CLIMATE RISK COUNTRY PROFILE

COOK ISLANDS

WORLD BANK GROUP

ADB ASIAN DEVELOPMENT BANK

Cover Photos: © Tim Parkinson, "Sunset at Rarotonga, Cook Islands" November 13, 2006 via Flickr, Creative Commons CC BY-NC-ND 2.0. © Ron Caswell, "Mataora Wreck, Rarotonga" February 7, 2011 via Flickr, Creative Commons CC BY-NCND 2.0.

Graphic Design: Circle Graphics, Reisterstown, MD.

ACKNOWLEDGEMENTS

This profile is part of a series of Climate Risk Country Profiles that are jointly developed by the World Bank Group (WBG) and the Asian Development Bank (ADB). These profiles synthesize the most relevant data and information on climate change, disaster risk reduction, and adaptation actions and policies at the country level. The profile is designed as a quick reference source for development practitioners to better integrate climate resilience in development planning and policy making. This effort is co-led by Veronique Morin (Senior Climate Change Specialist, WBG), Ana E. Bucher (Senior Climate Change Specialist, WBG) and Arghya Sinha Roy (Senior Climate Change Specialist, ADB).

This profile was written by Alex Chapman (Consultant, ADB), William Davies (Consultant, ADB), Ciaran Downey (Consultant), and Emmet Kiberd (Consultant). Technical review of the profiles was undertaken by Robert L. Wilby (Loughborough University). Additional support was provided by MacKenzie Dove (Senior Climate Change Consultant, WBG), Jason Johnston (Operations Analyst, WBG), Yunziyi Lang (Climate Change Analyst, WBG), Adele Casorla-Castillo (Consultant, ADB), and Charles Rodgers (Consultant, ADB). This profile also benefitted from inputs of WBG and ADB regional staff and country teams.

Climate and climate-related information is largely drawn from the Climate Change Knowledge Portal (CCKP), a WBG online platform with available global climate data and analysis based on the current Intergovernmental Panel on Climate Change (IPCC) reports and datasets. The team is grateful for all comments and suggestions received from the sector, regional, and country development specialists, as well as climate research scientists and institutions for their advice and guidance on use of climate related datasets.

CONTENTS

FOREWORD

Climate change is a major risk to good development outcomes, and the World Bank Group is committed to playing an important role in helping countries integrate climate action into their core development agendas. The World Bank Group (WBG) and the Asian Development Bank (ADB) are committed to supporting client countries to invest in and build a low-carbon, climate-resilient future, helping them to be better prepared to adapt to current and future climate impacts.

Both institutions are investing in incorporating and systematically managing climate risks in development operations through their individual corporate commitments.

For the World Bank Group: a key aspect of the World Bank Group's Action Plan on Adaptation and Resilience (2019) is to help countries shift from addressing adaptation as an incremental cost and isolated investment to systematically incorporating climate risks and opportunities at every phase of policy planning, investment design, implementation and evaluation of development outcomes. For all International Development Association and International Bank for Reconstruction and Development operations, climate and disaster risk screening is one of the mandatory corporate climate commitments. This is supported by the World Bank Group's Climate and Disaster Risk Screening Tool which enables all Bank staff to assess short- and long-term climate and disaster risks in operations and national or sectoral planning processes. This screening tool draws up-to-date and relevant information from the World Bank's Climate Change Knowledge Portal, a comprehensive online 'one-stop shop' for global, regional, and country data related to climate change and development.

For the Asian Development Bank (ADB): its Strategy 2030 identified "tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability" as one of its seven operational priorities. Its Climate Change Operational Framework 2017–2030 identified mainstreaming climate considerations into corporate strategies and policies, sector and thematic operational plans, country programming, and project design, implementation, monitoring, and evaluation of climate change considerations as the foremost institutional measure to deliver its commitments under Strategy 2030. ADB's climate risk management framework requires all projects to undergo climate risk screening at the concept stage and full climate risk and adaptation assessments for projects with medium to high risk.

Recognizing the value of consistent, easy-to-use technical resources for our common client countries as well as to support respective internal climate risk assessment and adaptation planning processes, the World Bank Group's Climate Change Group and ADB's Sustainable Development and Climate Change Department have worked together to develop this content. Standardizing and pooling expertise facilitates each institution in conducting initial assessments of climate risks and opportunities across sectors within a country, within institutional portfolios across regions, and acts as a global resource for development practitioners.

For common client countries, these profiles are intended to serve as public goods to facilitate upstream country diagnostics, policy dialogue, and strategic planning by providing comprehensive overviews of trends and projected changes in key climate parameters, sector-specific implications, relevant policies and programs, adaptation priorities and opportunities for further actions.

We hope that this combined effort from our institutions will spur deepening of long-term risk management in our client countries and support further cooperation at the operational level.

Bernice Van Bronkhorst
Global Director
Climate Change Group
The World Bank Group

Preety Bhandari
Chief of Climate Change and Disaster Risk Management Thematic Group
concurrently Director Climate Change and Disaster Risk Management Division
Sustainable Development and Climate Change Department
Asian Development Bank

KEY MESSAGES

- The Cook Islands are experiencing increasing temperatures, with warming trends expected to continue throughout the 21st century. Projected rates of warming are clouded by current models' inability to simulate very localized changes, but warming is expected to be in the range of 0.6°C–2.7°C depending on the 21st century rate of global emissions.
- Natural interannual and interdecadal variability ensures short- and medium-term rainfall changes are difficult to detect and project into the future for small islands. Further research is urgently required to develop models better suited to modelling the future climate of Pacific islands.
- The sea-level near the Cook Islands is projected to increase throughout the 21st century, with models showing a very high confidence in this trend. While most of the Cook Islands have higher elevation than their Pacific neighbors, this still exposes coastal communities to a greater storm-surge threat.
- The country's tourism economy is particularly vulnerable, with tourism infrastructure in the coastal zone exposed to hazards and potential declines in biodiversity, particularly corals, potentially impacting attractiveness to foreign visitors.
- A realignment of the nation's fisheries sector is likely, but with careful and sustainable management the future production outlook is not necessarily negative.
- Potential intensification of the most extreme tropical cyclone events threatens significant damage and loss to Cook Islanders; however, the science underpinning our understanding of future Pacific circulation patterns is weak, and likely trends are not well understood.

COUNTRY OVERVIEW

The Cook Islands are located south of the equator and consists of 15 islands spread across nearly 2 million square kilometers (km^2) of the South Pacific Ocean.[1,2] Its islands are among the world's most remote places. In 2016, the nation had a population of around 17,000 people, the majority of whom live on the main island of Rarotonga. The Cook Islands are in free association with New Zealand which allows for the sharing of some administrative and governance functions. As such, Cook Islanders hold New Zealand citizenship enabling them to migrate more freely than many of their Pacific neighbors. There are more than 50,000 Cook Islanders residing in New Zealand and a further 15,000 in Australia (altogether the Diaspora makes up nearly four times the resident population).[3] Migration, mainly to New Zealand, can be a challenging dynamic for the economic development of the Cook Islands.

1 World Bank (2015). Country Note: The Cook Islands, Disaster Risk Financing and Insurance. URL: http://documents1.worldbank.org/curated/en/405171468244771591/pdf/949800WP0Box380ry0Note0Cook0Islands.pdf

2 The Cook Islands is not a member of the World Bank Group (WBG). It has been a developing member country of the Asian Development Bank (ADB) since 1976.

3 ADB (2012). Economic Recovery Support Program Subprogram 2 (RRP COO 42503-023): Macroeconomic assessment. URL: https://www.adb.org/sites/default/files/linked-documents/42503-023-coo-oth.pdf

The Cook Islands are known for their extraordinary natural beauty, which attracts significant tourism. Tourism accounted for an estimated 70% of GDP in 2018. The success of the industry has led to the Cook Islands' economy to be one of the strongest in the South Pacific, with a GDP per capita of around $16,700 in 2016. Performance on poverty reduction and other social metrics is believed to have been strong, although national data is often lacking (**Table 1**). Nevertheless, the nation faces very significant challenges, particularly in relation to natural hazards and economic vulnerability.

The Cook Islands are located in an area that is highly exposed to tropical cyclones with damaging winds, storm surge, and floods.[4] To put this in perspective, between 1969/70 and 2010/11 an average of "18 cyclones per decade developed within or crossed the Cook Islands Exclusive Economic Zone (EEZ)".[5] The cumulative average annual losses to natural hazards has been estimated at around £5 million, or approximately 2% of GDP.[6] Within this context, the Cook Islands takes climate change extremely seriously. Cook Islands published its Third National Communication to the UNFCCC in 2019,[7] submitted its Nationally Determined Contribution in 2015, and ratified the Paris Climate Agreement in 2016.

Green, Inclusive and Resilient Recovery

The coronavirus disease (COVID-19) pandemic has led to unprecedented adverse social and economic impacts. Further, the pandemic has demonstrated the compounding impacts of adding yet another shock on top of the multiple challenges that vulnerable populations already face in day-to-day life, with the potential to create devastating health, social, economic and environmental crises that can leave a deep, long-lasting mark. However, as governments take urgent action and lay the foundations for their financial, economic, and social recovery, they have a unique opportunity to create economies that are more sustainable, inclusive and resilient. Short and long-term recovery efforts should prioritize investments that boost jobs and economic activity; have positive impacts on human, social and natural capital; protect biodiversity and ecosystems services; boost resilience; and advance the decarbonization of economies.

---

4 ADB (2016). Proposed Policy Based Loan Cook Islands: Disaster Resilience Program, Project Number: 50212-001. URL: https://www.adb.org/projects/50212-001/main

5 Pacific Catastrophe Risk Assessment and Financing Initiative (2011). Country Risk Profile: Cook Islands. URL: https://www.preventionweb.net/files/27076_cookislandspicrafi.pdf

6 Veve, E., and Olsson, S.B. (2018). Contingent Disaster Financing Drives Disaster Preparedness in the Cook Islands. Financial Protection Forum. URL: https://www.financialprotectionforum.org/blog/contingent-disaster-financing-drives-disaster-preparedness-in-the-cook-islands [accessed: 29/11/2019]

7 Office of the Prime Minister, Government of the Cook Islands (2019). Cook Islands Third National Communication under the UNFCCC. URL: https://unfccc.int/sites/default/files/resource/TNC%20FINAL.%20online.pdf

This document aims to succinctly summarize the climate risks faced by the Cook Islands. This includes rapid onset and long- term changes in key climate parameters, as well as impacts of these changes on communities, livelihoods and economies, many of which are already underway. This is a high-level synthesis of existing research and analyses, focusing on the geographic domain of the Cook Islands, therefore potentially excluding some international influences and localized impacts. The core climate projections presented are sourced from the Pacific-Australia Climate Change Science and Adaptation Planning Program,[8,9] as well as the World Bank Group's Climate Change Knowledge Portal (CCKP), incorporating climate projections from the Coupled Model Inter-comparison Project Phase 5 (CMIP5). This document is primarily meant for WBG and ADB staff to inform their climate actions. The document also aims and to direct the reader to many useful sources of secondary data and research.

TABLE 1. Key indicators

Indicator	Value	Source
Population Undernourished[10]	N/A	FAO, 2020
National Poverty Rate[11]	N/A	ADB, 2020a
Share of Wealth Held by Bottom 20%[12]	N/A	World Bank, 2019
Net Annual Migration Rate[13]	N/A	UNDESA, 2019
Infant Mortality Rate (Between Age 0 and 1)[14]	N/A	UNDESA, 2019
Average Annual Change in Urban Population[15]	0.37% (2015–20)	UNDESA, 2019
Dependents per 100 Independent Adults[16]	N/A	UNDESA, 2019
Urban Population as % of Total Population[17]	75.5% (2020)	CIA, 2020
External Debt Ratio to GNI[18]	12.3% (2019)	ADB, 2020b
Government Expenditure Ratio to GDP[19]	26.1% (2019)	ADB, 2020b

8 Australian Bureau of Meteorology and CSIRO (2014). Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports. Pacific-Australia Climate Change Science and Adaptation Planning Program Technical Report, Australian Bureau of Meteorology and CSIRO, Melbourne, Australia. URL: https://www.pacificclimatechangescience.org/wp-content/uploads/2014/07/PACCSAP_CountryReports2014_WEB_140710.pdf

9 The NextGen projections for the Pacific region under CMIP5 are expected to be available from July 2021. These will provide an update on the PACCSAP 2014 projections referenced in this profile. The process for providing the new NextGen CMIP6 projections for the Pacific is still in the planning phase.

10 FAO, IFAD, UNICEF, WFP, WHO (2020). The state of food security and nutrition in the world. Building Resilience for peace and food security. FAO. Rome. URL: http://www.fao.org/documents/card/en/c/ca9692en/

11 ADB (2020a). Basic Statistics 2020. URL: https://www.adb.org/publications/basic-statistics-2020 [accessed 04/03/2021]

12 World Bank (2019). Income share held by lowest 20%. URL: https://data.worldbank.org/indicator/SI.DST.FRST.20 [accessed 15/02/2021]

13 UNDESA (2019). World Population Prospects 2019. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 15/02/2021]

14 UNDESA (2019). World Population Prospects 2019. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 15/02/2021]

15 UNDESA (2019). World Urbanization Prospects 2019. URL: https://population.un.org/wup/Download/ [accessed 15/02/2021]

16 UNDESA (2019). World Population Prospects 2019. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 15/02/2021]

17 CIA (2020). *The World Factbook*. Central Intelligence Agency. Washington DC. URL: https://www.cia.gov/the-world-factbook/

18 ADB (2020b). Key Indicators for Asia and the Pacific 2020, 51st Edition. Asian Development Bank. Manila. URL: https://www.adb.org/sites/default/files/publication/632971/ki2020.pdf

19 ADB (2020b). Key Indicators for Asia and the Pacific 2020, 51st Edition. Asian Development Bank. Manila. URL: https://www.adb.org/sites/default/files/publication/632971/ki2020.pdf

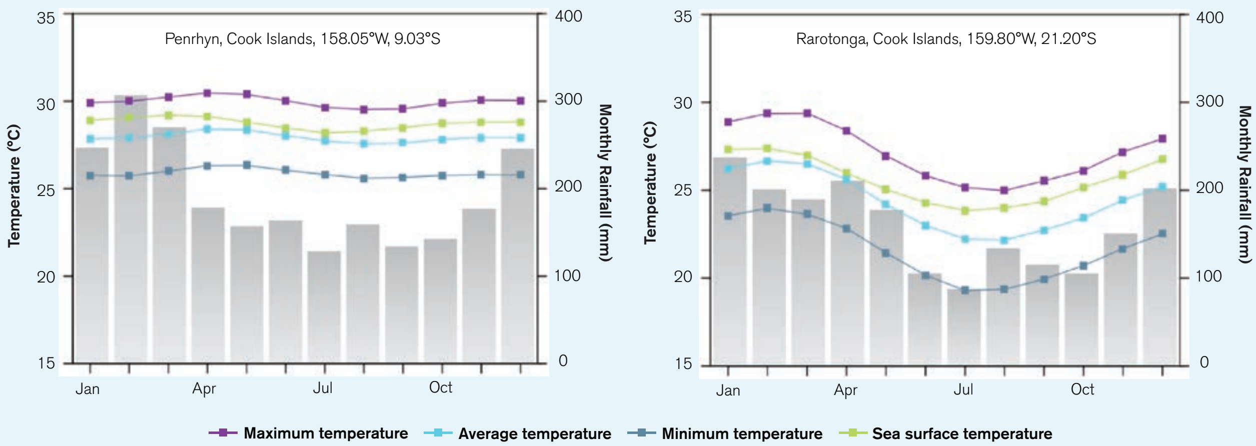
Climate Baseline

Overview

As is common in the Pacific, the Cook Islands experience a generally stable temperature regime fluctuating between an average of 26°C and 28°C all year round in the north, and between 23°C and 26°C in the south at Rarotonga. Maximum temperatures reach around 30°C and minimum temperatures around 20°C (**Figure 1**). The Cook Islands experience significant average annual rainfall, usually peaking between December and March and typically in the range of 1,200–2,000 millimeters (mm) per year. Climate in the Cook Islands is heavily influenced by the El Niño-Southern Oscillation (ENSO) climate dynamic and by the position of the South Pacific Convergence Zone (SPCZ) which brings with it thunderstorm activity.

Annual Cycle

FIGURE 1. Seasonal temperature and rainfall at Penrhyn (in the north) and Rarotonga (in the south).[20]



Key Trends

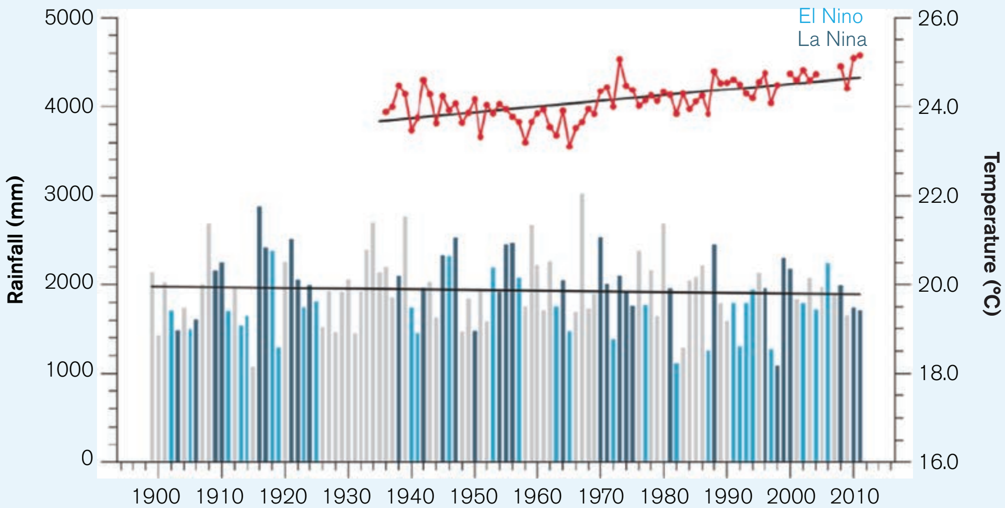
Temperature

Temperatures have been rising in the Cook Islands. A lack of high quality and consistent data challenge our understanding of the precise extent of warming, but the data shown in **Figure 2** as well as that reported by the Berkeley Earth dataset[21] suggest that temperature increases of at least 0.4°C have taken place since 1990. Warming over 1934–2011 is seen most strongly in the rise of minimum temperatures (at almost 0.2°C per decade) and weakest in maximum temperatures (around 0.1°C per decade).

[20] Australian Bureau of Meteorology (2015). Current and future climate of the Cook Islands. Pacific-Australia Climate Change Science and Adaptation Planning Program. URL: https://www.pacificclimatechange.net/document/current-and-future-climate-cook-islands-0

[21] Carbon Brief (2018). Mapped: How every part of the world has warmed – and could continue to warm. [26 September 2018]. URL: https://www.carbonbrief.org/mapped-how-every-part-of-the-world-has-warmed-and-could-continue-to-warm [accessed 25/10/2019]

FIGURE 2. Observed time series of annual average values of mean air temperature (red dots and line) and total rainfall (bars) Rarotonga in Southern Cook Islands. Light blue, dark blue and grey bars denote El Niño, La Niña and neutral years respectively. Solid black trend lines indicate a least squares fit.[8]



Precipitation

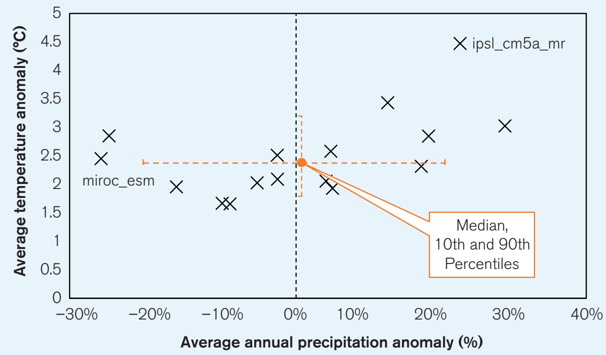
No changes in annual average rainfall over the Cook Islands which are attributable to human driven climate change have yet to be identified. Rainfall shows significant interannual variability, this is influenced in particular by the ENSO phenomenon. Average annual rainfall on the main island of Rarotonga is typically significantly below average in El Niño years. Conversely, in the north, El Niño years are associated with increased rainfall. El Niño years are also associated with more frequent tropical cyclones.

Climate Future

Model Ensemble

Due to differences in the way global circulation models (GCMs) represent the key physical processes and interactions within the climate system, projections of future climate conditions can vary widely between different GCMs. This is particularly the case for rainfall related variables and at sub-national scales. Exploring the spread of climate model outputs can assist in understanding uncertainties associated with climate models. The range of projections from 16 GCMs on the indicators of average temperature anomaly and annual precipitation anomaly for the Cook Islands under RCP8.5 is shown in **Figure 3**.

FIGURE 3. 'Projected average temperature change' and 'projected annual rainfall change' in the Cook Islands. Outputs of 16 models within the ensemble simulating RCP8.5 over the period 2080–2099. Models shown represent the subset of models within the ensemble which provide projections across all RCPs and therefore are most robust for comparison. Two models are labelled.



The majority of the models from which outputs are presented in this report are from the CMIP5 round of standardization and quality assurance. Unfortunately, models of this generation operate at large spatial scales and are not well equipped to simulate the future climate of small islands. Typically, the changes projected will relate more to the expected changes over nearby ocean than the island itself. Caution should therefore be applied in interpreting results. This highlights a major area for future development, a research opportunity, and an urgent need from the perspective of policy makers planning for climate change.

RCPs

The Representative Concentration Pathways (RCPs) represent four plausible futures, based on the rate of emissions reduction achieved at the global level. Four RCPs (i.e. RCP2.6, RCP4.5, RCP6.0, and RCP8.5) were selected and defined by their total radiative forcing (cumulative measure of GHG emissions from all sources) pathway and level by 2100. In this analysis, RCP2.6 and RCP8.5, the extremes of low and high emissions pathways, are the primary focus; RCP2.6 represents a very strong mitigation scenario, whereas RCP8.5 assumes business-as-usual scenario. For reference, **Table 2** provides information on all four RCPs over two-time horizons. In subsequent analysis RCPs 2.6 and 8.5, the extremes of low and high emissions pathways, are the primary focus. RCP2.6 would require rapid and systemic global action, achieving emissions reduction throughout the 21st century enough to reach net zero global emissions by around 2080. RCP8.5 assumes annual global emissions will continue to increase throughout the 21st century. Climate changes under each emissions pathway are presented against a reference period of 1986–2005 for all indicators. For more information, please refer to the RCP Database.

A Precautionary Approach

Studies published since the last iteration of the IPCC's report (AR5), such as Gasser et al. (2018), have presented evidence which suggests a greater probability that earth will experience medium and high-end warming scenarios than previously estimated.[22] Climate change projections associated with the highest emissions pathway (RCP8.5) are presented here to facilitate decision making which is robust to these risks.

[22] Gasser, T., Kechiar, M., Ciais, P., Burke, E. J., Kleinen, T., Zhu, D., . . . Obersteiner, M. (2018). Path-dependent reductions in CO2 emission budgets caused by permafrost carbon release. Nature Geoscience, 11, 830–835. URL: https://www.nature.com/articles/s41561-018-0227-0?WT.feed_name=subjects_climate-sciences

TABLE 2. An overview of temperature change projections (°C) in the Northern Cook Islands (top) and Southern Cook Islands (bottom) under four emissions pathways. Projected changes over the 1986–2005 baseline are given for 20-year periods centered on 2050 and 2090 with the 5th and 95th percentiles provided in brackets.

	Mean Surface Air Temp (Annual)		Max Temp (1-in-20 Year Event)		Min Temp (1-in-20 Year Event)	
Scenario	2050	2090	2050	2090	2050	2090
RCP2.6	0.7 (0.5, 1.2)	0.8 (0.5, 1.2)	0.8 (0.1, 1.2)	0.8 (0.2, 1.1)	0.7 (0, 1.1)	0.8 (0.2, 1.1)
RCP4.5	1 (0.6, 1.3)	1.3 (0.9, 2.1)	0.9 (0.4, 1.2)	1.3 (0.6, 1.9)	0.9 (0.5, 1.3)	1.3 (0.6, 2)
RCP6.0	0.9 (0.6, 1.4)	1.6 (1, 2.4)	NA	NA	NA	NA
RCP8.5	1.3 (0.9, 1.8)	2.7 (2, 3.8)	1.4 (0.5, 2.1)	2.8 (1.3, 4.2)	1.4 (0.9, 2)	2.8 (1.9, 4)

	Mean Surface Air Temp (Annual)		Max Temp (1-in-20 Year Event)		Min Temp (1-in-20 Year Event)	
Scenario	2050	2090	2050	2090	2050	2090
RCP2.6	0.6 (0.5, 1)	0.6 (0.5, 1.1)	0.5 (0, 0.9)	0.6 (0.1, 1.1)	0.6 (-0.1, 1)	0.6 (-0.1, 1)
RCP4.5	0.9 (0.6, 1.5)	1.2 (0.7, 2.1)	0.8 (0.3, 1.2)	1.2 (0.7, 1.8)	0.8 (0.4, 1.4)	1.1 (0.6, 1.8)
RCP6.0	0.8 (0.5, 1.4)	1.5 (1.1, 2.4)	NA	NA	NA	NA
RCP8.5	1.2 (0.8, 2)	2.5 (1.7, 4.2)	1.3 (0.9, 1.8)	2.7 (1.6, 3.9)	1.3 (0.6, 1.9)	2.8 (2, 4.5)

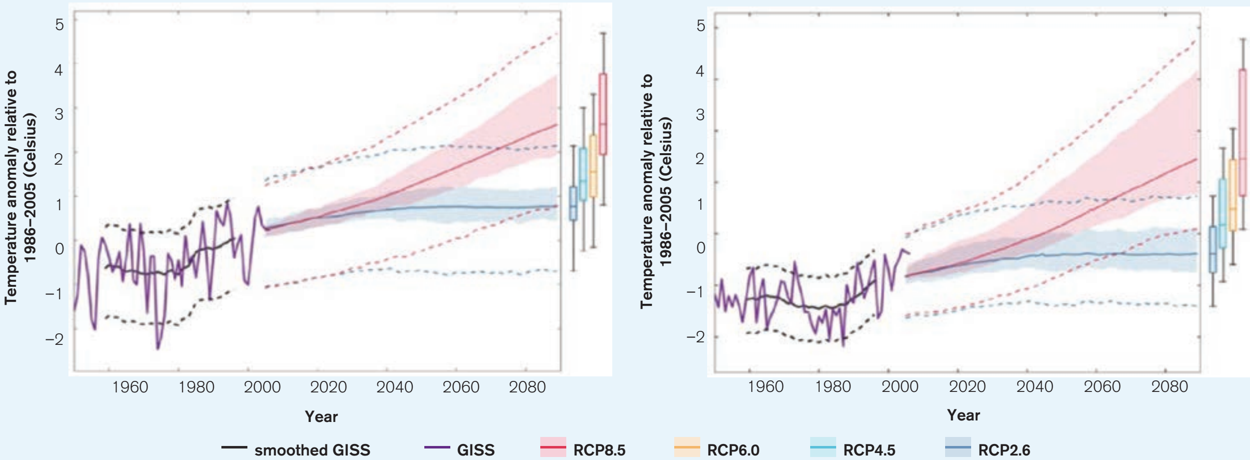
Temperature

Projections of future temperature change are presented in three primary formats. **Figures 3** and **4** display only the average temperature projections. While similar, these three indicators can provide slightly different information. Monthly and annual average temperatures are most commonly used for general estimation of climate change, but the daily maximum and minimum can explain more about how daily life might change in a region, affecting key variables such as the viability of ecosystems, health impacts, productivity of labor, and the yield of crops, which are often disproportionately influenced by temperature extremes.

Across the Pacific, temperatures are projected to increase between 1.4°C and 3.1°C. As shown in **Figure 4**, local temperature increases are expected across the Cook Islands, with warming varying widely across emissions pathways, especially after the 2030s. For instance, as indicated in **Table 2**, relative to the 1986–2005 baseline, a warming of 0.6°C–0.8°C for RCP2.6, meaning temperatures sustaining at approximately their level in 2018. Warming of 2.7°C–2.8°C (median ensemble estimate) is projected for the Cook Islands by the 2090s under the highest emissions pathway (RCP8.5). The significant difference in these estimates shows the impact global emission reduction efforts could have on future changes.

Future temperature rises in the Cook Islands are likely to be below the global average – the mean annual surface air temperature under the highest emissions pathway is projected to reach up to 2.8°C by the 2090s, compared to around 3.7°C globally. This difference may reflect the moderating effect of large amounts of nearby ocean cover, but considering that ocean cover can also distort model simulations, and the current iteration of global models does not have the spatial accuracy to reliably capture climate processes over Small Island States, these projections should be approached with caution.

FIGURE 4. Historical and simulated surface air temperature time series for the region surrounding the Northern Cook Islands (left) and the Southern Cook Islands (right). The graph shows the anomaly (from the base period 1986–2005) in surface air temperature from observations (the GISS dataset, in purple), and for the CMIP5 models under the very high (RCP8.5, in red) and very low (RCP2.6, in blue) emissions scenarios. The solid red and blue lines show the smoothed (20-year running average) multi-model mean anomaly in surface air temperature, while shading represents the spread of model values (5th–95th percentile). The dashed lines show the 5th–95th percentile of the observed interannual variability for the observed period (in black) and added to the projections as a visual guide (in red and blue). This indicates that future surface air temperature could be above or below the projected long-term averages due to interannual variability. The ranges of projections for a 20-year period centered on 2090 are shown by the bars on the right for RCP8.5, 6.0, 4.5 and 2.6.[23,8]



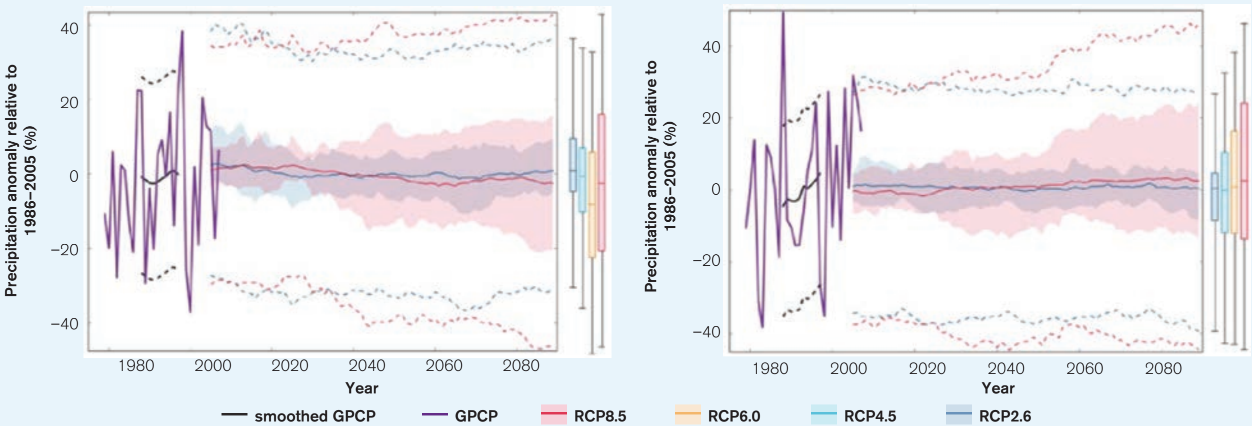
Precipitation

There is very high uncertainty around future changes in average annual precipitation since none of the model ensemble predictions are statistically significant and the estimated ranges are large. As shown in **Figures 3** and **5** projections range from –30% to 30% changes in average annual rainfall. Challenges to the certainty of the model average rainfall change are affected by the complexity of simulating tropical rainfall, as well as uncertainty in ENSO changes, which especially influences year-to-year rainfall variability within the region.

[23] Australian Bureau of Meteorology and CSIRO (2014). Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports. Pacific-Australia Climate Change Science and Adaptation Planning Program Technical Report, Australian Bureau of Meteorology and CSIRO, Melbourne, Australia. URL: https://www.pacificclimatechangescience.org/wp-content/uploads/2014/07/PACCSAP_CountryReports2014_WEB_140710.pdf

In terms of extreme rainfall events, a warmer atmosphere is likely to lead to an increase in their frequency and intensity. Cook Islands' Second National Communication to the UNFCCC shares projections which suggest intense single-day rainfall events could increase in frequency and intensity. For example, a 300 mm daily rainfall event, which currently only occurs once every 38 years on Rarotonga, could increase in probability such that it occurs once every 11 years by the end of the century.[7] However, the precise magnitude of such changes in extreme rainfall is not as certain due to deficiencies in the CMIP5 generation of GCMs.[24,8]

FIGURE 5. Historical and simulated annual average rainfall time series for the region surrounding the Northern Cook Islands (left) and the Southern Cook Islands (right). The graph shows the anomaly (from the base period 1986–2005) in rainfall from observations (the GPCP dataset, in purple), and for the CMIP5 models under the very high (RCP8.5, in red) and very low (RCP2.6, in blue) emissions scenarios. The solid red and blue lines show the smoothed (20-year running average) multi-model mean anomaly in rainfall, while shading represents the spread of model values (5–95th percentile). The dashed lines show the 5–95th percentile of the observed interannual variability for the observed period (in black) and added to the projections as a visual guide (in red and blue). This indicates that future rainfall could be above or below the projected long-term averages due to interannual variability. The ranges of projections for a 20-year period centered on 2090 are shown by the bars on the right for RCP8.5, 6.0, 4.5 and 2.6.[25]



[24] Australian Bureau of Meteorology and CSIRO (2014). Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports. Pacific-Australia Climate Change Science and Adaptation Planning Program Technical Report, Australian Bureau of Meteorology and CSIRO, Melbourne, Australia. URL: https://www.pacificclimatechangescience.org/wp-content/uploads/2014/07/PACCSAP_CountryReports2014_WEB_140710.pdf

[25] Australian Bureau of Meteorology and CSIRO (2014). Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports. Pacific-Australia Climate Change Science and Adaptation Planning Program Technical Report, Australian Bureau of Meteorology and CSIRO, Melbourne, Australia. URL: https://www.pacificclimatechangescience.org/wp-content/uploads/2014/07/PACCSAP_CountryReports2014_WEB_140710.pdf

Heatwaves

Cook Islands regularly experiences high maximum temperatures, with maximums averaging 29°C–30°C. Projected climate changes are expected to push temperatures above 30°C on a regular basis. The historic temperature regime in the Cook Islands was very stable; further research is required to better understand the implications of climate change, and its interaction with the ENSO phenomenon, for its future regime and potential heatwaves.

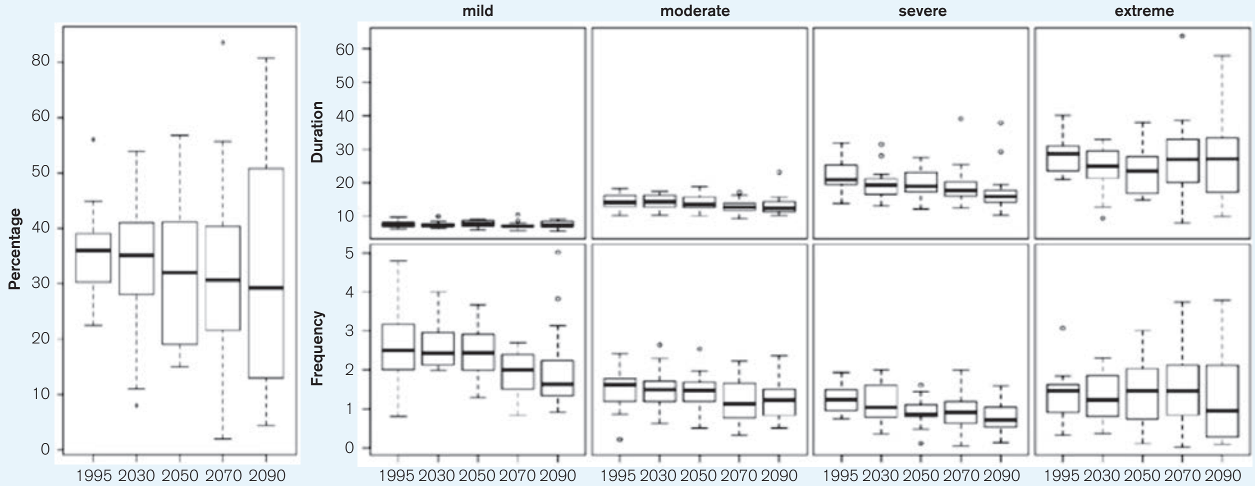
An additional factor for consideration is the potential for marine heatwaves. Research has shown that "from 1925 to 2016, global average marine heatwave frequency and duration increased by 34% and 17%, respectively, resulting in a 54% increase in annual marine heatwave days globally".[26] While such research has not specifically identified the Cook Islands under threat, the consequences of these trend may be serious for marine ecosystems in the region, which are adapted to survive under very stable temperature regimes, as well as the livelihoods dependent on them.

Drought

Drought can be expressed in many ways, from looking at simple precipitation deficits to complex estimates of remaining soil moisture. Research done for the report on "Climate Variability, Extremes and Change in the Western Tropical Pacific 2014", defines projected changes in the frequency and duration of mild, moderate, severe and extreme meteorological droughts using the Standardized Precipitation Index (SPI). This index is based solely on rainfall (i.e. periods of low rainfall are classified as drought), and does not take into account factors such as evapotranspiration or soil moisture content. It is noted that the SPI is commonly used in many regions including the Pacific due to the relative simplicity with which it is calculated, as well as its relevance across temporal and spatial scales. For the Cook Islands, it is likely that the percentage of time spent in drought may decrease, and this is generally shown across emissions scenarios **(Figure 6)**.[8] The exception is for droughts classed as 'extreme' around which there is great uncertainty and potential for both increases and decreases in frequency and duration based on current modelling. However, it should be noted that complex processes relating to rainfall projections, including the limited consensus of future ENSO influence for the region, hinder the confidence of these projections of drought frequency and duration, as well as magnitude of change.[8]

[26] Oliver, E. C., Donat, M. G., Burrows, M. T., Moore, P. J., Smale, D. A., Alexander, L. V., . . . & Holbrook, N. J. (2018). Longer and more frequent marine heatwaves over the past century. Nature communications, 9(1), 1324.

FIGURE 6. Box-plots showing percent of time in moderate, severe or extreme drought (left hand side), and average drought duration and frequency for the different categories of drought (mild, moderate, severe and extreme) for the Southern Cook Islands. These are shown for 20-year periods centered on 1995, 2030, 2050, 2070 and 2090 for the RCP8.5 (very high emissions) scenario. The thick dark lines show the median of all models, the box shows the interquartile (25–75%) range, the dashed lines show 1.5 times the interquartile range and circles show outlier results.[8]



Flood, Cyclones, and Storm Surge

The Cook Islands have very high exposure and vulnerability to the impact of flood, tropical cyclones, and storm surge which can strike in combination or isolation. Cyclones bring coastal and flash flooding even when only passing in the vicinity of the island. According to its Second National Communication to the UNFCCC around 1–6 cyclones pass the vicinity of the Cook Islands every year, windspeeds of over 119 kilometers per hour (km/h) make landfall around once every five years.[7] For example, in 2010 Cyclone Pat hit Aitutaki damaging 75% of homes on the island (pop. 2,000) resulting in the migration of some households and a year-long reconstruction process.[7]

The climate model ensemble projection is for a reduction in the frequency of cyclone genesis in the vicinity of the Cook Islands, this decline varies between 5%–50%.[27,8] Climate change is expected to interact with cyclone hazard in complex ways which are currently poorly understood. Known risks include the action of sea-level rise to enhance the damage caused by cyclone-induced storm surges, and the possibility of increased wind speed and precipitation intensity. Modelling of climate change impacts on cyclone intensity and frequency conducted across the globe points to a general trend of reduced cyclone frequency but increased intensity and frequency of the

[27] Australian Bureau of Meteorology and CSIRO (2014). Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports. Pacific-Australia Climate Change Science and Adaptation Planning Program Technical Report, Australian Bureau of Meteorology and CSIRO, Melbourne, Australia. URL: https://www.pacificclimatechangescience.org/wp-content/uploads/2014/07/PACCSAP_CountryReports2014_WEB_140710.pdf

most extreme events.[28,29] Trends emerging from the scientific literature in regard to tropical cyclone genesis and tracks in the Pacific point towards a climate change-driven westward shift in the genesis location of cyclones.[30] Evaluation of the climate change implications for severe wind hazard have thus far produced inconclusive results.[31] Other characteristics, such as maximum wave height, have been shown to be strongly linked to El Niño-Southern Oscillation, and as such will depend upon the poorly understood relationship between climate change and ENSO.[32] One study has suggested that under future climates, cyclone generation will become more frequent during El Niño events, but less frequent during La Niña events.[33] Further research is required to better understand potential changes in cyclone seasonality and routes, and the potential for cyclone hazards to be experienced in unprecedented locations.

CLIMATE CHANGE IMPACTS

Natural Resources

Water

The Cook Islands utilize a diverse range of water sources, including local streams, rainwater capture, and groundwater extraction. In some areas, communities are entirely dependent on rainwater. Extremes of both rainfall and drought can present challenges to the Islands' water supplies. Heavy rainfall can cause surface flooding which pulls contaminants and sediment into the supply and gastric illnesses are known to increase in frequency.[7] Droughts can also lead to contamination of supplies, and present particular challenges when tourist numbers and hence demand is high. Uncertainty in future rainfall projections presents challenges to decision makers. While the models' best estimate is of an increase in the availability of freshwater, there is potential that this increase will manifest in sporadic extreme rainfall events, and droughts will still be a problem. In this case disaster risk reduction remains of high importance.

---

28 Walsh, K., McBride, J., Klotzbach, P., Balachandran, S., Camargo, S., Holland, G., Knutson, T., Kossin, J., Lee, T., Sobel, A., Sugi, M. (2015). Tropical cyclones and climate change. WIREs Climate Change: 7: 65–89. DOI: https://doi.org/10.1002/wcc.371

29 Widlansky, M. J., Annamalai, H., Gingerich, S. B., Storlazzi, C. D., Marra, J. J., Hodges, K. I., . . . Kitoh, A. (2019). Tropical Cyclone Projections: Changing Climate Threats for Pacific Island Defense Installations. Weather, Climate, and Society, 11(1), 3–15. DOI: https://doi.org/10.1175/WCAS-D-17-0112.1

30 Wu, L., Wang, C., & Wang, B. (2015). Westward shift of western North Pacific tropical cyclogenesis. Geophysical Research Letters, 42(5), 1537–1542. DOI: https://doi.org/10.1002/2015GL063450

31 Siquera, A., Arthur, A., Woolf, M. (2014). Evaluation of severe wind hazard from tropical cyclones – current and future climate simulations. Pacific-Australia Climate Change Science and Adaptation Planning Program. URL: http://datadiscoverystudio.org/geoportal/rest/metadata/item/6cfcbc32c20448579f55edcd2a8383d1/html

32 Stephens, S. A., & Ramsay, D. L. (2014). Extreme cyclone wave climate in the Southwest Pacific Ocean: Influence of the El Niño Southern Oscillation and projected climate change. Global and Planetary Change, 123, 13–26. https://doi.org/https://doi.org/10.1016/j.gloplacha.2014.10.002

33 Chand, S. S., Tory, K. J., Ye, H., & Walsh, K. J. E. (2016). Projected increase in El Niño-driven tropical cyclone frequency in the Pacific. Nature Climate Change, 7, 123. DOI: https://doi.org/10.1038/nclimate3181

On the Cook Islands' atoll islands, such as Aitutaki, there is concern for the impact of sea-level rise on groundwater supplies. Freshwater lenses are under threat from saline intrusion. Water resources in these areas can be exposed to dual impacts. Alongside saline intrusion driven by rapid-onset high sea-levels, cyclones and the high wind speeds they create, also threaten damage to rainwater capture systems. Freshwater quality can take a long time to recover after disaster events.[34] In addition to the introduction of high-cost hard infrastructure to protect residents, the Cook Islands is taking forward nature-based approaches to flood mitigation such as coral restoration and tree planting as part of its adaptation efforts.[7]

The Coastal Zone

Sea-level rise threatens significant physical changes to coastal zones around the world. Global mean sea-level rise was estimated in the range of 0.44 meters (m)–0.74 m by the end of the 21st century by the IPCC's Fifth Assessment Report,[35] however, some studies published more recently have highlighted the potential for greater rises (**Table 3**). Sea-levels in the Cook Islands have already risen over 10 centimeters (cm) since 1950 and are projected to rise at approximately the global average rate, with significant variation according to the future

TABLE 3. Estimates of global mean sea-level rise by rate and total rise compared to 1986–2005 including likely range shown in brackets, data from Chapter 13 of the IPCC's Fifth Assessment Report with upper-end estimates based on higher levels of Antarctic ice-sheet loss from Le Bars et al. (2017).[36]

Scenario	Rate of Global Mean Sea-Level Rise in 2100	Global Mean Sea-Level Rise in 2100 Compared to 1986–2005
RCP2.6	4.4 mm/yr (2.0–6.8)	0.44 m (0.28–0.61)
RCP4.5	6.1 mm/yr (3.5–8.8)	0.53 m (0.36–0.71)
RCP6.0	7.4 mm/yr (4.7–10.3)	0.55 m (0.38–0.73)
RCP8.5	11.2 mm/yr (7.5–15.7)	0.74 m (0.52–0.98)
Estimate inclusive of high-end Antarctic ice-sheet loss		1.84 m (0.98–2.47)

34 Terry, J. P., & Falkland, A. C. (2010). Responses of atoll freshwater lenses to storm-surge overwash in the Northern Cook Islands. Hydrogeology Journal, 18(3), 749–759. URL: https://scholarbank.nus.edu.sg/handle/10635/49772

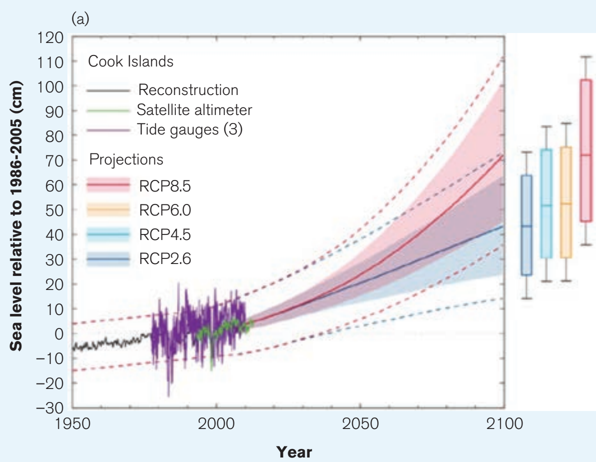
35 Church, J. a., Clark, P. U., Cazenave, A., Gregory, J. M., Jevrejeva, S., Levermann, A., . . . Unnikrishnan, A. S. (2013). Sea level change. In Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 1137–1216). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. URL: https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter13_FINAL.pdf

36 Le Bars, D., Drijhout, S., de Vries, H. (2017). A high-end sea level rise probabilistic projection including rapid Antarctic ice sheet mass loss. Environmental Research Letters: 12:4. URL: https://iopscience.iop.org/article/10.1088/1748-9326/aa6512

emissions pathway (**Figure 7**). Localized sea-level rise can in fact be an extremely complex phenomenon to measure and model, notably due to the influence of large-scale climate phenomena such as ENSO.

Sea-level rise is not just a threat due to long-term encroachment on coastal areas, but also due to the projected increase in the frequency of extreme sea-level events.[37] The return period of exceptionally high sea-levels, driven by climate circulations, is expected to reduce and low-lying Pacific island nations are particularly at risk.[38] Studies have shown that the extent of wave-driven flooding is impacted by coral reef height and health, highlighting the importance of coral conservation.[39] Coastal erosion and inundation of low-lying areas is a concern, particularly as the majority of development, and critical tourism infrastructure is located in the coastal zone. Coastal erosion is already believed to be accelerating on Rarotonga due particularly to the declining health of the local corals, and human impacts on the coastal zone. The Cook Islands' Third National Communication highlights the potential for the frequency of extreme sea-levels to double by the end of the 21st century.[7] Adaptive measures such as the construction of sea-walls have already been rolled-out in some areas, but these come with their own impacts, including accelerating nearby erosion rates.[7]

FIGURE 7. The observed tide-gauge records of relative sea-level (since the late 1970s) are indicated in purple, and the satellite record (since 1993) in green. The gridded (reconstructed) sea level data at the Cook Islands (since 1950) is shown in black. Multi-model mean projections from 1995–2100 are given for the RCP8.5 (red solid line) and RCP2.6 emissions scenarios (blue solid line), with the 5–95% uncertainty range shown by the red and blue shaded regions. The ranges of projections for four emission scenarios (RCPs 2.6, 4.5, 6.0, 8.5) by 2100 are also shown by the bars on the right. The dashed lines are an estimate of interannual variability in sea level (5–95% uncertainty range about the projections) and indicate that individual monthly averages of sea level can be above or below longer-term averages.[40]



[37] Widlansky, M. J., Timmermann, A., & Cai, W. (2015). Future extreme sea level seesaws in the tropical Pacific. Science Advances, 1(8). DOI: https://doi.org/10.1126/sciadv.1500560

[38] Vitousek, S., Barnard, P. L., Fletcher, C. H., Frazer, N., Erikson, L., & Storlazzi, C. D. (2017). Doubling of coastal flooding frequency within decades due to sea-level rise. Scientific Reports, 7(1), 1399. DOI: https://doi.org/10.1038/s41598-017-01362-7

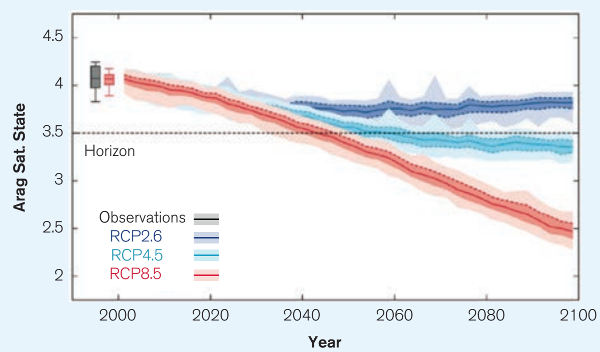
[39] Beetham, E., Kench, P. S., & Popinet, S. (2017). Future Reef Growth Can Mitigate Physical Impacts of Sea-Level Rise on Atoll Islands. Earth's Future, 5(10), 1002–1014. URL: https://doi.org/10.1002/2017EF000589

[40] Australian Bureau of Meteorology and CSIRO (2014). Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports. Pacific-Australia Climate Change Science and Adaptation Planning Program Technical Report, Australian Bureau of Meteorology and CSIRO, Melbourne, Australia. URL: https://www.pacificclimatechangescience.org/wp-content/uploads/2014/07/PACCSAP_CountryReports2014_WEB_140710.pdf

Coral Reefs and Fisheries

Calcium carbonite is used for the external skeletons of multiple marine organisms – for instance, plankton, coral reefs, and shell-fish. Increases in atmospheric carbon dioxide are understood to lead to reduced levels of calcium carbonite saturation on the ocean's service via an increase in ocean acidification and by decreasing carbonite ion concentrations. As a result, there are serious concerns that if carbonite minerals, such as aragonite, become under saturated, it could undermine current ocean ecosystems.[41] As shown in **Figure 8**, only under the lowest emissions scenario (RCP2.6) do aragonite saturation levels remain above the threshold for healthy coral ecosystems. Under higher emissions scenarios conditions transition to unsuitable for healthy coral by the 2050s. Such potential changes may not factor in other reef stressors, including other pressures of human exploitation, and impacts of ocean acidification, which are all also likely to affect the entire marine ecosystem and impact the key ecosystem services provided by reefs.

FIGURE 8. Projected changes in aragonite saturation state in the Northern (top) and Southern (bottom) Cook Islands from CMIP5 models under RCP2.6, 4.5 and 8.5. Shown are the median values (solid lines), the interquartile range (dashed lines), and 5% and 95% percentiles (light shading). The horizontal line represents the threshold at which transition to marginal conditions for coral reef health typically occurs.[8]



The fishing sector is a key component of the economy. Consumption is estimated at around 51 kilograms (kg) per capita per year, and higher in land-poor areas, highlighting its critical importance providing dietary protein.[42] While the local fisheries are valued at around 2–3% of GDP, their importance for subsistence is high and perhaps understated by this figure. In addition, foreign fishing vessels generally pay license fees which constituted around 11% of government income in 2014.[43]

[41] Orr, J. C., Fabry, V. J., Aumont, O., Bopp, L., Doney, S. C., Feely, R. A., . . . & Key, R. M. (2005). Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature, 437(7059), 681.

[42] FAO (2018). Role of fish in food security in selected Pacific Island Countries. Food and Agriculture Organization of the united Nations, policy brief No. 2 May 2018. URL: http://www.fao.org/publications/card/en/c/I9956EN/

[43] Gillett, R. (2016). Fisheries in the economies of Pacific Island countries and territories. Chapter 32: Government Revenues from Fisheries. Pacific Community/FFA/Australian Aid. URL: https://www.adb.org/sites/default/files/publication/27511/pacific-fisheries.pdf

Climate change and human resource exploitation represent a dual threat to fisheries. Species living in and around coral reefs, either permanently or in their juvenile period, and particularly larger species, face an extinction threat.[44] As a result of changes in temperature, dissolved oxygen, and acidity, the maximum catch potential of currently resident species has been forecast to decline significantly in the Cook Islands, potentially by over 50%.[45] However, there is some evidence that the deep sea fisheries within Cook Islands' exclusive economic zone may experience some benefits. The migration range of tuna, for example, is expected to shift eastward across the Pacific pushing tuna towards the Cook Islands.[46] Given the potential disturbance to the Pacific fisheries there have been strong calls for support to communities to identify suitable responses and financing mechanisms, and to adapt to the changing marine environment.[47]

Island Ecology

The unique biodiversity of the Cook Islands is already under significant pressure resulting from human introduction of non-native species, notably the Black Rat.[48] Sea-level rise not only threatens humans residing on Pacific islands, but also their unique ecosystem functions and ecology. Indeed, island biodiversity faces a variety of human pressures.[49] Research has shown that inundation of low-lying islands has the potential to remove important refuges for migrating sea birds.[50] In the case of the Cook Islands endemic bird species such as the Rarotonga starling are already threatened. As climate changes so the suitable range for species to inhabit shifts, typically either upslope or away from the equator. In the Island environment the capacity for species to shift is extremely limited and as such loss and extinction are becoming increasingly likely. Major concerns have been raised for the terrestrial ecology of low-lying Pacific islands, for example endemic lizards, which may become trapped in a shrinking habitat.[51] Research has also highlighted the risks to biodiversity in the Pacific through study of tree richness in New Caledonia, where the range sizes of 87%–96% of species was projected to decline, typically by 52%–84%.[52]

---

[44] Mellin, C., Mouillot, D., Kulbicki, M., McClanahan, T. R., Vigliola, L., Bradshaw, C. J. A., . . . Caley, M. J. (2016). Humans and seasonal climate variability threaten large-bodied coral reef fish with small ranges. Nature Communications, 7(1), 10491. DOI: https://doi.org/10.1038/ncomms10491

[45] Asch, R. G., Cheung, W. W. L., & Reygondeau, G. (2018). Future marine ecosystem drivers, biodiversity, and fisheries maximum catch potential in Pacific island countries and territories under climate change. Marine Policy, 88, 285–294. URL: https://www.sciencedirect.com/science/article/abs/pii/S0308597X17301409?via%3Dihub

[46] Bell, J., Taylor, M., Amos, M., and Andrew, N. (2016). Climate change and Pacific Island food systems. CCAFS and CTA. Copenhagen, Denmark and Wageningen, the Netherlands. URL: https://ccafs.cgiar.org/resources/publications/climate-change-and-pacific-island-food-systems

[47] Hanich, Q., Wabnitz, C. C. C., Ota, Y., Amos, M., Donato-Hunt, C., & Hunt, A. (2018). Small-scale fisheries under climate change in the Pacific islands region. Marine Policy, 88, 279–284. URL: https://ro.uow.edu.au/lhapapers/3351/

[48] Easby, C., and Compton, S. (2013). Spatial Distribution and Abundance of the Rarotonga Starling in the Cook Islands (Pacific Islands). In *Biodiversity and Societies in the Pacific Islands* eds. Larrue, S., and Dahl, A. Presses Universitaires de Provence. URL: https://www.researchgate.net/profile/Stephen_Compton/publication/259921133_Spatial_Distribution_and_Abundance_of_the_Rarotonga_Starling_in_the_CookIslands_Pacific_Islands/links/00b7d52e8a6fe47330000000/Spatial-Distribution-and-Abundance-of-the-Rarotonga-Starling-in-the-CookIslands-Pacific-Islands.pdf

[49] Jupiter, S., Mangubhai, S., & Kingsford, R. T. (2014). Conservation of Biodiversity in the Pacific Islands of Oceania: Challenges and Opportunities. Pacific Conservation Biology, 20(2), 206–220. URL: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.908.8776&rep=rep1&type=pdf

[50] Reynolds, M. H., Courtot, K. N., Berkowitz, P., Storlazzi, C. D., Moore, J., & Flint, E. (2015). Will the Effects of Sea-Level Rise Create Ecological Traps for Pacific Island Seabirds? PLOS ONE, 10(9), 1–23. DOI: https://doi.org/10.1371/journal.pone.0136773

[51] Taylor, S., & Kumar, L. (2016). Global Climate Change Impacts on Pacific Islands Terrestrial Biodiversity: A Review. Tropical Conservation Science, 9(1), 203–223. URL: https://doi.org/10.1177/194008291600900111

[52] Pouteau, R., & Birnbaum, P. (2016). Island biodiversity hotspots are getting hotter: vulnerability of tree species to climate change in New Caledonia. Biological Conservation, 201, 111–119. URL: https://agris.fao.org/agris-search/search.do?recordID=FR2017101025

Economic Sectors

Agriculture and Food

The importance of the agricultural sector in the national economic picture in the Cook Islands has been falling in recent decades, such that in 2018 the sector contributed only an estimated 3% to GDP.[53] Output can fluctuate greatly between years but over the 21st century has fallen slightly.[54] Nevertheless an estimated 63% of households in the Cook Islands engage in some form of small-scale agricultural activity.[55] A variety of hazards and climate phenomena affect the success of agricultural production including ENSO and linked drought impacts, saline intrusion, cyclones and high wind speeds, and intense rainfall. High levels of uncertainty in climate change projections presents challenges to adaptation and disaster risk reduction. Issues identified in the Cook Islands' Second National Communication include a lack of information on the potential for spread of pests and disease under a changing climate, the limited data on future rainfall patterns, and the availability of knowledge and resources for adaptation of cropping choices and practices.[7]

Climate change could influence food production via direct and indirect effects on crop growth processes. Direct effects include alterations to carbon dioxide availability, precipitation and temperatures. Indirect effects include through impacts on water resource availability and seasonality, soil organic matter transformation, soil erosion, changes in pest and disease profiles, the arrival of invasive species, and decline in arable areas due to the submergence of coastal lands. On an international level, these impacts are expected to damage key staple crop yields, even on lower emissions pathways. Tebaldi and Lobell (2018) estimate 5% and 6% declines in global wheat and maize yields respectively even if the Paris Climate Agreement is met and warming is limited to 1.5°C.[56] Shifts in the optimal and viable spatial ranges of certain crops are also inevitable, though the extent and speed of those shifts remains dependent on the emissions pathway. These impacts are expected to affect the global food supply chain. This represents a vulnerability for a nation such as the Cook Islands, which is heavily dependent on food imports. Indeed, in most years local food production is an order of magnitude less than total food imports. Albeit, a proportion of this imported food feeds tourists rather than the local population, as tourism is a critical element of the national economy this vulnerability remains pertinent.[57]

[53] ADB (2020b). Key Indicators for Asia and the Pacific 2020, 51st Edition. Asian Development Bank. ManilaURL: https://www.adb.org/sites/default/files/publication/632971/ki2020.pdf

[54] ADB (2020b). Key Indicators for Asia and the Pacific 2020, 51st Edition. Asian Development Bank. ManilaURL: https://www.adb.org/sites/default/files/publication/632971/ki2020.pdf

[55] Cook Islands Government (2016). JNAP II – Are we resilient? Joint National Action Plan for Disaster Risk Management & Climate Change Adaptation 2016–2020. URL: https://policycookislands.files.wordpress.com/2017/05/2017_joint-national-action-plan-for-disaster-risk-management-and-climate-change-adaptation-2016-2020_final.pdf

[56] Tebaldi, C., & Lobell, D. (2018). Differences, or lack thereof, in wheat and maize yields under three low-warming scenarios. Environmental Research Letters: 13: 065001. URL: https://iopscience.iop.org/article/10.1088/1748-9326/aaba48

[57] Ministry of Agriculture (2013). Strategies that reduces dependency on imported produce. Cook Islands Government. URL: http://www.mfem.gov.ck/images/MFEM_Documents/DCD_Docs/Agriculture/Strategies_for_Import_Substitution.pdf

Tourism

Tourism is the primary source of economic activity in the Cook Islands, contributing well over 60% to GDP. Tourism has strongly encouraged development in the Cook Islands' coastal zone and hence in highly hazard exposed areas. Pressure has been placed on land-use planning and zoning, as well disaster risk reduction and response systems.[58] These challenges were brought into focus by the significant economic impacts brought by the cyclone season of 2005, after which discussions intensified about the need to 'build back better'.[56] However, it remains the case that the large majority of Rarotonga's tourism infrastructure resides in areas with the highest exposure to storm surge.[59] While some aspects of future climate change remain uncertain, the intensity of the most extreme storm surges is likely to increase, as is the intensity of the most extreme heavy rainfall events. In this context disaster risk reduction in the tourism sector is of key importance. The Cook Islands' Third National Communication also highlights the risks to the tourism sector of degrading ecosystems and biodiversity loss which may reduce tourism attractiveness. The need for sustainable eco-tourism and successful adaptation of key services such as water and food supply are underscored.[7]

In addition to direct physical impacts, climate change may affect the tourism sector in the Cook Islands through global efforts to mitigate climate change. One possible manifestation is in the increased cost of international flights. One study estimated that while the cost of achieving an emissions-target compatible tourism sector may be proportionately low (3.6%). Nonetheless, the necessary increase in trip costs (estimated at $11 when averaging across every global trip but potentially higher on a long-haul destination such as Cook Islands) may reduce the Cook Islands' attractiveness as a tourist destination.[60] Further research is required to better constrain the suite of potential climate change impacts on the sector.

Communities

Poverty, Inequality and Vulnerability to Climate-Related Disaster

The Cook Islands has considerable economic vulnerability to hazards, particularly cyclone. According to the World Bank *"In the next 50 years, the Cook Islands has a 50 percent chance of experiencing a per-event loss exceeding NZ$97 million (US$79.5 million), and a 10 percent chance of experiencing a per-event loss exceeding NZ$327 million (US$268 million) from tropical cyclones"*.[61] In a nation with total GDP in the order of US$300 million (2016) these figures are very considerable and bring into focus the importance of disaster risk reduction and adaptation.

[58] Mannakkara, S., Wilkinson, S., Willie, M., & Heather, R. (2018). Building Back Better in the Cook Islands: A Focus on the Tourism Sector. Procedia Engineering, 212, 824–831. DOI: https://doi.org/10.1016/j.proeng.2018.01.106

[59] de Scally, F. A. (2014). Evaluation of storm surge risk: A case study from Rarotonga, Cook Islands. International Journal of Disaster Risk Reduction, 7, 9–27. URL: http://202.65.43.137/Library/Doc/MMR/Oceanography/International_Journal_of_Disaster_Risk_Reduction_Volume_7_issue_2014_doi_10.10162Fj.ijdrr.2013.12.002_de_Scally_Fes_A.____Evaluation_of_storm_surge_risk__A_case_study_from_Rarotonga_Cook_Islands.pdf

[60] Scott, D., Gössling, S., Hall, C. M., & Peeters, P. (2016). Can tourism be part of the decarbonized global economy? The costs and risks of alternate carbon reduction policy pathways. Journal of Sustainable Tourism, 24(1), 52–72. DOI: https://doi.org/10.1080/09669582.2015.1107080

[61] World Bank (2015). Country Note: The Cook Islands, Disaster Risk Financing and Insurance. URL: http://documents1.worldbank.org/curated/en/405171468244771591/pdf/949800WP0Box380ry0Note0Cook0Islands.pdf

Managing disaster risk in dynamic environments where human society has a long-established interaction with natural hazards means engaging with traditional coping mechanisms. Particularly, establishing their efficacy, and ensuring their preservation where necessary.[62] Research has suggested that traditional disaster management structures can be mixed in their suitability for tackling new climate change-linked challenges.[63] The Cook Islands has taken a proactive approach to adaptation activity and is seen as a leader in the Pacific context,[64] facilitated in part by its relative economic strength. However, as is the case in many Pacific nations, experiences are not uniform and can differ significantly in 'peripheral' communities.[61] It remains the case in the Cook Islands' that the highest levels of disaster risk are found in areas with the greatest social vulnerability.[57]

Many of the climate changes projected are likely to disproportionately affect the poorest groups in society. For instance, heavy manual labor jobs are commonly among the lowest paid whilst also being most at risk of productivity losses due to heat stress.[65] Poorer businesses are the least able to afford air conditioning, an increasing need given the projected increase in the need for air conditioning with temperature increases. Poorer farmers and communities are least able to afford local water storage, irrigation infrastructure, and technologies for adaptation.

The Cook Islands has significant dependence on foreign support and remittances due to the huge number of its population residing in New Zealand and Australia. The problem of depopulation and emigration of skilled workers is presenting acute challenges to the Cook Islands, including reducing capacity for disaster risk reduction. However, at the same time, it is also believed that accessible migration is part of the reason there are relatively better living conditions in the Cook Islands in comparison to other PIC islands.

Although there is some consensus that climate change may drive migration in the Pacific region and there is some evidence of this in some parts of the region, there has not been ample empirical analysis of the impacts of climate change on human populations. The complex relationship between climate change and impact on communities is too unpredictable because there are too many factors that may play a role in driving people to migrate. For example, people's reasons for migrating is often complex and varied and it is difficult to identify and determine whether people are primarily moving due to economic reasons or environmental "push". Furthermore, separating climate change induced migration from other factors such as economic or social factors is often too challenging.[66] If countries are able to adapt well to disasters, climate change induced migration may not necessarily be an inevitable consequence.[64] However, migration from the peripheries of the Cook Islands is already taking place, and its documentation is relatively poor.[67]

---

62 Fletcher, S. M., Thiessen, J., Gero, A., Rumsey, M., Kuruppu, N., & Willetts, J. (2013). Traditional coping strategies and disaster response: Examples from the South Pacific Region. Journal of Environmental and Public Health, 2013. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3884777/

63 Nunn, P. D., Aalbersberg, W., Lata, S., & Gwilliam, M. (2014). Beyond the core: community governance for climate-change adaptation in peripheral parts of Pacific Island Countries. Regional Environmental Change, 14(1), 221–235. DOI: https://doi.org/10.1007/s10113-013-0486-7

64 Robinson, S. (2017). Climate change adaptation trends in small island developing states. Mitigation and Adaptation Strategies for Global Change, 22(4), 669–691. URL: https://link.springer.com/article/10.1007/s11027-015-9693-5

65 Kjellstrom, T., Briggs, D., Freyberg, C., Lemke, B., Otto, M., Hyatt, O. (2016). Heat, human performance, and occupational health: A key issue for the assessment of global climate change impacts. Annual Review of Public Health: 37: 97-112. URL: https://pubmed.ncbi.nlm.nih.gov/26989826/

66 Migration and Climate Change, International Organization for Migration (IOM). Migration and Climate Change. IOM Migration Research Series No. 31 (2008): 25–26. URL: https://publications.iom.int/books/mrs-ndeg31-migration-and-climate-change

67 WHO (2014). The Cook Islands: National Report for the 2014 Small Islands Developing States (SIDS) Conference and post 2015 Sustainable Development Goals (SDGs). World Health Organization. URL: https://www.unenvironment.org/resources/report/cook-islands-national-report-2014-small-islands-developing-states-sids-conference

Gender

An increasing body of research has shown that climate-related disasters have impacted human populations in many areas including agricultural production, food security, water management and public health. The level of impacts and coping strategies of populations depends heavily on their socio-economic status, socio-cultural norms, access to resources, poverty as well as gender. Research has also provided more evidence that the effects are not gender neutral, as women and children are among the highest risk groups. Key factors that account for the differences between women's and men's vulnerability to climate change risks include: gender-based differences in time use; access to assets and credit, treatment by formal institutions, which can constrain women's opportunities, limited access to policy discussions and decision making, and a lack of sex-disaggregated data for policy change.[68]

Human Health

Heat-Related Mortality

Research has placed a threshold of 35°C (wet bulb ambient air temperature) on the human body's ability to regulate temperature, beyond which even a very short period of exposure can present risk of serious ill-health and death.[69] Temperatures significantly lower than the 35°C threshold of 'survivability' can still represent a major threat to human health. Climate change will push global temperatures closer to this temperature 'danger zone' both through slow-onset warming via an increase mean annual temperature and the intensity and frequency of heat waves. As in most Pacific islands conditions in the Cook Islands will move to significantly more dangerous levels under most future scenarios, but particularly the higher emissions pathway (RCP6.0 and RCP8.5). Although there are challenges of limited downscaled climate information to specify projections, it is likely that climate change will result in an increased number of people at risk of heat-related medical conditions, perhaps specifically related to the elderly, children, the chronically ill, the socially isolated and at-risk occupational groups.[70] It should be noted that the potential reduction in heat-related deaths achievable by pursuing lower emissions pathways is significant, as demonstrated by Mitchell et al. (2018).[71]

---

68 World Bank Group (2016). Gender Equality, Poverty Reduction, and Inclusive Growth. URL: http://documents1.worldbank.org/curated/en/820851467992505410/pdf/102114-REVISED-PUBLIC-WBG-Gender-Strategy.pdf

69 Im, E. S., Pal, J. S., & Eltahir, E. A. B. (2017). Deadly heat waves projected in the densely populated agricultural regions of South Asia. Science Advances, 3(8), 1–8. URL: https://advances.sciencemag.org/content/3/8/e1603322

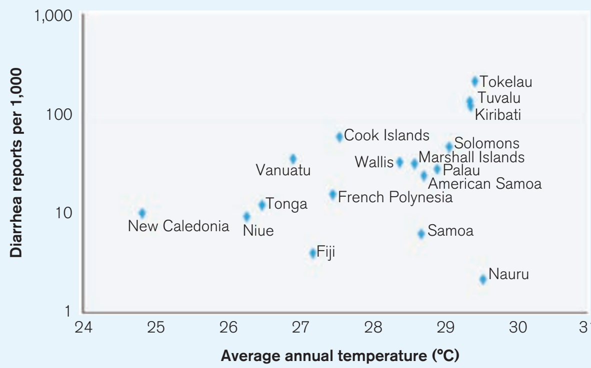
70 World Health Organization (2015). Climate and Health Country Profile – 2015 Maldives. URL: http://www.searo.who.int/entity/water_sanitation/mav_c_h_profile.pdf?ua=1. [accessed 30/06/2019].

71 Mitchell, D., Heaviside, C., Schaller, N., Allen, M., Ebi, K. L., Fischer, E. M., . . . Vardoulakis, S. (2018). Extreme heat-related mortality avoided under Paris Agreement goals. Nature Climate Change, 8(7), 551–553. DOI: 10.1038/s41558-018-0210-1

Disease and General Health

As in other countries, loss of a clean water supply can result in water contamination, which will have significant medical concerns. Generally, an increase in atmosphere and sea temperatures could also intensify risks in water and vector-borne diseases, such as diarrhea, disaster-related fatalities, injuries and illnesses, heat stress and conjunctivitis (pink-eye). In the case of the Cook Islands, high prevalence of Ciguatera Fish Poisoning (found in reef fish) has been noted and, given significant dependence on reef fish for protein, has had measurable economic impacts on communities.[72] In other locations Ciguatera has been linked to rising sea-surface temperatures[73], and hence climate change is a potentially growing driver in the Cook Islands.[7] It is noted that while the interaction between temperature and diarrheal disease is still unclear, one explanation of the association is that rotavirus and other bacteria that cause diarrhea are able to proliferate in warm marine water. Another possible explanation is that higher temperatures can cause food to spoil more rapidly, and thus cause food poisoning.[74] **Figure 9** shows research by Singh et al. (2001), which demonstrated the link between annual average temperature and average reporting rates of diarrheal disease specifically amongst Pacific island states.[75]

FIGURE 9. Annual average temperature and average reporting rates for diarrheal disease, Pacific islands (1986–1994). $r^2 = 0.49$; $p < 0.05$[73]



[72] Rongo, T., & van Woesik, R. (2012). Socioeconomic consequences of ciguatera poisoning in Rarotonga, southern Cook Islands. Harmful Algae, 20, 92–100. DOI: https://doi.org/10.1016/j.hal.2012.08.003

[73] Tester, P. A., Feldman, R. L., Nau, A. W., Kibler, S. R., & Litaker, R. W. (2010). Ciguatera fish poisoning and sea surface temperatures in the Caribbean Sea and the West Indies. Toxicon, 56(5), 698–710. DOI: 10.1016/j.toxicon.2010.02.026

[74] Bentham, G., & Langford, I. H. (2001). Environmental temperatures and the incidence of food poisoning in England and Wales. *International journal of biometeorology*, *45*(1), 22–26. DOI: 10.1007/s004840000083

[75] Singh, R. B., Hales, S., De Wet, N., Raj, R., Hearnden, M., & Weinstein, P. (2001). The influence of climate variation and change on diarrheal disease in the Pacific islands. Environmental health perspectives, 109(2), 155–159. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1240636/

National Adaptation Policies and Strategies

TABLE 4. Key national adaptation policies, plans and agreements

Policy/Strategy/Plan	Status	Document Access
Joint National Action Plan for Disaster Risk Management & Climate Change Adaptation	Enacted	2016
Intended Nationally Determined Contribution (INDC) to Paris Climate Agreement	Submitted	2016
National Communications to the UNFCCC	Three submitted	latest: 2019

Climate Change Priorities of ADB

ADB — Country Partnership Strategy

Cook Islands' Country Partnership Strategy falls under ADB's Pacific Approach 2016–2020. This approach includes three strategic priorities, the third of which—managing risks—is heavily focused on climate change. Key components of this strategic priority include:

- Building capacity, i.e. knowledge, skills, and practices, in sector agencies working in climate change and disaster risk management areas in order to improve practice in risk appreciation, planning, and implementation of adaptation and risk management interventions.
- Ensuring climate and disaster risks are assessed and accounted for in infrastructure investments
- Developing and implementing climate and disaster risk financing mechanisms and arrangements
- Ensuring climate proofing of health projects
- Safeguarding the environment in environmental policy development and regulatory frameworks
- Assisting with the roll-out of well-designed social protection policies, including coverage of issues related to climate hazards and emigration.

CLIMATE RISK COUNTRY PROFILE

COOK ISLANDS

WORLD BANK GROUP

ADB ASIAN DEVELOPMENT BANK