Kingdom of Tonga

Tonga's Second Nationally Determined Contribution

Submission under the Paris Agreement
December 2020

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Foreword

The Kingdom of Tonga is a Small Island Developing State (SIDS) with a population of just over 100,000 people and as such our total contribution to global greenhouse gas (GHG) emissions is negligible, especially when compared to countries with far larger and more developed economies. Nevertheless, Tonga is prepared to do its part and be an example of what we are asking from the rest of the world in terms of climate action. We are convinced that Tonga's development, need not come at the cost of our own natural environment nor of the livelihoods of future generations and we call for all countries to take the same decisive action to reduce their GHG emissions as a matter of urgency.

Critical to achieving the 1.5 °C goal of the Paris Agreement is the Nationally Determined Contribution (NDC) of each country, which articulates efforts by each country to reduce national emissions and adapt to the impacts of climate change. Tonga is proud to be amongst the countries submitting its Second NDC in 2020, as agreed under the timeline set by the Paris Agreement on Climate Change.

This year, more than ever, it is time for every country to double-down on its climate change commitments and support the full implementation of the Paris Agreement to spare our planet from the worst effects of a future in a changing climate. Despite the COVID-19 pandemic and the impacts it has had on Tonga's people and livelihoods, Tonga has increased its ambition to cut GHG emissions in our Second NDC and has laid out clear means to implement the targets that have been set, as well as providing the information required for clarity, transparency and accountability of our NDC.

Tonga is already and will continue to be heavily impacted by climate change, including changes in temperatures, shifts in rainfall patterns, rise in sea levels, ocean acidification, and the occurrence of tropical cyclones. There is no doubt that climate change is already affecting Tonga's development, the livelihood of its people and the possible futures for our nation. While Tonga will continue to invest large portions of its public finance and service capacity in the ambitious quest to achieve our climate mitigation and resilience objectives, achieving the targets set out in Tonga's Second NDC will require considerable support for financing, capacity and technology investment from external sources. Tonga will continue to do its part while counting on the support of all nations and our partners around the world.

As the Minister of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications (MEIDECC), it is indeed an honour and a privilege to submit Tonga's Second Nationally Determined Contribution.

HONOURABLE POASI TEI

Minister for Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications **(MEIDECC)**
TONGA

Acknowledgements

The Government of Tonga would like to acknowledge and thank the Regional Pacific NDC Hub and the New Zealand Ministry of Foreign Affairs and Trade (NZ MFAT) for their kind and generous support to review and enhance Tonga's Second NDC. Thanks, are also extended to the governments of Germany, the United Kingdom, New Zealand and Australia for their funding of the Regional Pacific NDC Hub and to the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH , the Pacific Community (SPC), the Secretariat of the Pacific Regional Environment Programme (SPREP) and the Global Green Growth Institute (GGGI) as the implementing partners of the Hub.

The development of Tonga's Second NDC has been led by the Department of Climate Change (DCC) of the Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications (MEIDECC) with technical assistance provided by GGGI. Notable contributions were also made by the members of the Joint National Action Plan on Climate Change and Disaster Risk Management (JNAP) Technical Team and by a broad group of stakeholders who attended the national NDC workshops and consultations. Kind contributions were also made by ClimateWorks Australia (CWA) and Relative Creative (Australia).

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Table of Contents

List of Tables

Acronyms and Abbreviations

°C	Degree Celcius
Ω	Aragonite saturation
ADB	Asian Development Bank
AFOLU	Agriculture, Forestry and Other Land Use
CH_4	Methane
cm	centimetres
CMA	Conference of the Parties serving as the meeting of the Parties to the Paris Agreement
CO_2	Carbon dioxide
CO_{2e}	Carbon dioxide equivalent
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CWA	ClimateWorks Australia
DCC	Department of Climate Change
ENSO	El Niño Southern Oscillation
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
Gg	Gigagrams
GGGI	Global Green Growth Institute
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GoT	Government of Tonga
GNI	Gross National Income
HDI	Human Development Index
ICTU	Information to facilitate clarity, transparency and understanding
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
JNAP	Joint National Action Plan on Climate Change Adaptation & Disaster Risk Management
JNAP 2	Joint National Action Plan 2 on Climate Change Adaptation & Disaster Risk Management, 2018-2028
km^2	kilometres square
LT-LEDS	Long-Term Low Emission Development Strategy
m	metres
MAFF	Ministry of Agriculture, Food and Forests

MEIDECC	Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications
NZ MFAT	New Zealand Ministry of Foreign Affairs and Trade
mm	millimetres
MPAs	Marine Protected Areas
N_2O	Nitrous oxide
NCDs	Non-communicable diseases
NDC	Nationally Determined Contribution
NGHGI	National Greenhouse Gas Inventories
NGOs	Non-Governmental Organizations
PACC	Pacific Adaptation to Climate Change
ppm	Parts per million
SF_6	Sulphur hexafluoride
SIDS	Small Island Developing State
SMAs	Special Management Areas
SPC	The Pacific Community
SPREP	The Secretariat of the Pacific Regional Environment Programme
TNC	Third National Communication on Climate Change
TEEMP	Tonga Energy Efficiency Master Plan
TERM	Tonga Energy Road Map
TSDF II	Tonga Strategic Development Framework 2015-2025
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization

Key Messages

The Kingdom of Tonga (Tonga) is one of the most vulnerable countries in the world to climate change due to its geographic location, status as a SIDS, and the importance of natural resources to its main economic sectors of fisheries, agriculture and tourism. The World Risk Report 2017 has ranked Tonga as the second most at-risk country in the world for natural hazards, including tropical cyclones and flooding, as well as sea-level rise. Although Tonga makes a negligible contribution to global GHG emissions, there is no doubt that climate change is already affecting Tonga's development and the livelihood of its people and future.

The impact of climate change-induced phenomena such as sea-level rise, ocean acidification, temperature rise and increased intensity of tropical cyclones continue to pose a threat to the people of Tonga, its society, livelihoods, and its natural environment. Irreversible loss and damage from extreme weather events and coastal erosions are putting the Government's poverty alleviation commitments and national development objectives at risk, and this risk is now compounded by the impacts of the COVID-19 pandemic.

According to Tonga's Third National Communication on Climate Change (TNC) to the United Nation Framework Convention Climate Change (UNFCCC), Tonga emitted a total of 310.4 Gg of CO_2-equivalent in 2006, with the Energy sector accounting for 39%, Agriculture, forestry and other land use (AFOLU) accounting for 61%, and Waste accounting for 0.3% of total GHG emissions. Taking into account its negligible emissions and limited resources, as well as the ongoing disruption and uncertainty brought about by the COVID-19 pandemic, Tonga's Second NDC is nevertheless ambitious and reflects the urgency of the Paris Agreement. Tonga's targets for mitigation are as follows:

- **Energy**: 13% (16 Gg) reduction in GHG emissions by 2030 compared to 2006 through a transition to 70% renewable electricity as well as energy efficiency measures.
- **AFOLU**: establishment of a forest inventory as prerequisite to identify a GHG emission target for Tonga's Third NDC in 2025, and planting one million trees by 2023.
- **Waste**: expansion of the formal waste collection system as prerequisite to identify a GHG emission target for Tonga's Third NDC in 2025.

Adaptation to the adverse impacts of climate change within this NDC focusses on coping with the impacts of an increase in temperature and a rise in sea level. In the context of adaptation, the Government of Tonga has set three targets:

- 30% of land in Tonga utilized for agro-forestry or forestry by 2025,
- Prevent any permanent loss of land to rising sea levels on Tonga's four main islands (i.e. Tongatapu, Ha'apai, Vava'u, and 'Eua),
- Maintenance of the existing stocks of fish and other marine species through a commitment to expand the area covered by Marine Protected Areas (MPAs) and Special Management Areas (SMAs) to 30% of the Tonga's Exclusive Economic Zone (EEZ).

In addition, Tonga is currently developing a Long-Term Low Emission Development Strategy (LT-LEDS) which will be submitted to the UNFCCC in 2021.

1. Introduction

The Government of Tonga (GoT) developed its Intended Nationally Determined Contributions (INDC) and submitted it to the UNFCCC in 2015 and ratified the Paris Agreement on 21st September 2016. When the Paris Agreement came into force on 4th November 2016, Tonga's INDC submitted in 2015 automatically became Tonga's first NDC.

In accordance with decision 1/CP.21, Tonga hereby communicates its 2020 NDC, its Second NDC towards achieving the objective of the UNFCCC as set out in its Article 2, as well as accompanying information to facilitate clarity, transparency, and understanding (ICTU) of its NDC.

The process to develop Tonga's Second NDC included a review of the 2015 INDC, determining the progress made to date towards achieving its targets and identifying recommendations for the formulation of Tonga's Second NDC. The review and the recommendations were informed by data sets, academic studies, policies, strategies, roadmaps and other reports and structured interviews with stakeholders in Tonga. The review and recommendations were discussed, comments were received and integrated, and the findings were validated by the JNAP Technical Team and relevant stakeholders through national workshops. The Second NDC was then prepared building on the recommendations which had been developed and was taken through a final validation process with the JNAP Technical Team and national stakeholders. Tonga's Second NDC was then approved by the Tongan Cabinet.

Tonga's Second NDC is aligned with other international conventions and agreements that Tonga is a party to, including but not limited to the Convention on Biological Diversity and the Montreal Protocol.

2. National Circumstances

2.1 Geographical characteristics

Tonga has four main island groups extended over a south to north axis. Tongatapu (260 km^2) and ‘Eua (87 km^2) in the south, Ha‘apai (109 km^2) in the middle, Vava‘u (121 km^2) in the north and Niuafo‘ou (15 km^2) and Niuatoputapu (71.7 km^2) in the far north. Nuku‘alofa is the capital of Tonga, which is located on the main island of Tongatapu.

2.2 Climate profile

Tonga’s tropical climate reflects its position within the southeast trade wind zone of the South Pacific. Tonga’s climate is tropical throughout the year, with two distinct seasons: namely dry season (May- October) and wet season (November-April). The northern islands of Tonga receive more rainfall than the southern islands.

The driest month is July, and the wettest month is March. During the dry season, the rainfall level received ranges from 100.53 to 145.87 mm/decade while the maximum and minimum temperature varies from 24.7 to 28.1°C/decade and from 14.71 to 22.33°C/decade respectively. The wet season is summertime in Tonga, where the rainfall level varies from 140.85 to 235.73 mm/decade while the maximum and minimum temperature varies from 27.6 to 30.3°C/decade, 20.78 to 24.34°C/decade respectively.

In terms of winds, the southeast trades dominate Tonga. The strength of winds is normally light to moderate with a wind speed of 10 to 16 knots at a distance of 7 to 9 km/hr which is strongly correlated to Tonga’s Southeast trade winds. During dry season, the wind speed is strong in the northern islands of Tonga with little variation in the southern islands. During the wet season, which is summertime in Tonga, tropical cyclones can bring very strong winds at a speed of 22 to more than 65 knots. Tropical cyclones have become more intense than historical records of cyclone occurrences.

The El Niño-Southern Oscillation (ENSO) plays a significant role in Tonga's climatic patterns. ENSO is associated with large year-to-year changes in the risks of drought, flood, tropical cyclones and coral bleaching throughout the region. Water temperature continues to increase by 0.0004°C since 1993. Sea level rise has also increased by 0.007 m/year since 1993.

Climate determines the state of natural resources such as water, forest, biodiversity and other sectors such as agriculture, fisheries, tourism and health. Henceforth, Tonga is highly vulnerable to the impacts of climate change.

2.3 Environmental resources

Natural resources are the primary source of living for the people of Tonga. Despite being highly vulnerable to the impacts of climate change, natural resources are also affected by population growth and environmental degradation. Forest area covers 12.5% of the lands while 43.1% is by agricultural land and 44.4% by settlement areas including roads and other transportation features, barren land/wasteland, and other construction purposes. Captured rainwater and underground aquifers are the main sources of water resources in Tonga. Water is used daily for household usage, industrial, agricultural, and commercial purposes. These uses put pressure on water resources and are likely to be exacerbated by climate change. The quality and quantity of surface water can be affected by human activities and climate change. Warmer temperature is affecting the water cycle resulting on changes of the amount of rainfall during cyclone season. The demands for water in Tonga are very high as all Tongans need water to maintain health and other economic activities.

2.4 Population profile

The total population of Tonga is about 100,651 as of 2016 (Department of Statistics Tonga, 2016) with 50,255 males and 50,396 females. Tongatapu remains the most populated island in the archipelago, followed by Vava'u, Ha'apai, 'Eua, Niuatoputapu then Niuafo'ou. The population decreased by 2.5% from 2011 to 2016 and this is largely due to emigration. The 2016 census data also showed that the populations of the outer islands in Tonga have also decreased with many people migrating to the main islands for education and other purposes.

Tonga has a relatively young population, with a median age of 22 years. More than one third (39%) of the population is aged 15 years and younger, while only 9% are 60 years and older. Tongatapu's population was 74,611, constituting 74% of Tonga's total population. This has increased from 73% in 2011. The urban population of Tongatapu was 23,221 (23% of the total population). The average population density was 155 people per km^2. However, this varies widely across island division and districts, with the population density in Tongatapu being 286 people per km^2 compared to only 17 people per km^2 in the Niuas (Niuatoputapu and Niuafo'ou).

2.5 Socio-economic background

The key economic sectors in Tonga are agriculture, fisheries and tourism. Remittances to Gross Domestic Product (GDP) ratio in 2015 was 26.5%, which shows the importance of remittances in the economy of Tonga, whereas, exports to GDP ratio was 3.3% in the same year[1]. Gross National Income (GNI) per capita is around 4.3 thousand US dollars[2]. Tonga is heavily dependent on imported fossil fuel to meet energy demand. The use of renewable energy is increasing but is dependent on external funding and technical support. According to Asian Development Bank (ADB) (2019) the total unemployment rate is 1.1%, with the female unemployment rate at 2%, higher than the male unemployment rate at 0.5%. About 11% of the population aged 15 and older in rural areas are subsistence workers compared with only 1% of the population aged 15 and older in urban areas. 22.1% of the population in Tonga in 2015 lived under the national poverty line. Tonga's Human Development Index (HDI) in 2015 was 0.721, slightly higher than 0.7, the average of developing countries in the same year.

[1] Tonga Strategic Development Framework 2015-2025
[2] https://data.worldbank.org/indicator/NY.GNP.PCAP.CD?end=2018&locations=TO&start=2005

3. Mitigation

According to Tonga's TNC to the UNFCCC, Tonga emitted a total of 310.4 Gg of CO_2-equivalent in 2006, with the Energy sector accounting for 39%, AFOLU accounting for 61%, and Waste accounting for 0.3% of total GHG emissions. However, uncertainty in land use data, combined with paucity of information regarding assumptions and methodologies used to calculate GHG emissions and carbon sequestration from living biomass undermines the reliability of the estimate for the AFOLU sector.

Tonga wishes to communicate the following targets for reducing GHG emissions (table 1):

1. **Energy**: 13% (16 Gg) reduction in GHG emissions by 2030 compared to 2006,
2. **Industrial processes and product use (IPPU)**: no target,
3. **AFOLU**: non-emission targets of establishing a forest inventory as prerequisite to identify a GHG emission target for Tonga's Third NDC in 2025, and planting one million trees by 2023,
4. **Waste**: non-emission target of expanding the formal waste collection system as prerequisite to identify a GHG emission target Tonga's Third NDC in 2025.

Table 1. Mitigation targets, means and requirements

Target	Means	Requirement
13% (16 Gg) reduction in GHG emissions from energy by 2030 compared to 2006	70% of electricity generated from renewable sources by 2030 through combination of solar, wind and battery storage	• Financing • Upgrade of network infrastructure
	Mandatory vehicle standards and/or incentives through tax, fees, import tariffs	• Alignment of price signals for consumers with targets • Public acceptance
	Adoption of minimum energy performance standards	• Financing • Public acceptance • Enforcement

Identification of a GHG emission target for agriculture, forestry and other land use for Tonga's Third NDC in 2025	Establishment of a forest inventory	• Financing • Technical capacity
Planting one million trees by 2023	To be determined: kind of trees to be planted, land on which trees to be planted, and who will be responsible for planting the trees	• Financing • Technical capacity • Consent from various stakeholders
Identification of a GHG emission target for waste for Tonga's Third NDC in 2025	Expansion of the formal waste collection system	• Financing • Technical capacity

Source: Kingdom of Tonga

3.1 Energy Sector

3.1.1 Targets

Tonga set the target of reducing GHG emissions from the combustion of fossil fuels by 13% (16 Gg) by 2030 compared to 2006. This target is to be achieved by implementing the following measures:

- 70% of electricity generated from renewable sources,
- 2% efficiency gain per year for newly purchased light-duty vehicles,
- Limit growth in grid-connected residential electricity end-use to 1% per year on average for the period 2021-2030 by adopting minimum energy performance standards for appliances, lighting, and electrical equipment.

3.1.2 Overview of measures and requirements to achieve targets

First, generating 70% of electricity from renewable sources requires considerable expansion of generation capacity from solar and wind as well as a substantial increase in battery storage and upgrading of the existing network infrastructure. Technology transfer, capacity building and external financial support will be required to build, operate, and maintain the necessary infrastructure.

Second, achieving a 2% efficiency gain per year for newly purchased light-duty vehicles either requires establishing mandatory vehicle standards and/or

incentives for purchasing more efficient vehicles through taxes, fees, or import tariffs. While price incentives would likely directly affect consumer choices, mandatory standards would profit from being aligned with price signals for consumers in order to be effective. Establishing mandatory standards and price incentives will require public acceptance as both will likely have an impact on vehicle prices and/or vehicle size.

Third, limiting growth in grid-connected residential electricity end-use to 1% per year on average for the period 2021-2030 may be achieved by adopting minimum energy performance standards for appliances, lighting, and electrical equipment. The successful adoption of energy performance standards will require public acceptance as their introduction will likely increase purchasing prices, though possibly reducing electricity costs. For both vehicle and appliance standards and incentives, technology transfer, capacity building and external financial support may be required.

3.2 Industrial processes and product use (IPPU) Sector

Tonga does not have any target to reduce GHG emissions from IPPU for two reasons. First, GHG emissions from IPPU represent a fraction of Tonga's total GHG emissions given the absence of mineral, chemical, metal, electronics, and other manufacturing industries as well as the limited use of lubricants, paraffin waxes and solvents. Second, the paucity of data on GHG emissions from IPPU prevents the establishment of a verifiable target.

3.3 Agriculture, forestry and other land use (AFOLU) Sector

3.3.1 Targets

Tonga set two non-emission targets for AFOLU:

- establishing a forest inventory by 2025
- planting one million trees by 2023.

3.3.2 Overview of measures and requirements to achieve targets

First, while not reducing GHG emissions, the establishment of forest inventory will improve clarity and transparency for the AFOLU sector, providing a basis for the calculation of GHG emissions and carbon sequestration from forests and other woody biomass. Such an inventory will serve as the foundation for quantifying GHG emissions from the sector and identifying a GHG emission

target for Tonga's Third NDC in 2025. Currently, the paucity of reliable data leads to significant uncertainty in any attempt to quantify GHG emissions and carbon sequestration from forests and other woody biomass.[3] The establishment of such a forest inventory requires financing and the development of the necessary technical capacity within the administration to maintain the inventory.

Second, the successful achievement of planting one million trees will reduce GHG emissions. However, it is not possible to quantify this target in terms of GHG emission reductions, as the volume of reductions will depend on the kind and the age of trees to be planted. Successfully planting one million trees will require technical expertise, financial support, and consent from various stakeholders in order to determine what kind of trees will be planted, the land on which the trees will be planted, and who will be responsible for planting the trees.

3.4 Waste Sector

3.3.1 Targets

Tonga set a non-emission target for the Waste sector of expanding the formal waste collection system, including the collection of relevant data on waste amounts and waste composition, as a prerequisite to identify a GHG emissions target for the sector in Tonga's Third NDC in 2025. Expanding the country's formal waste collection system will also allow to improve transparency and clarity regarding assumptions and methodologies used to calculate GHG emissions from the Waste sector.

3.3.2 Overview of measures and requirements to achieve targets

The expansion of the formal waste collection systems requires financing and the development of the necessary technical capacity within the Tonga Waste Authority Limited and the administration to collect the relevant data in order to determine GHG emissions from waste and identify a quantifiable target for reducing GHG emissions.

[3] For example, the Government of Tonga's Third National Communication states that GHG emissions from land use, land use change and forestry (LULUCF) are entirely offset by carbon sequestration from the country's forests, with changes in forest and other woody biomass capturing an estimated 1,437.5 gigagrams of CO_2e and abandonment of managed lands sequestering a further 441.8 gigagrams of CO_2e (Government of Tonga, 2019). However, these estimates could not be confirmed based on the available land use data.

4. Adaptation

4.1 Priorities and objectives for adaptation

In Tonga, adapting to the adverse impacts of climate change focusses on coping with the impacts of an increase in temperature and a rise in sea level. Adapting to the impacts of these two phenomena is regarded as a priority for two reasons. First, there is a high confidence in the available scientific evidence that these two phenomena are a direct manifestation of climate change in Tonga. There is considerable uncertainty about the relationship between climate change and other phenomena, including changes in rainfall patterns, occurrence of droughts, and occurrence of tropical cyclones. Second, there are feasible measures available to respond to the impact of increasing temperatures and rising sea levels on a national scale. There are no effective measures to respond to other phenomena, such as ocean acidification, on a national scale. For more information, please refer to *Annex A2. Impacts of climate change on Tonga*.

4.2 Overview of targets, measures and requirements

In the context of adaptation, the GoT identified three targets:

- 30% of land in Tonga utilized for agro-forestry or forestry by 2025,
- Prevent any permanent loss of land to rising sea levels on Tonga's four main islands (i.e. Tongatapu, Ha'apai, Vava'u, and 'Eua),
- Maintenance of the existing stocks of fish and other marine species.

Table 2. Adaptation targets, means and requirements

Target	Means	Requirement
30% of land in Tonga utilized for agro-forestry or forestry by 2025	Planting of 1 million trees by 2023	• Technical expertise • Financial support • Consensus on the kind of trees to be planted, the land on which the trees are to be planted, and responsibility for planting the trees
Prevent any permanent loss of land to rising sea levels on Tonga's four main islands	Expansion of MPAs and SMAs to 30% of Tonga's EEZ	• Consensus on definition of MPAs and SMAs • Strengthened enforcement
Maintenance of the existing stocks of fish and other marine species		

Source: Kingdom of Tonga

These targets were derived from the 20 targets identified in the Joint National Action Plan 2 on Climate Change and Disaster Risk Management, 2018-2028 (JNAP 2). However, for the purpose of the Second NDC, three targets have been selected as being closely related to the priorities of coping with increasing temperatures and rising sea levels. In addition, for the purpose of the Second NDC, the selected targets were defined more closely and formulated as quantifiable targets in order to be able to evaluate progress:

- The target of 30% of land being utilized for agro-forestry or forestry has been amended by a target year.
- The target of preventing any permanent land loss to rising sea levels has been derived from the JNAP 2 target of resilient coastal development, infrastructures, and integrated coastal ecosystems management.
- The target of maintaining Tonga's stocks of fish and other marine species has been derived from the JNAP 2 target of resilient fisheries and marine and coastal ecosystems.

The target of 30% of land in Tonga being utilized for agro-forestry or forestry is envisioned to be achieved by planting of 1 million trees by 2023, among others. Successfully planting 1 million trees will require technical expertise, financial support, and consent from various stakeholders in order to determine what kind of trees will be planted, the land on which the trees will be planted, and who will be responsible for planting the trees.

The expansion of Marine Protected Areas (MPAs) and Special Management Areas (SMAs) is regarded as an important means to achieve the two targets of preventing any permanent loss of land to rising sea levels on Tonga's four main islands and maintaining existing stocks of fish and other marine species. In that context, the GoT aims to expand the areas covered by MPAs and SMAs to 30% of Tonga's EEZ. In order to be effective, the expansion of MPAs will require a clear definition of MPAs — including if and how they differ from SMAs — as well as strengthened enforcement.

5. Planning Process

5.1 Information on the process to prepare the NDC

The Tonga Strategic Development Framework 2015-2025 (TSDF II) is the overarching national planning document and the principles of the TSDF II have informed the development of Tonga's Second NDC. There are a number of key sectoral policies and plans which have also informed Tonga's Second NDC. These include the Tonga Energy Road Map (TERM), the Tonga Energy Efficiency Master Plan (TEEMP), the National Forestry Policy and the JNAP 2.

The Department of Climate Change(DCC) has led the development of Tonga's Second NDC. DCC reviewed the progress made to date towards achieving the targets identified in the INDC and identified means of how to enhance Tonga's Second NDC. As part of this process, DCC took a coordinating role in gathering input from stakeholders, both for evaluating progress on the INDC and designing Tonga's Second NDC. The review of progress and the development of recommendations for the Second NDC were informed by data sets, academic studies, policies, strategies, roadmaps and other reports and structured interviews with stakeholders in Tonga, including government and non-government organisations (NGOs). *Further details of the review and recommendations process are available in Annex 3 of this NDC in the "Tonga Nationally Determined Contributions Review Report".*

The review and recommendations were discussed, comments were received and integrated, and the findings were validated by the Tonga JNAP Technical Team and relevant stakeholders through national workshops. These meetings were attended by stakeholders from government, private sector and NGOs with approximately 25 women and 20 men taking part in the workshops. Tonga's Second NDC was then prepared building on the recommendations which had been developed and went through a final validation process with the JNAP Technical Team and national stakeholders. Once Tonga's Second NDC contents had been agreed across ministries, the NDC was submitted to and approved by Cabinet.

5.2 Information on implementation plans

Tonga is currently developing a LT-LEDS which will be submitted to the UNFCCC in 2021. Tonga's Second NDC is aligned with the upcoming LT-LEDS and stakeholder dialogue for the development of the LT-LEDS has fed into the development of the Second NDC. The GoT also intends to develop a NDC Roadmap and Investment Plan in 2021.

6. Fairness and Ambition

Tonga is a SIDS and its GHG emissions are negligible on a global scale. Due to its geography and economy, Tonga is highly affected by the adverse impact of climate change. Tonga is classified as one of the most at-risk countries in the world in terms of its exposure to the unfolding effects of climate change. The ongoing need for Tonga to invest large portions of its public finance and service capacity in the ambitious quest to achieve our climate resilience objectives is a consequence of the emissions of other large countries over many generations as they developed and became wealthy. Achieving the targets set out in Tonga's Second NDC will require considerable support for financing, capacity and technology investment. Accounting for these circumstances, Tonga considers its Second NDC as fair and ambitious.

Annex

A1. Information to facilitate clarity, transparency and understanding (ICTU) of Tonga's Second NDC

1. Quantifiable information on the reference point (including, as appropriate, a base year)	
(a) Reference year(s), base year(s), reference period(s) or other starting point(s);	• Base year for GHG emission target: 2006 • Base year for planting one million trees: 2020
(b) Quantifiable information on the reference indicators, their values in the reference year(s), base year(s), reference period(s) or other starting point(s), and, as applicable, in the target year;	Total GHG emissions from Energy sector in 2006 was 120.4 gigagrams (Gg)
(c) For strategies, plans and actions referred to in Article 4, paragraph 6, of the Paris Agreement, or polices and measures as components of nationally determined contributions where paragraph 1(b) above is not applicable, Parties to provide other relevant information;	Relevant strategies, plans and actions include: • Long-term low emission development strategy (LT-LEDS) • Tonga Energy Road Map (TERM) • Tonga Energy Efficiency Master Plan (TEEMP) • Joint National Adaptation Plan 2 on Climate Change and Disaster Management, 2018-2028 (JNAP)
(d) Target relative to the reference indicator, expressed numerically, for example in percentage or amount of reduction;	13% (16 Gg) reduction in GHG emissions by 2030 compared to 2006
(e) Information on sources of data used in quantifying the reference point(s);	GoT's Third National Communication on Climate Change

(f) Information on the circumstances under which the Party may update the values of the reference indicators.	GHG emissions from Energy sector in 2006 may be updated and recalculated as a result of methodological improvements. Information on updates made will be included in the GoT's TNC to the UNFCCC.
2. Time frames and/or periods for implementation	
(a) Time frame and/or period for implementation, including start and end date, consistent with any further relevant decision adopted by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA);	From 1st January 2021 to 31st December 2030
(b) Whether it is a single-year or multi-year target, as applicable.	Single year target
3. Scope and coverage	
(a) General description of the target;	GHG emission reduction target: • Sector-specific target of reducing GHG emissions from the combustion of fossil fuels by 13% (16 Gg) by 2025 compared to 2006 Non-emission targets: • Identification of a GHG emission target for AFOLU sector by 2025 • Planting 1 million trees by 2023 • Identification of a GHG emission target for the Waste sector by 2025
(b) Sectors, gases, categories and pools covered by the nationally determined contribution, including, as applicable, consistent with Intergovernmental Panel on Climate Change (IPCC) guidelines;	Sectors: • Energy Gases: • Carbon dioxide (CO_2), • Methane (CH_4), • Nitrous oxide (N_2O),

	• Carbon monoxide (CO) • Sulphur dioxide (SO_2) • Non-Volatile organic compound (NMVOC) • Nitrogen Oxide (NOx)
(c) How the Party has taken into consideration paragraphs 31 (c) and (d) of decision 1/CP.21;	Tonga aimed to include all categories of anthropogenic emissions or removals in its Second NDC. However, targets for GHG emission reductions could only be developed for the Energy sector because: • IPPU sector: There is a paucity of data for the IPPU sector, preventing the inclusion of the sector. In addition, GHG emissions from IPPU represent a fraction of Tonga's total GHG emissions given the absence of mineral, chemical, metal, electronics and other manufacturing industries as well as the limited use of lubricants, paraffin waxes and solvents. Therefore, omission of the sector has a negligible impact on Tonga's Second NDC. • AFOLU sector: Paucity of reliable data leads to significant uncertainty in any attempt to quantify GHG emissions and carbon sequestration from forests and other woody biomass. For example, the Government of Tonga's TNC states that GHG emissions from LULUCF are entirely offset by carbon sequestration from the country's forests, with changes in forest and other woody biomass capturing an estimated 1,437.5 Gg of CO_2e and abandonment of managed lands sequestering a further 441.8 Gg of CO_2e (Government of Tonga 2019). However, these estimates could not be confirmed based on the available land-use data. Therefore, the AFOLU sector is not considered as part of Tonga's Second NDC. However, Tonga is striving to include anthropogenic emissions or

	removals from AFOLU sector in Tonga's Third NDC in 2025. • Waste: Paucity of relevant data on waste amounts and waste composition prevented considering GHG emissions from the Waste sector as part of Tonga's Second NDC. However, Tonga is striving to include anthropogenic emissions from waste in Tonga's Third NDC in 2025.
(d) Mitigation co-benefits resulting from Parties' adaptation actions and/or economic diversification plans, including description of specific projects, measures and initiatives of Parties' adaptation actions and/or economic diversification plans.	Not applicable. Tonga accounts for any mitigation co-benefits from adaptation actions and/or economic diversification as mitigation actions in accordance with the assumptions and methodological approaches indicated in section 5 of this document.
4. Planning Processes	
(a) Information on the planning processes that the Party undertook to prepare its nationally determined contribution and, if available, on the Party's implementation plans, including, as appropriate:	
(i) Domestic institutional arrangements, public participation and engagement with local communities and indigenous peoples, in a gender-responsive manner;	The DCC was responsible for developing Tonga's Second NDC. As part of this process, the DCC took a coordinating role in gathering input from stakeholders, both for evaluating progress on the INDC and designing Tonga's Second NDC. Stakeholders included government officials, technical experts, and representatives of civil society. In addition, the targets and measures put forward in Tonga's Second NDC have been informed by academic studies, policies, strategies, and roadmaps. The contents of the Tonga's Second NDC were agreed across ministries and approved by the cabinet.
(ii) Contextual matters, including, inter alia, as appropriate:	

a. National circumstances, such as geography, climate, economy, sustainable development and poverty eradication;	Tonga is a SIDS consisting of 176 islands. Tonga's economy is characterized by agriculture and fishing, with a high level of subsistence agriculture and dependence on remittances. Both, Tonga's geography and its economic structure make the country susceptible to the adverse impacts of climate change. More information on Tonga's national circumstances is available in its TNC to the UNFCCC.
b. Best practices and experience related to the preparation of the nationally determined contributions;	Tonga regards coordination between and consultation of all relevant stakeholders as a prerequisite to develop its Second NDC and its effective implementation. Tonga also regards consistency with existing policies, strategies, and roadmaps as pertinent for developing its Second NDC and its effective implementation. Tonga recognises the need to strengthen data collection in order to comply with the 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines. Tonga's Second NDC puts forward specific targets to increase clarity and transparency in this area.
c. Other contextual aspirations and priorities acknowledged when joining the Paris Agreement;	Food security: Given the country's geographical and economic characteristics, ensuring food security for its population is a priority for Tonga Social inclusion: Tonga puts a strong emphasis on ensuring the consideration of aspects such as gender, income, age, etc. when developing its Second NDCs.
(b) Specific information applicable to Parties, including regional economic integration organizations and their	Not applicable. Tonga is not part of any joint fulfilment agreement under Article 4, paragraph 2 of the Paris Agreement.

member States, that have reached an agreement to act jointly under Article 4, paragraph 2, of the Paris Agreement, including the Parties that agreed to act jointly and the terms of the agreement, in accordance with Article 4, paragraphs 16–18, of the Paris Agreement;	
(c) How the Party's preparation of its nationally determined contribution has been informed by the outcomes of the global stocktake, in accordance with Article 4, paragraph 9, of the Paris Agreement;	According to Article 14, paragraph 2 of the Paris Agreement, the first global stocktake will take place in 2023. In line with Article 14, paragraph 3 of the Paris Agreement, the outcome of the global stocktake will inform Tonga in updating and enhancing its Second NDC.
(d) Each Party with a nationally determined contribution under Article 4 of the Paris Agreement that consists of adaptation action and/or economic diversification plans resulting in mitigation co-benefits consistent with Article 4, paragraph 7, of the Paris Agreement to submit information on:	
(i) How the economic and social consequences of response measures have been considered in developing the nationally determined contribution;	Not applicable. Tonga accounts for any mitigation co-benefits from adaptation actions and/or economic diversification as mitigation actions in accordance with the assumptions and methodological

(ii) Specific projects, measures and activities to be implemented to contribute to mitigation co-benefits, including information on adaptation plans that also yield mitigation co-benefits, which may cover, but are not limited to, key sectors, such as energy, resources, water resources, coastal resources, human settlements and urban planning, agriculture and forestry; and economic diversification actions, which may cover, but are not limited to, sectors such as manufacturing and industry, energy and mining, transport and communication, construction, tourism, real estate, agriculture and fisheries.	approaches indicated in section 5 of this document.
5. Assumptions and methodological approaches, including those for estimating and accounting for anthropogenic greenhouse gas emissions and, as appropriate, removals:	
(a) Assumptions and methodological approaches used for accounting for anthropogenic greenhouse gas emissions and removals corresponding to the Party's NDC**, consistent with decision 1/CP.21, paragraph 31, and accounting guidance adopted by the CMA;**	For the Energy sector, Tonga reported GHG emissions and determined its GHG emission targets following the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (NGHGI), using the tier 1 approach and applying default emission factors. Tonga strives to report a complete GHG inventory by 2025, following the 2006 IPCC Guidelines for NGHGI, and the 2019 Refinement to the 2006 IPCC Guidelines for NGHGI, using the tier 1 approach and applying default emission factors.

(b) Assumptions and methodological approaches used for accounting for the implementation of policies and measures or strategies in the NDC;	When accounting for the implementation of policies and measures or strategies in the NDC for the Energy sector, Tonga will apply the 2006 IPCC Guidelines for NGHGI, using the tier 1 approach and applying default emission factors. When reporting progress towards the targets set in Tonga's Second NDC, Tonga will strive to apply the 2006 IPCC Guidelines for NGHGI, and the 2019 Refinement to the 2006 IPCC Guidelines for NGHGI, using the tier 1 approach and applying default emission factors.
(c) If applicable, information on how the Party will take into account existing methods and guidance under the Convention to account for anthropogenic emissions and removals, in accordance with Article 4, paragraph 14, of the Paris Agreement, as appropriate;	For the Energy sector, Tonga reported GHG emissions following the 2006 IPCC Guidelines for NGHGI, using the tier 1 approach and applying default emission factors. Tonga strives to report a complete GHG inventory by 2025, following the 2006 IPCC Guidelines for NGHGI, and the 2019 Refinement to the 2006 IPCC Guidelines for NGHGI, using the tier 1 approach and applying default emission factors.
(d) IPCC methodologies and metrics used for estimating anthropogenic greenhouse gas emissions and removals;	For the Energy sector, Tonga reported GHG emissions following the 2006 IPCC Guidelines for NGHGI, using the tier 1 approach and applying default emission factors.
(e) Sector-, category- or activity-specific assumptions, methodologies and approaches consistent with IPCC guidance, as appropriate, including, as applicable:	
(i) Approach to addressing emissions and subsequent removals from natural disturbances on managed lands;	Not applicable as the current GHG inventory does not adequately capture GHG emissions and removals from AFOLU. Tonga strives to report anthropogenic emissions or removals from AFOLU, following the 2006 IPCC Guidelines for NGHGI, and the 2019 Refinement to the 2006
(ii) Approach used to account for emissions and removals	

from harvested wood products;	IPCC Guidelines for NGHGI, using the tier 1 approach and applying default emission factors.
(iii) Approach used to address the effects of age-class structure in forests;	
(f) Other assumptions and methodological approaches used for understanding the nationally determined contribution and, if applicable, estimating corresponding emissions and removals, including:	
(i) How the reference indicators, baseline(s) and/or reference level(s), including, where applicable, sector-, category- or activity-specific reference levels, are constructed, including, for example, key parameters, assumptions, definitions, methodologies, data sources and models used;	Not applicable. For the Energy sector, Tonga reported GHG emissions following the 2006 IPCC Guidelines for NGHGI, using the tier 1 approach and applying default emission factors.
(ii) For Parties with nationally determined contributions that contain non-greenhouse-gas components, information on assumptions and methodological approaches used in relation to those components, as applicable;	Tonga's non-GHG components largely aim at improving clarity and transparency, enabling Tonga to report anthropogenic emissions or removals from AFOLU and Waste, following the 2006 IPCC Guidelines for NGHGI, and the 2019 Refinement to the 2006 IPCC Guidelines for NGHGI, using the tier 1 approach and applying default emission factors. There are no specific assumptions and methodological approaches underpinning these components.
(iii) For climate forcers included in nationally determined contributions not covered by IPCC guidelines, information on how the climate forcers are estimated;	Not applicable. Tonga's Second NDC does not include any climate forcers that are not covered by the IPCC guidelines.
(iv) Further technical information, as necessary;	Not applicable.
(g) The intention to use voluntary cooperation under	Tonga intends to achieve the mitigation objectives under its Second NDC exclusively

Article 6 of the Paris Agreement, if applicable.	through domestic efforts and does not envision any internationally transferred mitigation outcomes.
6. How the Party considers that its nationally determined contribution is fair and ambitious in the light of its national circumstances:	
(a) How the Party considers that its nationally determined contribution is fair and ambitious in the light of its national circumstances;	Tonga is a SIDS and its GHG emissions are negligible on a global scale. Due to its geography and economy, Tonga is highly affected by the adverse impact of climate change. Accounting for these circumstances, Tonga considers its Second NDC as fair and ambitious.
(b) Fairness considerations, including reflecting on equity;	
(c) How the Party has addressed Article 4, paragraph 3, of the Paris Agreement;	The targets set in Tonga's Second NDC represent a progression beyond Tonga's 2015 NDC in that: Tonga's Second NDC, for the first time, sets a clear and transparent target for reducing GHG emissions, and Tonga's Second NDC, for the first time, sets clear and transparent non-emission targets for the AFOLU and Waste sectors.
(d) How the Party has addressed Article 4, paragraph 4, of the Paris Agreement;	The non-GHG emissions targets set in the Tonga's Second NDC aim at establishing the prerequisites for Tonga to develop an economy-wide GHG emission reduction target as part of Tonga's Third NDC in 2025, accounting for anthropogenic emissions or removals from Energy, AFOLU and Waste, following the 2006 IPCC Guidelines for NGHGI, and the 2019 Refinement to the 2006 IPCC Guidelines for NGHGI, using the tier 1 approach and applying default emission factors.
(e) How the Party has addressed Article 4, paragraph 6, of the Paris Agreement.	In alignment with its Tonga's Second NDC, Tonga is preparing a LT-LEDS to be launched in 2021.
7. How the nationally determined contribution contributes towards achieving the objective of the Convention as set out in its Article 2	

(a) How the nationally determined contribution contributes towards achieving the objective of the Convention as set out in its Article 2;	As part of Tonga's Second NDC, Tonga has identified a clear and transparent target to reduce GHG emissions and charted a course towards gradually increasing its ambitions in the future by expanding its target from a sector-specific to an economy-wide target. Tonga has also identified clear targets towards increasing the country's ability to adapt to the adverse impacts of climate change. As part of Tonga's Second NDC, Tonga has also identified where financing will be required to achieve its targets.
(b) How the nationally determined contribution contributes towards Article 2, paragraph 1(a), and Article 4, paragraph 1, of the Paris Agreement.	As part of Tonga's Second NDC, Tonga has identified a clear and transparent target to reduce GHG emissions and charted a course towards gradually increasing its ambitions in the future by expanding its target from a sector-specific to an economy-wide target.

A2. Impacts of climate change on Tonga

For the purpose of clarity and transparency, this section assesses the impact of five different phenomena related to climate change in Tonga: changes in temperatures, shifts in rainfall patterns, a rise in sea levels, ocean acidification, and the occurrence of tropical cyclones. It summarizes what can be regarded as consensus in the existing literature, highlights areas of uncertainty, and indicates areas in need of future research.

Table 3. Overview of phenomena related to climate change in Tonga

Phenomenon	Confidence (direction of change)	Projections in existing literature		Potential Impacts
		PACCSAP 2014	GoT 2019	
Rise in temperatures	Very high	Increase in temperatures by up to 1.0°C by 2030 and up to 1.8-4.1°C by 2090	Increase in surface air temperature by up to 0.7 ± 0.2°C by 2030, 2.6 ± 0.3°C by 2090 (high emissions)	• Decreased yield and quality of crops • Reduced fish catch and degradation of corals • Increase in vector- and waterborne diseases
Increase in rainfall	Low	Little change in annual mean rainfall	Increase of annual mean rainfall by 2 to 3% by 2030 under a high emissions scenario	• Increase in flooding and damage to infrastructure • Decrease in agricultural productivity • Degradation of coral reefs due to pollution of coastal areas by sediments and debris
	High	More extreme rain events	More extreme rain events	

				• Increase in vector- and waterborne diseases
Occurrence of droughts	Low	Decrease slightly in frequency of droughts	Little change is projected in the incidence of droughts	• Decrease in agricultural productivity • Reduced access to drinking water and reduced food security
Rise in sea levels	Very high	Rise in sea levels by 7 to 18 cm by 2030 and 41 to 88 cm by 2090	Rise in mean sea levels by 7 to 27 cm by 2030 and 11 to 51 cm by 2055	• Land loss • Damage to infrastructure and property • Salinization of groundwater • Migration of population • Degradation of coral reefs
Increase in ocean acidification	Very high	Aragonite saturation levels in the ocean will decrease to 3.5 Ω by 2035 and continue to decline after	Continue trend of acidification	• Destruction of coral reefs • Reduced catch of calcifying invertebrates and demersal fish
Decline in frequency but increase in intensity of cyclones	Medium	Decrease in frequency of cyclones of 6 to 35% Increase in mean maximum wind speed of tropical cyclones of	Decrease in number but increase in intensity of cyclones in the southeast Pacific Ocean basin	• Decrease in agricultural productivity with severe damage to perennial tree crops such as coconuts, bananas, and breadfruit

		between 2% and 11%		• Destruction of infrastructure • Damage of coral reefs • Increase in vector- and waterborne diseases

Source: Compiled by GGGI

Rise in temperatures

Under all emission scenarios, temperatures in Tonga are predicted to rise. The Australian Bureau of Meteorology and CSIRO (2014) indicate that temperatures will increase by 1.0°C by 2030 under all emission scenarios, and between 0.2°C and 4.1°C by 2090 depending on the emission scenario. The Government of Tonga's TNC suggests an increase in temperature of up to 0.7°C by 2030 and 2.6°C by 2090. An increase in temperatures has direct repercussions for agriculture, fishery, and human health.

First, impacts from rising temperatures are expected to be particularly pronounced in the Agriculture sector. Agriculture is a crucial sector in Tonga, accounting for approximately 15% of the country's GDP in 2018/19, with a quarter of the country's employed labourers working in agriculture, forestry and fishing (Tonga Statistics Department 2019; Tonga Statistics Department 2018). Furthermore, in 2015, more than 80% of Tonga's population were engaged in agriculture to meet their own food needs or earn cash income through sale, with squash, yam, taro, sweet potato and cassava representing the most common crops (MAFF et al. 2015). Higher temperatures can lead to lower crop yields because levels of photosynthesis decrease at temperatures above 25°C for tropical crops, like sweet potato, cassava, taro, and yams (Hay et al. 2003).

Second, according to Dutra et al. 2018, increase in temperature along with nutrient enrichment and ocean acidification can affect corals' immune response, thus increasing the susceptibility of corals to diseases and affecting their survivability and growth. Higher sea surface temperatures of Tonga's coastal waters have reportedly led to reduced fish catch as a result of widespread coral bleaching (Government of Tonga 2018b).

Third, Tonga, along with most Pacific island countries, face effects of water scarcity, vector-, food- and waterborne diseases (McIver et al. 2016). Increasing

temperatures are known to facilitate the spread of foodborne diseases such as diarrheal disease, ciguatera and salmonella, due to an increase in the concentration of certain pathogens in food along the pathway from preparation and handling to cooking, serving and storing (WHO 2015). In addition, an increase in temperature may exacerbate Tonga's incidences of non-communicable diseases (NCDs) such as obesity and diabetes. As one of the countries with the highest obesity and diabetes rates worldwide — affecting two in five and one in five Tongans respectively — an increase in temperature may contribute to further worsening of public health (WHO 2016). For example, temperature extremes put type-2 diabetes patients at increased risk (Hajat et al. 2017). Similarly, Moellering and Smith (2012) suggest that as air conditioning increases with the rise in temperatures, energy expenditure of the human body decreases which may contribute to rising obesity rates.

Increase in extreme rainfall events

Projections for the impact of climate change on rainfall patterns are subject to considerable uncertainty. While existing projections suggest with high confidence that extreme rain events will occur more frequently, there is low confidence that mean annual rainfall will be affected by climate change (Government of Tonga 2019; Australian Bureau of Meteorology and CSIRO 2014). An increase in extreme rain events can be expected to adversely impact infrastructure, agriculture, and public health in Tonga.

First, an increase in extreme rainfall events threatens to reduce agricultural productivity in Tonga (Government of Tonga 2018b). As a large share of Tonga's population relies on subsistence agriculture, reduced production might threaten food security of many households. Furthermore, lower productivity as a result of an increase in extreme rainfall events will likely affect revenue from agriculture exports which are vital for the Tongan economy (Government of Tonga 2019). In 2019, agriculture products represented almost half of the country's export revenue (National Reserve Bank of Tonga 2019).

Second, Tonga occasionally faces heavy rainfall that causes flooding and prolonged ponding of water, which is associated with health risks such as waterborne and vector diseases, including dengue fever (Fakhruddin 2015). In 2017, the Tongan Ministry of Health has expressed concerns with the increased risk of dengue fever due to heavy rainfall (Tonga Broadcasting Commission 2017). Moreover, in the Pacific, WHO (2015) identified diarrheal illness as the most

significant category of waterborne disease caused by changes in temperature, rainfall and humidity.

Third, while a systematic analysis is prevented by paucity of data, extreme rainfall events are considered to cause considerable damage to infrastructure. Finally, heavy rainfall in combination with insufficient drainage systems increases surface runoff, resulting in the pollution of nearby coastal areas due to sediments and debris washing into these areas (Government of Tonga 2018b).

Occurrence of droughts

Existing projections suggest little change in the incidence of droughts in Tonga due to climate change. However, confidence levels behind these projections are low since the confidence level of changes in mean rainfall change is low. Furthermore, there is no consensus about projected changes in ENSO and their impact on rainfall patterns (Australian Bureau of Meteorology and CSIRO 2014; Government of Tonga 2019). Although droughts might not increase due to climate change, they already pose a threat, particularly to Tonga's agriculture sector and public health. If climate change was to result in more prolonged droughts, their impact would further increase.

First, agricultural droughts — i.e. insufficient soil moisture to meet the needs of a crop — are already occurring regularly in Tonga (Government of Tonga 2019). Such droughts severely affect agriculture productivity in the country, resulting in stunted growth of annual crops such as squash, vegetables, yams, sweet potatoes, root crops, and coconuts (Government of Tonga 2018b; FAO and MAFF 2014).

Second, despite the uncertainty in the projection of droughts in Tonga, droughts already pose health threats to the country's population. For example, prolonged dry periods have caused reduced access to potable water (Fakhruddin 2015). Historically, droughts in 1982 to 1983 and 1997 to 1998 resulted in water shortage, devastating agriculture harvests in those years and causing food shortages (Government of Tonga 2018a). Such threats would be exacerbated in case the frequency or intensity of droughts were to increase as a result of climate change.

Rise in sea levels

Sea levels in Tongan territorial waters are predicted to rise under all emissions scenarios, though projections show considerable differences in the magnitude of that rise, with projections suggesting a 7 to 27 cm rise by 2030 and an increase of 11 to 88 cm by 2090 (Australian Bureau of Meteorology and CSIRO 2014; Government of Tonga 2019). Rising sea levels have a large spectrum of potential impacts, from land loss to salinization of groundwater to degradation of coral reefs and migration, among others.

First, along with many countries in the South Pacific, Tonga has experienced the risk of inundation and flooding as a result of sea-level rise, making low-lying islands inhabitable (Mimura 1999). Additionally, short-duration coastal flooding events can have devastating impacts on coastal infrastructure that further increases risks to populations residing in coastal areas (Aucan 2018). While a systematic analysis is prevented by the paucity of data, more than 80% of Tonga's population resides within a distance of less than 1km from the shore, suggesting a very high vulnerability to rising sea levels (Neil et al. 2019). Sea level rise combined with extreme weather events is likely to contribute to an increase in inundation of low-lying areas. Estimates suggest that flooding and inundation will affect approximately 4 to 14% of the total population of Tongatapu (Rawat et al. 2016). Even under a medium emissions scenario,[4] considerable parts of Tongatapu are projected to be inundated by 2090. In particular, this would affect Nuku'alofa and the northern coasts of Tongatapu (Climate Central 2020). Ultimately, a considerable share of the population may have to relocate closer to the center of the islands.

Second, rise in sea level will cause seawater intrusion in low-lying coastal areas, which can reduce the availability of fresh water as the salinity of groundwater increases (Government of Tonga 2018b). Furthermore, the marginal areas of farmland on the coast are expected to experience higher moisture and increased salinization due to inundation or flooding, reducing their suitability for agriculture (Rawat et al. 2016). Land loss, in addition to saltwater intrusion, is also predicted to reduce the availability of potable water (Fakhruddin 2015).

[4] Medium emissions scenario is based on RCP 4.5 and consistent with the Paris Agreement's target of limiting global warming to 2°C (Climate Central 2020).

Increase in ocean acidification

Higher concentrations of carbon dioxide (CO_2) in the atmosphere causes more CO_2 to be absorbed by the world's oceans. As more CO_2 dissolves in the sea, ocean pH decreases, and aragonite saturation levels fall. This process is commonly referred to as ocean acidification. Coral reefs are highly vulnerable to projected decreases in ocean pH and aragonite saturation levels, as corals and crustaceans use aragonite to build their skeletons. At atmospheric concentrations of CO_2 above 450 ppm, aragonite levels could fall to levels that make it impossible for corals to sustain building their skeletons (Bell et al. 2011).

In Tonga, aragonite saturation levels are predicted to decrease to 3.5 Ω by 2035 and continue to decline further (Australian Bureau of Meteorology and CSIRO 2014, Government of Tonga 2019), threatening corals' reef-building calcification rates and structural integrity, making coral reefs the most vulnerable marine habitat in the tropical Pacific region (Fakhruddin 2015).

In particular, according to Dutra et al. 2018, increase in ocean acidification is expected to impact coral physiology (calcification rates, ability to repair tissues and growth), behaviour (feeding rate), reproduction (early life-stage survival, timing of spawning) as well as weaken calcified structures, and alter coral stress-response mechanisms (Fabricius et al. 2015; Fabricius et al. 2011). In addition, ocean acidification is predicted to pose moderate to high risk to the demersal fish and intertidal invertebrates with shells made of calcium carbonate (Fakhruddin 2015). These combined impacts could potentially have detrimental consequences for fisheries (IPCC 2014; Dutra et al. 2018). With more than 13% of Tongan households engaged in fisheries for both consumption and sale, this would affect a considerable share of the population (Tonga Statistics Department 2018).

Decline in frequency but increase in intensity of tropical cyclones

While the number of tropical cyclones is projected to decrease, their intensity in the Southeast Pacific Ocean basin in Tonga will increase (Government of Tonga 2019). The frequency is predicted to decrease varying from 6 to 35%, while the mean maximum wind speeds are predicted to increase between 2% and 11% (Australian Bureau of Meteorology and CSIRO 2014). However, these projections are made with only moderate confidence. If climate change was to lead to an increase in the intensity of tropical cyclones, it can be expected that the already existing negative impacts on agriculture, coral reefs and fisheries, and public health would be exacerbated.

First, Tonga is regularly affected by tropical cyclones which cause considerable damage to agriculture and related infrastructure. Tropical Cyclones are accompanied by heavy winds, rainfall, and storm surges that devastate crops and trees (FAO 2010). For instance, Tropical Cyclone Gita in 2018 significantly damaged perennial tree crops, such as coconuts, bananas and breadfruit (Government of Tonga 2018b). Tropical Cyclone Harold in 2020 contributed a drop in agricultural export volumes by nearly 30%, with lower exports of taro and cassava (National Reserve Bank of Tonga. 2020). In addition, tropical cyclones contribute to soil erosion and salinization, which lead to loss of soil nutrients in coastal areas and stream catchments, creating unfavourable conditions for crop cultivation (FAO 2010; Government of Tonga 2018b). In addition, past tropical cyclones have caused considerable damage to infrastructures, such as transport infrastructure and buildings. In turn, some of that infrastructure is essential to support the Agriculture sector, like farm buildings and fences (FAO 2010).

Second, tropical cyclones – in combination with heavy rainfall – affect coral reefs, fisheries and related infrastructure (Dutra et al. 2018; FAO 2014). Once damage has been done by tropical cyclones, fish habitats such as coral reefs take years to re-establish and function normally, thus negatively affecting ecosystems that depend on coral reefs (Government of Tonga 2019). Furthermore, tropical cyclones destroy fishing vessels and equipment. For example, Tropical Cyclone Ian in 2014 severely devastated the fisheries sector of Ha'apai, due to damage sustained to fishing boats, outboard motors and an estimated 100% of all fishing gears (FAO 2014). If climate change was to cause an increase in the intensity of tropical cyclones, the damage to coral reefs and fisheries would increase accordingly.

Third, tropical cyclones, along with other extreme weather events, have a direct impact on health, especially from water contamination (WHO 2015). As tropical

cyclones bring heavy rainfall and provoke flooding, water treatment plants tend to be overwhelmed, leading to cross-contamination between sewage and drinking water pipes, sewage overflow, or bypass into local waterways (Semenza and Nichols 2007).

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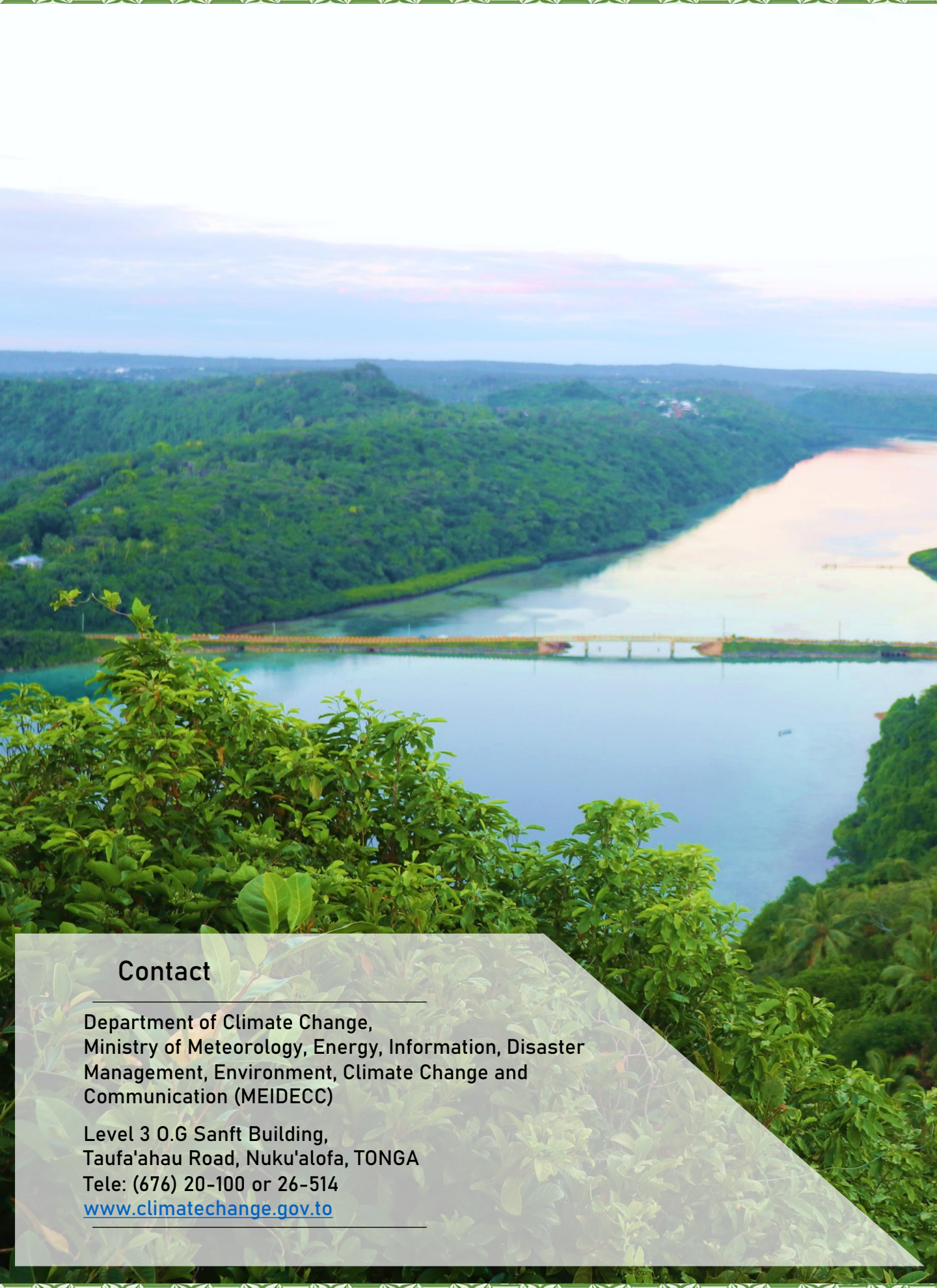
A3. Tonga NDC Review Report

The Tonga NDC Review Report is annexed herewith for information purpose only. It can be accessed on the Department of Climate Change portal.
www.climatechange.gov.to



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