred during the emergency, sustained total effects of SCR 22.9 million (or 22.7 percent of the total). Likewise, the impact on the environment, a public asset, were estimated at SCR 39.5 million (or 39.1 percent of the total).

Furthermore disaster effects are spread over time; while the destruction of infrastructure occurred during the passing of Tropical Cyclone Fantala, agricultural production losses are projected to continue accruing for the next few years. During this time, the coconut palm tree groves would need to be replaced with new plantations that would require nurturing for about seven years, depending on the coconut palm tree variety selected for replanting, before the new trees reach maturity and can be harvested. Even though the agricultural lands in Farquhar Island could, in principle, be used for other short-cycle crops, the low fertility of the soils makes them marginal for most cash crop species, limiting the livelihood options available to the

production of coconut-based products such as copra, crude coconut oil, and copra cake[1] for animal feed. Similarly, tourism, artisanal fishing and the processing of high quality dried salted fish will only resume after assets have been replaced and infrastructure reconstructed.

An analysis of the distribution of disaster effects reveals that the cross-cutting sector experienced most of the economic effects, with SCR 64.6 million (i.e. 64.0 percent of total effects); followed by the productive sectors with SCR 20.9 million (i.e. 20.7 percent of total effects). The Social and Infrastructure sectors followed with SCR 9.5 million (i.e. 9.4 percent of total effects) and SCR 6.0 million (i.e. 6.0 percent of total effects), respectively (Figure ES2).

Figure ES2. Breakdown of disaster effects by main sectors of activity (percentage)

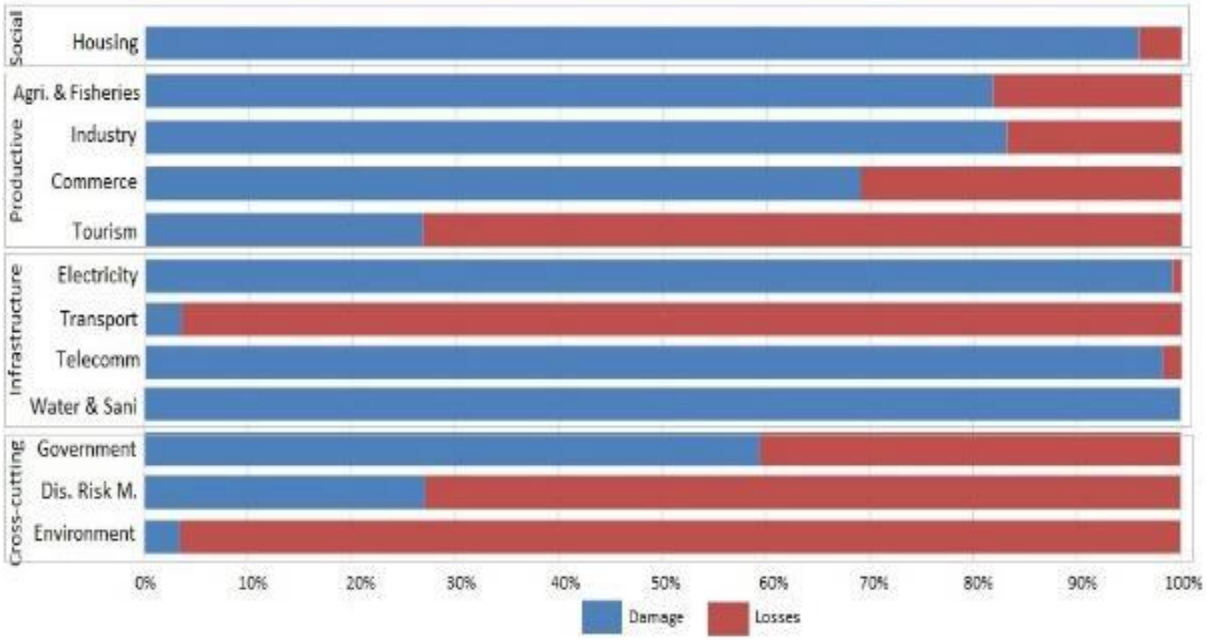


Source: PDNA

Disaster effects can be broken down in physical damage and changes in economic flows. The changes in economic flows, SCR 64.5 million, represent 64 percent of the effects and are most evident in the Environment, Transport, Disaster Risk Management and Tourism. Most of the damage was observed in the Water & Sanitation, Telecommunication, Electricity and Housing. (Figure ES3).

[1]Copra cake is an important feed ingredient and is also the by-product of the oil extraction from dried coconut kernels.

Figure ES3. Damages and Losses within Assessed Sectors



Source: PDNA

The impact on the Farquhar Atoll's natural and human environments

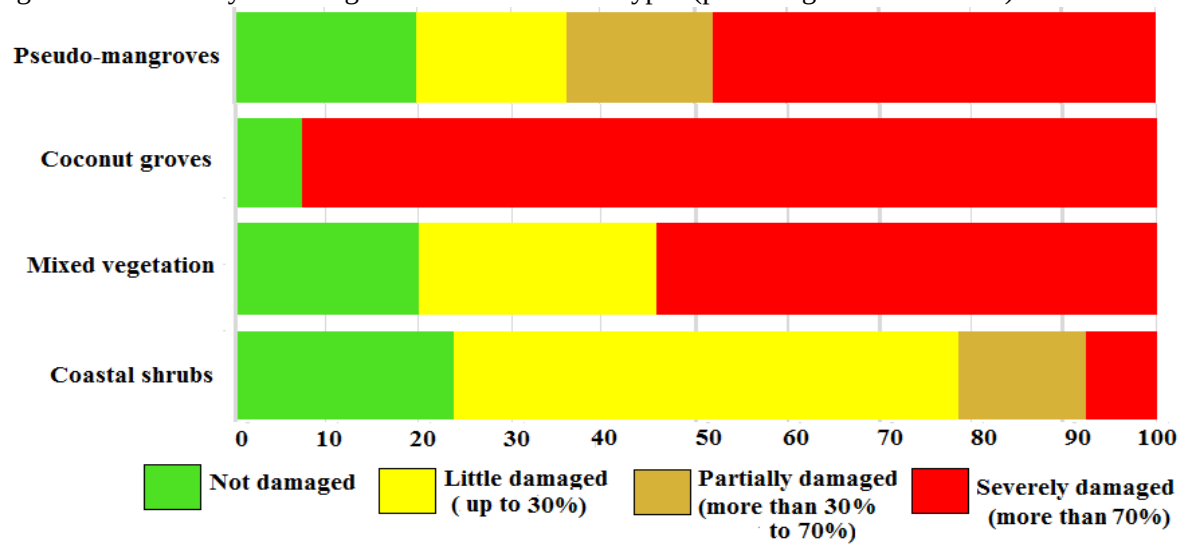
Farquhar Atoll's ecosystems sustained serious damages in the aftermath of Tropical Cyclone Fantala. Affected habitats include coconut palm tree groves, mixed vegetation areas (composed of native and introduced species), coastal shrubs covering beach crests and sand dunes, pseudo-mangroves,[2] edged by native shrubs, and the biologically and structurally complex coral reef ecosystem, composed of corals, algae, sea grass beds, and sand banks. However, given the unsafe sea condition at the time of the assessment, a direct inspection of the coral reef is yet to be carried out.

As shown in Figure ES4, the spatial extent and intensity of damages were found to be much higher on highly-modified environments (i.e. mixed vegetation and coconut groves) than on natural ecosystems (sand beaches, coastal shrubs, and pseudo-mangrove swamps), which highlights the higher resilience of the native species and less altered habitats to extreme weather events, when compared to introduced species and greatly altered habitats. The rather limited impacts of the cyclone on the natural habitats indicate a high potential for their natural recovery and prove that Farquhar's ecosystems are well adapted to cyclonic events.

Given the recognized global importance of the Farquhar Atoll's natural ecosystems, a separate chapter is dedicated to the cyclone impacts on the environment, with detailed descriptions of impacts on natural habitats, vegetation, and fauna, is included in this report.

[2] This report follows previous technical publications on Farquhar's ecosystems and elsewhere where the generic term "pseudo-mangrove" is used to refer to stands of plant species commonly found in association with true mangroves (i.e. species adapted to growing in saline conditions that also produce viviparous fruits or have pneumatophores) and mangrove ecosystems. Before the passing of Tropical Cyclone Fantala, the North Island's pseudo-mangrove habitat was composed of a small swamp with three *Rhizophora* sp. trees. In South Island, the pseudo-mangrove refers to a swamp edged by *Pemphis acidula* shrubs.

Figure ES4. Intensity of damage on terrestrial habitat types (percentage of habitat area)



Source: PDNA

Macroeconomic Impact

The PDNA estimated the total value of damages and disruption of production flows to be SCR 101 million (US$7.5 million), equivalent to about 0.52 percent of the country's 2015 gross domestic product (GDP[3]), which indicates that the disaster effects[4] on the national economy are relatively small, however they are large for the island's economic activities, its environment and strategic role considering that all IDC infrastructure, the entire Seychelles Coast Guard installations and the coconut plantations had been destroyed.

Recovery Strategy and Needs

The passing of Tropical Cyclone Fantala over the Farquhar Atoll, which devastated highly-modified environments, i.e. coconut palm tree groves and mixed forests, offers a window of opportunity to promote the restoration of degraded natural ecosystems and thereby accelerate the achievement of the Government's biodiversity conservation goals for the atoll. Accordingly, the Government of the Seychelles and the IDC[5], with the technical support from ICS, are committed to phasing out unsustainable practices while promoting environmentally-friendly economic activities, such as high-end nature-oriented tourism (e.g. fly-fishing, and bird watching), ensuring that any increase in the number of tourists will solely be allowed with strict adherence to technical recommendations on the maximum number of people that may visit the atoll without causing damage to its unique environment. In addition, the recovery strategy will promote sustainable livelihoods that are compatible with, and contribute to, the long-term protection of Farquhar's natural ecosystems and the services they provide. Therefore, the resilient recovery approach is based upon the following three pillars: (1) biodiversity and environmental protection; (2) blue and eco-sensitive economic development; and (3) security and disaster risk management.

It is also recommended to adopt a *build back better* approach, which would be the guiding principle of the recovery and reconstruction strategy. This approach will help increase the overall resilience of the affected population and assets and promote sustainable development. The recovery strategy should address

[3]According to the World Bank, the Seychelles' 2015 GDP was US$ 1.438 billion. http://data.worldbank.org/country/seychelles. Accessed on August 8, 2016.
[4] See the glossary, Annex 1, for a definition of this term, and related terms as used in the context of the PDNA.
[5] IDC. http://www.idc.sc/index.php/About-IDC/about-idc.html

emerging needs related to the reconstruction of damaged assets and the reactivation of productive activities. This strategy is expected to promote the rehabilitation of, offer sustainable alternatives to, and promote the expansion of tourism-related options, based on three guiding principles: (i) the protection of the Atoll's natural environment and its unique biodiversity; (ii) promoting sustainable, environmentally-friendly economic activities; and (iii) mainstreaming disaster risk management and climate change adaptation as the overarching themes for the selection of interventions leading to build resilience to adverse natural events.

Key Recommendations

- Prioritize the recovery of the SCG's capacity to monitor from the Farquhar Atoll its territorial and Exclusive Economic Zone (EEZ) waters, strengthening disaster preparedness and response capacities, including Search & Rescue;
- Recover economic activities based on the overall goal of maintaining the atoll's extraordinary biodiversity by promoting eco-sensitive and marine oriented activities that support the sustainability of the atoll's contribution to the country's sustainable social and economic development;
- Rebuild infrastructure to cyclone proof standards, and replicate this approach on the other Outer Islands.

The Post-disaster recovery needs and related costs are estimated at **SCR 112 million**, equivalent to approximately **US$8.3 million** (Table ES2).

Table ES2: Post Disaster Recovery Needs

Sector		Recovery Needs (SCR)
Social		**SCR 18,867,000**
	Housing	18,867,000
Productive		**SCR 15,165,000**
	Agri. & Fisheries	882,000
	Industry	5,308,000
	Commerce	992,000
	Tourism	7,983,000
Infrastructure		**SCR 6,225,000**
	Electricity	3,832,000
	Transport	194,000
	Telecommunication	1,112,000
	Water & Sanitation	1,087,000
Cross-cutting		**SCR 71,503,000**
	Government	25,770,000
	Disaster RM	5,500,000
	Environment	40,233,000
	Total	**SCR 111,760,000**

Source: PDNA

Recovery Financing

There are several sources that could be tapped by the IDC and the Government of the Seychelles (GoS) to finance the post-cyclone recovery activities at Farquhar Island.

Insurance: The Farquhar infrastructure and assets were partially insured by IDC. After the cyclone landfall, a chartered quantity surveyor and a structural engineer were sent to Farquhar to assess the damaged property for insurance claim purposes. IDC filed an insurance claim and anticipates to receive a payment (in an amount yet to be settled) that would contribute to reducing the amount of additional financing needed for the recovery. Additional funding to cover the recovery of company-owned assets is expected to be covered, to the extent possible, by the company's own resources.

Domestic: As for the public assets, the GoS is looking into several financing options within the national budget to support the recovery of priority activities that focus on environmental protection and maritime safety and security, including a partial drawdown on the DPL with Cat DDO.[6]

External: The GoS could mobilize financing from external funding sources such as (i) grant support from global funds, such as the Global Environment Facility (GEF) and the Green Climate Fund (GCF); (ii) financial and technical assistance from bilateral donors; and (iii) in-kind support from partner countries.

It is also recommended that the GoS further continues to strengthen its disaster risk financing strategy in the broader context of building overall resilience to disasters and the effects of Climate Change in the cyclone prone Outer Islands.

[6] The World Bank. "Seychelles: World Bank funding to help improve emergency and economic resilience." http://www.worldbank.org/en/news/press-release/2014/09/26/seychelles-world-bank-funding-to-help-improve-emergency-and-economic-resilience

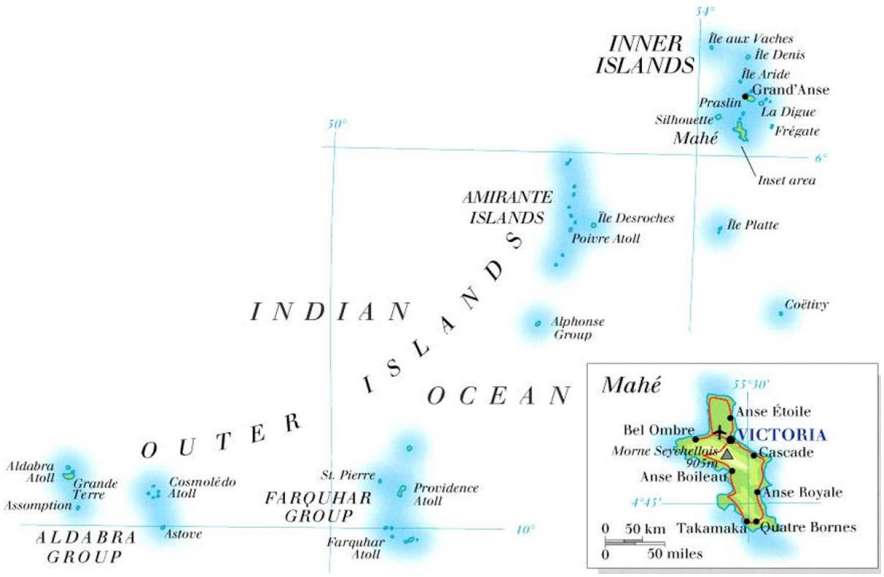
Chapter 1. Background Information

Country Disaster Profile

As a small island state, the Seychelles is exposed to a disproportionately high economic, social, and environmental impact of natural and environmental disasters. The country's location and topography make it vulnerable to tropical cyclones, tsunamis, storm surge, extreme rainfall, flooding, landslides, rockslides and forest fires.[7] These adverse effects are further exacerbated by the medium to long-term effects of climate change and present significant risks to the country's sustainable development.

Vulnerability characteristics such as the concentration of population and development in narrow coastal zones make the country extremely sensitive to adverse events triggered by natural hazards and climate change. Between 1980 and 2013, the impact of natural disasters totaled US$40.1 million, affecting 21,328 people (equivalent to more than 23 percent of Seychelles' population in 2014). Major events included (i) severe floods on the three main islands and a landslide at St. Louis, leading to US$0.16 million in damages (August 31–September 1, 1985); (ii) Cyclone Ikonjo on Desroches Island, causing US$1.5 million in damages (May 17–23, 1990); (iii) the ENSO rainfall event of August 12–17, 1997, leading to US$1.7 million in damages; (iv) the Great Indian Ocean Tsunami of December 26, 2004, resulting in US$30 million in damages; (v) Tropical Cyclone Bondo, December 2006 (no impact figures available); and (vi) Tropical Cyclone Felleng in January 2013, triggering floods, mudslides, and rock fall, resulting in US$8.4 million in damages and losses in key sectors.[8]

Figure 1.1. Map of the Inner and Outer Islands of the Republic of Seychelles



Source: UNDP[9]

[7]United Nations Development Programme: Disaster risk profile of the Republic of Seychelles (July 2008), Government of Seychelles/World Bank Damage, Loss and Needs Assessment (2013).

[8] Seychelles Damage, Loss and Needs Assessment: 2013 Floods. Report by Government of the Seychelles.

[9] UNDP. Strengthening Seychelles' Protected Area System through NGO Management Modalities GEF project ID 3925. UNDP Project ID 00076774. Mid-Term Evaluation Report. Nov 17, 2013

The Outer Islands

The Outer Islands are situated beyond the Mahé plateau,[10] comprising 73 low lying islands between 230 km and 1150 km from Mahé. These islands are mostly coralline, each unique in their own right. Primarily due to their isolation from the main island of Mahé, some of these islands are amongst the very few surviving pristine natural habitats for flora, fauna, and marine ecosystems in the world.

The Outer Islands contributed considerably to developing economic activity in the country, especially during the 1960s and 1970s. These islands provided the inhabitants of the island of Mahé, the main island where the national capital is located, with a reliable source of income and livelihood through the exploitation of copra,[11] guano, and the artisanal production of dried fish and turtle meat. However, due in part, to the decline in demand for these products in the mid-1970s, the Islands' overall contribution to the Seychelles' economy diminished. This situation was further accelerated by the opening of the Pointe Larue International Airport in 1972, on the Island of Mahé, which contributed to a substantial shift in the country's economy, from an economy based mostly on agriculture and artisan fishing activities, to one where the service sector accounts for nearly four-fifths of the country's GDP. These sectors went on to employ almost three-fourths of the workforce. Within the service sector, the tourism industry accounts for almost one-fourth of total GDP. This economic transformation has accelerated the increasing concentration of the country's population in the Inner Islands, following increased employment opportunities within the tourism industry and in activities related to the growing industrial fishery, which currently generates income for the national economy through the licensing of commercial tuna fish within the country's 1.3 million square kilometer EEZ, and related fish processing and export industries, including canned tuna and frozen fish, two of the country's main exports. With most economic activity happening around the Inner Islands, and more than four-fifths of the country's population living on Mahé Island—mostly in the capital city, Victoria—the direct economic contribution of the Outer Islands continues to diminish, along with a substantial reduction of the size of the resident populations living on these islands.

Farquhar Atoll

Farquhar atoll is a set of ten small islands[12] belonging to the Seychelles' Outer Islands, situated 770 kilometers South-South-West of Mahé Island. Farquhar is the largest atoll of the Seychelles, covering an area of about 17,800 ha. The larger islands, North Island and South Island, make up 97 percent of the landmass of 799 ha. Three small islands, known as the Manaha Islands, separate these areas. Three other islands, Déposés, Ile du Milieu, and Lapins, lie in close proximity to one another on the northern rim of the atoll. Banc du Sable and Goëlettes are the most easterly, and the most southerly islands, respectively.[13]

Farquhar Atoll has become renowned for its marine based ecotourism and particularly for fly-fishing activities. Large numbers of tourists visit the atoll during its fly-fishing season, which runs from October

[10] Seychelles-Mauritius Plateau. Seychelles-Mauritius Plateau, also called Mascarene Plateau, submarine plateau, made up of a very shallow, extensive ridge in the Indian Ocean that forms a crescent through the Seychelles and Amirante islands. The ridge extends from latitude 4° to 21° S and from longitude 54° to 63° E. It is believed to be a small continental outlier similar to Madagascar and separated from the continent. The granitic Seychelles islands, which rise from the ridge, are considered anomalous in an ocean basin because most oceanic rocks are basaltic. The southern part of the plateau is, however, volcanic. Encyclopedia Britannica.
http://www.britannica.com/place/Seychelles-Mauritius-Plateau

[11] Dried kernel used for coconut oil extraction.

[12] Farquhar Atoll is comprised of 10 islands: North Island and South Island are the largest; others are Goëlettes, North Manaha, Middle Manaha, South Manaha, Banc du Sable, Lapin, Milieu, and Deposee.

[13] Islands Development Company website. http://www.idc.sc/index.php/Farquhar-Island/location.html

to May, for a period of approximately 25 weeks. The shallow waters around the atoll become deep gradually, creating one of the best fishing environments in the country. Anglers stand in the water, thigh deep and cast their flies into the crystal clear turquoise waters. Most people visit the islands through fishing tour packages and are accommodated in the IDC[14] guest house (with a 10-bed capacity, commonly fully-booked for the entire season), while others buy packages that include a live-aboard yacht. Visitors can practice scuba diving and snorkeling along the beaches, however, fly-fishing and deep sea fisheries are the lure for most people visiting the atoll.

Box 1. THE ISLANDS DEVELOPMENT COMPANY

The IDC is a parastatal corporation registered under the Seychelles Company Act of 1972 and has been entrusted with the management and development of 14 islands, including the Farquhar Atoll's islands, owned by the Government of Seychelles. The IDC is governed by a board of directors whose mandate is to successfully manage the company to achieve its business objectives and fulfilling its corporate social responsibilities. The main goal of IDC is to manage the islands leased from the Government of Seychelles on a 99-year contract. IDC core activities include the sustainable management and development of the Outer Islands, by promoting economic activities that are environmentally compatible, such as nature-oriented tourism, and contribute to social and economic development, such as sustainable production of coconut-derived products and artisanal fisheries.

IDC's Mission
Ensure the Outer Islands' active contribution to the socio-economic development of the Seychelles while adhering to the highest environmental standards.

Business Objectives
The business objective of IDC is to render the Outer Islands habitable by developing basic infrastructure and services needed for their sustainable development. IDC derives financial benefits from economic activities, such as the production and selling of coconuts, coconut oil, copra, pounac, zig broom, salted fish, charcoal and furniture, and tourism to finance and sustain social infrastructure investments, including schools, health facilities, and housing. In addition, IDC facilitates private sector investments on the islands through a government-sanctioned tender process.

The Government of Seychelles, in partnership with the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF), launched in 2014 the Outer Islands Project (OIP). The project activity titled "Expansion and strengthening of the protected area subsystem of the Outer Islands of Seychelles and its integration into the broader land and seascape[15]" seeks to promote the conservation and

[14]The Islands Development Company is a parastatal corporation registered in 1980 under the Seychelles Company Act of 1972. IDC is responsible for the management and development of 14 islands of the Government of Seychelles, including Farquhar.

[15] GEF. Expansion and Strengthening of the Protected Area Subsystem of the Outer Islands of Seychelles and its Integration into the broader land and seascape. Project Identification Form. GEF Project ID 4717. https://www.thegef.org/gef/project_detail?projID=4717

sustainable use of land and marine biodiversity of islands, including Farquhar Atoll. The ICS acts as conservation advisor to IDC and is responsible for the implementation of the OIP on Farquhar.

The Farquhar Atoll can be accessed both by plane and boat and the main agricultural production activities are farming, salted fish production, and processing of coconut-derived products such as copra, pounac,[16] and coconut oil.

Strategic Importance of the Farquhar Atoll

In addition to the high-end tourism revenues generated by its biologically exuberant and fragile terrestrial and marine ecosystems, the Farquhar Atoll is also strategically important since it encompasses the southern-most islands of the Seychelles. In order to monitor and patrol its territorial waters and extensive EEZ against unlawful activities, such as illegal fishing and piracy, the SCG maintains a mission post, including buildings, communications and surveillance equipment, all of which were destroyed by Tropical Cyclone Fantala.

Flora and Fauna

Farquhar Atoll is recognized as an outstanding site for its ecological value and the status of its flora and fauna. The impacts of Tropical Cyclone Fantala on the Farquhar's fauna are further described in chapter 3 and annex 4.

Several Farquhar Atoll islands have been designated as Important Bird and Biodiversity Areas (IBA), according to an internationally agreed set of criteria for the conservation of bird populations. The IBA program identified the Goëlettes Island as the most interesting site for bird populations. The almost treeless island is covered with grasses and a few low Scaevola bushes (*Scaevola sericea*). There is a huge seasonal colony of 200,000-400,000 pairs of Sooty tern (*Onychoprion fuscata*) and around 10,000 pairs of Brown noddy (*Anous stolidus*). In 1897, Commander Stuart Farquhar discovered a small colony of Roseate terns (*Sterna dougallii*) in one corner of the island. However, visits to Goëlettes by ornithologists have been so rare that it was more than a hundred years later that this species' presence on the island was reported for a second time by ICS' naturalists. In 2006, ICS scientists recorded a previously unknown colony of Black-naped terns (*Sterna sumatrana*) at Bancs de Sable. The bird breeding monitoring program carried out by ICS revealed between 77 and 137 breeding pairs, which may confirm the atoll's breeding population to be the largest in the entire region.

Tropical Cyclone Fantala

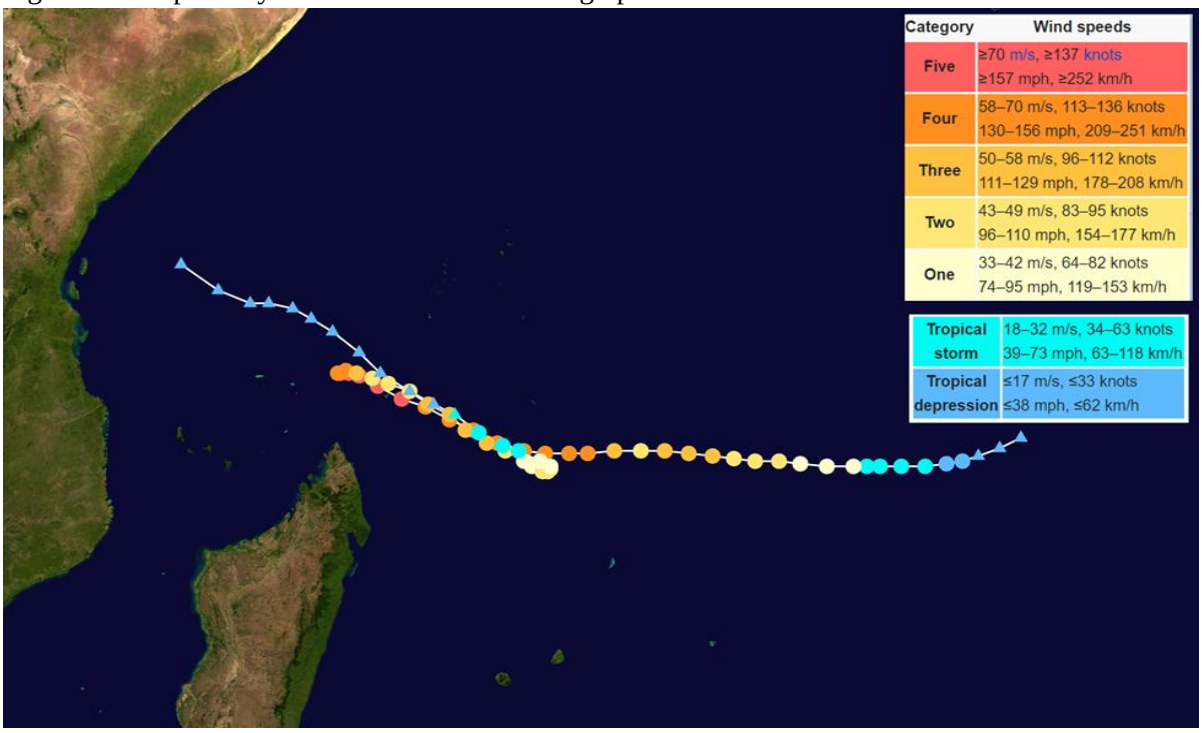
Fantala started as a tropical disturbance with central pressure 1003hPa near 12.7 degrees south and 62.7 degrees east on 11 April 2016 (Figure Int1), the Seychelles' National Meteorological Services (SNMS) issued its first advisory bulletin after receiving the information from the Regional Tropical Cyclone Warning Centre, Météo-France La Réunion (RSMC La Réunion). The tropical disturbance then deepened rapidly as a tropical cyclone as it moved toward the Seychelles' Outer Islands, developing further into an intense tropical cyclone before hitting Farquhar Atoll on Sunday 17 as a very intense tropical cyclone. At that time, the estimated central pressure had decreased to 910hPa and the wind speed reached between 300 to 350km/hr (Météo France, RSMC La Réunion 2016), completely destroying almost all standing infrastructure and coconut groves in Farquhar Atoll.

[16] Pounac is the residue from grinded coconut meat, used as animal feed.

On April 17 and 19 2016, the Farquhar Atoll, one of Seychelles' Outer Islands located in the South, was hit by the strongest tropical cyclone ever recorded to have developed over the Indian Ocean basin, damaging almost everything on the atoll, compelling the Government of Seychelles to declare Farquhar Atoll a disaster zone. Tropical Cyclone Fantala was the sixth cyclone during the 2015/16 tropical cyclone season, and the strongest Southwest Indian Ocean cyclone ever recorded.

Tropical Cyclone Fantala then left Farquhar to move further to the northwest of the atoll but made a quick U-turn and hit Farquhar for a second time in the early morning on Tuesday 19. It continued to track eastward, or backward, toward its place of origin. However, on the second pass over Farquhar, it is presumed to have been less severe because at that time, Fantala had lost strength and the estimated wind speed was about 140 to 160km/hr (Météo France, RSMC La Réunion).

Figure 1.2 Tropical Cyclone Fantala historic infographic.



Source: Wikipedia. WikiProject Tropical Cyclones/Tracks, using background image from NASA; and tracking data from NOAA.

For more than a week of meandering back and forth along the same latitudinal zone, the cyclone headed towards Farquhar for a third time, threatening to hit Aldabra, the world's second-largest coral atoll and an UNESCO World Heritage Site, also part of the Outer Islands. Fortunately, the tropical system weakened to a low-pressure system during its passage to the north of these islands around April 25 and 26.

Disaster Preparedness and Response

During the progression of the emergency, the Seychelles National Meteorological Services (SNMS) issued and updated a total of 21 advisories and warning bulletins to most weather sensitive sectors and relevant agencies, including the Division of Risk and Disaster Management (DRDM) and the general public. The performance of the communications and public dissemination of alerts was adequate in general, however reaching fishermen was identified as an area with room for improvement, as fishermen and their assets are

considered particularly vulnerable to extreme weather events. Fortunately, no fatalities were recorded as a result of the passing of Tropical Cyclone Fantala.

Farquhar Atolls is the only Outer Island that has a concrete bunker that serves as a cyclone shelter. Most of the residents were evacuated before the event. Only essential staff from the SCG and IDC stayed behind for post event clean-up and repairs. They took shelter in the bunker during the period that Tropical Cyclone Fantala made landfall on Farquhar Atoll.

DRDM, SNMS, IDC, SCG closely coordinated in the days before Tropical Cyclone Fantala made landfall. On April 17 DRDM, IDC and first responders met for a final brace up and response preparation meeting and on April 18 for a preliminary assessment based on information received from Farquhar Atoll. A total of 21 advisories and warning bulletins were issued during this period. On April 15, the advisory was increased to yellow, which was increased to orange on April 17 and code red on April 18. On April 22, the Advisory was downgraded.

The regional meteorological specialized center, Météo-France La Réunion, requested data from the SNMS' AWS in Farquhar Island, but since the station was disabled, no monitoring data was available to share with the regional center.

On April 19th 2016, UNITAR/UNOSAT triggered the International Charter on Space and Major Disasters on behalf of the UN Resident Coordinator Office (RCO - Seychelles & Mauritius) to support, by means of satellite imagery analysis, the emergency response operations in the affected areas.

On April 20, the GoS declared the Farquhar Atoll a disaster zone, based on initial findings, and upon recommendation of the DRDM, and in accordance with the Disaster Risk Management Act of 2014, Section 39(3).

A first assessment mission, consisting of staff from DRDM, IDC and Seychelles Broadcasting Corporation conducted a first assessment on April 22, after which it was concluded that a more in-depth PDNA would need to take place.

Chapter 2: Disaster Effects

Assessment Objectives and Methodology

The main objective of the PDNA was to provide the GoS with a reliable estimate of the disaster effects,[17] and recommendations for a Recovery Framework (RF). Specifically, the assessment aimed to: (i) identify the effects of Tropical Cyclone Fantala on Farquhar Atoll and potential impacts on nearby islands; (ii) identify needs for the rehabilitation, propose restoration options, and assess their costs; and (iii) provide training to officials from national and local government agencies and other relevant stakeholders on the PDNA methodology and the components of a Disaster Recovery Framework that integrates disaster risk reduction considerations as part of its guiding principles. The assessment targeted those sectors identified by the Government as the most critical: environment, including terrestrial ecosystems, coast, coral reefs; agriculture (coconut groves) and infrastructure, including buildings, and telecommunication infrastructures.

The PDNA is a methodology for joint assessment and recovery planning that seeks to assess the impact of the disaster and define a strategy for recovery, including the estimation of financial resources required.[18] The assessment evaluates the disaster effects, pulling together information on the physical damages of the disaster and on its socio-economic aspects (economic losses, changes in service delivery and governance caused by the disasters, and increased risks and vulnerabilities). On these bases, it evaluates the overall impact of the disaster on the macro-economic and human development context of a country. Based on this information, the PDNA determines the needs and recovery priorities generated by the disaster and produces a consolidated report that lends to a resilient recovery strategy.

The PDNA process is government led and owned. The European Union (EU), World Bank, and the United Nations Development Group (UNDG), and other stakeholders may provide technical support and facilitation, as determined and requested by the government. The PDNA process involves the participation of the affected population, local authorities, NGOs, donors, civil society, and the private sector. Given the broad range of organizations, individuals, and communities that need to be involved, cooperation and coordination is essential for achieving a participatory and comprehensive PDNA.

The PDNA produces four core deliverables:

1. *A consolidated assessment report* based on sector reports that present a cross-cutting, comprehensive assessment of the impact of the disaster
2. *A recovery strategy* that defines the vision for national recovery and outlines recovery actions for each sector and affected region (The strategy clarifies objectives and interventions, expected results, the timeframe, and the expected cost for the recovery process.)
3. *A basis for resource mobilization* in support of the country's recovery
4. *An outline for a country-led recovery process through the formulation of a recovery strategy*

The PDNA does not duplicate national and international rapid humanitarian assessments but complements them with the objective of ensuring one consolidated process. If humanitarian assessments have been carried out by the government, the UN, civil society or other groups, the information and analysis contained is used to reinforce the PDNA exercise.

[17] See Annex1. Glossary of a definition of these terms, in the context of the PDNA methodology.

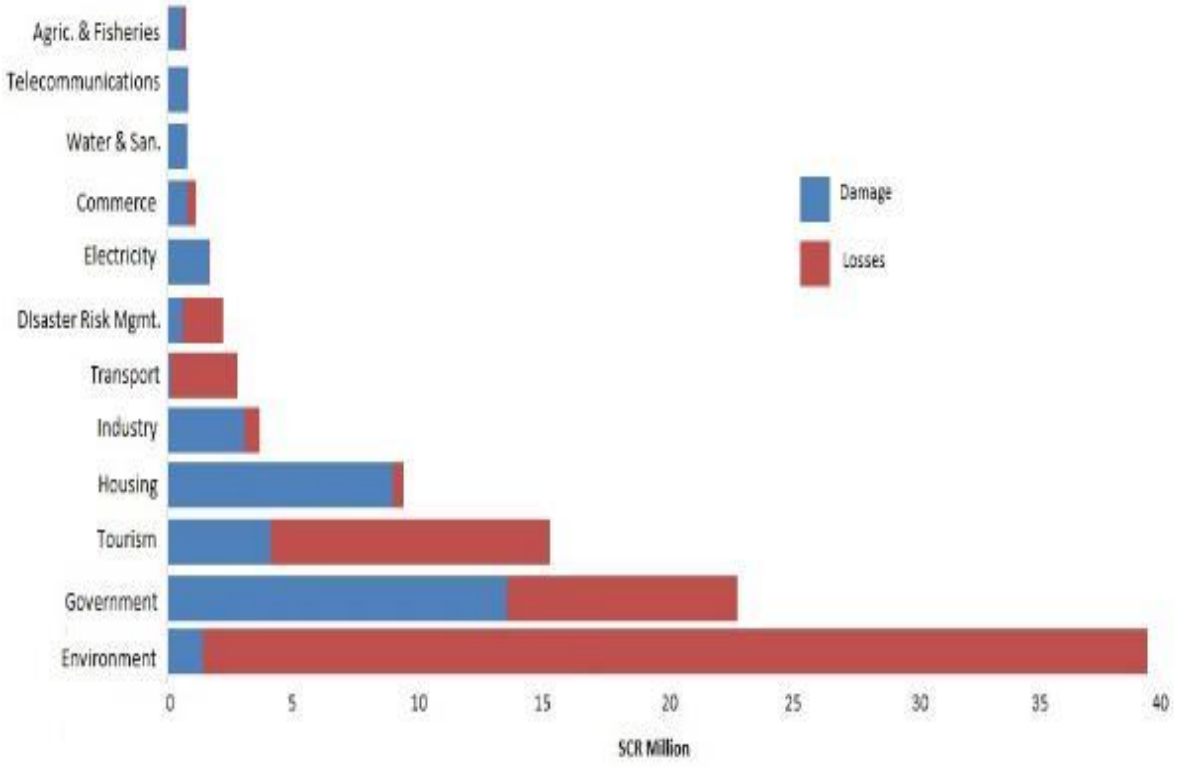
[18] The PDNA is the result of a commitment articulated in the joint agreement on post-crisis cooperation, signed between the European Union, the World Bank, and the United Nations Development Group in 2008. Through the agreement, PDNA partners commit to supporting government ownership and leadership of the post-disaster needs assessment process.

Since there was considerable impact on the environment, a more qualitative description of cyclone impacts on the atoll's natural habitats complemented the PDNA methodology. This allowed the assessment team to estimate potential impacts on the quantity and quality of ecosystem services, as well as make recommendations for developing an environmental recovery strategy.

This chapter provides an overview of the economic activities and the extent of damage and losses in the sectors covered in this report. Figure 2.1 summaries the damage and losses in the sectors assessed with the PDNA methodology.

Impact Assessment by Sectors

Figure 2.1. Damages and Losses by Sector (SCR million)



Source: PDNA

Social Sectors

Housing

The Farquhar village had a resident population of around 40 people, mainly composed of IDC personnel and ICS staff. The PDNA assessment of the housing sector covers the accommodations for 16 IDC and ICS staff members as well as a cyclone shelter, an office, and household goods. Except for the cyclone shelter, all houses were destroyed, along with household goods. The estimated cost of demolition and rubble removal is accounted for as losses. Any new construction and retrofitting will have to consider the higher wind-velocities the islands experienced and upgrade the design specifications accordingly for each building type.

Sub-Sector	Damage (SCR)	Losses (SCR)
Housing	9,080,038	390,792

Productive Sectors

Agriculture & Fisheries

The islands possessed almost 300 ha of coconut palm tree groves and a sizable number of filao (*Casuarina equisetifolia*) trees. The assessment estimates that cyclone severely affects more than 95 percent of coconut palm tree groves and filao trees. However, due to the limited production of coconut palm and derived products, it is estimated that only 2 ha of coconut palm tree groves were exploited for commercial purposes. In addition to the fly-fishing activity undertaken by the seasonal tourists, the atoll's small-scale production of salted fish was halted due to the damages to the production facility and sun-dryers caused by the cyclone's strong winds and excessive rainfall. The table below covers the damage to the sun-dryers and estimated loss to income due to halted salted fish production. Effects on production of coconut-derived products are covered under the Industry sector, while the environmental impact of the damaged coconut palm tree groves is covered in the Environment sector.

Sub-Sector	Damage (SCR)	Losses (SCR)
Agriculture & Fisheries	582,300	129,500

Industry

This sector mainly covers the cyclone's effects on the small-scale production of coconut-derived products and processing facilities such as cold storage building, sheds, calorifier, and copra crusher. Estimated losses are mainly due to loss of income resulting from destroyed merchandise, as well as the shutdown of processing of coconut-derived products, expected to last for a period of seven years, i.e. the time estimated for planting and nursing coconut palm seedlings until they reach maturity.

Sub-Sector	Damage (SCR)	Losses (SCR)
Industry	3,061,985	621,030

Commerce

Aside from the high-yield tourism activities, covered under the Tourism sector, Farquhar did not have any commercial activities apart from a shop. This shop served tourists and the small resident populations with limited goods. The sector covers the effects due to damaged shop and furniture, and the estimated sale losses over a period of one year.

Sub-Sector	Damage (SCR)	Losses (SCR)
Commerce	780,000	350,000

Tourism

Each year Farquhar Atoll attracts high-end tourists during the two tourist seasons, for a total 25 weeks. Before the passing of Tropical Cyclone Fantala, visitors were hosted at a six-room guest-house that was severely damaged by the cyclone's strong winds and rainfall. IDC estimates that regular tourism operations can only start again during the February 2017 tourist season, if all critical infrastructure needed to support related activities are reconstructed.

The effects cover the damage to the guest-house and related facilities as well as the projected loss of revenue from reduced provision of tourism and travel-related services, until damaged facilities are in place and fully operational.

Sub-Sector	Damage (SCR)	Losses (SCR)
Tourism	4,115,735	11,249,840

Infrastructure Sector

Electricity

Three electricity generators powered the facilities at Farquhar village. Tropical Cyclone Fantala partially damaged the power generators and the rooms housing them. In addition, the rainfall contaminated the fuel supplies used to operate the power generators. Therefore, the damage was assessed as the cost of repairing the power generators, and rebuilding or retrofitting the generator rooms and shade. The electrical cabling was not impacted by the cyclone. The losses account for the rubble removal.

Sub-Sector	Damage (SCR)	Losses (SCR)
Electricity	1,639,200	14,125

Transport

The Farquhar Atoll has very limited transport infrastructure that includes the airstrip and approach roads (unpaved) to and around the village. The airstrip was not damaged but, like the approach roads, was completely blocked with fallen trees, requiring several days to clear the debris. The damage in the sector covers the repairing of the arrival shelter, while losses account for clearing of roads and debris removal from the arrival shelter, as well as the additional cost of three chartered boat trips from Mahé to Farquhar with workers, supplies, and machinery needed to carry out road clearing and rubble removal activities.

Sub-Sector	Damage (SCR)	Losses (SCR)
Transport	97,200	2,669,958

Telecommunications

Before the passing of Tropical Cyclone Fantala, the Seychelles Coast Guard base on Farquhar operated (i) a Very Small Aperture Terminal (VSAT) installation that provided voice and data connectivity on the atoll, and (ii) a Seychelles Civil Aviation Authority (SCAA) signal tower for air traffic navigation. Both installations were destroyed by the cyclone. They need to be urgently rebuilt and their functionality fully restored. The assessment of damage covers the cost of a new VSAT installation, VSAT facility, and SCAA tower, while losses cover the cost of rubble removal. A critical parameter to take into consideration for the redesign of these telecommunications installations is the observed increase in cyclone wind velocities, ensuring that they can withstand winds of up to 380 kmph.

Sub-Sector	Damage (SCR)	Losses (SCR)
Telecommunication	774,600	14,125

Water & Sanitation

A desalination plant damaged by the cyclone provided Farquhar's potable water supply . The damage covers the repairing of the equipment and storage shelter. There are no losses associated with water and sanitation.

Sub-Sector	Damage (SCR)	Losses (SCR)
Water and sanitation	794,400	-

Cross-cutting Sectors

Seychelles Coast Guard

The SCG mission post in Farquhar had a Surveillance Radar system that became operational earlier this year. The post included three buildings, boat landing craft, VSAT, power generators, and related facilities. The radar is part of the SCG Coastal Surveillance Radar System, a network of six radars, cameras, and communication equipment installed on five islands. The SCG post provides support to safety and security monitoring activities in the Outer Islands, territorial waters and EEZ. Furthermore, the SCG post in Farquhar carries out Search & Rescue operations and monitors marine tourism activities. The SCG Surveillance System supports the monitoring of transnational illegal activities and other maritime security concerns, including piracy. Considering that the Farquhar Atoll includes the southernmost islands of the Seychelles, the SCG post on the atoll plays a critical role in the effective patrolling of the country's extensive maritime border and EEZ.

Before the passing of Tropical Cyclone Fantala, this station was regularly staffed with 6 to 8 SCG personnel. Due to the heavy damage caused by the cyclone, at the time of the assessment, a 4-person crew responsible for securing the damaged equipment, cleaning up debris and maintaining the facilities manned the mission post. The SCG estimated that it would take up to 15 months for this post to be fully operational again.

The station equipment and buildings were severely damaged during the passing of the cyclone. In order to restore the SCG post, it is recommended that the infrastructure be redesigned to be able to withstand wind velocities of up to 380 kmph. In terms of equipment, the following are also included in the recovery needs. The following are also recommended: (i) replacement of the Electro Optics System (EOS) camera and transmission box; (ii) new HF radio equipment and data management functionality, with antenna for reliable communications between Farquhar and Mahé; and (iii) portable generator for emergency communications—all of which incorporate enhanced technical specifications that take into consideration the potential materialization of meteorological events of the same or higher intensity as category-5 Tropical Cyclone Fantala.

Losses cover (i) the projected additional costs to continue providing surveillance and Search & Rescue operations, using additional patrol boat trips and aircraft missions until the SCG Farquhar post services are fully restored; (ii) the cost of demolition and rubble removal and (iii) travel and logistics for the technical crew tasked with the installation and commissioning of the specialized equipment (e.g. radar system, VSAT, Met station).

Sub-Sector	Damage (SCR)	Losses (SCR)
Government (Coast Guard)	**13,640,000**	**9,300,000**

Disaster Risk Management

The effects in this sector are comprised of the damage to the Automatic Weather Station (AWS) installed on Farquhar that needs to be urgently replaced, incorporating enhanced specifications for higher wind-velocities of up to 380 kmph. Losses include the emergency evacuation of personnel by chartered aircraft.

It should be noted that the AWS was not functional for two months before the cyclone due to logistical difficulties in regular maintenance on this remote location, where Met department has no personnel on the ground. This situation underscores the need to strengthen the weather monitoring and forecasting capabilities of the GoS to effectively monitor the weather and provide early warning to distant islands. These improvements will require expansion of the AWS network and other necessary systems in the outer islands to increase system redundancy and reliability. Equally critical is the need to budget adequate, reliable resources for the weather observational network's Operations and Maintenance (O&M).

Sub-Sector	Damage (SCR)	Losses (SCR)	
Disaster Risk Management	**600,000**	**1,613,296**	

Environment

The effects in this sector include damage to coconut groves and losses caused by the cost of clearing of fallen coconut palm trees and debris. Losses are calculated based on the most probable scenario for recovery, which involves a three-year period needed for clearing the coconut palm tree groves damaged by the cyclone, as well as for the gradual planting of new coconut palm seedlings. The time for recovery and the resources needed for implementing the necessary interventions are based on IDC's experience in performing similar tasks on the islands under its management. The overall effects on the environment, however, may represent a lower estimate, as the effects may increase once a direct inspection of damages to the coral reef can be performed and an assessment of potentially negative impacts of the cyclone on this ecosystem and the services it provides can be carried out. The assessment of damages to the coral reef is expected to be carried out as soon as conditions are appropriate.

With regard to fauna, the Red-footed Booby (*Sula sula*), is likely to be the most heavily impacted of all seabirds. Most of the breeding habitat the birds were using has been destroyed. Tropical Cyclone Fantala hit at the height of the breeding season, when there were many birds with nests containing eggs or chicks. Other seabirds, turtles and invertebrates experienced little to no impact.

Sub-Sector	Damage (SCR)	Losses (SCR)
Environment	**1,374,792**	**38,110,500**

Chapter 3. Impact Assessment on the Environment

Summary

Farquhar Atoll's environment sustained serious damage in the aftermath of Tropical Cyclone Fantala, which directly affected natural habitats as well as infrastructure and nature-linked economic activities. Tropical Cyclone Fantala affected the main eastern islands of the atoll, where a field assessment was carried out from May 12 to 13, 2016. The assessment mainly focused on the two largest islands, North Island and South Island, and included the three smaller Manaha Islands, located between the much larger North and South Islands, as well as Goëlettes Island.

The damage caused by Tropical Cyclone Fantala was mainly due to high velocity winds that devastated large sections of the Farquhar islands' vegetation cover. The storm surge generated by Tropical Cyclone Fantala had localized and contrasting impacts on different sectors on the same island and between the islands, triggering coastal erosion in some places and sediment accumulation in others. Affected habitats include coconut palm tree groves, mixed vegetation areas (composed of native and introduced species), coastal shrubs covering beach crests and sand dunes, pseudo-mangroves[19] edged by native shrubs, and the biologically and structurally complex coral reef ecosystem, composed of corals, algae, sea grass beds, and sand banks. However, given unsafe sea conditions at the time of the assessment, a direct inspection of the coral reef is yet to be carried out.

Across the atoll, the most severely damaged habitats were the coconut groves (93 percent severely damaged), and the mixed vegetation areas (54 percent severely damaged), whereas the indigenous coastal shrubs showed high resistance to the cyclonic wind, with only 7 percent of the affected area severely damaged (Tables 3.1 and 3.2; and Figure ES4).

Table 3.1: Intensity of damage to natural habitats resulting from the passing of Tropical Cyclone Fantala over Farquhar Atoll

Intensity of damage (percentage of habitat type area) **Habitat**	Little or no damaged (<30 %)	Partially damaged (30-70%)	Severely damaged (>70%)
Coastal shrubs	79	14	7
Mixed vegetation	46	0	54
Coconut groves	7	0	93
Pseudo-mangroves	36	16	48

Source: PDNA

A two-day field visit, supported by the use of oblique aerial photographs taken on May 12 and 13, 2016, was carried out on the atoll's two main islands, North Island and South Island, as well as on nearby Goëlettes Island. This chapter aims to provide a systematic account of the impacts of Tropical Cyclone Fantala on Farquhar Atoll's five main terrestrial habitats: (i) sandy beaches; (ii) coastal shrubs covering

[19] Please, refer to footnote 4 for an explanation of this term.

beach crests and sand dunes; (iii) mixed vegetation including shrubs and grassland; (iv) coconut groves; and (v) pseudo-mangroves.

Due to heavy swells and limited visibility, assessments of the cyclone impacts on the coral reef ecosystem has been postponed. It should be noted that this chapter includes the assessment of the physical damage caused by the cyclone on the coconut groves, while the effects on coconut-derived production are included in the assessment of the Industry subsector, under the Productive Sector.

Key recommendations for the Environment sector include: (i) implementing an environmentally-friendly, build back better approach in the recovery process; (ii) enforcing existing policies and regulations aimed at promoting economic activities that are environmentally and economically sustainable; and (iii) the strengthening of enabling regulatory frameworks and institutional arrangements that contribute to the protection of Farquhar Atoll's natural assets, as well as restoring already degraded areas in North and South Islands, a condition that was exacerbated by the passing of Tropical Cyclone Fantala.

Key recovery needs related to the environment sector are as follows: for the short term, (i) clear debris from devastated vegetated areas, (ii) replant coconut palm trees on perimeters according to their intended use—either for recreating a tropical ambience for tourism purposes or for commercial exploitation— taking into consideration revised projections of future demand for coconut and coconut-derived products; and (iii) capitalize on the window of opportunity provided by the cyclone's flattening of a large number of non-native trees on South Island and Manaha Islands to promote the natural and assisted re-vegetation of natural habitats with native species; and (iv) assess potential adverse environmental impacts of using introduced tree species, such as filao trees, and the sustainability of using such species as a source of timber and charcoal, limiting the number of non-native trees to a minimum. In the long term, adopt and implement the country's specific biodiversity and conservation goals for these islands, phasing out all unsustainable practices while promoting environmentally-friendly economic activities such as high-end nature-oriented tourism (e.g. fly-fishing, and bird-watching)

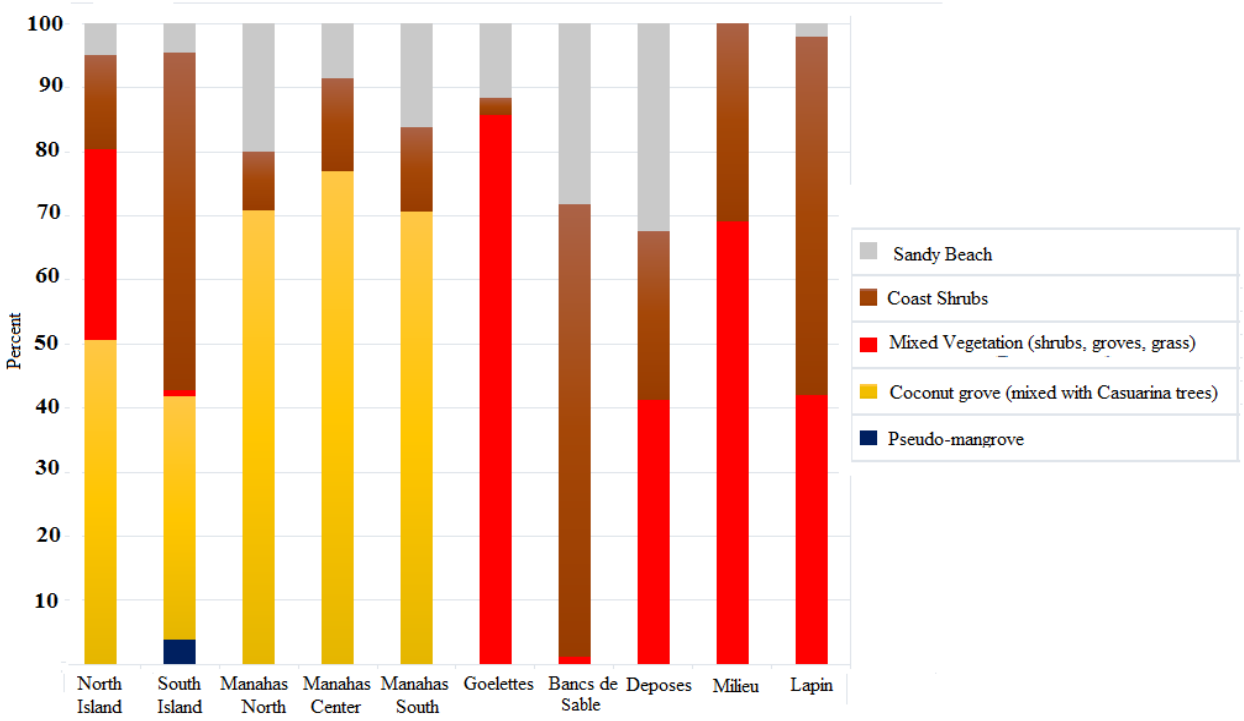
Background on the Natural Environment

Farquhar Atoll has a range of natural habitats including: (i) sandy beaches (46 ha) (ii) beach crests and sand dunes covered by coastal shrubs (274 ha) (iii) mixed vegetation areas (i.e. with native and introduced plant species), mainly composed of trees and grasses (145 ha) (iv) introduced coconut-palm groves, intermingled with the also introduced filao (*Casuarina equisetifolia)*—mainly used as windbreakers and as a source of timber—(352 ha) and (v) pseudo-mangrove swamps (15 ha, of which about 0.01 ha was covered by true mangrove species), edged by *Pemphis acidula* (Figure A3.1). The presence of specific habitats among the islands exhibits marked differences. For instance, the North Island and the Manaha Islands show highly modified terrestrial habitats, with 50 to 80 percent vegetation cover made of coconut palm tree groves and mixed native and non-native vegetation. Meanwhile, on other islands natural vegetation and habitats still predominate, covering above 60 percent of their land area. It is worth noting that South Island is the only island having extended pseudo-mangrove swamps on its lagoon side.

The Farquhar Atoll's terrestrial habitats substantially degraded from the 1800s to the 1980s as a result of clearing of the natural vegetation cover on North, South, and the Manaha Islands, resulting from the expansion of coconut palm tree groves for the production of coconut-derived products and harvesting of the non-native filao timber. Nevertheless, due in part to the relative isolation of these islands, they have remained comparatively protected from human activities and still retain many native species and functional ecosystems (i.e. ecosystems that are fully self-perpetuating without requiring human intervention to

maintain its natural processes). Farquhar Atoll's natural ecosystems and the environmental services that they provide directly contribute to the Seychelles' economy, particularly through income generated by sport fishing tourism, as well as nurseries and feeding grounds for the populations of several commercially and ecologically important marine fish species.

Figure 3.1. Percent area covered by habitat type on Farquhar Atoll's islands



Source: PDNA

The largest islands of Farquhar Atoll have **sandy beaches** on their ocean and lagoon sides. On the atoll scale, sandy beaches represent around 36 km of shoreline (17 km on North Island, 14 km on South Island, and around 5 km on islets) and cover an area of 45.5 ha, most of which are found on North Island (18.7 ha) and South Island (17.9 ha). Beaches represent 5.5 percent of the total land area on the atoll scale. The beaches are generally wide and display indicators of being healthy, including showing either stability or accretion, present along most of the shoreline length.

The seaward beaches of North Island, especially near the village, are affected by chronic erosion, which was first reported in 1970 (Stoddart and Poore, 1970).[20]. The ocean side beaches of North Island and South Island are important nesting habitats for the Green turtle (*Chelonia mydas)* and the Hawksbill turtle (*Eretmochelys imbricata)*, while the lagoon serves as a nursery and foraging ground for juveniles, remarkably abundant around Bancs de Sable Island. Fortunately, human pressure on the atoll beaches is very limited, as these beaches are not being exploited for economic purposes, other than the occasional landing and departure of visitors to the islands.

[20] Stoddart D.R., Poore M. E.D., 1970. Geography and Ecology of Farquhar Atoll, Atoll Research Bulletin, n° 136, pp. 7-26.

Coastal shrubs composed of several Indo-Pacific indigenous species (mainly *Scaevola sericea*, along with *Tournefortia argentea, Pemphis acidula,* and *Suriana maritima*) are found on beach crests and sand dunes. They extend further inland on South Island, where shore-parallel sand dunes are well-developed, reaching around 15 m in elevation and extending up to 500 m inland from the vegetation line. On the atoll scale, this habitat covers 274 ha, representing 33 percent of the atoll land area. Coastal shrubs are generally healthy and they play a major role in sand dune stabilization. Human pressure on this habitat is currently very limited, as there are no socio-economic activities directly linked to this environment. However, the introduction of coconut palm trees (*Cocos nucifera*) and filao trees (*Casuarina equisetifolia*) on the largest islands has progressively led to the replacement of the native coastal shrubs by these non-native species along some sections of the coastline (e.g. on the northern and north-east coasts of North Island).

Mixed vegetation is composed of an assemblage of indigenous and introduced grass, shrub, and tree species. It constitutes a transitional habitat between the natural coastal habitats (i.e. sandy beaches, beach crests, and sand dunes) and the highly modified environment of the interior of the islands. Mixed vegetation mainly occurs on North Island, due to the establishment of the main settlement on this island, as well as on some small islands, such as Goëlettes. It covers 145 ha representing, 17 percent of the total island area of the atoll. Furthermore, the extended herb-mat that covers most of Goëlettes' land area (about 27 ha) is a major nesting site for the Sooty tern (*Onychoprion fuscatus).*

Coconut groves are present on North Island, South Island, and the Manaha Islands, due to the establishment of coconut groves on North Island since the mid-19th century, and on South Island at the beginning of the 20th century. Due to limited exploitation and maintenance, coconut groves include other tree species, especially filao trees (*Casuarina equisetifolia*) that were introduced for timber and as wind breakers. Coconut groves cover 352 ha, representing 42 percent of the total land area of the atoll. However, only an area of about 2 ha of coconut palm tree is harvested for commercial purposes. Coconut groves are present on five islands. The areas covered by Coconut groves, as well as the percentage of land area covered by this habitat type, on each of these islands are as follows: North Island (192 ha, 51%); South Island (150 ha, about 38%); Manaha North (2 ha, about 71 %); Manaha Center (6 ha about 77 %); and Manaha South (3 ha, about 71%) (Table A3.1).

A tiny true **mangrove swamp** of about 0.01 ha is found on North Island, while three **pseudo-mangrove swamps** edged by *Pemphis acidula* (covering an area of 15 ha) are present on the lagoon side of South Island. The latter are bordered by the coconut grove on their eastern side and by elongated north-oriented sand spits on their lagoon side. These swamps connect with lagoon waters through inlets. The *Pemphis acidula* shrubs edging pseudo-mangrove swamps provide nesting sites for Red-footed boobies (*Sula sula*). This healthy ecosystem is little disturbed by human activities, although introduced tree species (i.e. coconut palm and filao trees) have grown nearby.

Fauna

Seabirds - BirdLife international has ranked the islands of Goëlettes and Bancs du Sable as an IBA. Goëlettes is almost treeless but covered in grasses and a few low *vouloutye* bushes (*Scaevola sericea*). There is a huge seasonal colony of about 300,000 pairs of Sooty tern (*Onychoprion fuscatus*) and around 10,000 pairs of Brown noddy (*Anous stolidus)*. In 2006, ICS researchers recorded a previously unknown colony of Black-naped terns (*Sterna sumatrana)* at Bancs du Sable Island.[21] Breeding monitoring activities

[21]Adam, P-A., Skerrett, A. and Rocamora, G. 2009. First confirmed breeding record of Black-naped Tern Sterna sumatrana from St François Atoll and a new population estimate for Seychelles and the Afrotropical region. Bull ABC 16 (1): 78-82.

carried out by ICS revealed the existence of 77 to 137 pairs, possibly representing the largest population of this species in the entire region. Before the passage of Tropical Cyclone Fantala, South Island was characterized by the remarkable size of its Red-footed booby (*Sula sula*) population, which has increased about 70 times in the last 16 years (from 50-70 pairs counted in 1999 to 4,200 pairs recorded in June 2015). The Red-footed booby progressively expanded northward, colonizing the Manaha Islands and North Island. The ICS findings suggested very high breeding successes over the past years and adequate food availability in the nearby waters, coupled with the arrival of birds from other rookeries.

Sea turtles - The outside beaches of North Island and South Island are critical nesting habitats for several hundred "Endangered"[22] Green Turtle (*Chelonia mydas)*, and the much less abundant, "Critically Endangered"[23] Hawksbill (*Eretmochelys imbricata)*. The impact of Tropical Cyclone Fantala on sea turtles, sea bird colonies, and key invertebrates are further discussed in Annex 4.

Reef Fish - A total of 140 species and 44 genera of scleractinian corals were identified in 2009 by an interdisciplinary research team (Friedlander et al., 2014).[24] The coral assemblage at Farquhar consists primarily of slow-growing massive and encrusting genera, particularly Porites and Montipora, that are more resistant to high-energy environments and bleaching, whereas the faster-growing but vulnerable branching genera, such as Acropora and Pocillopora, are less abundant and mainly found along channels and leeward habitats (Friedlander et al., 2014; Duhec et al., 2014).[25] Since the start of 2016, because of abnormal high sea surface temperatures (SST) and calm conditions which impact the western Indian Ocean, severe bleaching events were observed around both the Inner and Outer Islands of the Seychelles. Data from March to April revealed that Farquhar and Providence reefs were less impacted, with up to 30 percent of bleaching compared with the Inner Islands, and the Outer Islands of Desroches and Alphonse where 80 percent of colonies showed signs of bleaching. Such differences could be explained by the reduction in SST during the bad weather experienced by the Farquhar Group[26] in February, which helped the affected corals to recover from the bleaching event observed in January. In particular, the massive and sub-massive (e.g. Stylophora) genera showed signs of high resilience.

A total of 56 fish families were encountered on quantitative surveys around Farquhar Atoll during a research expedition in 2009 (Friedlander *et al.,* 2014). Farquhar atoll is well known for its great diversity of coral reef fish. For example, certain groupers such as the 'Vulnerable' Black-saddled coral grouper (*Plectropomus laevis)*, and the "Near-threatened" Brown-marbled grouper (*Epinephelus fuscoguttatus*), both found in abundance in the atoll, are rarely caught on the Seychelles plateau. Farquhar Atoll's waters also support an important population of 'Endangered' Napoleon wrasse (*Cheilinus undulatus)*, and the Bumphead parrotfish (*Bolbometopon muricatum*), listed as "vulnerable" by the IUCN. The atoll is also known to host multi-species fish-spawning aggregation sites. Studies carried out by the Seychelles Fishing Authority have shown that the abundance of some grouper species is about three times greater than in the North Amirantes and up to 30 times that of the granitic islands (Robinson and Samoilys, 2013).[27] Spawning

[22]According to IUCN Red List of Threatened Species 2015-4. http://www.iucnredlist.org/details/4615/0 **.** Accessed on June 2, 2016.
[23]IUCN Red List of Threatened Species 2015-4**.** http://www.iucnredlist.org/details/8005/0 .Acc. June 2, 2016.
[24] Friedlander A.M., Obura D., Aumeeruddy R., Ballesteros E., Church J., Cebrian E., Sala E., 2014. Coexistence of low coral cover and high fish biomass at Farquhar Atoll, Seychelles. PLoS ONE 9(1): e87359.
[25] Duhec, A.V., Jeanne, R.F. and Narty, C. (2014). Identifying key environmental threats to the Outer Islands of Seychelles through the collection of baseline and monitoring data. Pangaea Project. Third Cruise Report, Farquhar Atoll.
[26] Farquhar Group includes the Farquhar Atoll, Providence Atoll, St. Pierre Island, and 3 submerged banks.
[27] Robinson J and Samoilys MA (Co-editors) (2013) Reef Fish Spawning Aggregations in the Western Indian Ocean: Research for Management. WIOMSA/SIDA/SFA/CORDIO. WIOMSA Book Series 13.

aggregations are critically important for the replenishment of the Atoll's reef fish population. The protection of these critical sites is enforced by IDC and monitored by ICS. According to the Islands Conservation Society's subsistence fishery monitoring program, data collected within a period of two years showed that the most exploited, highly valuable species, including the Spangled Emperor (*Lethrinus nebulosus*), Two-spot red snapper (*Lutjanus bohar*), and Brown-marbled grouper (*Epinephelus fuscoguttatus*), are abundant and their populations are healthy. The coral fish community also plays a key role in the dynamics of the coral reef ecosystem that contributes to the maintenance of the reef framework, by inter alia, curtailing the establishment of large stands of macro-algae and keeping the reef substrate suitable for the establishment of new coral recruits, helping the whole ecosystem cope with major climatic events such as the passing of cyclones. The Farquhar fish community, however, remains at risk of illegal fishing activities.

Disaster effects on the Environment

Terrestrial habitats

The spatial extent and intensity of damages were found to be much higher on highly-modified environments (i.e. mixed vegetation and coconut groves) than on natural habitats (sand beaches, coastal shrubs and pseudo-mangrove swamps), as illustrated in Table 3.2, Figure ES4, and Photo 1 (see Annex 2, Photo Gallery).

Table 3.2 Intensity of damage to terrestrial habitat types (area affected -percent of habitat type)

Habitat Type	Not damaged (ha - %)		Little damaged (Less than 30 %) (ha - %)		Partially damaged (More than 30 % to 70%) (ha - %)		Severely damaged (More than 70%) (ha - %)	
Coastal shrubs	63.3	24%	145.0	55%	36.6	14%	20.0	7%
Mixed vegetation	23.3	20%	30.3	26%	0	0%	63.1	54%
Coconut groves	25.1	7%	0	0%	0	0%	326.9	93%
Pseudo-mangroves	3.1	20%	2.5	16%	2.5	16%	7.4	48%

Source: PDNA

The impacts of Tropical Cyclone Fantala on **sandy beaches** were assessed based on field observations and on the comparative analysis of pre-cyclone and post-cyclone images, using a satellite image; and aerial photographs taken on May 12 and 13, 2016, respectively. Field observations allowed the measuring of impacts of the cyclonic wind and waves on the sediment budget of beaches, based on the assessment of accretional and erosional features. Additionally, the comparative analysis of the pre-and-post-cyclone images allowed the assessment of changes in shoreline position, using the vegetation line as a shoreline proxy. The team assessed whether the cyclone had triggered a shoreline retreat, shoreline advance, or caused no change in shoreline position.

Although changes in shoreline position were not quantitatively measured, as post-cyclone satellite images were not available at the time of analysis, the erosional impact of Tropical Cyclone Fantala on beaches was assessed using a qualitative, three-level, measurement scale. Beaches were considered to fall in one of the following categories of impact: (a) *not to little degraded*, where Tropical Cyclone Fantala had no or very limited impacts on shoreline position and beach condition; (b) *partially degraded*, where Tropical Cyclone Fantala caused significant shoreline retreat (> 4 m) and beach lowering (up to 0.20 m) and (c) *severely degraded*, where the cyclone caused significant shoreline retreat (> 4 m) and marked beach lowering (uprooting of trees that were growing, at the respective position, on the beach).

Sandy beaches exhibited limited wave-induced erosion. Erosional impacts mainly included the cutting of scarps in the beach crest (Photo 2) and the lowering of the beach because of sediment loss. On the northern coast of North Island, which is affected by chronic beach erosion, wave attack, compounded by the strong winds, triggered significant shoreline retreat (estimated between 4 and 8 m) and the uprooting and fall of mature filao (*Casuarina equisetifolia*) trees (Photo 3). Sand loss also exposed the roots of trees that had been destroyed by past cyclones, notably TC Bondo (2006) (Photo 4). Considering these impacts, it was estimated that 4 percent of the total beach area of North Island was severely impacted by the cyclone, while 96 percent was either *not damaged or experienced little* degradation. In contrast, the beaches of South Island and Goëlettes Island suffered *little to no* erosional impact. While localized erosion scarps were detectable on post-cyclone images of South Island (e.g. on the beach bordering the inter-islet channel separating South Island from the southernmost Manaha Islands), the vegetation line was found to be generally stable.

At most sites, beaches showed either little or no erosion. In places, they even exhibited significant accretion. Depositional features mainly included *(i)* the formation of a new beach crest composed of coral debris, as recorded on the southern section of the ocean coast of South Island and on the south-eastern coast of Goëlettes (Photo 5); *(ii)* the deposition of fresh sand and coral debris at the beach surface, causing an increase in beach volume (Photos 6 and 7). In conclusion, the impacts of Tropical Cyclone Fantala on Farquhar islands beaches were partly damaging (i.e. erosional), but also partly positive (i.e. accretional).

Both the wind and waves generated by Tropical Cyclone Fantala caused damage to the **coastal shrubs** covering beach crests and sand dunes. The impacts of the wind included branch breaking bark being ripped off, defoliation, and plant deformation in the direction of the wind (Photo 8). These damages were found to be widespread, whereas the damaging impacts of the cyclonic waves on coastal shrubs were limited to the beach crest and they only occurred where the latter eroded, causing plant uprooting (Photo 9).

A qualitative, three-level measurement scale was used to assess physical damage to coastal shrubs: (i) *little degradation* where shrubs are still standing and showing strength, despite leaf loss and branch breaking; (ii) *partial degradation*, where plants were tilted by the wind, showing foliage loss and widespread branch breaking; and (iii) *severely degraded*, where most branches were broken or the plant uprooted. Generally, the dominant *Scaevola sericea* showed higher resistance to the wind than *Tournefortia argentea, Suriana maritima,* and *Pemphis acidula.* Damages to both shoreline and inland shrubs were found to be highly variable from one place to another. While some ocean sites exhibited total destruction, others showed no sign of impact. Moreover, impacts were generally lower on the sheltered lagoon shores than on the highly exposed ocean shores (Photo 10), except on the west east oriented lagoon shoreline located to the south of the village on North Island. It was also observed that on some shoreline sections, the coastal shrubs trapped wind-blown sand and coral debris transported to the coast by the cyclonic waves, which resulted in a 0.20 to 0.50 m increase in the elevation of beach crests (Photos 11, 12 and 13).

In inner coastal dunes, the coastal shrubs were differentially damaged by wind and salt. While the vegetation was undamaged in extended areas (Photo 14), it was extensively burnt by wind and salt in the elongated depressions separating the shore-parallel rows of sand dunes on South Island (Photo 15).

In total, about 202 ha (i.e. 74 percent of the land area covered by coastal shrubs) (see Table 3.2 and A3.1) were affected by the cyclone; 145 ha (i.e. 72 percent of the affected area covered by this habitat type) showed *little damage* (<30%); 37 ha (i.e.18 percent of the affected coastal-shrubs area) showed *partial damage* (30-70%); while the remaining 20 ha (i.e. 10 percent of the affected coastal-shrub area) suffered *severe damage* (>70%). In conclusion, native coastal shrubs exhibited higher resistance to the cyclonic wind and waves than introduced filao and coconut trees, evidencing the well-adapted nature of the indigenous vegetation to intense climate events.

The impacts of the cyclone on the **mixed vegetation** (including *Casuarina equisetifolia* trees) and **coconut palm tree groves** mainly included tree uprooting and trunk cutting at mid-height (Photo 16).

Physical damage to **mixed vegetation** and **coconut palm tree groves** was ranked as follows: (i) *little degraded* if trees were still standing and showing strength; (ii) *partially degraded* where widespread foliage loss and branch breaking occurred, together with visible tilting; and (iii) *severely degraded* where trees were broken or uprooted. Physical damage to coconut palm and filao trees ranged between 85 and 100 percent in most places. The assessment found 327 ha of coconut palm tree groves severely damaged, i.e. 93 percent of the total area covered by Coconut groves. It was also observed that on the sheltered lagoon shores of North and South islands patches of coconut palm trees, covering a total area of 25 ha (i.e.7 percent of the total area covered by Coconut groves), remained standing (Photo 17).

While the mixed vegetation habitats trees were destroyed, the areas covered with grass suffered minor damage (Photo 18). It was also observed that, in two places in particular, the extension of grassland from the beach crest to inner areas allowed widespread wave intrusion that caused sediment deposition. On North Island, due to the northwest-southeast orientation of the airstrip and almost total disappearance of the coastal shrubs at its southern end, wind and waves penetrated up to 100-150 m inland, depositing sand and coral debris on the airstrip. Likewise, on Goëlettes Island, where 86 percent of the land area is covered with mixed vegetation, including grassland (Table A3.1), the cyclonic waves met no obstacle and therefore propagated over 50 to 90 m inland, causing sand and coral debris deposition (Photo 19).

It was estimated that 54 percent of the area covered by the mixed vegetation habitat, particularly the wooded areas within this habitat type, was severely affected by the cyclone. Meanwhile, the remaining 46 percent of the area covered by the habitat type areas—covered mostly with grass and shrubs—suffered little or no damage.

The assessment team used the same classes established for coastal shrubs and forests to assess the damage caused to **mangrove and pseudo-mangrove swamps**. The tiny 0.01 ha true mangrove located on North Island was destroyed. Additionally, the *Pemphis acidula* (ironwood) vegetation edging South Island's pseudo mangrove swamps exhibited considerable damage (branch and trunk breaking, defoliation, pinning to the ground), with 80 percent of the total area being affected. However, the intensity of damage varied significantly from place to place (Photo 20). While 60 percent of the area covered by *Pemphis acidula* was *severely damaged* due to complete uprooting or branch breaking, 20 percent was *partially damaged* (30-70%) and 20 percent *little damaged* (<30%). It was observed that 20 percent of the area covered by pseudo-mangrove swamps was not damaged (Table 3.2).

The habitats considered in the assessment of impacts on the Environment Sector are those that are not directly exploited for human activities. Moreover, they are very specific to reef island environments and even present some unique, local characteristics. Furthermore, the value of environmental services can be huge, however, monetizing such services, many of which are intangible assets, is not an easy task. As a result, trying to assess financial damages and losses caused by ecosystem degradation is even a greater challenge. Therefore, for this report, the PDNA team agreed to limit the assessment of damages and losses on the Environment Sector to the estimate costs of clearance and replanting of damaged coconut groves.

Loss estimates are therefore based on the three-year period considered necessary by IDC Management to clear the debris from the damaged coconut groves, and gradually replant new coconut palm seedlings. On North Island, 190 ha of coconut palm tree grove have to be cleared. However, only 50 ha are expected to be replanted with coconut palm trees, as such area is considered enough to fulfill both production and landscaping needs. One or two rows of filao trees would also be planted at the edge of the coconut palm tree grove. The cost of clearance and replanting on North Island was estimated at SCR141,150 per day, based on a workforce of 150 person-day. Meanwhile, for South Island and the Manaha Islands, IDC plans to clear vegetation debris, but not reintroduce exotic plant species, as South Island is scheduled to be designated as a National Park; while the Manaha Islands would be designated as a buffer zone between the productive activities performed in North Island and the strictly environmental protection activities that will be permitted on South Island. These figures are based on IDC's previous experience in performing similar activities.

The cost of cleanup activities to be carried out on South Island and the Manaha Islands were estimated to be 50 percent of the estimated costs of clean up and replanting on North Island (i.e. SCR 70,575 per day, based on a workforce of 75 person-day). Two 20-worker teams would operate in tandem (i) on North Island and (ii) on South Island and the Manaha Islands, respectively, over a period of three years, which is the estimated time to carry out the planned recovery activities within the Environment sector. Therefore, it is estimated that the yearly costs would be SCR8,939,500 for clearance and replanting on North Island; and SCR3,764,000 for clearance on South Island and the Manaha Islands, for an estimated SCR38,110,500 in losses over the three-year period.

The **damages** within the Environment sector were estimated at SCR1,374,792. An additional amount of SCR 1,374,792 was identified as needed to cover additional costs related to the recovery of affected natural habitats, bringing total Recovery needs for the Environment Sector to SCR40,232,892.

Estimated damages and losses, as well as the recovery needs for the Environment sector are indicative, however, as it is expected that they may increase, once the assessment of impacts on the coral reef can be carried out.

Fauna and marine environmental assets

With regard to the Fauna, the Red-footed Booby (*Sula sula*) is likely to be the most heavily impacted of all seabirds. Most of the breeding habitat it was using has been destroyed and Tropical Cyclone Fantala hit at the height of the breeding season when there were many birds with nests containing eggs or chicks. Other seabirds as well as turtles and invertebrates experienced little to no impact. (See Annex 4 for further details).

Unfortunately, heavy swells and limited visibility prevented the team from assessing damage to coral reefs and related fish resources. The assessment team strongly recommends that an assessment of the impacts of Tropical Cyclone Fantala on coral reefs and related marine resources be undertaken as soon as weather and water conditions are favorable.

Recovery Strategy & Needs

For the effective recovery of environmental assets, a number of activities that build on existing policies and projects as well as new ones are proposed, along with short- to long-term planning. These activities will generate three benefits: (i) they will contribute to the restoration of affected environmental assets; (ii) they will improve our understanding of the impacts of major cyclonic events, such as the passing of Tropical Cyclone Fantala over the Farquhar Atoll, with which relevant stakeholders will be able to draw important lessons to strengthen local capacities for carrying out effective environmental monitoring as well as post-event assessments; and (iii) they will strengthen DRR policies and support the design of a strategy for climate change adaptation that takes into consideration the unique biogeographic characteristics as well as the socio-economic and cultural features of the Outer Islands. The proposed activities reflect the discussions held with Government authorities and IDC Management.

General guidelines

The recovery strategy is informed and will build on:

- IDC's mission, which seeks to "ensure that the Outer Islands are actively involved in the socio-economic development of the Seychelles while adhering to the highest environmental standards." To achieve its mission, IDC enforces a series of policies for the differentiated management of the islands under its charge, including: (*i*) designating North Island for the carrying out of activities that promote social and economic development (based on the production of dried salted fish; harvesting of coconut fruit and production of coconut-derived products; and marine-based ecotourism activities, such as fly fishing); and (*ii*) the other islands, i.e. South Island and uninhabited islets, designed as biodiversity conservation areas. In such a context, recovery strategies include both human-assisted interventions such as clearance and replanting, as well as the strengthening of local capacities for environmental monitoring.

- The Outer Islands Project (OIP), launched in 2014 by the Government of Seychelles, in partnership with the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF). The project, titled "Expansion and strengthening of the protected area subsystem of the Outer Islands of Seychelles and its integration into the broader land and seascape," seeks to promote the conservation and sustainable use of land and marine biodiversity of islands, including Farquhar Atoll, Desroches, Poivre, D'Arros, St Joseph, and Alphonse Group. On the Farquhar Atoll, the protected area will consist of South Island (to be designated as a National Park, under the IUCN Category II), Goëlettes Island and Bancs du sable (designated as Strict Nature Reserves, IUCN Category I), and the marine seascape extending 1 km from the edge of the reef flat (i.e. 22,290 ha). The smaller uninhabited islets of Farquhar Atoll and adjacent waters of the lagoon are already recognized as IBAs. ICS, on its conservation advisory role to IDC, contributes to the implementation of the OIP through regular monitoring activities on Farquhar. In this context, the passing of Tropical Cyclone Fantala, which devastated highly-modified environments, i.e. coconut palm tree groves and mixed forests, offers a window of opportunity to promote the restoration of natural ecosystems and thereby accelerate the achievement of the biodiversity conservation goals for the Farquhar Atoll.

- The promotion of productive activities, including those that protect traditional livelihoods, and that contribute, at the same time, to the environmental sustainability of the Farquhar Atoll. Among the activities that can be considered environmentally friendly, high-end ecotourism plays a key role in the sustainability of economic activities in the Farquhar Atoll. IDC's objective is to increase tourism occupancy from 25 to 35 weeks a year. In this regard, IDC is committed to ensure that any increase in the number of tourists will be solely allowed with strict adherence to technical recommendations on the maximum number of people that may visit the atoll at the same time without causing destruction of the physical, socio-cultural or environmental characteristics of Farquhar. The restoration of the coconut palm tree landscape on North

Island, which was severely damaged by the cyclone, is planned as one of the activities that will be carried out to restore the tropical ambience at Farquhar village.

Short-term recovery strategy and needs (over one year following Tropical Cyclone Fantala)

The short-term recovery strategy comprises three main activities:

- **At the atoll-wide level, carrying out of a comprehensive assessment of the impacts of Tropical Cyclone Fantala on the atoll's terrestrial and marine environments.** The assessment should include: (i) impacts on the coral reef ecosystem, reef fish, fish spawning aggregation, subsistence fishing, and sea turtle nesting; and (ii) impacts on shoreline configuration and coastal morphology, including beach crests and sand dunes; as well as impacts on native vegetation. For carrying out the proposed assessment, the following inputs are expected: (a) active involvement of ICS science team in the carrying out of relevant marine environmental monitoring activities. It is recommended that said monitoring be started as soon as possible to ensure that critical post-event observational and quantitative data, as well as important lessons to be drawn from the passing of Tropical Cyclone Fantala over Farquhar, are not lost due to a delay in the systematic collection of post-event data. (b) A comparative analysis of satellite imagery taken before and after the passing of Tropical Cyclone Fantala. Said analysis would allow: (i) building a complete pre-cyclone database, which currently does not exist, and would complement ICS current monitoring activities, focused on the marine environment and fauna (seabirds, coral reefs, reef fish and sea turtles); (ii) verify and complement this PDNA's key findings; and (iii) based on the new information generated by the detailed assessment, provide the baseline information for the long term monitoring of the affected habitats and ecosystems; documenting the ecological and physical responses to catastrophic events, such as the passing of Tropical Cyclone Fantala, and their role in building environmental resilience to extreme weather-related events.

- **Clean up of vegetation debris on North Island, South Island, and the Manaha Islands; Gradual replanting of coconut palm and filao trees on North Island**; **Composting of biological debris will be encouraged to reduce the carbon footprint**. Accordingly, burning of biodegradable debris will be discouraged.

-On North Island, restoration of a 30m-wide coastal vegetation belt composed of Scaevola sericea, Tournefortia argentea, and Suriana maritima. Restoring coastal shrubs will contribute to the reduction of coastal degradation, due in part to: (i) the natural protective buffer provided by these shrubs which contributes to the mitigation of the destructive impacts of extreme weather events and waves on exposed assets; and (ii) to the coastal shrubs' role in facilitating vertical sediment accumulation by trapping sand during fair weather conditions, and trapping coral debris during storm events; and allowing beach crests and foredunes to grow upwards, potentially contributing to mitigating salt-water intrusion on coastal lands.

The absence of coastal shrubs at the ends of the airstrip, —where coastal erosion is evident (Photos 21 and 22)—, may have contributed to the degrees of sand and coral debris accumulation over the airstrip area (Photo 23) which required IDC to employ a cleanup crew to restore safe aircraft landing and takeoff operations. It is hypothesized that if they were present, coastal shrubs would have measurably reduced the amount of sediment accumulation on the airstrip, thereby reducing the time needed for reestablishing normal aircraft operations after the passing of Tropical Cyclone Fantala. In addition, restoring coastal shrubs may help reduce the risk of seawater intrusion, and the risk of soil degradation by salinization. Furthermore, restoring coastal shrubs along the coastline would also help restore sea turtle and seabird nesting habitats that were either destroyed or degraded by coastal erosion or by the establishment of stands of introduced plant species. The restoration of coastal shrubs, with fast-growing native species, could easily be carried out because said species, known to be well adapted to these island environments, are locally abundant (Figure 3.2).

Medium term recovery (1-3 years)

To learn and build upon the Tropical Cyclone Fantala experience, it is recommended to:

- Over the next three years, evaluate relevant parameters of the resilience capacity of ecosystems and terrestrial and marine species impacted by the cyclone, including: coral reef ecosystem; coastal shrubs; the Pemphis acidula vegetation of pseudo-mangrove swamps; seabird colonies, and marine turtles; as well as to document changes on the physical configuration of coastal features that were affected by the cyclone, i.e. sandy beaches and sand dunes, taking into consideration e.g. recovery of eroded beaches, re-vegetation with native species of areas that were damaged by the cyclone; colonization processes on new sediment deposits; and reorganization of newly deposited sediments triggered by seasonal swells. Building on this experience, design a multi-disciplinary methodological framework for assessing the impacts of tropical cyclones and to document how natural ecosystems respond to extreme weather events in the Seychelles' Outer Islands.

Environmental monitoring should be carried out on North Island as well as on the islands' lesser altered ecosystem, i.e. those scheduled to be designated as protected areas, including South Island, Goëlettes and Bancs du Sable, where the comparative analysis of the differentiated impacts of Tropical Cyclone Fantala and other extreme weather events could provide important lessons to improve the effectiveness of environmental management interventions on North Island and elsewhere on the Outer Island.

- Strengthen local environmental monitoring and post-event assessment capacities through (i) the development and strengthening of ICS technical capacities to carry out systematic monitoring of the islands' terrestrial environments; (ii) assessment of existing information management capacity needs, including a technical review of the existing environment database and the upgrading of said database to expand its functionality to also properly manage relevant data on terrestrial ecosystems; (iii) and the establishment of protocols for data processing and analysis.

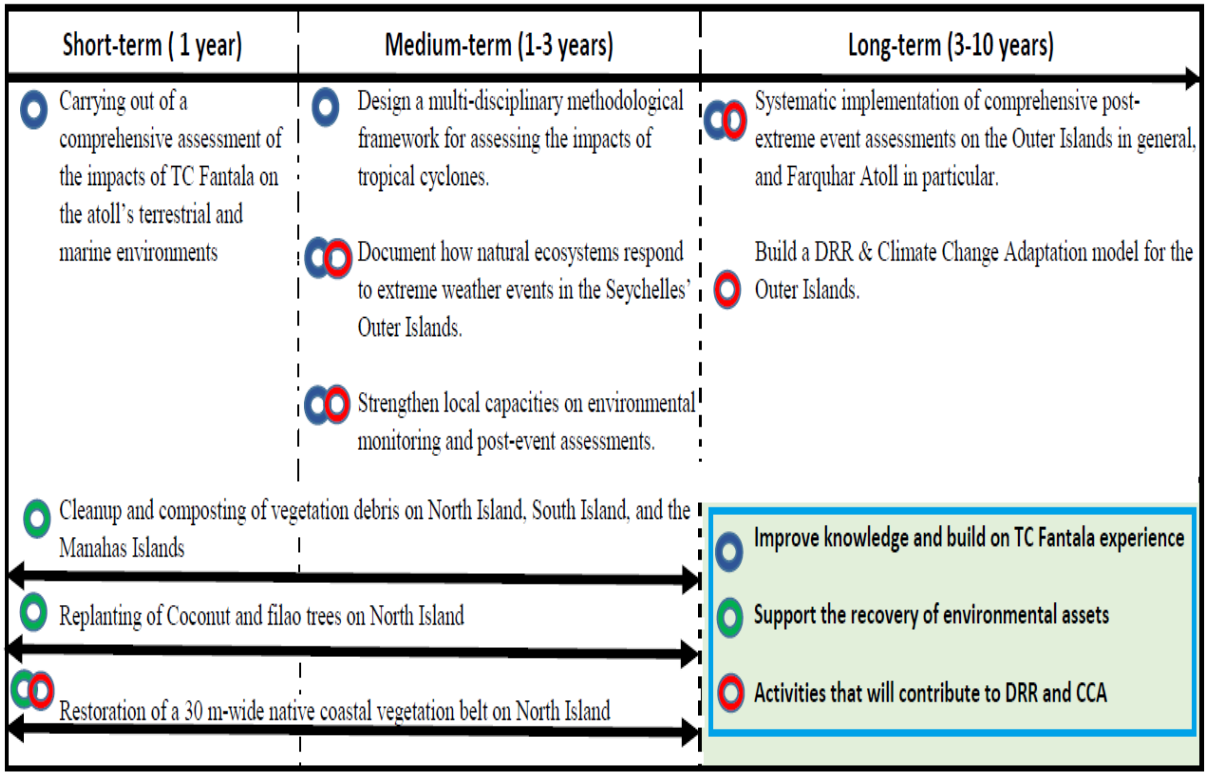
Long-term recovery (>3 years)

Improved Disaster Risk Reduction (DRR) policies for the Outer Islands, and in particular, for the Farquhar Atoll, will contribute to build social, economic, and environmental resilience to extreme weather events. DRR policies shall be informed by, *inter alia*:

- The systematic implementation of comprehensive post-extreme event assessments on the Outer Islands in general, and on Farquhar Atoll in particular, which will help document the impacts of extreme events on natural ecosystems as well as identify post-extreme event recovery pathways that incorporate both sustainable targeted structural (e.g. improved building standards for cyclone shelters) and non-structural inventions (e.g. assisted re-vegetation of coast ecosystems; relocation of activities or structures to less-sensitive areas), as well as allowing natural processes, particularly natural succession, to continue without human interference.

- Build a DRR and Climate Change Adaptation model for the Outer Islands, based on Farquhar Atoll's observed increase on the frequency of extreme weather events, and taking into consideration the Outer Islands' particular disaster risk profiles. The DRR and CCA model will help improve the Government of the Seychelles' and relevant stakeholders' investment planning processes for the Outer Islands.

Figure 3.2. Recommended environmental recovery strategy for Farquhar Atoll



Source: PDNA

Chapter 4. Recovery Strategy

Recovery Vision and Guiding Principles

Adopting a disaster risk reduction plan is recommended, and a, people-centered approach to recovery (see Table 4.1) with the goal of strengthening the resilience of populations to adverse natural events, promoting sustainable economic activities and livelihoods that are compatible with and contribute to the long-term protection of the Outer Islands' natural ecosystems and the services they provide.

Table 4.1: Vision and Principles Underpinning the Recovery Process in Farquhar Atoll

Vision for recovery	The **resilience** of the resident population and socio-economic activities in Farquhar Atoll are enhanced and investments are secured through the recovery process.
Guiding principles	• Implement a *Building Back Better* approach, integrating disaster risk reduction (DRR) considerations in all recovery interventions; complemented by a • *Build Back Greener* approach to recovery that takes into consideration the potential environmental footprint of the interventions, particularly those that involve the rebuilding or retrofitting of permanent infrastructures, aimed to promote an overall low-carbon development approach. • Ensure that environmental sustainability is the overarching theme that guides all investments and interventions. • Strengthen environmental monitoring and disaster risk management capacities shall be an important component of the recovery process. • Clear communication and transparency must be promoted among all relevant national and local stakeholders involved in the recovery process. • Integrity and accountability in the management of public funds made available for the recovery.
Recovery issues and strategy	• Prioritization of needs and interventions. • Enhancement of economic opportunities that contribute to diversify livelihoods, while protecting the environment, through *inter alia*, the promotion of diversified tourism packages and the provision of professional training opportunities. • Protect the resident community's livelihoods associated with the production of coconut palm-derived products, artisanal fisheries, and dry fish processing activities.
Institutional framework	• Government Agency with a clear mandate and the necessary resources to coordinate the recovery strategy. • Implementing agencies' specific roles clearly delineated as well as the coordinating mechanisms among them.
Financing for recovery	• Coordinating body: (i) Island Development Company, (ii) Ministry of Finance, Trade and the Blue Economy; and (iii) Ministry of Environment, Energy and Climate Change.

Source: PDNA

General Recommendations

- **Prioritize the re-establishment of the Seychelles Coast Guard's capacity to monitor from the Farquhar Atoll the country's territorial and Exclusive Economic Zone waters, strengthening disaster preparedness and emergency response capacities**. Given the strategic importance of the SCG post at Farquhar Atoll for the performing of national security operations along the Seychelles' territorial waters and EEZ; and maritime Search & Rescue operations, as well as safety and security support to activities within the Farquhar Atoll; it is of utmost importance to prioritize the reconstruction of the SCG facilities at Farquhar, including the installation of a new communications tower and related communications equipment.

- **Reactivate economic activities, incorporating the technical recommendations of relevant experts on the types and scale of acceptable productive activities that are sustainable and compatible with the long-term development and conservation goals for the Farquhar Atoll**. Bring tourism-oriented visitation to pre-cyclone levels, exploring the feasibility of increasing tourism absorption capacity. Any increase on the number of visitors shall seriously consider experts' recommendations on the maximum number of people that may visit Farquhar at the same time without causing deterioration of the physical, socio-cultural or environmental characteristics of the atoll. Similarly, production of coconut-derived products (e.g. coconut oil and copra) as well as salted fish shall be brought back to pre-cyclone levels.

- **Install new Automatic Weather Stations (AWS) at Farquhar. Consider the need to increase the density and coverage of the country's meteorological network**. As demonstrated by the passing of Tropical Cyclone Fantala, timely access to reliable meteorological data is critical for informing emergency operations related to rapid-onset extreme meteorological events. The installation of a new AWS is urgently needed in Fa rquhar. Expanding the coverage and density of the country's meteorological network to other Outer Islands is an urgent need for strengthening and improving weather monitoring and forecasting capabilities, as well as to improve the effectiveness of the country's meteorological Early Warning System. Hence, the sustainability of the operation of the AWS at Farquhar, as well as other nodes of the weather-monitoring network across the whole country, should not be an afterthought, and adequate and predictable funding options should be budgeted and provided for operations & maintenance. Along with proper equipment, there is a need to update and harmonize the country's Standard Operating Procedures for disaster preparedness and emergency response. This need is particularly urgent for the Farquhar Atoll and Outer Islands located along the path of tropical cyclones.

- **Build storm shelters capable of withstanding category 5 cyclones, and keep them properly equipped with portable radios and survival kits, on all Outer Islands located along the path of cyclones.** Cyclone shelters save lives. The remoteness of the Outer Islands poses a serious challenge to residents and tourists. Therefore, it makes sense to build additional cyclone shelters on other islands. These shelters shall be built to comply with technical specifications to withstand category 5 cyclones and shall be kept properly equipped with battery-powered radio-communication devices as well as emergency survival kits. Cyclone shelters should be used as the refuge of last resort as it would be expected that people at-risk are informed of any evolving emergency situation in a timely manner, as well as SOP for emergency evacuation would be in place and known by all concerned stakeholders.

Sector-specific Recommendations

Productive Activities

- **Reactivate productive activities, taking into consideration the long-term development and conservation goals for the respective locations within the Farquhar Atoll**. Among these economic

activities, the production of coconut-derived products, and salted fish shall be brought back to pre-cyclone levels to protect livelihoods based on said products. Likewise, to bring tourism activities back to pre-cyclone levels, the basic logistical and physical infrastructures needed for safe ecotourism operations shall be put in place.

- **Start a comprehensive environmental monitoring and conservation program, initially at Farquhar and later, to possibly extended it to other Outer Islands**. A better understanding of the specific characteristics of the Farquhar Atoll and neighboring islands' ecosystems and biota, —including their fragility or resilience to human activities—, could be used to inform feasibility studies aimed to the design of more diversified ecotourism packages that takes into consideration their potential environmental footprint on terrestrial and marine environments.

Infrastructure

- **Revise and enhance building design standards as to incorporate specifications for higher wind velocity (>380kmph)**. Specifically, new buildings shall be able to withstand Category 5 Tropical Cyclone wind speeds, with emphases on foundations, concrete roofs, doors, and windows. Furthermore, partially damaged buildings should be retrofitted to adequate levels of protection against extreme wind velocities.

- **Equipment and machinery, particularly those non-portable, must be housed in cyclone proof structures.** Telecommunication towers and similar structures, such satellite dishes, —which are normally outside and exposed to the weather—, need to be protected from the potential damage caused by flying debris and other projectiles, during severe storm events. A power supply backup system should also be put in place, as part of a local Contingency Plan and Continuity of Operations Plan.

Cross Cutting

- **Reestablish the Seychelles Coast Guard's full capacity to monitor, from the Farquhar Atoll, the country's territorial and Exclusive Economic Zone waters, strengthening disaster preparedness and emergency response capacities, including Search & Rescue operations.**
- **Implement the Environment & Biodiversity Recovery Plan**, ensuring regular oversight.
- **Enhance environmental monitoring at Farquhar Atoll**.

- **Carry out planting activities on affected habitats using native species only. Limit the use of introduced species to areas designated for productive activities**, such as for coconut palm-derived products or for creating a tropical ambience around built facilities.

- **Strengthen weather monitoring, forecasting, and early warning capabilities**, as well as coordination and collaboration among relevant agencies (e.g. SNMS, IDC/SIF, SCG and DRDM)

- **Consolidate the existing GIS database on natural assets to also incorporate information on the physical health of beaches and sand dunes, as well as pseudo mangroves swamps**, as an effort to build a robust baseline dataset that will allow the comparative spatial and temporal assessment of the impacts of rapid onset events, such as cyclones; as well as those impacts triggered by slow evolving events such as sea-level rise and seasonality patterns. Data on the impacts of Tropical Cyclone Bondo and Tropical Cyclone Fantala on the Farquhar Atoll shoreline and terrestrial environments shall be incorporated into the GIS database management system.

Timeframe for Recovery Strategy Implementation

Short term (up to six months)

- Re-establish the SCG's capacity to monitor from Farquhar the surrounding territorial and EEZ
- Install a new Automatic Weather Station at Farquhar, allocating adequate funds for O&M
- Debris removal and safe disposal. Site cleanup and replanting on North Island. Biodegradable debris shall be used for onsite composting
- Retrofitting and rebuilding of the island infrastructure with improved cyclone-resistant standards
- Enhanced policy directives and building standards for cyclone-prone Outer Islands and its enforcement
- Comprehensive environmental assessment and recovery plan for Farquhar Atoll

Medium to long-term (up to five years)

- Systematic implementation of comprehensive post-event assessments program, documenting best practices for resilience recovery
- Strengthening local capacities for environmental monitoring of terrestrial and marine ecosystems
- Carrying out multi-disciplinary feasibility studies on productive activities that are sustainable and contribute to protect livelihoods as well as contribute to improve DRR and CCA and the long-term protection of Farquhar's natural environments.
- Based on Farquhar experience, build a model of DRR and climate change adaptation for Outer Islands that considers the improvement of the country's EWS and the building of cyclone shelters

Recovery Needs

Post-Disaster Recovery Needs to implement the recovery program in each sector—integrating disaster risk reduction considerations with the goal of promoting a sustainable recovery and the build back better, build greener approach—, were estimated at **SCR 111.8 million**, equivalent to **US$ 8.3 million**.

Table 4.2 Estimated Recovery and Reconstruction Needs

Sector		Recovery Needs (SCR)
Social		**SCR 18,867,000**
	Housing	18,867,000
Productive		**SCR 15,165,000**
	Agri. & Fisheries	882,000
	Industry	5,308,000
	Commerce	992,000
	Tourism	7,983,000
Infrastructure		**SCR 6,225,000**
	Electricity	3,832,000
	Transport	194,000
	Telecommunication	1,112,000
	Water & Sanitation	1,087,000
Cross-cutting		**SCR 71,503,000**
	Government	25,770,000
	Disaster RM	5,500,000
	Environment	40,233,000
Total		**SCR 111,760,000**

Source: PDNA

Recovery Financing

There are several sources that could be tapped by the Islands Development Company (IDC) and Government of the Seychelles (GoS) to finance the post-cyclone recovery activities at Farquhar Island.

Insurance: The Farquhar village assets were partially insured by IDC. After the cyclone landfall, a chartered quantity surveyor and a structural engineer were sent to Farquhar to assess the damaged property for insurance claim purposes. IDC filed an insurance claim and anticipates to receive a payment (in an amount yet to be settled) that would contribute to reducing the amount of additional financing needed for the recovery. Additional funding to cover the recovery of company-owned assets is expected to be covered, to the extent possible, by the company's own resources.

Domestic: The GoS is looking into several financing options within the national budget to support the recovery of priority activities that focus on environmental protection and maritime safety and security, including a drawdown on the DPL with Cat DDO.

External: The GoS could mobilize financing from external funding sources such as: (i) grant support from global funds such as the Global Environment Facility (GEF) and/or Green Climate Fund (GCF); (iii) financial and technical assistance from bilateral donors; and (iii) in-kind support from partner countries.

It is also recommended that the GoS continue to strengthen its disaster risk financing strategy in the broader context of building overall resilience to disasters in the cyclone prone Outer Islands.

Annex1.Glossary[28]

Build back better: Approach to reconstruction to reduce vulnerability and improve pre-disaster conditions, while promoting a more effective, resilient, environmentally adequate and sustainable reconstruction. Build back better uses the opportunity of having to rebuild to examine the suitability of reconstructing in the same location and conditions.

Contingency planning: A pre-disaster management process that analyses specific potential events or emerging situations that might threaten society or the environment, establishes arrangements (operational, technical, and financial) in advance to enable timely, effective, and appropriate response and recovery processes. Contingency planning results in organized and coordinated courses of action with clearly identified institutional roles and resources, information processes, and operational arrangements for specific actors at times of need. Based on scenarios of possible emergency conditions or disaster events, it allows key actors to envision, anticipate, and solve problems that can arise during crises. Contingency planning is an important part of overall preparedness. Contingency plans need to be regularly updated and exercised.

Damage: Total or partial destruction of infrastructure and physical assets due to a disaster, valued at current replacement costs. The value is estimated as the replacement value in current monetary terms (market value at the time of the disaster).

Disaster: A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources.

> *Comment:* Disasters are often described as a result of the combination of the exposure to a hazard; the conditions of vulnerability that are present; and insufficient capacity or measures to reduce or cope with the potential negative consequences. Disaster impacts may include loss of life, injury, disease, and other negative effects on human physical, mental, and social well-being, together with damage to property, destruction of assets, loss of services, social and economic disruption, and environmental degradation.

Disaster effects: The effects of a disaster event that results in damages (see *damage*) and changes in flows, such as economic and production losses, altered access to goods and services, altered governance, and changed risk assessed in all sectors.

Disaster impact: On the basis of the disaster effects, it is the estimated impact on the economy (macroeconomic and microeconomic impact on the economy and the affected population), and on human development.

Early warning system: Set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities, and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss.

Exposure: People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses.

[28]Based on United Nations' Office for Disaster Risk Reduction (UNISDR), "Terminology," http://www.unisdr.org/we/inform/terminology.

Comment: Measures of exposure can include the number of people or types of assets in an area. These can be combined with the specific vulnerability of the exposed elements to any particular hazard to estimate the quantitative risks associated with that hazard in the area of interest.

Losses: Changes in economic flows due to the effects of disaster. They include the decline in output in productive sectors and the lower revenues and higher operation cost in the provision of services. Also, losses are the unexpected expenditures to meet emergency needs.

Preparedness: The knowledge and capacities developed by governments, professional response and recovery organizations, communities, and individuals to effectively anticipate, respond to, and recover from the impacts of likely, imminent, or current hazard events or conditions.

Recovery: The restoration, and improvement where appropriate, of facilities, livelihoods, and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors. In the context of a PDNA, recovery encompasses both the reconstruction of damaged or destroyed physical assets including appropriate improvements to reduce risk and build back better; and the recovery from affected flows. The restoration of socioeconomic activities is considered as well as part of the recovery process.

Rehabilitation: Generally used as a synonym of recovery.

Resilience: The ability of a system, community, or society exposed to hazards to resist, absorb, accommodate to, and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.

Resilient recovery: In the post-disaster context it entails the inclusion of resilience-building measures as a means to improve pre-disaster conditions allowing a transition to a more sustainable development.

Reconstruction: The process of repair or reconstruction of destroyed or damaged physical assets and infrastructures, allowing for improvements in terms of risk reduction and building back better, as warranted by the damage occurred; Focuses primarily on the reparation, construction, or replacement of damaged infrastructure and other physical assets.

Risk: The combination of the probability of an event and its negative consequences. Risk is the result of a specific hazard impact on preexisting conditions of vulnerability. The word *risk* has two distinctive connotations: in popular usage the emphasis is usually placed on the concept of chance or possibility, such as in "the risk of an accident"; whereas in technical settings the emphasis is usually placed on the consequences, in terms of "potential losses" for some particular cause, place, and period. It can be noted that people do not necessarily share the same perceptions of the significance and underlying causes of different risks.

Risk management: The systematic approach and practice of managing uncertainty to minimize potential harm and loss.

Comment: Risk management comprises risk assessment and analysis, and the implementation of strategies and specific actions to control, reduce, and transfer risks (risk reduction). It is widely practiced by organizations to minimize risk in investment decisions and to address operational risks such as those of business disruption, production failure, environmental damage, social impacts, and damage from fire and natural hazards. Risk management is a core issue for sectors such as water supply, energy, and agriculture whose production is directly affected by extremes of weather and climate.

Risk assessment: A methodology to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods, and the environment on which they depend.

Risk transfer: The process of formally or informally shifting the financial consequences of particular risks from one party to another whereby a household, community, enterprise, or state authority will obtain resources from the other party after a disaster occurs in exchange for ongoing or compensatory social or financial benefits provided to that other party.

Vulnerability: The characteristics and circumstances of a community, system, or asset that make it susceptible to the damaging effects of a hazard.

> *Comment:* There are many aspects of vulnerability, arising from various physical, social, economic, and environmental factors. Examples may include poor design and construction of buildings, inadequate protection of assets, lack of public information and awareness, limited official recognition of risks and preparedness measures, and disregard for wise environmental management. Vulnerability varies significantly within a community and over time. This definition identifies vulnerability as a characteristic of the element of interest (community, system, or asset) which is independent of its exposure. However, in common use the word is often used more broadly to include the element's exposure.

Annex 2. Photo Gallery[29]

Environment chapter photos 1-23

Photo 1: Aerial view of South Island showing the differing impacts of Tropical Cyclone Fantala on natural beach-dune systems contrasting with its highly devastating effects on coconut groves.

Photo 2: Cutting of scarps in the beach crest by the cyclonic waves, ocean coast of North Island

[29] Photo credits. Photos 1 to 23. PDNA

Photo 3: Shoreline retreat causing *Casuarina equisetifolia* tree fall on the village beach, North Island

Photo 4: Sand loss exposing the roots of trees that had been destroyed by past cyclones, village area, North Island

Photo 5: Formation of a new beach crest by the cyclonic waves, ocean coast of South Island

Photo 6: Coral debris deposits on the upper beach, Goëlettes Island (Note the blackish color of old deposits contrasting with the whitish color of the deposits brought by Tropical Cyclone Fantala's waves

Photo 7: Tropical Cyclone Fantala's deposits, composed of both smooth coral debris that had been broken by previous intense events and of fresh living corals broken by the cyclone's waves

Photo 8: Damages caused by the cyclonic wind to the coastal shrubs along the airstrip, North Island

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Photo 9: Uprooting of coastal shrubs caused by the erosional impacts of the cyclonic waves on the beach crest, ocean coast of North Island

Photo 10: Limited damage caused to coastal shrubs on the sheltered lagoon coast of Goëlettes Island

Photo 11: Increase in the elevation of the beach crest due to sand trapping by coastal shrubs, ocean coast of North Island

Photo 12: Trapping of wind-blown sand by coastal shrubs, ocean coast of South Island

Photo 13: Trapping of coral debris by coastal shrubs on the ocean coast of South Island

Photo 14: Undamaged *Scaevola taccada* bushes, South Island sand dunes

Photo 15: Wind- and salt-burnt shrubs, South Island sand dunes

Photo 16: Complete destruction of the coconut palm grove, northern part of South Island

Photo 17: Standing coconut palm trees on the southern part of South Island

Photo 18. Limited damage to grassland habitats, Goëlettes Island

Photo 19. Extensive sand and coral debris accumulation caused by the cyclonic waves in open grassland areas, Goëlettes Island

Photo 20. Contrasting impacts of the cyclonic wind on *Pemphis acidula* shrubs, southern swamp, South Island

Photos 21. High exposure of Farquhar's airstrip to cyclonic waves at its northern end

Photo 22. High exposure of Farquhar's airstrip to cyclonic waves at its southern end

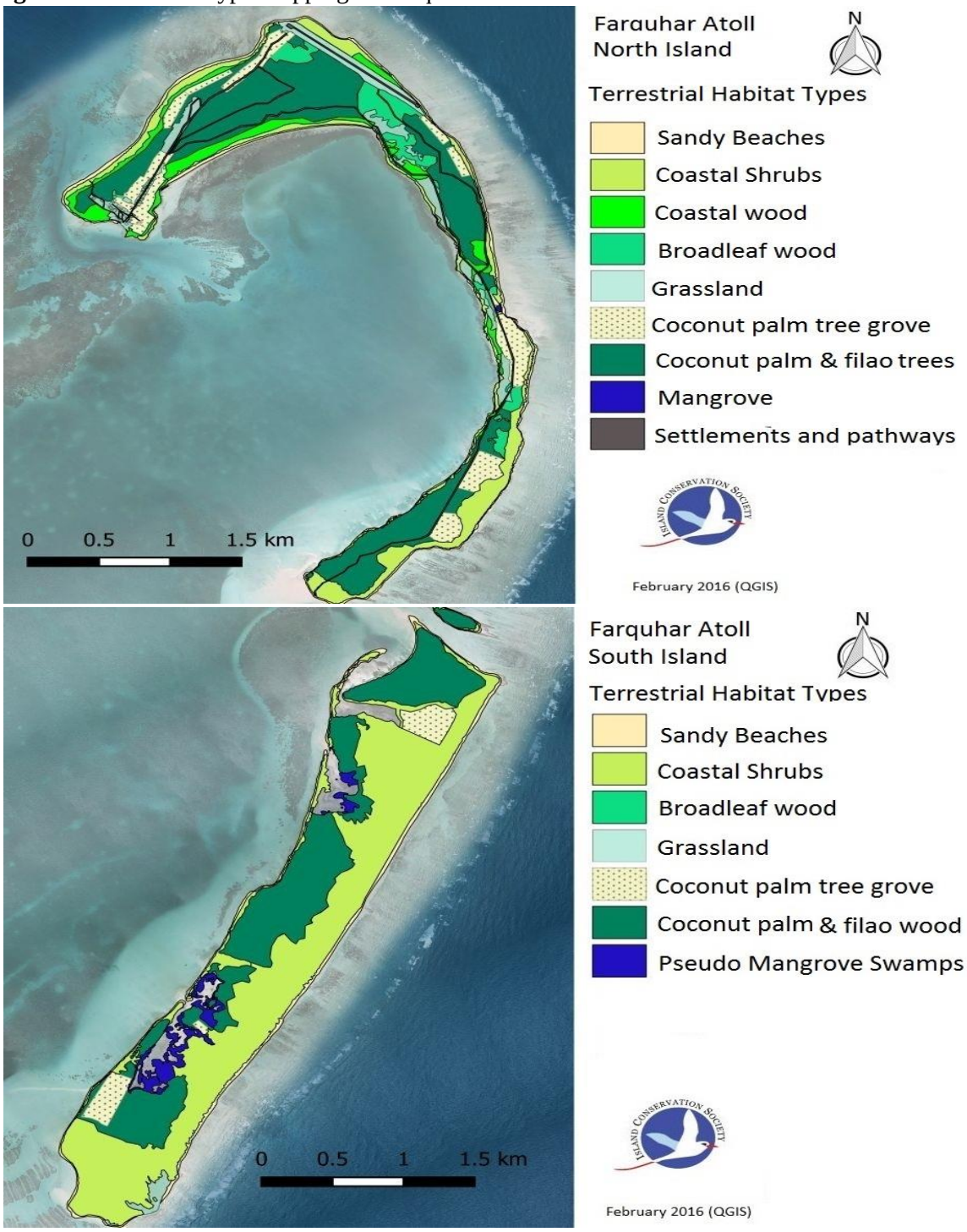
Photo 23. Extended deposition of sand and coral debris in the axis of the airstrip

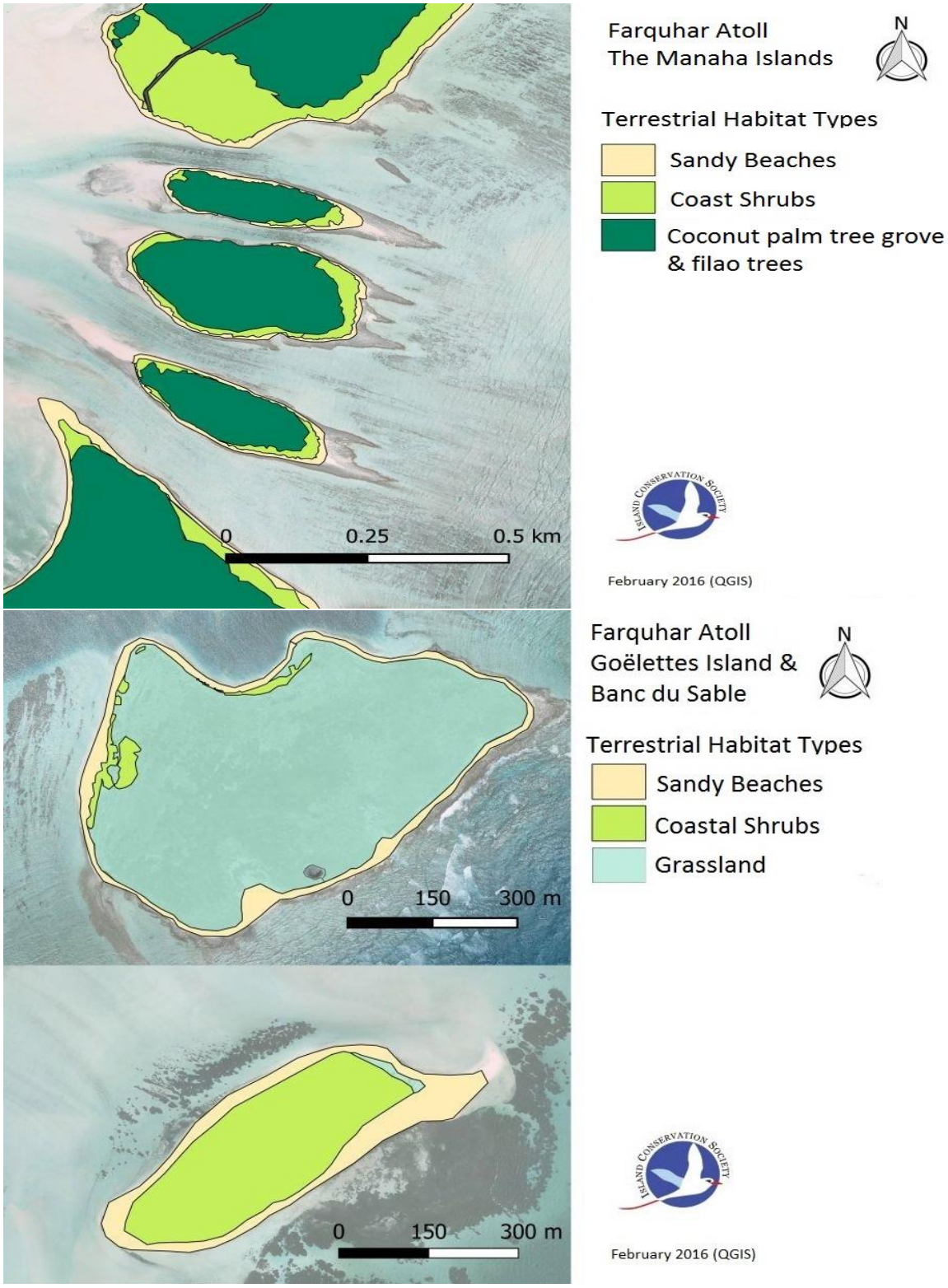
Damages to infrastructure, inputs and coconut palm tree groves[30]

[30] Photo credits. GoS

Annex 3. Habitat mapping on Farquhar Atoll

Figure A3.1 Habitat Type Mapping on Farquhar Atoll





Source: ICS-QGIS 2016

Habitats	Area (Ha)
1. Sandy Beach	18,70
2. Beach crest & sand dune covered by native shrubs	55,69
3. Mixed vegetation (shrubs, forest, grass)	112,59
4. Coconut (including mixed forest of *Casuarina* & Coconut trees)	191,79
5. Pseudo mangrove swamp (edged by *Pemphis acidula*)	0,01
TOTAL	**378,78**

Habitats	Area (Ha)	Manahas North	Manahas Central	Manahas South
1. Sandy Beach	17,90	0,57	0,64	0,65
2. Beach crest & sand dune covered by native shrubs	207,33	0,26	1,10	0,52
3. Mixed vegetation (shrubs, forest, grass)	4,04	0,00	0,00	0,00
4. Coconut (including mixed forest of *Casuarina* & Coconut trees)	149,50	2,02	5,80	2,83
5. Pseudo mangrove swamp (edged by *Pemphis acidula*)	15,30	0,00	0,00	0,00
TOTAL	**394,07**	**2,85**	**7,54**	**4,00**

Habitats (area in Ha)	Goëlettes	Bancs de Sable	Déposés	Milieu	Lapin
1. Sandy Beach	3,70	3,13	0,22	0,00	0,01
2. Beach crest & sand dune covered by native shrubs	0,85	7,81	0,18	0,12	0,28
3. Mixed vegetation (shrubs, forest, grass)	27,18	0,13	0,28	0,27	0,21
4. Coconut (including mixed forest of *Casuarina* & Coconut trees)	0,00	0,00	0,00	0,00	0,00
5. Pseudo mangrove swamp (edged by *Pemphis acidula*)	0,00	0,00	0,00	0,00	0,00
TOTAL	**31,74**	**11,07**	**0,68**	**0,39**	**0,50**

(Source: ICS 2016)

The categories of habitats considered are: *sandy beaches*, *coastal shrubs* covering *beach crests and sand dunes*; *mixed vegetation* including coastal forest, grassland, broadleaf wood and gardens; *coconut palm groves* including coconut palm tree groves & coconut palm/filao tree; and *mangroves* (on North Island only) and *pseudo-mangrove swamps* (see table A3.1).

Table A3.1 Habitat Types. Total Area (and Percent) coverage by habitat type on Farquhar Atoll's islands.

Habitat type	Total Area (Ha)	North Island		South Island		Manaha Islands					
						North		Center		South	
		Area (Ha)	% cover	Area (Ha)	% cover	Area (Ha)	% cover	Area (Ha)	% cover	Area (Ha)	% cover
Pseudo-mangrove	**15.3**	>1	>1	15	4	0	0	0	0	0	0
Coconut grove (including mixed Casuarina trees)	**351.9**	192	51	150	38	2	71	6	77	3	71
Mixed vegetation (shrubs, forest, grass)	**144.7**	113	30	4	1	0	0	0	0	0	0
Coastal shrubs	**274.1**	56	15	207	53	>1	9	1	15	>1	13
Sandy Beach	**45.5**	19	5	18	5	>1	20	>1	8	>1	16
	831.6	379		394		3		8		4	

Habitat type	Total Area (%)	Goelettes		Bancs de Sable		Deposes		Milieu		Lapin	
		Area (Ha)	% cover	Area (Ha)	% cover	Area (Ha)	% cover	Area (Ha)	% cover	Area (Ha)	% cover
Pseudo-mangrove	1.8	0	0	0	0	0	0	0	0	0	0
Coconut grove (including mixed Casuarina trees)	42.3	0	0	0	0	0	0	0	0	0	0
Mixed vegetation (shrubs, forest, grass)	17.4	27	86	>1	1	>1	41	>1	69	>1	42
Coastal shrubs	33.0	>1	3	8	71	>1	26	>1	31	>1	56
Sandy Beach	5.5	4	12	3	28	>1	32	0	0	>1	2
		32		11		>1		>1		>1	

Annex 4. Impacts of Tropical Cyclone Fantala on the Atoll's fauna

Impacts on seabirds[31]

Red-footed Booby (*Sula sula*)

This species is likely to be the most heavily impacted of all seabirds. Most of the breeding habitat it was using has been destroyed and Tropical Cyclone Fantala hit at the height of the breeding season when there were many birds with nests containing eggs or chicks. All nests were destroyed and most likely, eggs were destroyed and chicks died. On 13 May, approximately 700 adults were observed in trees and bushes on the lagoon side of South Island. There were a few (less than 10) immature birds. It is not known how many adults died, but only one corpse was observed on South Island (but many could have blown away). There was no sign of any attempt to rebuild nests on 13 May and indeed available sites are very few. Birds favor taller vegetation where available, and some were nesting on filao (*Casuarina equisetifolia*) though this is introduced. These birds also nest in low shrubs including *Pemphis acidula*, which exists on South Island. The number of adult birds has been reduced, but possibly not by a large percentage. It remains to be seen how successfully these birds would adapt to the available nesting sites.

Sooty Tern (*Onychoprion fuscatus*)

There has been no impact so far. Small numbers (a few dozen) had begun to arrive before Tropical Cyclone Fantala and in advance of the breeding season but had not begun to nest. Observations on Goëlettes on 13 May indicated many thousands of birds had arrived and begun prospecting nesting sites. It is anticipated that all being well, breeding will commence soon.

Roseate Tern (*Sterna dougallii*)

There is no impact as far as is known. No birds had arrived before Tropical Cyclone Fantala. Only one bird was observed on 13 May, but numbers are in any case very low and there was only a short time available to search. It is expected that more birds will arrive soon to breed.

Black-naped Tern (*Sterna sumatrana*)

There is likely to have been some impact, but limited. This species had just begun to breed when Tropical Cyclone Fantala struck. This species is relatively sedentary compared to other seabirds, feeding inshore and remaining at islands and atolls year-round. Sixteen birds were observed on the beach at Goëlettes. There may have been some impact but as a ground nester, its breeding habitat is not impacted.

Lesser Noddy (*Anous tenuirostris*)

This species colonized Goëlettes in recent years. It could have been impacted, but perhaps not very much. The area of Tournefortia (soldierbrush) on Goëlettes Island where this species breeds has been greatly reduced in height and density but plants have survived and will recover. In April 2016, 32 nests were observed which have been destroyed by the cyclone. A few individuals were observed including one that had built a new nest at a lower height.

Brown Noddy (*Anous stolidus*)

There is likely to have been some impact but limited. Smaller numbers were observed on 13 May than one would normally expect to be present at Farquhar. On Goëlettes, it nests on the ground or in shrubs. It is unlikely to be heavily impacted.

Fairy Tern (*Gygis alba*)

There may have been some impact but limited. This is a tree-nesting species but lays on bare horizontal branches. There are plenty of suitable nesting sites. Numbers appeared to be fairly normal on 13 May. One egg was observed on North Island.

[31] Based on personal communications and technical reports provided by ICS scientists Aurelié Duhe and Adrian Skerrett.

Greater Crested Tern (*Sterna bergii*)
The nearest breeding site is Bancs Providence where birds will have fledged very recently. Small numbers were observed near the southern tip of South Island, including several juveniles still dependent upon parents. There is no known impact though some losses are probable given that Fantala struck when at least some chicks would not have fledged.

White-tailed Tropicbird (*Phaethon lepturus*)
This species does not breed but is an irregular visitor. One bird was observed at South Island. There is no observable impact.

Great Frigatebird (*Fregata minor*)
Aldabra is the nearest breeding site. Farquhar is a roosting site. Small numbers were observed. Apart from the loss of roosting trees which are not vital to the species, there is probably no impact.

Seabirds were found on known key breeding sites (particularly, Sooty Terns, *Onychoprion fuscatus*, on Goëlettes; and Red Footed Boobies, *Sula*, on South Island), indicating that Important Bird Areas have withstood the passing of Tropical Cyclone Fantala. The image below shows a large colony of Red footed boobies on South Island

Source: PDNA

Impacts on sea turtles

Where beach erosion and marine inundation occurred, they likely had destructive impacts on turtle nests and they are likely to reduce hatching success. However, undamaged turtle nests and post-cyclone turtle tracks were found on ocean side beaches.

Land invertebrates

Farquhar holds a large population of land and shore crabs, which play a key role in the functioning of the ecosystems and habitats where they live. Shore crabs are expected to be highly impacted by the big waves but the population of the emblematic Coconut crab (*Birgus latro*) the population appeared particularly healthy in some islands, with individuals reaching impressing sizes. The coconut crab, one of the largest land-living arthropods, is protected under the Seychelles Wildlife Act, after having been over exploited throughout the Seychelles Islands; they became locally extinct in the Inner Islands due to both habitat loss and human predation. Aldabra, in the Outer Islands, holds the largest population in the Seychelles.