USAID CLIMATE READY

KNOWLEDGE PRODUCTS

Pacific Island Country Climate Factsheets

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Pacific Island Country Climate Factsheets

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Cover Photo by
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Cover Photo Caption
Fishing boat approaching the town of London on Kiritimati Island in the Line Islands group of Kiribati.

Country Maps & Images
Maps are graphical representation designed for general reference purposes only. Images from Shutterstock.

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ACRONYMS

AR	Assessment Report
AUD	Australian Dollars
CCA	Climate Change Adaptation
CMIP	Coupled Model Intercomparison Project
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
ENZO	El Nino Southern Oscillation
ESS	Environmental and Social Safeguards
FJD	Fijian Dollars
FSM	Federated States of Micronesia
GDP	Gross Domestic Product
GHG	Greenhouse Gases
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-tropical Convergence Zone
JNAP	Joint National Action Plan
LDC	Least Developed Countries
NDC	Nationally Determined Contribution
NOAA	National Oceanic and Atmospheric Administration
PIC	Pacific Island Country
PNG	Papua New Guinea
RMI	Republic of the Marshall Islands
SIDS	Small Island Developing States
SPCZ	South Pacific Convergence Zone
SPREP	Secretariat of the Pacific Regional Environment Program
SST	Sea Surface Temperature
TC	Tropical Cyclone
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USD	United States Dollars

USAID CLIMATE READY PROJECT

USAID Climate Ready is a five-year regional project funded by the USAID and implemented by DT Global, a United States based institutional contractor with worldwide experience implementing environment programs.

USAID Climate Ready works in 11 Pacific Island Countries (PICs): Federated States of Micronesia, Fiji, Kiribati, Palau, Papua New Guinea, Republic of the Marshall Islands, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu.

USAID Climate Ready works with PIC governments and other stakeholders to prioritize areas of support that align with their climate and disaster resilience plans and goals to:

1. Draft and implement policies that achieve national adaptation goals;
2. Access and utilize international sources of climate financing; and
3. Improve systems and expertise to better manage and monitor adaption projects.

BACKGROUND TO THIS TOOL

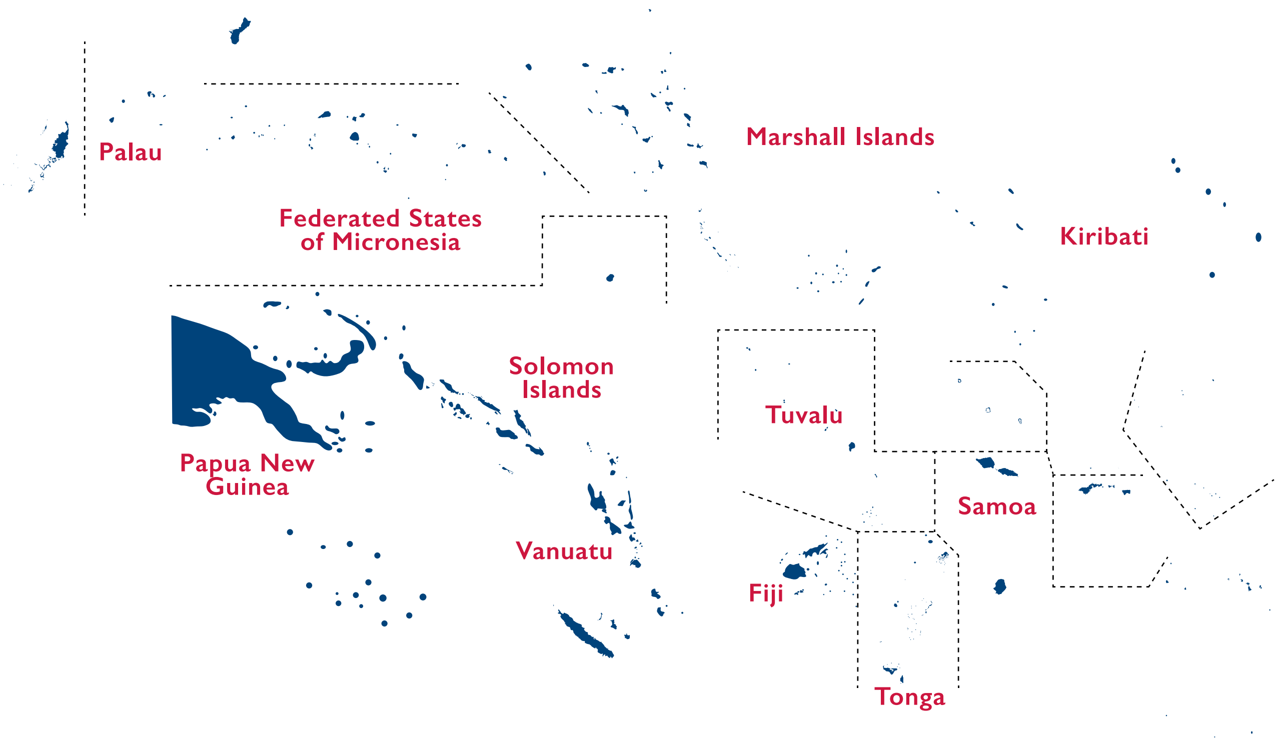
These Country Climate Factsheets contain data and information drawn from a USAID-supported Climate Change Adaptation Project Preparation training course facilitated by Dr. Keith Bettinger and delivered to government and non-government partners in 10 countries across the Pacific under the USAID Climate Ready Project.

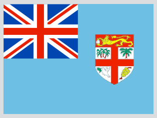
THE PURPOSE OF THIS TOOL

The aim of these Country Climate Factsheets is to equip proposal writers seeking funding from international climate finance organizations – such as the Green Climate Fund, the Global Environment Facility and the Adaptation Fund – with essential and quick-reference information to input into project concepts or proposals.

Each Country Climate Factsheet contained in this compendium is a standalone document with data directly relevant to the applications of funders such as the Green Climate Fund and Global Environment Facility.

USAID CLIMATE READY PROJECT WORKS IN 11 PACIFIC ISLAND COUNTRIES

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Republic of the Marshall Islands


Republic of Palau


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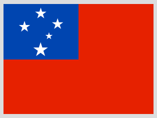
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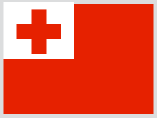
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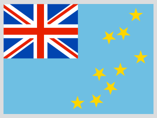
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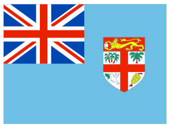
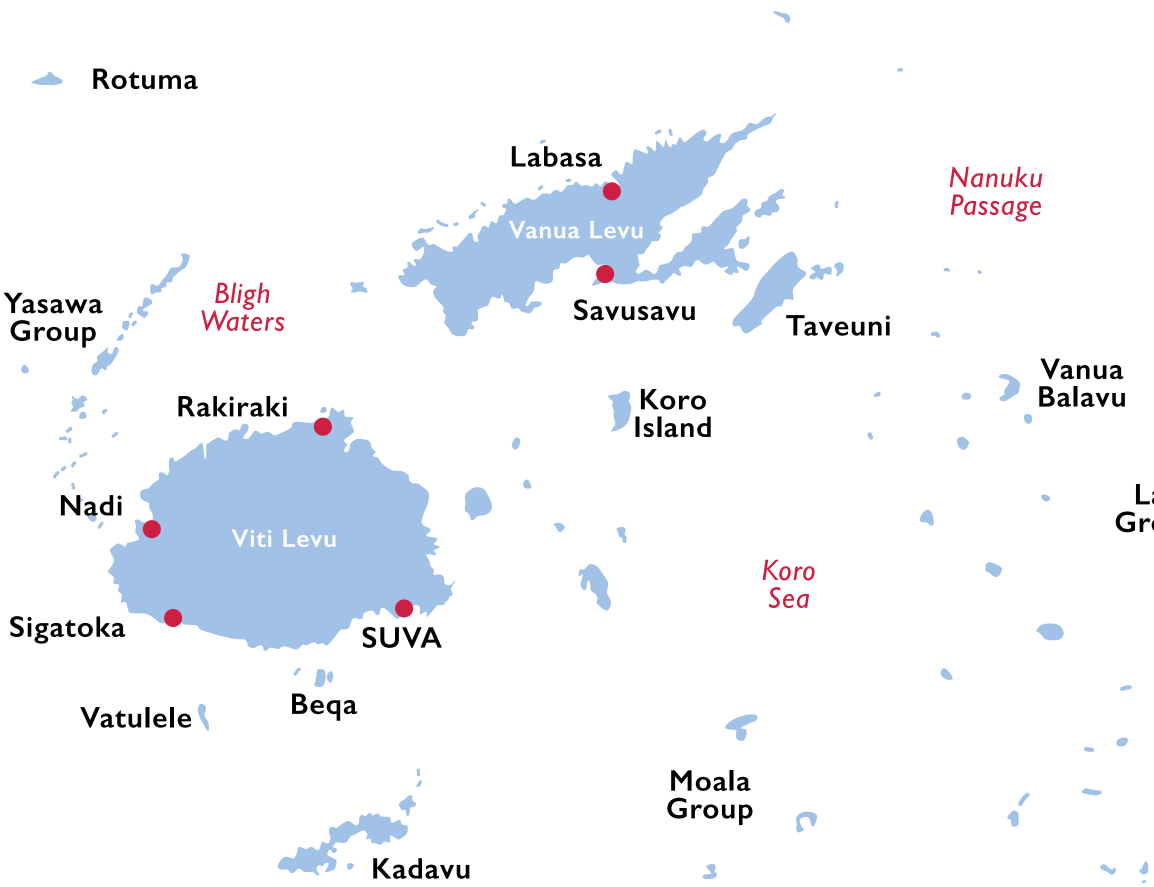
Republic of Vanuatu

FIJI ISLANDS





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GEOGRAPHY

FIJI ISLANDS

- The island nation of Fiji is located near the Equator in the central Pacific Ocean between 16°S - 20°S latitude and 177°E - 178°W longitude[1].
- Fiji has a total land area of 18,333 km^2 and an exclusive economic zone of 1.3 million km^2[1].
- Fiji is made up of 322 islands and approximately 110 are inhabited[2].
- The two largest Islands (Viti Levu 10,429 km^2 and Vanua Levu 5,556 km^2) make up 87% of the total land area, are mountainous and of volcanic origin[1].
- Other main islands are Taveuni (470 km^2), Kadavu (411 km^2) and Koro (104 km^2)[3].
- The remaining islands in the Fijian archipelago consist of small volcanic islands, low-lying atolls and elevated reefs[2].
- The highest point in Fiji, Mount Tomanivi, found on Viti Levu, rises 1,324 m above sea level[2].
- Islands in Fiji are characterized by diverse ecosystems including significant areas of natural forests and wide ranges of coastal and marine ecosystems ranging from extensive areas of mangroves to various coral formations[3].
- On the larger volcanic islands dominated by steep deeply incised mountainous terrain, a relative abundance of annual rainfall, perennial rivers, good surface drainage and numerous springs ensure that there is no fundamental problem in obtaining domestic water supplies[3].
- Rainfall triggered landslides are a significant risk in Fiji due to the country's steep terrain, weathered rock properties and frequent cyclones, storms and heavy rainfall events[4].
- On the low-lying, smaller and outer islands, there are no such perennial streams so fresh water is a much scarcer resource[3].
- Freshwater wetlands occupy 0.3% of Fiji's land area[3].
- Almost all forest cover is on communally owned native land, 13,960 ha on private freehold and 5,600 hectares on government lease land[3].
- Viti Levu is the economic center of Fiji, with Suva, the capital located on the south coast, and Nadi, the tourism center on the west coast[1].
- The population of Fiji is 926,276 (2018 est.) and approximately 70% of the population lives on Viti Levu[2].
- Over half of Fiji's population (54%; 2017 est.) is urbanized and is concentrated in three rapidly growing urban areas
    - Suva-Lami-Nasinu-Nausori in southeast Viti Levu;
    - Nadi-Lautoka-Ba in west-northwest Viti Levu; and
    - Weilevu-Labasa-Nasea in northwest Vanua Levu[4].
- Of the Melanesian countries, Fiji, due to outmigration, has a low overall population growth, In addition, Fiji is more urbanized than other countries in Melanesia, with the majority of the population now living in urban and peri-urban areas[5].

GEOGRAPHY

FIJI ISLANDS

- It is estimated that the population for Fiji will reach the one million mark in 2030 and 61% of the population will be living in urban areas[6].
- It is estimated that there are close to 78,000 people currently living in 128 squatter settlements in the major urban areas[7].
- Fiji's Gross Domestic Product (GDP) is approximately USD5.6 billion (2017 est.)[2].
- Fiji's economy is second largest in the Pacific next to Papua New Guinea[7].
- Fiji is a middle-income country with a per capita income at approximately USD4,700 with large income disparities particularly across rural and urban areas[8].
- Fiji is a hub for re-exports to the rest of the Pacific and has a large tourism industry which contributes to 38% of the GDP and attracts over 750,000 visitors per year[4].
- In Fiji, agriculture is organized more along commercial lines, although the subsistence sector remains important and large-scale agriculture comprises consists mainly of sugarcane[3].
- Around 64,500 Fiji households (37%) derive some form of income from agriculture which represents approximately 8% of GDP[4].
- Approximately 34% of the population live below the national basic need's poverty line but extreme poverty in Fiji is rare[4].
- Ambitions objectives of the Fijian Development plan are to more than double the real GDP by 2036 and to provide universal access to all services, including housing, electricity, clean and safe water and sanitation, high-quality education and health care[4].
- Fiji, as a small island developing state (SIDS) and because of its remote location, is at the forefront of being impacted by climate change[6].
- Fiji's small size, vulnerability to climate variability and change, and manmade and natural hazards coupled with the pace of socio-economic development and exacerbated by rapid urbanization has resulted in an increase in squatter and informal settlements[7].
- Factors contributing to the increased number of urban squatters include high rural-urban migration, inadequate supply of urban housing stock, inadequate supply of fully serviced lots, and limited access to finance and affordable housing areas[7].
- The degradation of the Pacific Ocean, especially the marine space of Fiji's large exclusive economic zone due to overfishing, pollution, climate change-induced damage to coral reefs and other factors, are diminishing the productive capacity of the marine environment as a source of income, cultural identity and food security[7].
- Degradation to the ocean has severe implications for Fiji's economic growth, as the country relies heavily on its natural resources for economic development; fisheries, forestry and agriculture are its primary industries[6].


Aerial View of Nadi River - Nadi, Fiji.

- As of 2010 there were 30 (single observation) climate stations, eight synoptic (multiple observation) climate stations and 52 rain gauges in Fiji's climate monitoring network[1].
- Climate records with data available from before 1900 are available for at least six climate stations[1].
- Climate records for both Suva and Nadi airports are homogeneous (consistent through time) and more than 99% complete[1].
- The climate of Fiji is generally categorized as an oceanic tropical marine climate[9].
- The annual range in average monthly maximum temperature is about 4°C from Suva and 3°C for Nadi.
- Fiji has two distinct seasons[1]:
    - Dry/Cool season (May to October) and Wet/Warm season (November to April).
- Approximately 63% of Suva's rain and 77% of Nadi rain falls in the wet season[1].
- The seasonal cycle is strongly affected by the South Pacific Convergence Zone (SPCZ), which is most intense during the wet season[1].
- The effects of large-scale climate features such as the SPCZ and trade winds are modified on some islands due to the influence of mountains[1].

GEOGRAPHY

- Regions exposed to the trade winds can receive mean annual rainfall in excess of 4,000 mm, while leeward regions receive on average less than 2,000 mm annually with less than 25% of annual rainfall in the dry season[1].
- Year-to-year natural climate variability is high in Fiji and is explained by the El Niño Southern Oscillation (ENSO)[1].
- There are significant correlations between ENSO indices and both rainfall and air temperature in Fiji[1].
- Generally, El Niño years are drier and cooler than average while La Niña years are wetter and warmer than average[1].
- More than 80% of meteorological droughts since 1920 are associated with El Nino events[1].
- During moderate to strong El Niño events, the annual rainfall is reduced by as much as 20-50% over most parts of Fiji as experienced during the 1982/83, 1986/87, 1992/93 and 1997/98 events[9].
- From a health protection perspective, it is noted that the 1997/98 severe drought period (relating to the El Niño event) occurred concurrently with the 1997/98 dengue epidemic, the worst in Fiji with about 24,000 cases – 17,000 hospital admissions and 13 deaths[9].
- River flooding occurs almost every wet season and occasionally in the dry season during La Niña[1].
- The tropical cyclone season in Fiji is usually between November and April but occasionally in October and May during El Nino Years[1].
- Between 1969 and 2010, 70 tropical cyclones passed within 400 km of Suva (17 per decade)[1].
- On 20 February 2016, Fiji was hit by Category 5 Tropical Cyclone Winston which impacted 540,000 people equivalent to 62% of the country's total population, caused an estimated USD2 billion in damages and resulted in 44 deaths[4].
- Large-scale flooding in Fiji is mostly associated with prolonged heavy rainfall during the passage of a tropical cyclone, tropical depression and/or enhanced, slow moving convergence zone and localized flash flooding during the wet season is quite common[9].
- Sea flooding is usually associated with the passage of tropical cyclones close to the coast, however, heavy swells, generated by deep depressions and/or intense high-pressure systems some distance away from Fiji have also caused flooding to low-lying coastal areas and at times, heavy swells coincide with king tides and cause flooding and damage to coastal areas[9].
- Fires occasionally occur on the leeward sides of the main islands in the dry season during a significant period without rainfall[1].

FIJI ISLANDS

GLOBAL CLIMATE CHANGE

TEMPERATURE

- 2018 was the fourth warmest year in the 1880–2018 record, behind 2016 (highest), 2015 (second highest), and 2017 (third highest)[10].
- 2018 was the second warmest year on record without an El Niño present in the tropical Pacific Ocean[10].
- 2018 marks the 42nd consecutive year (since 1977) with global land and ocean temperatures above 20th century average[10].
- Nine of the 10 warmest years have occurred since 2005[10].
- The 2018 globally averaged sea surface temperature was 1.19°F (0.66°C) above the 20th century average[10]. This was the fourth highest among all years in the 1880-2018 record, again behind 2016 (highest) and 2015 (second highest) and 2017 (third highest)[10].

SEA LEVEL RISE

- In 2017 global sea level was 77 mm above the 1993 average, which is the highest annual average in the satellite record[11].
- 2017 was the sixth consecutive year, and the 22nd out of the last 24 years in which global mean sea level increased relative to the previous year[11].
- Global average sea level rises at a rate of just over 3.1 mm per year due to a combination of melting glaciers and ice sheets and from the thermal expansion of seawater[11].
- The rate of sea level rise has doubled since 1993 compared to the 20th century average[11].

OCEAN ACIDIFICATION AND TEMPERATURE

- Oceans are absorbing about 25% of the carbon dioxide emitted to the atmosphere annually and as a result are becoming more acidic[12].
- The world's oceans have absorbed about 93% of the excess heat caused by greenhouse gas warming since the mid-20th century[13].
- Ocean heat content has increased at all depths[13].
- Increasing sea surface temperatures, rising sea levels, changing patterns of precipitation and winds, and ocean circulation are contributing to overall decline oxygen concentrations in the oceans[13].

REGIONAL CLIMATE CHANGE

FIJI ISLANDS

TEMPERATURE

- Averaged as a whole, Oceania had its 3rd warmest year in 2018 since regional records began in 1910[10].
- Much warmer than average temperatures occurred in equatorial western Pacific encompassing the geographic area of containing the country of Fiji[10].
- In the Pacific region, land-surface temperatures have been rising at the rate of +0.17°C (0.31°F) per decade since the 1980s, slightly ahead of the global trend[14].
- An upward trend in temperature in both Suva (+0.14°C per decade) and Nadi (+0.12°C per decade) has been observed (between 1950 to 2010), however neither of these trends were shown to be significantly significant[1].
- Ocean temperatures have risen gradually since the 1950s with the rate increasing over time and since the 1970s the rate of warming has been approximately 0.12°C per decade[1].
- At regional scales natural variability plays a large role in determining sea-surface temperature making it difficult to identify long-term trends[1].

PRECIPITATION

- Non-significant decrease in rainfall was observed in Suva between 1950 and 2009, and in Nadi for the period 1950-2009[1].

SEA LEVEL RISE

- The sea level rise near Fiji measured by satellite altimeters since 1993 is about 6 mm per year compared with the global average of 3.2 ± 0.4 mm per year. Seasonal sea levels are significantly lower during El Niño conditions and higher during La Niña conditions[1].
- The sea surface temperature from the Lautoka tide gauge indicates a warming trend of 0.05˚C/year (the tide gauge data are insufficient to deduce any long-term trend)[9].
- The mean sea level at the Lautoka tide gauge is changing at a rate of 4.6 mm/year (the tide gauge data are insufficient to deduce any long-term trend)[9].

REGIONAL CLIMATE CHANGE

MARINE SYSTEMS

- Coral reefs face threats at multiple scales ranging from global increases in oceanic temperature and ocean acidification, to local factors such as point and non-point source pollution, increased disturbance, and fishing pressure[15].
- Species diversity for both fished and non-fished species groups decreases as human population increases[15].
- In Fijian maritime boundaries, the aragonite saturation state has declined from 4.5 in the late 18th century to 3.9 in 2000 (which negatively impacts the development of corals)[1].

EXTREME EVENTS

- The north-western coastlines of both Viti Levu and Vanua Levu show the greatest risk of storm surges because they face the direction from which tropical cyclones most commonly approach Fiji[1].
- The probability of changes to the frequency and intensity of extreme rainfall events and storm surges remains poorly understood for small islands[16].

FUTURE CLIMATE PROJECTIONS

- Surface air temperature and sea-surface temperature are projected to continue to increase over the course of the 21st century [1,17].
- Beyond 2030 the projected warming in Fiji diverges depending on the greenhouse gas emissions pathway that humanity follows (see the table below)[1].

NOTE: Climate projections have been derived for Fiji by the Australian Bureau of Meteorology using the Coupled Model Intercomparison Project (CMIP3) database for up to three greenhouse gas emission scenarios: B1 (low emissions), A1B (medium emissions) and A2 (high emissions)[1].

Projected change in surface air temperature (°C) for 2030 (2020–2039), 2055 (2046–2065) and 2090 (2080–2099), relative to 1990 (1980–1999) base period for the three emission scenarios are shown below[1].

EMISSION SCENARIO	2030	2055	2090
LOW B1	+0.6 ± 0.4	+1.0 ± 0.5	+1.4 ± 0.7
MEDIUM: A1B	+0.7 ± 0.5	+1.4 ± 0.5	+2.1 ± 0.8
HIGH: A2	+0.7 ± 0.3	+1.4 ± 0.3	+2.6 ± 0.6

The CMIP3 scenarios are a product of the Inter-Governmental Panel on Climate change (IPCC) forth Assessment Report (AR4) but are considered equivalent to the more recent CMIP5 scenarios from the AR5. In regards to air temperature CMIP3 and CMIP5 have been shown to produce similar results and ranges of uncertainty by the end of the century[17]. The newest regional climate projections which are part of the CMIP6 are currently in development and result will be officially released in 2022 with the IPCC AR6.

- Wet season rainfall is projected to increase across the country over the century[1].
- An increase (>5%) in annual and seasonal mean rainfall is projected by approximately half of the CMIP3 models by as early as 2030, with the majority of models simulating a large increase (>15%) by 2090[1].
- The majority of CMIP3 models simulate little change (-5% to 5%) in wet season rainfall by 2030, however by 2090 the majority simulate an increase (>5%), with approximately one third simulating a large increase (>15%) under the A2 (high) emissions scenario[1].

FUTURE CLIMATE PROJECTIONS

- The intensity and frequency of days of extreme heat are projected to increase over the course of the 21st century[1].
- The intensity and frequency of days of extreme rainfall are projected to increase over the course of the 21st century[1].
- Projections from all analyzed CMIP3 models indicate that the annual maximum aragonite saturation state will reach values below 3.5 by about 2035 and continue to decline thereafter[1].
- The impact of acidification change on the health of reef ecosystems is likely to be compounded by other stressors including coral bleaching, storm damage and fishing pressure[1].
- Acidity levels of the ocean are expected to increase across Fiji over the course of the 21st century[1].
- The CMIP3 models simulate a rise in sea-level in Fiji between approximately 5-15 cm by 2030, with increases of 20-60 cm indicated by 2090 under the high emission scenarios[1].
- Frequency of cyclone activity in the region of Fiji is projected to decline but the intensity of the most severe cyclones is projected to increase[1,17].
- Global sea surface temperature is projected to continue to increase through the 21st century under all emissions scenarios[17].
- Elevated sea temperatures and CO2 concentrations from climate change are already contributing to large-scale ecological change across the globe[16,17].
- Devastating impacts on coral reefs between 2030 and 2050 are expected in the region as bleaching level stress is reached annually under all emission scenarios[17].
- Severe degradation and potential loss of corals from most global locations is expected by 2050 under current warming trajectories[17].
- Regional ocean oxygen levels are projected to decrease by as much as 3.5% by the end of the century under a low mitigation scenario relative to pre-industrial levels[13].

IMPACTS OF CLIMATE CHANGE

- Fijian communities are experiencing climate change impacts such as eroding shorelines and riverbanks, shortage of water, depleted fisheries stock, reduced food production, large-scale flooding, increase in outbreaks of vector borne diseases and sea level rise[6].
- Climate change constitutes one of the greatest barriers to sustainable development as it puts Fiji's biodiversity and ecosystems, particularly marine and coastal, at risk[6].
- Climate change is having a widespread impact, affecting all sectors of the economy from health, infrastructure, water resources, agriculture, forestry and fisheries[3].
- Fiji is particularly vulnerable to increased frequency and intensity of natural disasters and to sea level rise, which will have negative impacts on food security (through declines in fresh water availability, crop production and fisheries), coral reef and forest biodiversity and the prevalence of certain infectious diseases (especially those spread through contaminated water, lack of safe drinking water and unsatisfactory sanitation)[7].
- The predicted climate change and sea level rise could have profound consequences for some urban centers, agriculture and coastal development[3].
- Increases in temperature and rainfall will affect the yields of various agricultural products as well as exposure to various pests and disease[4].
- Cyclones can damage or destroy crops and trees, agricultural assets and infrastructure as well as cause the death of livestock[4].
- Cyclones and storm surges can impact the fisheries sector through damage or loss of boats, fishing equipment and aquaculture infrastructure and stock as well as through damage or destruction of coral reefs and associated coastal fisheries habitats[4].
- Flooding can inundate crops, leading to failed harvests and the death of livestock, and it can inundate aquaculture ponds, leading to damaged ponds, siltation, and loss of stock and can result in the loss of freshwater mussels and fish[4].
- Soil erosion from extreme precipitation events results in much of the country's topsoil being lost which has significant implications for long-term food and nutrition security[8].
- Over the last 16 years (2001-2016) cyclones have caused at least USD369 million in damages and losses to the agriculture sector equivalent to around FJD50 million per year on average[4].
- Increased droughts, floods and extreme events such as cyclones affect every sector of Fiji's economy and impact employment levels, the availability of natural resources and resilience[6].
- A major impact from extreme weather events is seen in the health sector where there is an observed increase in hospital admissions and treatments from injuries and infectious diseases such as diarrhea, typhoid, dengue and leptospirosis as well as an increase in malnutrition and stress related ailments[18].

February 25, 2016 - Destruction caused by tropical cyclone Winston - Viti Levu, Fiji

- Fiji is among the most vulnerable countries to health impacts of climate change[5].
- The long-term effects of climate change will affect health in the Pacific, with impacts through vector-borne disasters (such as dengue fever), water-borne diseases (especially diarrhea), and non-communicable disease sensitive to temperatures such as cardiovascular and respiratory diseases[4].
- The average losses due to tropical cyclones and floods are estimated at more than USD233 million per year, representing more than 5 percent of Fiji's GDP[4].
- Economic losses caused by Fiji's 1998 drought were estimated ab between FJD275 million and FJD300 million[4].
- Tropical cyclones and flood losses also translate into an average of 25,700 people being pushed into poverty every year in Fiji[4].
- The cost of natural hazard-induced disaster is likely to increase over the coming decades, driven by socioeconomic trends such as increasing urbanization and concentrations of development along coastlines and climate change[4].
- Climate change threatens the physical, biological, and human elements necessary for Pacific Island cultures to sustain their way of life[19].

MITIGATION & ADAPTATION TO CLIMATE CHANGE

- The adverse effects of climate change and sea level rise present significant risks to the sustainable development of SIDS and the long-term effects threaten the very existence of some small islands[3].
- Droughts, floods and extreme events such as cyclones affect every sector of Fiji's economy and impact employment levels, the availability of natural resources and resilience[6].
- Fiji was the first country to ratify the Paris Climate Change Agreement on 22 April, 2016, an Agreement dubbed as the world's greatest diplomatic success[20].
- The government of Fiji is committed to addressing the impacts of climate change on health systems including human health through its international commitments under the UN Framework Convention on Climate Change and the implementation of the People's Charter for Change, Peace and Progress (2008), the Roadmap for Democracy and Sustainable Socio-Economic Development (2010,2014), Green Growth Framework (2014) and the National Climate Change Policy (2012)[18].
- Fiji has contributed a mere 0.04% of greenhouse gas emissions (2015 est.) to the atmosphere compared to the global average[6].
- The Fijian government recognizes the importance of adapting to climate change and coordinating climate change related adaptation policies, strategies, plans, and activities to reduce the vulnerability and enhance the resilience of Fiji's communities to the impacts of climate change and disasters[6].
- Effective coordination of a multi-disciplinary approach and a well-established government position on issues and policies will need to be strengthened to effectively address the impacts of climate change[6].
- According to the Nationally Determined Contribution, the target is for the renewable energy share in electricity generation to approach 100% by 2030.
- The Fijian government has recognized that adaptation is about mainstreaming climate change into development and not a separate and parallel activity to development[8].
- To build resilience to climate change, adaptation measures will be implemented to protect freshwater aquifers from saltwater intrusion[20].
- There is a need to ensure that buildings constructed in urban and rural areas are cyclone resistant[6].
- Thousands of people are living in low-lying outer islands which are difficult and expensive to protect against sea level rise and storm surges, calling into question their viability over the long term[4].
- There is a lack of climate-resilient housing across the country and an inadequate level of insurance coverage of housing stock[4].

MITIGATION & ADAPTATION TO CLIMATE CHANGE

- Most households cannot afford house insurance and consequently must rebuild homesteads with limited personal savings and debt[4].
- Deforestation is reducing the capacity of trees to mitigate the effect of carbon emissions and poorly regulated mining activities and marine-based waste disposal further threaten natural resources[7].
- To build resilience to climate change, adaptation measures will be implemented to protect freshwater aquifers from saltwater intrusion[20].
- There is a need to ensure climate change mitigation and adaptation become a part of the national and sub national development planning and budgetary process[6].
- Resource management and conservation are essential for healthy and stable communities on islands with limited resources because overexploitation could damage or permanently destroy natural resources[19].
- To adapt to climate change, increased funding will be directed towards agriculture research into crop varieties that can be more resilient to expected changes in weather patterns[20].
- As part of Fiji's national development plan, increased risk and vulnerability to climate change, water and sewerage infrastructure will be made more climate-resilient, and freshwater resources will be protected from pollution and unsustainable use[20].

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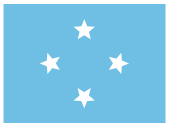
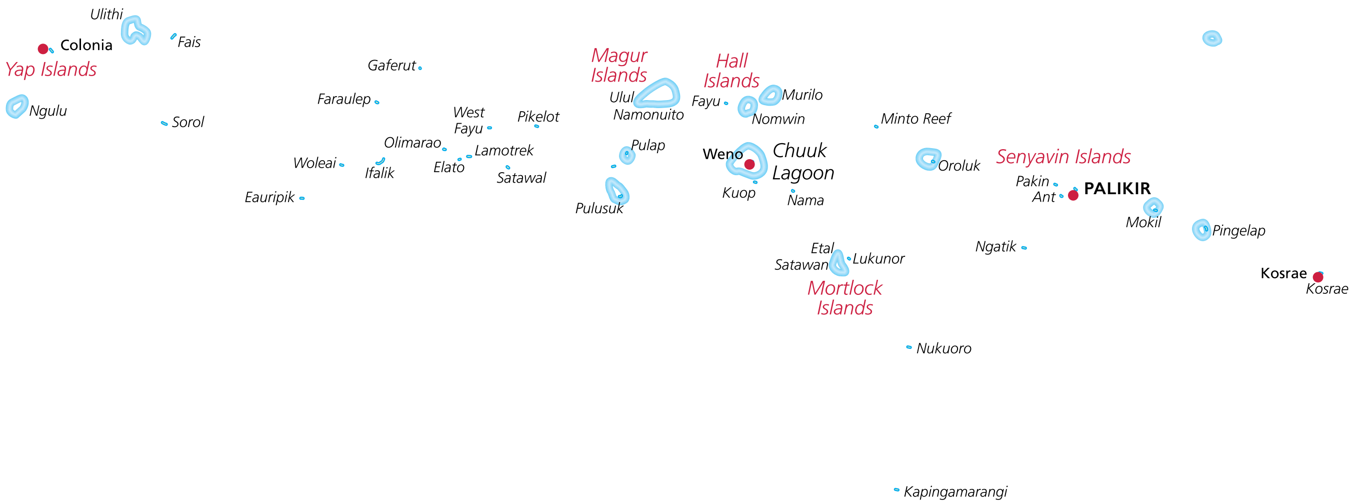
FEDERATED STATES OF MICRONESIA





GEOGRAPHY

GLOBAL CLIMATE CHANGE

REGIONAL CLIMATE CHANGE

FUTURE CLIMATE PROJECTIONS

IMPACTS OF CLIMATE CHANGE

MITIGATION & ADAPTATION TO CLIMATE CHANGE

GEOGRAPHY

- The Federated States of Micronesia (FSM) cover a vast expanse of the western Pacific ocean, spanning a distance of over 2,700 km[1].
- Geographical boundaries are located between Kosrae island in the east (5˚19' N, 162˚58' E) and Ngulu Atoll in the west (8˚18'N,137˚39' E)[1].
- The FSM consists of 607 individual islands which distributed along the northern margin of the Caroline tectonic plate.
- Overall FSM contains an exclusive economic zone of 2.98 million km^2 but only 702 km^2 of land.
- The country consists of four states, Yap, Chuuk, Pohnpei, and Kosrae (listed in order from west to east)[2].
- The FSM Include the high Islands of Kosrae and Pohnpei, the four main islands of Yap, and 16 rocky islands in the Chuuk Lagoon and over 500 low islets on the outlying atolls of the country[1].
- The largest Island is Pohnpei at 345 km[2].
- Total estimated population of the FSM based on the 2000 census is 107,000:[3]
  - Chuuk = 53,500;
  - Pohnpei = 34,500;
  - Yap = 11,200; and
  - Kosrae = 7,700.
- The Highest Elevation in the FSM is Mt Totolom on Pohnpei (791 m)[1].
- Mt Winipat on Tol island in the Chuuk Lagoon (229 m)[1].
- Mt Tabiwol on Yap (178 m)[1].
- In the FSM there is very little seasonal variation in monthly mean, maximum and minimum air temperature, with less than 1.5˚C difference between the coldest and hottest months[2].
- Sea surface temperatures around the FSM influence the seasonal variation in air temperature[2].
- The country has two distinct seasons: Dry season from November to April and Wet season from May to October[2].
- The wet season occurs when the Inter-tropical Convergence Zone is strongest and furthest north[2].
- The main extreme events that occur in the FSM are droughts, typhoons, storm waves, flooding and landslides[2].
- As of 2011 there were 23 operational observation meteorological stations in the FSM[2].
  - Hourly observations: 5 Stations in Chuuk State, 6 Stations in Pohnpei State and 3 Stations in Yap State.
  - Daily Observations: 2 Stations in Pohnpei and 7 stations in Yap.
- Climate and Sea level in FSM are strongly Modulated by El Nino Southern Oscillation[4].

Island of Kosrae, Federated States of Micronesia

- Temperatures a typically warmer during El Niño events and cooler during La Niña Events[2].
- El Niño events are associated with drier conditions and occasional droughts while La Niña events are associated with wetter conditions and an increase in the number of tropical storms[2].
- During a strong El Niño Ocean waters are cooler in FSM which reduces fishing yields as tuna are displaced eastward[5].
- During the winter and spring months following an El Niño event droughts tend to be the most extreme6. Rainfall in eastern FSM can be as much as 60% below normal after an El Niño year[5].
- Droughts are a serious concern in FSM, although these islands can have a large amount of rainfall annually, storage capacity is limited thus groundwater supplies are small[6].
- During severe drought conditions only a few large leeward islands are able to maintain a substantial freshwater lens[6].
- Typhoons can affect the FSM between June and November. Typhoon frequency varies from year to year ranging from 0 to 12 in a given year. Typhoons are more common during El Nino Years[2,5].

GLOBAL CLIMATE CHANGE

TEMPERATURE

- The 2017 average global temperature across land and ocean surface areas was 0.84˚C above the 20th century average[7].
- Third warmest year in National Oceanic and Atmospheric Administration's (NOAA) 138-year record[7].
- 2017 marks the 41st consecutive year (since 1977) with global land and ocean temperatures above 20th century average[7].
- The 6 warmest years on record have occurred since 2010[7].

SEA LEVEL RISE

- In 2016 global sea level was 82 mm above the 1993 average[8].
- Sea level rises at a rate of just over 3.4 mm per year due to a combination of melting glaciers and ice sheets and from the thermal expansion of seawater[8].
- The rate of sea level rise has doubled since 1993 compared to the century average[8].

OCEAN ACIDIFICATION AND TEMPERATURE

- Oceans are absorbing about 25% of the carbon dioxide emitted to the atmosphere annual and as a result are becoming more acidic[9].
- The world's oceans have absorbed about 93% of the excess heat caused by greenhouse gas warming since the mid-20th century[10].
- Ocean heat content has increased at all depths[10].
- Increasing sea surface temperatures, rising sea levels, changing patterns of precipitation and winds, and ocean circulation are contributing to overall decline oxygen concentrations in the oceans[10].

MICRONESIA

REGIONAL CLIMATE CHANGE

TEMPERATURE

- Averaged as a whole, Oceania had its sixth warmest year since continental records began in 1910[7].
- Record warmest temperatures occurred in equatorial western pacific encompassing the area of containing the FSM[7].
- Increases in annual and seasonal (wet and dry) maximum, minimum, and mean surface air temperatures have been observed in both Pohnpei and Yap over 60 year period (1950-2009)[2].
- Annual mean air temperatures have increased (~0.5 - 1˚C) across the FSM since 1951[11].
- Mean temperatures on Yap and Pohnpei have been increasing at a rate of +0.11˚C and +0.12˚C per decade (respectively)[2].
- Maximum temperatures on Yap Island have increased at a rate of +0.18˚C per decade during the dry season[2].

PRECIPITATION

- A 15% decline in annual rainfall has been observed in the eastern-most islands of FSM[9].
- Precipitation patterns are highly regionalized, often with local variations in those regions. Average annual rainfall amounts over the last 50 years indicate that western Micronesia is getting wetter while eastern Micronesia is trending drier[12].
- In Pohnpei, decreases in annual (-68 mm decade-1), wet season (-52 mm decade-1) and dry season (-26 mm decade-1) rainfall have been observed since 1950[2].
- In Yap, a decrease in annual (-3 mm decade-1) and dry season (-15 mm decade-1) rainfall, and increases in wet season (+14 mm decade-1) rainfall have been observed since 1950[2].

SEA LEVEL RISE

- Satellite data indicate sea level has risen in the FSM by over 10 mm per year since 1993 which is larger than the global average of 3.2 mm per year[2].
- Seasonal sea levels are significantly lower during El Niño conditions and higher during La Niña conditions[2].

MICRONESIA

REGIONAL CLIMATE CHANGE

CORAL REEFS

- Over the last 25 years coral bleaching heat stress has dramatically increased across the Pacific Ocean with pronounced bleaching found in FSM. Eastern and Western portions of FSM have experienced a 58% and 28% increase in the number of days with ocean heat stress over this time period (respectively)[12].

EXTREME EVENTS

- The probability of changes to the frequency and intensity of extreme rainfall events and storm surges remains poorly understood for small islands[13].

FUTURE CLIMATE PROJECTIONS

MICRONESIA

- Beyond 2035 the projected warming diverges depending on the path that humanity follows 1.6-4.3˚C by 2100[11].
    - High emission 2030 +0.4 – 1.1 ˚C2
    - High emission 2055 +1.0 – 1.8 ˚C2
    - High emission 2090 +2.1 – 3.5 ˚C2
- Most global models project an increase in average and seasonal rainfall over the course of the 21st century[2].
- Droughts are projected to become less frequent throughout this century[2].
- More extreme rainfall days are likely to occur[2].
- Less frequency but more intense typhoons in the region[2].
- Sea surface temperate is projected to continue to increase through the 21st century under all emissions scenarios[11].
- Devastating impacts on coral reefs between 2030 and 2050 as bleaching level stress is reached annually under all emission scenarios[11].
- Severe degradation and potential loss of corals from most global locations by 2050 under current warming trajectories[11].
- Acidity levels of the ocean are expected to increase across FSM[2].
- Mean sea-level is projected to continue to rise over the course of the 21st century[2].
- There is a greater than 90% chance that global mean sea level will rise at least 0.2 m but no more than 2 m by 2100[8].
- Oxygen levels are projected to decrease by as much as 3.5% by the end of the century under a low mitigation scenario relative to pre industrial levels[10].

MICRONESIA

IMPACTS OF CLIMATE CHANGE

- Small island communities are at greater risk from sea level rise in comparison with other geographic areas because most of their population and infrastructure are in the coastal zone[13].
- More intense rainfall has the potential to increase flooding, damage crops and move pollutants into coastal waters[2].
- In FSM seawater contaminated aquifers, wells have destroyed nearly half of the nation's croplands[4].
- FSM is among the top five countries that will be most impacted by sea level rise by the end of the century[13].
- Higher sea surface temperatures, will increases coral bleaching leading to a change in coral species composition, coral disease, coral death, and habitat loss[6].
- Open ocean fisheries will be affected negatively over the long term[6].
- Climate driven health risks from the spread of infectious disease, loss of settlements and infrastructure, and decline of ecosystems that affect small island economies and livelihoods, and human well-being are under researched[13].
- Climate change related migration is particularly relevant to low island communities in FSM and presents significant practical, cultural and legal challenges[9].
- The impact of increased acidification on the health of the reef ecosystem is likely to be compounded by other stressors including coral bleaching, storm damage and fishing pressure[2].
- It is unclear whether climate change will lead to an increased frequency in storms, however there is a wide agreement that the intensity of storms will increases as ocean waters warm[11].
- In 2015, Super Typhoon Maysak, was responsible for 4 deaths and 10 injuries in FSM and caused an estimated USD8.5 million in damages[14].
- Climate change threatens the physical, biological, and human elements necessary for Pacific Island cultures to sustain their way of life[6].

MITIGATION & ADAPTATION TO CLIMATE CHANGE

- FSM contribution to climate change has always been marginal[15].
- Commitment to reduce 28% of greenhouse gas emissions by 2025 below 2000 levels[15].
- Additional reductions up to 35% below 2000 levels are subject to the availability of additional financial, technical and capacity building support from the international community[15].
- Resource management and conversation are essential for healthy and stable communities on islands with limited resources because overexploitation could damage or permanently destroy resources[6].

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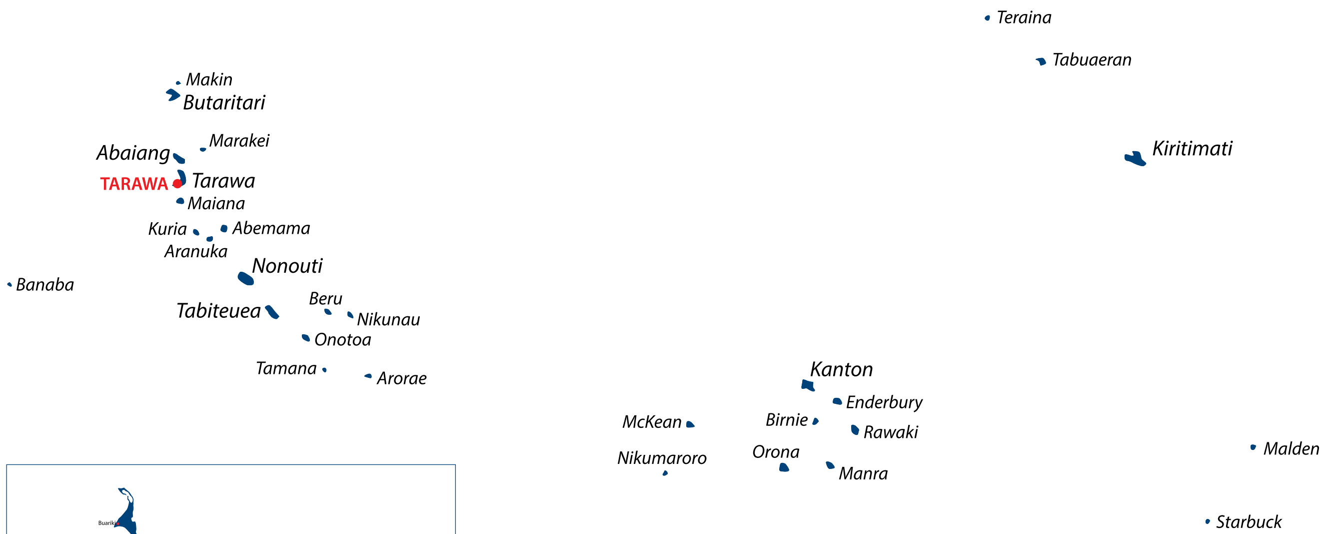
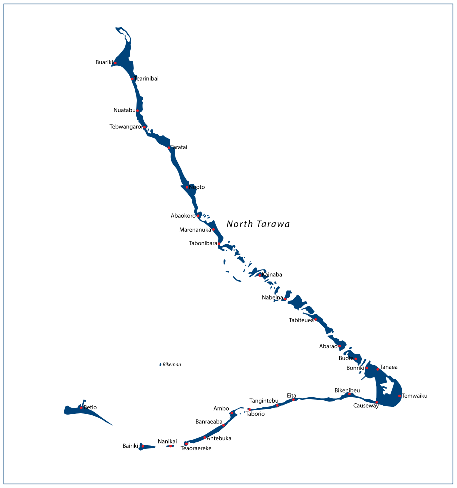
KIRIBATI





GEOGRAPHY

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KIRIBATI

GEOGRAPHY

- The island nation of Kiribati is located near the Equator in the central Pacific Ocean between 5N - 12°S latitude and 168E - 152°W longitude[1].
- Kiribati has a total land area of 801.8 km^2 and an exclusive economic zone of 3.5 million km^2[(2)].
- The distance between the most westerly situated Island and the most easterly situated island is 4000 km [(3)] (which is East to West distance across Australia).
- Kiribati consists of 32 low lying atolls and one raised limestone island[1].
- Kiribati has three island chains: the Gilbert (17 islands), Phoenix (8 islands) and Line Islands (8 islands)[2].
- The Gilbert Islands (in Western Kiribati) border the Marshall Islands to the North, Nauru to the West and Tuvalu to the South. The Phoenix Islands (in central Kiribati), has Tokelau to the south and the Line Islands (in the East of Kiribati) have French Polynesia to the south and Hawaii to the north[2].
- Banaba (Ocean Island), about 450 km to the west of the main Gilbert Group, is a raised coral island, 6.5 km^2 in area and with a maximum elevation of 87m [(2)].
- The rest of the islands are no more than 3-4 meters above sea level1 at their highest points.
- The Phoenix Islands are uninhabited (except for a handful of caretakers on Kanton Island) and are one of the largest marine parks in the world[4].
- Of the Line Islands, only Kiritimati Island, Tabuaeran Island and Teeraina Island are presently inhabited[2].
- Kiritimati (Christmas Island) in the Line Islands is the world's largest coral atoll, with an area of 327 km^2, which represents almost half the total land area of Kiribati[2].
- The capital of Kiribati is South Tarawa in the Gilbert Islands[4].
- Kiribati is one of the few nations in the world that consists almost entirely of coral atolls which makes it extremely vulnerable to the adverse impacts of climate change[5].
- Kiribati's sandy islands have few natural resources including water and are prone to drought[5].
- The islands of Kiribati have very harsh conditions for plants and this has resulted in a flora of approximately 306 species of which only 83 may be indigenous[2] and there are few, if any, endemic species4.
- Despite the limitations of land, soil and freshwater resources, the people of Kiribati have developed sophisticated subsistence agricultural systems based mainly on coconut, breadfruit, pandanus and swamp taro[4].
- The estimated population of Kiribati in 2017 was 116,000[6].
- In all, 48.7% of the population lives in the capital of South Tarawa, which has a population density of 3,173 people per square kilometer[4].

GEOGRAPHY

KIRIBATI

- South Tarawa provides opportunities for cash employment and consumption as well as access to higher education and specialist social services not available elsewhere in Kiribati which has led to population growth of 5.2% in recent years into both North and South Tarawa[7].
- Population pressures have resulted in overcrowding that is putting stress on housing, land management, crucial public infrastructure and the natural environment including underground water reserves[5].
- The high population of South Tarawa, particularly on Betio (the largest township in South Tarawa), has created significant socioeconomic and environmental problems (such as water and sanitation, scarcity of land space, lagoon pollution and rubbish) and is a key driver of over-fishing in the Tarawa lagoon[8].
- Some 18% of the population is in permanent employment, and over half of these work for the government[7].
- The population of Kiribati is expected to reach 130,000 by 2025[8].
- The latest Kiribati National Disability Survey identified 11,863 people living with disabilities in 2015 which represents 9% of the of the population ages five and up[9].
- Gross Domestic Product (GDP) was AUD206.4 million in 2014 but GDP per capita was among the lowest of all Pacific countries[5].
- The public sector dominates Kiribati's economy and provides two-thirds of all formal sector employment and accounts for almost 50% of GDP[4].
- In 2015 the Republic of Kiribati was ranked 170th of 186 countries on per capita GDP[7].
- Poverty and hardship are widespread with 21.8 percent of the population under the Basic Needs Poverty Line in 2006[5]: South Tarawa 22.4% highest, and Line and Phoenix Islands 8.9%.
- As an atoll country, Kiribati is almost entirely dependent upon imported food and fuel and subsistence farming and fishing are the primary economic activities[7].
- The majority of the population residing on the rural islands of Kiribati depend on agricultural food crops from coconut breadfruit, pawpaw (papaya) trees, babai (taro) and other crops[10].
- Fisheries play a crucial role in ensuring sustainable food and supplementary of protein nutrients to people of Kiribati, their means of livelihood and source of revenue for economic growth and employment[10].
- In 2017, Kiribati was ranked the 15th most at-risk country to natural disasters in the world[11].
- Kiribati is characterized by the United Nations as a Least Developed Country and a Small Island Developing State (SIDS) that has made a marginal contribution to the climate change catastrophe, yet is extremely vulnerable to climate change impacts[7].
- General population growth and health issues are contributing to the loss of productivity and increasing marginalization and vulnerability[5].

GEOGRAPHY

KIRIBATI

- Environmental factors, including the challenge of climate change, and agriculture food production, impact people's daily lives and well-being[5].
- As of 2010, there were five operational observation meteorological stations in Kiribati[1].
- Tarawa, the primary station is in the Gilbert Islands and Kiritimati Atoll is the primary station in the Line Islands[1].
- All five operational stations, including Banaba and Tabuaeran, have rainfall records which began between 1909 and 1945 and Tarawa have rainfall records form 1950 and are 95% complete[1].
- The southern Gilbert Islands and the Phoenix Islands have a dry maritime equatorial climate, whereas those islands situated further north have a more humid tropical climate[2].
- Average temperatures range between 24° and 30°C across the country are relatively constant throughout the year and are closely related to sea-surface temperatures[1,2].
    - The country has two distinct seasons: Dry season from June-November (te Au Maiaki) and Wet season from December-July (te Au Meang). Driest month is October and wettest month is January (268 mm).
    - At Kiritimati in the Eastern part of the country wet season extends from January to June with the wettest months in March and April.
- The annual rainfall is extremely variable, not only between islands but also from year to year[2].
- The average annual rainfall in the Gilbert Islands ranges from 1,000 mm/yr in the vicinity of the equator to over 3,100 mm in the northern islands[2].
- In the Phoenix Islands, most islands receive an annual rainfall in the range 750 -1,300 mm, while in the Line Islands, the annual rainfall ranges between 690 mm on Malden Island to 2,900 mm on Teeraina Island[2].
- Kiritimati Island, situated on the border between the wet and dry belts north of the equator, is relatively dry in most years[2].
- Banaba, the southern Gilberts and the Phoenix Islands are subject to periodic droughts when as little as 200 mm of rain may fall in one year[2].
- Year-to-year natural climate variability is high in Kiribati and is explained by the El Niño Southern Oscillation (ENSO)[1].
- There are significant correlations between ENSO indices and both rainfall and air temperature in Kiribati[1].
- Generally, El Niño years are drier than average while La Niña years are wetter than average[1].
- In the driest years Tarawa received as little as 150 mm, while in the wettest years more than 4,000 mm fell[1].

Tarawa, Kiribati

- In both Tarawa and Kiritimati, rainfall and maximum temperatures are much higher during El Niño and much lower during la Niña years[1].
- Drought, usually associated with La Niña Events, is occasionally severe in Kiribati[1].
- From 2007-2009 a drought severely affected water supply in the southern Gilberta Islands and Banaba Island. During this period ground water turned brackish and leaves of most plants turned yellow, copra production declined, ground water brackish and the leaves of most plants turned yellow[1].
- Kiribati rarely experiences cyclones due to its position in the equatorial belt and only three tropical cyclones rarely passed within 400 km of the Kiribati islands between 1970 to 2010.
- In March 2015, parts Kiribati experienced flooding and destruction of seawalls and coastal infrastructure as the result of Cyclone Pam, a Category 5 cyclone that devastated Vanuatu[7].

GLOBAL CLIMATE CHANGE

KIRIBATI

TEMPERATURE

- The 2018 average global temperature across land and ocean surface areas was 0.84˚C above the 20th century average[12].
- 2018 was the fourth warmest year in the 1880–2018 record, behind 2016 (highest), 2015 (second highest), and 2017 (third highest)[12].
- 2018 was the second warmest year on record without an El Niño present in the tropical Pacific Ocean[12].
- 2018 marks the 42nd consecutive year (since 1977) with global land and ocean temperatures above 20th century average[12].
- Nine of the 10 warmest years have occurred since 2005[12].
- The 2018 globally averaged sea surface temperature was 1.19°F (0.66°C) above the 20th century average[12]. This was the fourth highest among all years in the 1880-2018 record, again behind 2016 (highest) and 2015 (second highest) and 2017 (third highest)[12].

SEA LEVEL RISE

- In 2017 global sea level was 77 mm above the 1993 average, which is the highest annual average in the satellite record[13].
- 2017 was the sixth consecutive year, and the 22nd out of the last 24 years in which global mean sea level increased relative to the previous year[13].
- Global average sea level rises at a rate of just over 3.1 mm per year due to a combination of melting glaciers and ice sheets and from the thermal expansion of seawater[13].
- The rate of sea level rise has doubled since 1993 compared to the 20th century average[13].

OCEAN ACIDIFICATION AND TEMPERATURE

- Oceans are absorbing about 25% of the carbon dioxide emitted to the atmosphere annually and as a result are becoming more acidic[14].
- The world's oceans have absorbed about 93% of the excess heat caused by greenhouse gas warming since the mid-20th century[15].
- Ocean heat content has increased at all depths[15].
- Increasing sea surface temperatures, rising sea levels, changing patterns of precipitation and winds, and ocean circulation are contributing to overall decline oxygen concentrations in the oceans[15].

REGIONAL CLIMATE CHANGE

KIRIBATI

TEMPERATURE

- Averaged as a whole, Oceania had its third warmest year in 2018 since regional records began in 1910[12].
- Much warmer than average temperatures occurred in equatorial western pacific encompassing the geographic area of containing the country of Kiribati[12].
- In the Pacific region, land-surface temperatures have been rising at the rate of +0.17°C (0.31°F) per decade since the 1980s, slightly ahead of the global trend[16].
- An upward trend in temperature of +0.18 C per decade (Not Significant) has been observed in Tarawa (between 1950 to 2010)[1].
- Ocean temperatures have risen gradually since the 1950s with the rate increasing over time and since the 1970s the rate of warming has been approximately 0.12°C per decade[1].
- At regional scales natural variability plays a large role in determining sea-surface temperature making it difficult to identify long-term trends[1].

PRECIPITATION

- In both Tarawa and Kiritimati positive annual rainfall tend for the period 1950-2009 have been observed between 1950 to 2009)[1].
- A statistically significant increase of 115 mm per decade was observed on Kiritmati Island between 1950 to 2009)[1].

SEA LEVEL RISE

- The sea level rise near Kiribati measured by satellite altimeters since 1993 ranges from 1-4 mm per year, compared with the global average of 3.2 ± 0.4 mm per year. Seasonal sea levels are significantly lower during El Niño conditions and higher during La Niña conditions[1].

KIRIBATI

REGIONAL CLIMATE CHANGE

MARINE SYSTEMS

- Coral reefs face threats at multiple scales ranging from global increases in oceanic temperature and ocean acidification, to local factors such as point and non-point source pollution, increased disturbance, and fishing pressure[17].
- Species diversity for both fished and non-fished species groups decreases as human population increases[17].
- In Kiribati aragonite saturation state has declined from 4.5 in the late 18th century to 3.9 in 2000 (which is not optimal for coral growth)[1].

EXTREME EVENTS

- The probability of changes to the frequency and intensity of extreme rainfall events and storm surges remains poorly understood for small islands[18].

FUTURE CLIMATE PROJECTIONS

- Surface air temperature and sea-surface temperature are projected to continue to increase over the course of the 21st century[1,19].
- Beyond 2030 the projected warming in Kiribati diverges depending on the greenhouse gas emissions pathway that humanity follows (see the table below). NOTE: Climate projections have been derived for Kiribati by the Australian Bureau of Meteorology using the Coupled Model Intercomparison Project (CMIP3) database for up to three greenhouse gas emission scenarios: B1 (low emissions), A1B (medium emissions) and A2 (high emissions)[1].

Projected change in surface air temperature (°C) for 2030 (2020– 2039), 2055 (2046–2065) and 2090 (2080–2099), relative to 1990 (1980– 1999) base period for the three emission scenarios are shown below[1].

EMISSION SCENARIO	2030	2055	2090
LOW B1	+0.7 ± 0.5	+1.3 ± 0.6	+1.7 ± 0.7
MEDIUM: A1B	+0.8 ± 0.6	+1.6 ± 0.7	+2.6 ± 0.9
HIGH: A2	+0.8 ± 0.5	+1.6 ± 0.6	+3.0 ± 0.8

The CMIP3 scenarios are a product of the Inter-Governmental Panel on Climate change (IPCC) forth Assessment Report (AR4) but are considered equivalent to the more recent CMIP5 scenarios from the AR5. In regards to air temperature CMIP3 and CMIP5 have been shown to produce similar results and ranges of uncertainty by the end of the century[19]. The newest regional climate projections which are part of the CMIP6 are currently in development and result will be officially released in 2022 with the IPCC AR6.

- Wet and dry season rainfall are projected to increase over the century[1].
- An increase (>5%) in annual and seasonal mean rainfall is projected by approximately half of the CMIP3 models by as early as 2030, with the majority of models simulating a large increase (>15%) by 2090[1].
- The intensity and frequency of days of extreme heat are projected to increase over the course of the 21st century[1].

FUTURE CLIMATE PROJECTIONS

KIRIBATI

- The intensity and frequency of days of extreme rainfall are projected to increase over the course of the 21st century[1].
- Projections from all analyzed CMIP3 models indicate that the annual maximum aragonite saturation state will reach values below 3.5 by about 2045 in the Gilbert Islands, by about 2030 in the Line Islands, and 2055 in the Phoenix Islands. The aragonite saturation will continue to decline thereafter.
- The impact of acidification change on the health of reef ecosystems is likely to be compounded by other stressors including coral bleaching, storm damage and fishing pressure[1].
- Acidity levels of the ocean are expected to increase across Kiribati over the course of the 21st century[1].
- The CMIP3 models simulate a rise in sea-level of between approximately 5-14 cm by 2030, with increases of 20-58 cm indicated by 2090 under the high emission scenarios[1].
- Frequency of cyclone activity in the region of Kiribati is projected to decline but the intensity of the most severe cyclones is projected to increase[1,19].
- Global sea surface temperature is projected to continue to increase through the 21st century under all emissions scenarios[19].
- Elevated sea temperatures and CO2 concentrations from climate change are already contributing to large-scale ecological change across the globe[18,19].
- Devastating impacts on coral reefs between 2030 and 2050 are expected in the region as bleaching level stress is reached annually under all emission scenarios[19].
- Severe degradation and potential loss of corals from most global locations is expected by 2050 under current warming trajectories[19].

IMPACTS OF CLIMATE CHANGE

- Climate change threatens the physical, biological, and human elements necessary for Pacific Island cultures to sustain their way of life[20].
- Climate change threatens the sustainability of economic development in Kiribati5.
- Sea level rise and exacerbated natural disasters such as drought and weather fluctuations pose significant and direct additional threats to sectors and resources central to human and national development[7].
- Wave inundation and erosion are frequent impacts of climate change destroying key areas of land and contaminating the fresh groundwater lens which is vital for the population's water security[7].
- Sea level rise and exacerbated natural disasters such as drought and weather fluctuations pose significant and direct additional threats to sectors and resources central to human and national development[7].
- The results of sea level rise and increasing storm surge threaten the very existence and livelihoods of large segments of the population, increase the incidences of water-borne and vector-borne diseases undermining water and food security and the livelihoods and basic needs of the population, while also causing incremental damage to buildings and infrastructure[7].
- Two small uninhabited Kiribati islets, Tebua Tarawa and Abanuea, disappeared underwater in 1999[7].
- In the long-term, the most serious concern is that sea-level rise will threaten the very existence of Kiribati as a nation. But in the short- to medium-term, a number of other projected impacts are of immediate concern. Of particular note is the concern as to whether the water supply and food production systems can continue to meet the basic needs of the rapidly increasing population of Kiribati[7].
- The effects of climate change are felt first and most acutely by vulnerable and marginalized populations, including women, children, youth, people with disabilities, minorities, the elderly and the urban poor[7].
- Agricultural systems and production in Kiribati are likely to be undermined by future climate change due to the effects of erosion, increased contamination of groundwater, storm surges, heat stress and droughts[10].
- While lagoon and coastal fisheries currently provide sufficient protein for most I-Kiribati (people native to Kiribati), there is a real challenge to long-term food security from population pressures, the problem of overfishing, if it is not managed and controlled at a sustainable level, the impacts of climate change and increases in global food prices[8].

KIRIBATI

IMPACTS OF CLIMATE CHANGE

- Climate change would result in alterations to water temperatures, currents, and marine food chains, which can affect location and abundance of tuna species[8].
- Rising sea surface temperatures and more acidic oceans will likely impact on the growth of hard corals (and their complex fish habitats) leading to a decline in coral reefs and coastal fisheries and a decrease in food security[8].
- More powerful storms are predicted, with increased risks of damage to wharfs and essential infrastructure which creates higher financial risks for coastal aquaculture due to more frequent damage to equipment[8].
- As a result of climate change, coastal erosion, sea water intrusion into the fresh water lenses, destruction of trees that are important sources of food, medicines and building materials, and the destruction of settlements due to higher king tides and storm surges, accompanying higher mean sea levels, are threatening the sustainable survival of human societies on the atoll islands of Kiribati[21].
- Climate change is also having detrimental effects on important cultural heritage in Kiribati, including customary practices, traditional knowledge and native languages[21].

MITIGATION & ADAPTATION TO CLIMATE CHANGE

- Kiribati's contribution to global warming is insignificant with emissions per capita among the lowest in the world[7].
- According to its Nationally Determined Contribution, the Government of Kiribati has committed to reduce emissions by 13.7% by 2025 and with appropriate international assistance, Kiribati can reduce its emissions by more than 60% by 2030[7].
- Kiribati will proactively protect and sustainably manage its mangrove resources, as well as protect and enhance coastal vegetation and seagrass beds[7].
- The Kiribati government, along with governments of other countries comprising low-lying atolls and reef islands, has placed considerable emphasis on strategies to manage problems caused by climate change, especially the prospect of higher sea levels[21]. For example, the Joint Implementation Plan on Climate Change and Disaster Risk Management was released in August 2014. Its goal is to reduce vulnerabilities to the impacts of climate change and disaster risk[4]. In addition, the Government of Kiribati has developed a Climate Change and Climate Risk Communications Strategy 2013-2016 to increase awareness and understanding of climate change and the risks involved[5].
- Current adaptation programs are underway, among others, to install alternative rainwater harvesting facilities and identification of unused water lenses on outer-islands for protection and proper management[10].
- The National Framework for Climate Change and Climate Change Adaptation (April 2013) establishes a framework for an effective national response to address the impacts of climate change that requires that climate change and climate change adaptation assume a prominent role within the national development planning process[7].
- The protection of fragile water resources and improvement of Fresh water supply has been supported under the coordinated efforts of the World Bank funded Kiribati Adaptation Program Phase III, Kiriwatsan and the USAID/Secretariat of the Pacific Regional Environment Program (SPREP) support to climate change adaptation initiative[5].
- Only a few sectors have transferred strategic actions to address climate and disaster risks into their annual Sector Operational Plans and Ministerial Plans of Operations and budgeting[4].
- Resource management and conservation are essential for healthy and stable communities on islands with limited resources because overexploitation could damage or permanently destroy natural resources[20].
- Local protection from overfishing and pollution may enhance ecosystem resilience to warm episodes and coral bleaching that result from global warming[22].
- Research has shown that climate driven health risks from the spread of infectious disease, loss of settlements and infrastructure, and decline of ecosystems that affect small island economies and livelihoods, and human well-being are under researched[18].

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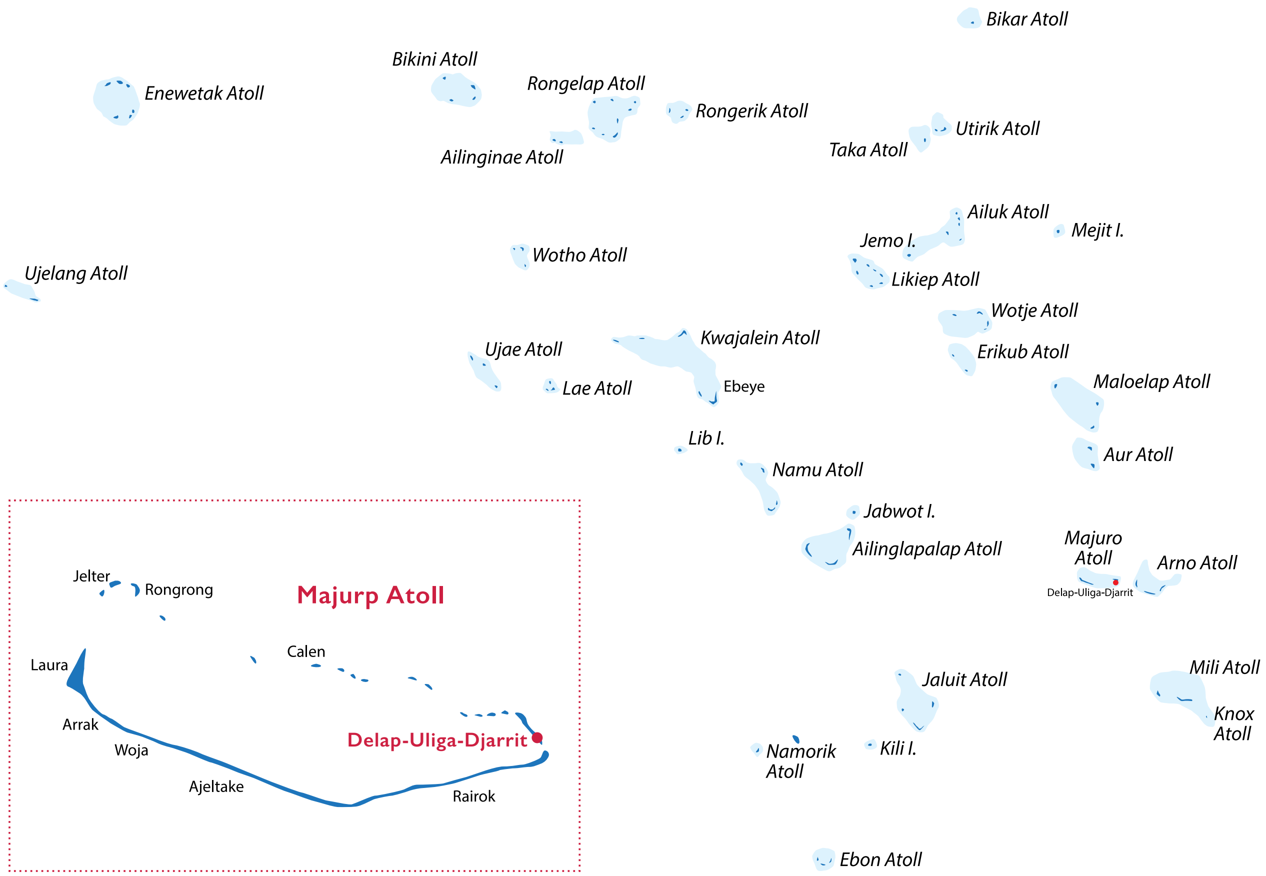
REPUBLIC OF THE MARSHALL ISLANDS



GEOGRAPHY

GLOBAL CLIMATE CHANGE

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GEOGRAPHY

MARSHALL ISLANDS

- The Marshall islands lay north of the equator in the western North Pacific Ocean between 4 -14°N latitude and 160 - 173°E longitude[1].
- The Republic of the Marshall Islands (RMI) consists of 29 individual low-lying atolls and islands grouped in two parallel chains[1].
- The Ratak (sunrise) chain is to the east[1].
- The Ralik (sunset) chain is to the west[1].
- Total land area of RMI is 181 km^2 which forms the country's exclusive economic zone1 and not one point in the country is farther than 1 km from the sea[2].
- All of the islands and atolls are low lying and the highest point is 10 m above sea level[3].
- Total estimated population of the RMI (based on the 2010 census) is 53,1584 and the capital city of Majuro is the most populated atoll with 52% of the country's population[5].
  - Majuro Island population = 27,797[4]
  - Kwajalein atoll population= 11,408[4]
- Kwajalein atoll, in the Ralik chain, is the largest atoll on the planet[3].
- Agricultural production in RMI is concentrated on the atolls away from Majuro and Kwajalein, with from coconuts and breadfruit representing the major crops[3].
- No Marshallese word refers to what Westerners would consider meteorological conditions[2]. Translating the word "climate" into Marshallese (mejatoto) implies environment, the cosmos, nature, and cultures as well as weather and climate[2].
- In the RMI there is very little seasonal variation in monthly mean (average), maximum and minimum air temperature, with less than 1˚C difference between the coldest and hottest months[1].
- The country has two distinct seasons[1]:
  - Dry season from Tijōba (December) to Eprōl (April).
  - Wet season from Māe (May) to Nobōm̧ba (November).
- The climate is moist and tropical and is heavily influenced by the northeast trade wind belt[5].
- The Köppen-Geiger classification is "Af" (Tropical Rainforest): Temperature of the coolest month 18 C or higher and precipitation in the driest month at least 60 mm[6].
- The Inter-Tropical Convergence Zone brings rainfall throughout the year however it is strongest and furthest north during the wet-season[1].
- Annual rainfall varies considerably from north to south with the Southern Atolls receiving 300-340 cm/yr. and the Northern Atolls receiving 175 cm/yr.[5]

GEOGRAPHY

- Droughts and storm waves are the main extreme events that impact the Marshall Islands[1].
- As of 2015 there were nine operational observation meteorological stations in the RMI[5].
    - Multiple observations within a 24-hour period are taken at eight of these stations (Majuro, Utirik, Ailinglaplap, Jaluit, Wotje, Mili, Amata Kabua International Airport and Kwajalein) and single day observation is taken at Laura and Arno[5].
    - Meteorological data for Majuro and Kwajalein atolls from the mid-1950's to present are available from the National Oceanic Atmospheric Administration National Weather Service Hydrometeorological Design Studies Center.
    - Tidal data for Majuro from 1993 to present are available through the South Pacific Sea Level and Climate Monitoring Project maintained by the Australia Bureau of Meteorology as well as the University of Hawai'i Sea Level Center from 1968 to 1999[5].
- The main influence of year-to-year natural climate variability in the Marshall Islands is the El Niño Southern Oscillation (ENSO)[1].
- Temperatures are typically warmer during El Niño events and cooler during La Niña Events[1].
- El Niño events are associated with drier conditions and occasional droughts while La Niña events are associated with wetter conditions and an increase in the number of tropical storms[1].
- Variations in the ENSO cycle are a strong and predictive driver of meteorological drought in RMI[3].
    - During the winter and spring months following an El Niño event droughts tend to be the most extreme[7].
    - During a severe El Niño, rainfall can be suppressed by as much as 80% in RMI[1].
    - Periods of very low rainfall and droughts of 1965, 1970, 1977, 1983, 1992 and 1998 correlate with the El Nino events of 1965-1966, 1969-1970, 1976-1977, 1982-1983, 1991-1992 and 1997-1998[8].
    - One of the strongest El Niño events recorded in history occurred during 2015-2016, which resulted in severe drought in RMI[9].
- Although RMI can have a large amount of rainfall annually, storage capacity is limited, thus groundwater supplies are small[7].
- It has been estimated that due to evaporation only 50% of the rain falling on Majuro actually contributes to recharging the freshwater lens beneath the island3 thus droughts are a serious concern in RMI.
- Tropical cyclones (Typhoons) usually form between September and November but are often weak when the pass through the region[1].

GLOBAL CLIMATE CHANGE

MARSHALL ISLANDS

TEMPERATURE

- The 2017 average global temperature across land and ocean surface areas was 0.84˚C above the 20th century average[10].
- 2017 was the third warmest year in National Oceanic and Atmospheric Administration's 138-year record behind the record year 2016 (+0.94°C) and 2015 (+0.90°C) both influenced by a strong El Niño[10].
- 2017 was the warmest year on record without an El Niño present in the tropical Pacific Ocean[10].
- 2017 marks the 41st consecutive year (since 1977) with global land and ocean temperatures above 20th century average[10].
- The six warmest years on record have occurred since 2010[10].

SEA LEVEL RISE

- In 2016 global sea level was 82 mm above the 1993 average[11].
- Sea level rises at a rate of just over 3.4 mm per year due to a combination of melting glaciers and ice sheets and from the thermal expansion of seawater[11].
- The rate of sea level rise has doubled since 1993 compared to the 20th century average[11].

OCEAN ACIDIFICATION AND TEMPERATURE

- Oceans are absorbing about 25% of the carbon dioxide emitted to the atmosphere annually and as a result are becoming more acidic[12].
- The world's oceans have absorbed about 93% of the excess heat caused by greenhouse gas warming since the mid-20th century[13].
- Ocean heat content has increased at all depths[13].
- Increasing sea surface temperatures, rising sea levels, changing patterns of precipitation and winds, and ocean circulation are contributing to overall decline oxygen concentrations in the oceans[13].

REGIONAL CLIMATE CHANGE

MARSHALL ISLANDS

TEMPERATURE

- Averaged as a whole, Oceania had its 6th warmest year in 2017 since regional records began in 1910[10].
- Record warmest temperatures occurred in equatorial western pacific encompassing the geographic area of containing the RMI[10].
- In the Pacific region, land-surface temperatures have been rising at the rate of +0.17°C (0.31°F) per decade since the 1980s, slightly ahead of the global trend. Since 2005, nearly all surface stations have seen annual temperature anomalies above the long-term average[14].
- Warming trends of a similar magnitude are evident in both annual and seasonal mean air temperatures at Majuro (1956-2009). Annual and seasonal minimum air temperature trends are stronger than those for maximum air temperature[1].

PRECIPITATION

- A statistically significant 15% decrease in annual rainfall was reported for RMI (1954-2011)[7] (Note: Statistically significant is the likelihood that a relationship between two or more variables is caused by something other than chance: In this example the variables are rainfall and time).
- In RMI, dry season trends in rainfall are negative and statistically significant and wet season trends are also negative but not significant[1].
- The 2015-2016 total rainfall at Majuro form October 2015 to July was the driest 10-month period in the 62-year historical record[3].

SEA LEVEL RISE

- Regional and local sea level trends may differ significantly from the globally averaged rate over multiyear to multidecadal time scales (since 1990 as low as 1.1 mm/yr. at the Honolulu tide gauge and as high as 5.4 mm/yr. at the Kwajalein tide gauge)[14].
- The sea level rise in Kwajalein 5.4 mm/yr. is 2 mm/yr. greater than the global average[14].
- Over the past 100 years the sea level in Kwajalein has risen 21.9 cm[14].
- Seasonal sea levels are significantly lower during El Niño conditions and higher during La Niña conditions[1].

Kwajalein Atoll, Marshall Islands

CORAL REEFS

- Extended periods of bleaching heat stress (greater than 8 days exposed heat stress) did not occur in the Marshall islands until 2014[14].
- Days exposed to coral bleaching heat stress in RMI have increased from 11 days per year (1982-91) to 25 days per year (2007-2016) which is a 128% in crease[14].

EXTREME EVENTS

- The probability of changes to the frequency and intensity of extreme rainfall events and storm surges remains poorly understood for small islands[15].

FUTURE CLIMATE PROJECTIONS

- Beyond 2035 the projected warming diverges depending on the greenhouse gas emissions pathway that humanity follows (In RMI; 1.4 - 3.5˚C by 2090; see table below)[1]. Climate projections have been derived for RMI by the Australian Bureau of Meteorology using the Coupled Model Intercomparison Project (CMIP3) database for up to three greenhouse gas emission scenarios: B1 (low emissions), A1B (medium emissions) and A2 (high emissions)[1].

Projected change in surface air temperature (°C) for 2030 (2020–2039), 2055 (2046–2065) and 2090 (2080–2099), relative to 1990 (1980–1999) base period for the three emission scenarios are shown below[1].

EMISSION SCENARIO	2030	2055	2090
LOW B1	+0.6 ± 0.4	+1.0 ± 0.5	+1.5 ± 0.7
MEDIUM: A1B	+0.8 ± 0.4	+1.5 ± 0.6	+2.3 ± 0.9
HIGH: A2	+0.7 ± 0.4	+1.4 ± 0.4	+2.8 ± 0.7

The CMIP3 scenarios are considered equivalent to the more recent CMIP5 scenarios. In regards to air temperature CMIP3 and CMIP5 have been shown to produce similar results and ranges of uncertainty by the end of the century[16].

- Most global models project an increase in annual and seasonal rainfall over the course of the 21st century in RMI[1].
- Droughts are projected to become less frequent throughout this century in RMI[1].
- More extreme rainfall days are likely to occur in RMI[1].
- Less frequent but more intense typhoons are projected for the region[1].
- Global sea surface temperature is projected to continue to increase through the 21st century under all emissions scenarios[16].
- Devastating impacts on coral reefs between 2030 and 2050 are expected in the region as bleaching level stress is reached annually under all emission scenarios[16].

FUTURE CLIMATE PROJECTIONS

- Severe degradation and potential loss of corals from most global locations by 2050 under current warming trajectories[16].
- Acidity levels of the ocean are expected to increase across RMI[1].
- Mean sea level is projected to continue to rise over the course of the 21st century[1].
    - By 2100 a rise of 0.5 m in sea level is very likely and a rise greater than 2.0 m is plausible for RMI[14].
    - Projections for sea level rise in Hawaii and other tropical Pacific islands call for an additional 20%–30% above the global mean[14].
- Ocean oxygen levels are projected to decrease by as much as 3.5% by the end of the century under a low mitigation scenario relative to pre industrial levels[13].

IMPACTS OF CLIMATE CHANGE

MARSHALL ISLANDS

- RMI is one of four countries that consists entirely of low lying atolls and islands, and which face perhaps the most urgent and daunting climate change challenges in the world[5].
- The climate change threats of immediate concern include sea level rise in combination with storm surges causing flooding, accelerated coastal erosion and saline intrusion into freshwater lenses; periodic droughts associated with ENSO events and coral bleaching resulting from increased temperature and ocean acidification in combination with extreme low tides[5].
- RMI is among the top five countries that will be most impacted by sea level rise by the end of the century[15].
- Small island communities are at greater risk from sea level rise in comparison with other geographic areas because most of their population and infrastructure are in the coastal zone[15].
- In low-lying atoll nations such as RMI there is extremely high vulnerability to the impacts of climate change[5]. Sea level rise, coastal erosion, impacts on plants and animals and changes in rainfall patterns make climate change an environmental sustainability issue, exacerbate development pressure and pose a threat to security[5].
- RMI's people are among the most vulnerable in the world to the impacts of climate change and many of these impacts are already occurring, inflicting damage and imposing substantial costs on the Marshallese government and people[17].
- More intense rainfall has the potential to increase flooding, damage crops and move pollutants into coastal waters[1].
- Higher sea surface temperatures, will increases coral bleaching leading to a change in coral species composition, coral disease, coral death, and habitat loss[7].
- Open ocean fisheries will be affected negatively over the long term[7].
- The impact of increased acidification on the health of the reef ecosystem is likely to be compounded by other stressors including coral bleaching, storm damage and fishing pressure[1].
- It is unclear whether climate change will lead to an increased frequency in storms, however there is a wide agreement that the intensity of storms will increase as ocean waters warm[16].
- Climate change threatens the physical, biological, and human elements necessary for Pacific Island cultures to sustain their way of life[7].
- Climate driven health risks from the spread of infectious disease, loss of settlements and infrastructure, and decline of ecosystems that affect small island economies and livelihoods, and human well-being are under researched[15].
- Climate change related migration is particularly relevant to low island communities in RMI and presents significant practical, cultural and legal challenges[12].
- During the drought of 2016, 21,000 people in RMI were negatively impacted, predominately on the outer islands9. The estimated economic impact of this drought was approximately USD4.9 million[9].

MITIGATION & ADAPTATION TO CLIMATE CHANGE

MARSHALL ISLANDS

- RMI's contribution to climate change has always been marginal (<0.00001% of global emissions)[17].
- Almost 90% of the national energy needs are currently satisfied by imported petroleum, although biomass remains important for cooking and crop drying on outer islands[17].
- Since 2008 there has been a rapid expansion of solar investment to add renewable energy generation to the existing diesel-powered grids on urban islands[17].
- RMI has made a commitment to reduce 28% of greenhouse gas emissions by 2025 below 2000 levels[17].
- Additional reductions up to 35% below 2000 levels are subject to the availability of additional financial, technical and capacity building support from the international community[17].
- Resource management and conversation are essential for healthy and stable communities on islands with limited resources because overexploitation could damage or permanently destroy natural resources[7].
- RMI considers that adaptation action will have mitigation co-benefit, with efforts such as mangrove and agriculture rehabilitation programs likely to enhance carbon sinks as well as assist with protection of water resources and health of the RMI people[17].
- The Joint National Action Plan for Climate Change Adaptation and Disaster Risk Management provides a detailed strategy for historically and co-operatively addressing risk in the RMI[18].

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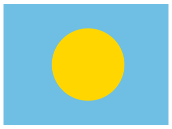
REPUBLIC OF PALAU



GEOGRAPHY

GLOBAL CLIMATE CHANGE

REGIONAL CLIMATE CHANGE

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GEOGRAPHY

PALAU

- The Republic of Palau is an archipelago in the western Pacific ocean located between 3° and 9° North Latitude and 131° and 135° East Longitude[1].
- The Palau archipelago stretches over 400 miles in a north-south direction and located approximately 800 km East of the Philippines and 800 km north of Papua New Guinea[2].
- Total land area is 535 km^2, with 25 percent of Palau's land mass below ten meters above sea level[2].
- Palau is located on the eastern edge of the Philippines tectonic plate and close to the western edge of the Pacific Plate[2].
- There are over 500 individual islands in Palau, 9 of which are currently inhabited and divided into 16 States[1].
- Babeldaob island is the largest in Palau island chain and the second largest island in Micronesia and constitutes 75 Percent of Palau's total landmass[1].
- The capitol of Palau is in the state of Melekeok which is centrally located on Babeldaob but Koror Island remains the center of commerce and hosts 80% of the population[1].
- The total estimated population in Palau is 21,431 (July 2017 est.)[3].
- The Highest Elevation in the Palau is Mt Ngerchelchuus, which is located on Babeldaob island and rises 242 m above sea level[4].
- Daily temperate in Palau is around 28°C throughout the year and changes in temperature from season to season are small (0.8°C) between the warmest and coldest months[5].
- Sea surface temperatures around the Palau influence the seasonal variation in air temperature[1].
- The Republic of Palau boasts a maritime tropical, climate[1]. Annual mean rainfall is about 3,810 mm yr-1 with distinct seasonal variations[2].
- The country has two distinct seasons[5].
    - Dry season from February to April[5].
    - Wet season from May to October[5].
- Palau receives more than 200 mm of rainfall every month due to its location on the edge of the Pacific Warm Pool and the Year-long Influence of the Inter-tropical Convergence Zone[5].
- Between June and August the west pacific Monsoon brings heavy rainfall to Palau5.
- Average Relative Humidity is 82%[1].
- The main extreme events that occur in Palau are droughts, typhoons, storm waves, and flooding[6].
- Climate and Sea level in Palau are strongly Modulated by El Nino Southern Oscillation (ENSO)[5].
- Temperatures a typically warmer during El Niño events and cooler during La Niña Events[7].

Islands of Palau

- El Niño events are associated with drier conditions and occasional droughts while La Niña events are associated with wetter conditions and an increase in the number of tropical storms[7].
- During a strong El Niño Ocean waters are cooler in the western Pacific which reduces fishing yields as tuna are displaced eastward[8].
- ENSO variations have substantial effects on inter-annual variations of rainfall and Palau is anomalously dry during El Niño Events[9]. During the winter and spring months following an El Niño event droughts tend to be the most extreme[9].
- Typhoons can affect Palau between June and November. In a 42-year period between 1969 and 2010, 97 typhoons developed in or crossed into Palau (23 per decade)5. Typhoons are more common in the western Pacific during El Nino Years[7,8]

GLOBAL CLIMATE CHANGE

TEMPERATURE

- The 2017 average global temperature across land and ocean surface areas was 0.84˚C above the 20th century average[10].
- Third warmest year in National Oceanic and Atmospheric Administration's 138-year record[10].
- 2017 marks the 41st consecutive year (since 1977) with global land and ocean temperatures above 20th century average[10].
- The six warmest years on record have occurred since 2010[10].

SEA LEVEL RISE

- In 2016 global sea level was 82 mm above the 1993 average[11].
- Sea level rises at a rate of just over 3.4 mm per year due to a combination of melting glaciers and ice sheets and from the thermal expansion of seawater[11].
- The rate of sea level rise has doubled since 1993 compared to the century average[11].

OCEAN ACIDIFICATION AND TEMPERATURE

- Oceans are absorbing about 25% of the carbon dioxide emitted to the atmosphere annual and as a result are becoming more acidic[12].
- The world's oceans have absorbed about 93% of the excess heat caused by greenhouse gas warming since the mid-20th century[13].
- Ocean heat content has increased at all depths[13].
- Increasing sea surface temperatures, rising sea levels, changing patterns of precipitation and winds, and ocean circulation are contributing to overall decline oxygen concentrations in the oceans[13].

PALAU

REGIONAL CLIMATE CHANGE

TEMPERATURE

- Averaged as a whole, Oceania had its sixth warmest year since continental records began in 1910[10].
- Record warmest temperatures occurred in equatorial western pacific encompassing the geographic area of Palau[10].
- Increases in annual and seasonal (wet and dry) maximum surface air temperatures have been observed since 1953 at a rate of 0.11˚C[6].
- Increases in average temperatures has also resulted in a rise in the number of hot days and warm nights and a decline in cooler weather[5].

PRECIPITATION

- Palau has experienced substantial year-to-year variations in rainfall, with no clear tends since 1948[5].
- There has been little change in extreme daily rainfall since the mid1950s[5].

SEA LEVEL RISE

- Satellite data indicate sea level has risen in the western Pacific by over 10 mm per year since 1993 which is larger than the global average of 3.2 mm per year[7].
- Seasonal sea levels are significantly lower during El Niño conditions and higher during La Niña conditions[7].

CORAL REEFS

- Coral bleaching in 1998 and 2010 caused large-scale coral deaths in reef systems around the globe, with the 1998 event heavily impacting Palau[9].
- Both the intensity of ocean heat stress and the number of days corals are exposed to heat stress have increased in the Western Pacific. Increases in the number of days with ocean heat stress in Western Micronesia have increased by 28% since 1982[14].

PALAU

FUTURE CLIMATE PROJECTIONS

- Beyond 2035 the projected warming diverges depending on the path that humanity follows (1.6-4.3˚C by 2100[15].
    - High emission 2030 +0.4 – 1.1 ˚C[7]
    - High emission 2055 +1.0 – 1.8 ˚C[7]
    - High emission 2090 +2.1 – 3.5 ˚C[7]
- Rainfall is expected to increase over the course of the 21st century. However there is uncertainty in the rainfall projections and not all models show consistent results[5].
- Wet and dry years will still occur in response to natural variability[5].
- Droughts are projected to become less frequent throughout this century[5].
- Extreme rainfall days are likely to occur more often and be more intense[5].
- Droughts are projected to become less frequent throughout this century[7].
- Less frequency but more intense typhoons in the region[7].
- Sea surface temperature is projected to continue to increase through the 21st century under all emissions scenarios[15].
- Devastating impacts on coral reefs between 2030 and 2050 as bleaching level stress is reached annually under all emission scenarios[15].
- Severe degradation and potential loss of corals from most global locations by 2050 under current warming trajectories[15].
- Acidity levels of the Ocean are expected to increase across the region[7].
- Mean sea level is projected to continue to rise over the course of the 21st century[7].
- There is a greater than 90% chance that global mean sea level will rise at least 0.2 m but no more than 2 m by 2100[11].
- Oxygen levels are projected to decrease by as much as 3.5% by the end of the century under a low mitigation scenario relative to pre industrial levels[13].
- The probability of changes to the frequency and intensity of extreme rainfall events and storm surges remains poorly understood for small islands[16].
- On a global scale, projections indicate there is likely to be a decrease in the number of typhoons by the end of the 2st century[16].
- An increase in the average maximum wind speed of typhoons by between 2% and 11% and an increase in rainfall intensity of about 20% within 100 km of the Typhoon center are also projected[5].

IMPACTS OF CLIMATE CHANGE

PALAU

- Small island communities are at greater risk from sea level rise in comparison with other geographic areas because most of their population and infrastructure are in the coastal zone[16].
- More intense rainfall has the potential to increase flooding, damage crops and move pollutants into coastal waters[7].
- Palau is among the top five countries that will be most impacted by sea level rise by the end of the century[16].
- Higher sea surface temperatures will increase coral bleaching leading to a change in coral species composition, coral disease, coral death, and habitat loss[9].
- Open ocean fisheries will be affected negatively over the long term[9].
- Climate driven health risks from the spread of infectious disease, loss of settlements and infrastructure, and decline of ecosystems that affect small island economies and livelihoods, and human well-being are under researched[16].
- Climate change related migration is particularly relevant to low island communities in Micronesia and presents significant practical, cultural and legal challenges[12].
- The impact of increased acidification on the health of the reef ecosystem is likely to be compounded by other stressors including coral bleaching, storm damage and fishing pressure[7].
- It is unclear whether climate change will lead to an increased frequency in storms, however there is a wide agreement that the intensity of storms will increases as ocean waters warm[15].
- Climate change threatens the physical, biological, and human elements necessary for Pacific Island cultures to sustain their way of life[9].

MITIGATION & ADAPTATION TO CLIMATE CHANGE

PALAU

- Palau has commitment to reduce 22% of greenhouse gas emissions by 2025 below 2005 levels[17].
- Resource management and conversation are essential for healthy and stable communities on islands with limited resources because overexploitation could damage or permanently destroy resources[9].
- Palau has proposed and implemented policies that build resilience to climate change and disasters[6].

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PAPUA NEW GUINEA

GEOGRAPHY

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GEOGRAPHY

- The island nation of Papua New Guinea (PNG) lies south of the equator, in the western South Pacific Ocean, between 2 - 12°S latitude and 141 - 156°E longitude[1].
- As part of Oceania, PNG occupies the eastern half of the island of New Guinea with three additional small islands and over 600 islets and atolls to the north and east[2].
- PNG shares a land border with Indonesia located on the western half of New Guinea2.
- PNG has a total land area of 460,00 km^2 and an Economic Exclusion Zone of more than 3 million km^2[(1)].
- The landscape of PNG consists of diverse geography characterized by rugged mountain ranges, deep valleys, swift rivers, open plains, tropical forests and swampy inlets on the coast[2].
- The highest peak, Mount Wilhelm is found in the Simbu Province and rises 4510 m above sea level[1].
- The capital, Port Moresby, is located on the southeast side of New Guinea Island and is home to the Government of PNG[3].
- Almost 63% of the land area in PNG is covered forest and 2.6% (2011 est.) is devoted to agricultural lands[4].
- PNG is located on the Australia and Pacific tectonic plates, thus this region has a high exposure to geologic hazards, including volcanic eruptions, earthquakes, tsunamis and landslides[2].
- PNG ranks in the top six countries for the highest percentage of population exposed to earthquake hazards[2].
- PNG's economy is heavily dependent on natural resources, both for the sustenance of its people and future economic expansion, like many other Pacific Island Countries[2].
- PNG occupies less than 1% of the world landmass but is home to 6-7% of the total world's biodiversity[5]. This represents some 400,000 to 700,000 species from the estimated 14 million species on Earth[5].
- PNG is rich with marine biodiversity and is home to over 1,500 species of coral reef fishes and at least 514 species of coral[6].
- PNG has a constitutional monarchy with three spheres of government: National, Provincial and local[4].
- The islands are grouped into 20 provinces, the autonomous region Bougainville and the National Capital District of Port Moresby, with 89 districts and 318 local governments[4].
- PNG has 800 distinct languages, making it one of the most diverse populations in the world[2].
- PNG is one of the least densely populated countries in the world with 15 people per square kilometer[7].
- Total estimated population of PNG (based on the 2018 estimate) is 8.59 million[7].

GEOGRAPHY

- Urban population is estimated at 13.2% of the total population[2].
    - Port Moresby = 310,000[7].
    - Lae = 76,255[7].
    - Arawa = 40,266[7].
- PNG's rate of population growth 1.67% and their life expectancy 67.4 years[2].
- Population is in PNG is expected to continue to grow and in 2050 there will be an estimated 13.9 million people and in 2095 there will be an estimated 18.7 million people living in the country[7].
- At present (2018), 30% of the population lives below the poverty line the international poverty line of USD1.25 per day[7].
- Approximately 82% of the population engages in subsistence agriculture and only 15% of the population is employed in a formal wage earning sector[2].
- PNG has the highest incidence of HIV/AIDS in the Pacific[7].
- PNG has a high prevalence of malaria in the Asia-Pacific region with an estimated 2.1 million reported cases occurring there[8].
- In 2017, 8.2 million people were at risk for contracting malaria, there were 2.1 million reported cases and 3,053 malaria-related deaths[8].
- The 2017 Gross Domestic Product (GDP) of PNG was USD30.2 billion (2017 est.)[4].
- Mining and oil production are the main sources of revenue for PNG, accounting for 60% of export earnings and 20% of government revenue[3].
- Agricultural crops are a major source of revenue in particular copra, coffee , palm oil an cocoa[3].
- Despite the abundance of natural resources, including natural gas and gold which has fueled the county's economic growth, much of the population continues to live in poverty, particularly women and children[2].
- PNG remains, after a period of several years, near to the top of the list of countries whose populations are threatened by natural disasters, and whose government is incapable of protecting, or barely even helping, its citizens[9].
- In 2016, PNG was ranked the 11th most at-risk country to natural disasters in the world[9].
- As of 2012, there were 39 operational observation meteorological stations in PNG[3].
- Multiple observations within a 24-hr period are taken at 18 locations, once a day climate observations are taken at 3 stations, and a single observation of daily rainfall is taken at 18 stations[3].
- Air temperatures are relatively constant throughout the year and are closely related to sea surface temperatures[3].


Kimbe Bay, Papua New Guinea

- The country has two distinct seasons[3]: Dry season from May to October[3], and Wet season from November to April.
- Seasonal climate varies across the country, where in the south (Port Moresby) the West Pacific Monsoon is responsible for 78% of the rainfall in the wet season and in the North (Kavieng) rainfall is more consistent year-round due to the influence of the Inter-tropical convergence zone and to a lesser extent the South Pacific Convergence Zone[3].
- Average rainfall in Kavieng (3150 mm) is much higher than Port Moresby (1190 mm)[3].
- Year-to-year natural climate variability is high in PNG and explained by the El Niño Southern Oscillation (ENSO)[3].
- There are significant correlations between ENSO indices and both rainfall and air temperature in PNG[3].
- Generally, El Niño years are drier than average while La Niña years are wetter than average[3].
- In Port Moresby, the dry season in El Niño years tends to be cooler than normal and warmer in La Niña years, while the wet season is cooler than normal in El Niño years[3].
- In Kavieng, During El Niño, wet seasons are wetter and warmer than usual[3].
- In both Port Moresby and Kavieng, the wettest years receive up to three times the amount of rainfall than the driest years[3].
- The tropical cyclone season in the PNG region is between November and April and occurrences outside of this period are rare[3].
- Between 1969 and 2010, 23 tropical cyclones passed within approximately 400 km of Port Moresby[3]. This represents approximately 6-cyclones per decade[3].

GLOBAL CLIMATE CHANGE

TEMPERATURE

- The 2018 average global temperature across land and ocean surface areas was 0.84˚C above the 20th century average[10].
- 2018 was the fourth warmest year in the 1880–2018 record, behind 2016 (highest), 2015 (second highest), and 2017 (third highest)[10].
- 2018 was the second warmest year on record without an El Niño present in the tropical Pacific Ocean[10].
- 2018 marks the 42nd consecutive year (since 1977) with global land and ocean temperatures above 20th century average[10].
- Nine of the 10 warmest years have occurred since 2005[10].
- The 2018 globally averaged sea surface temperature was 1.19°F (0.66°C) above the 20th century average[10]. This was the fourth highest among all years in the 1880-2018 record, again behind 2016 (highest) and 2015 (second highest) and 2017 (third highest)[10].

SEA LEVEL RISE

- In 2017 global sea level was 77mm above the 1993 average, which is the highest annual average in the satellite record[11].
- 2017 was the sixth consecutive year, and the 22nd out of the last 24 years in which global mean sea level increased relative to the previous year[11].
- Sea level rises at a rate of just over 3.1 mm per year due to a combination of melting glaciers and ice sheets and from the thermal expansion of seawater[11].
- The rate of sea level rise has doubled since 1993 compared to the 20th century average[11].

OCEAN ACIDIFICATION AND TEMPERATURE

- Oceans are absorbing about 25% of the carbon dioxide emitted to the atmosphere annually and as a result are becoming more acidic[12].
- The world's oceans have absorbed about 93% of the excess heat caused by greenhouse gas warming since the mid-20th century[13].
- Ocean heat content has increased at all depths[13].
- Increasing sea surface temperatures, rising sea levels, changing patterns of precipitation and winds, and ocean circulation are contributing to overall decline oxygen concentrations in the oceans[13].

REGIONAL CLIMATE CHANGE

PAPUA NEW GUINEA

TEMPERATURE

- Averaged as a whole, Oceania had its 3rd warmest year in 2018 since regional records began in 1910[10].
- Much warmer than average temperatures occurred in equatorial western pacific encompassing the geographic area of containing the country of PNG[10].
- In the Pacific region, land-surface temperatures have been rising at the rate of +0.17°C (0.31°F) per decade since the 1980s, slightly ahead of the global trend[14]
- Warming trends of a similar magnitude are evident in both annual and seasonal mean air temperatures in Port Moresby (1950-2009) with the strongest trend found in the wet season mean air temperature (+0.32° C per decade)[3].
- Ocean temperatures have risen gradually since the 1950s with the rate increasing over time and since the 1970s the rate of warming has been approximately 0.13°C per decade[3].

PRECIPITATION

- Annual and seasonal rainfall trends for Port Moresby and Kavieng for the period 1950-2009 are not statistically significant[3].

SEA LEVEL RISE

- The sea level rise near PNG is measured by satellite altimeters and since 1993 is about 7 mm per year, larger than the global average of 3.1 mm per year[3].
- Seasonal sea levels are significantly lower during El Niño conditions and higher during La Niña conditions[3].

REGIONAL CLIMATE CHANGE

PAPUA NEW GUINEA

MARINE SYSTEMS

- Coral reefs face threats at multiple scales ranging from global increases in oceanic temperature and ocean acidification, to local factors such as point and non-point source pollution, increased disturbance, and fishing pressure[6].
- Species diversity for both fished and non-fished species groups decreases as human population increases[6].
- In PNG aragonite saturation state has declined from 4.5 in the late 18th century to 3.9 in 2000 (which is not optimal for coral growth)[3].

EXTREME EVENTS

- The probability of changes to the frequency and intensity of extreme rainfall events and storm surges remains poorly understood for small islands[15].

FUTURE CLIMATE PROJECTIONS

PAPUA NEW GUINEA

- Surface air temperature and sea-surface temperature are projected to continue to increase over the course of the 21st century[3,16].
- Beyond 2035 the projected warming in PNG diverges depending on the greenhouse gas emissions pathway that humanity follows (see table below)[3]. NOTE: Climate projections have been derived for Vanuatu by the Australian Bureau of Meteorology using the Coupled Model Intercomparison Project (CMIP3) database for up to three greenhouse gas emission scenarios: B1 (low emissions), A1B (medium emissions) and A2 (high emissions)[3].

Projected change in surface air temperature (°C) for 2030 (2020–2039), 2055 (2046–2065) and 2090 (2080–2099), relative to 1990 (1980–1999) base period for the three emission scenarios are shown below[3].

EMISSION SCENARIO	2030	2055	2090
LOW B1	+0.7 ± 0.4	+1.1 ± 0.5	+1.6 ± 0.6
MEDIUM: A1B	+0.8 ± 0.4	+1.5 ± 0.5	+2.4 ± 0.8
HIGH: A2	+0.7 ± 0.3	+1.4 ± 0.4	+2.8 ± 0.6

The CMIP3 scenarios are a product of the Inter-Governmental Panel on Climate change (IPCC) forth Assessment Report (AR4) but are considered equivalent to the more recent CMIP5 scenarios from the AR5. In regards to air temperature CMIP3 and CMIP5 have been shown to produce similar results and ranges of uncertainty by the end of the century[16]. The newest regional climate projections which are part of the CMIP6 are currently in development and result will be officially released in 2020 with the IPCC AR6.

- The majority of CMIP3 models simulate little change (-5% to 5%) in wet season rainfall by 2030, however, by 2090 under the A2 (high) emissions scenario, the majority simulate an increase (>15%) in wet-season rainfall[3].
- The intensity and frequency of days of extreme heat are projected to increase over the course of the 21st century[3].
- The intensity and frequency of days of extreme rainfall are projected to increase over the course of the 21st century[3].

FUTURE CLIMATE PROJECTIONS

PAPUA NEW GUINEA

- Incidences of drought in PNG are projected to decreases over the course of the 21st century[3].
- Acidity levels of the ocean are expected to increase across PNG over the course of the 21st century[3].
- Projections from all analyzed CMIP3 models indicate that the annual maximum aragonite saturation state will reach values below 3.5 by about 2035 and continue to decline thereafter[3].
- The impact of acidification change on the health of the reef ecosystems is likely to be compounded by other stressors including coral bleaching, storm damage and fishing pressure[3].
- The CMIP3 models simulate a rise of between approximately 5-15 cm by 2030, with increases of 20-60 cm indicated by 2090 under the high emission scenarios[3].
- Frequency of cyclone activity in the region of PNG is projected to decline but the intensity of the most severe cyclones is projected to increase[3,16].
- Global sea surface temperature is projected to continue to increase through the 21st century under all emissions scenarios[16].
- Elevated sea temperatures and CO2 concentrations from climate change are already contributing to large-scale ecological change across the globe[15,16].
- Devastating impacts on coral reefs between 2030 and 2050 are expected in the region as bleaching level stress is reached annually under all emission scenarios[16].
- Severe degradation and potential loss of corals from most global locations is expected by 2050 under current warming trajectories[16].
- Mean sea level is projected to continue to rise over the course of the 21st century[3]. Between 5-15 cm by 2030 and 20-60 cm by 2090 under high emission scenarios[3].
- Ocean oxygen levels are projected to decrease by as much as 3.5% by the end of the century under a low mitigation scenario relative to pre industrial levels[13].

IMPACTS OF CLIMATE CHANGE

PAPUA NEW GUINEA

- Climate change threatens the physical, biological, and human elements necessary for Pacific Island cultures to sustain their way of life[17].
- Natural disasters driven by climate conditions (i.e., excluding seismic and volcanic activity) as well as gradual shifts in climatic conditions disrupt daily life, cause damage to assets and infrastructure, destroy livelihoods, endanger cultural and ecological treasures, and kill or injure people[18].
- Hazards like coastal flooding, inland flooding and droughts take a severe toll on the people and the economy. Climate change are predicted to exacerbate some of these event driven hazards and may also introduce new hazards due to gradual shifts in climate conditions - most prominently, increased malaria penetration in the highlands, changed agricultural yields and damaged coral reefs[18].
- Droughts and fires also effect the country causing vegetation and crop loss[2].
- Tsunamis are also a threat to low-lying areas of the country due to its position on the edge of the Caroline and Australian tectonic plates[2].
- The North Coast and Island regions of PNG face the most important climate change hazards, threatening both coastal populations and important economic centers[2].
- Water stress is a significant concern across the country, not only in terms of lack of drinking water, but also in terms of impacts on health and livelihood activities[19].
- The lack of water impoundments and or water reclamation schemes serves to increase the vulnerability of the largely agrarian communities in PNG[2].
- The Highlands are most severely impacted by drought events and populations move in search of food and water[2].
- Changes in climatic conditions, both through increased average precipitation and increased extreme rainfall events, will strongly affect the impact of inland floods[20].
- In recent decades, landslides have caused considerable damage to road infrastructure and re-mote communities[20].
- Inland flooding, driven by heavy irregular rainfalls, regularly affects valleys and wetlands in both lowlands and highlands[20].
- In the 15 year period from 1998 to 2013 and through four catastrophic flood events, coastal floods have affected some 8,000 people per year caused USD10-20million of damage per year, displaced 500 people and killed five people[20].
- Rising sea levels worsen the effect of coastal floods and necessitated the evacuation of people from the Carteret Atolls and Duke of York Islands, as salinization and flooding damaged fragile communities and cultures, making them uninhabitable[20].

IMPACTS OF CLIMATE CHANGE

PAPUA NEW GUINEA

- In 1997, a CARE International assessment estimated that over 300,000 people were in severe stages of food insecurity caused by drought and frost[2].
- From 2015 to 2016, prolonged El Niño induced drought conditions in PNG adversely impacted the agricultural food production system which led to insufficient amounts of water available for crops and human beings to consume resulting in more than 2 million people at risk of famine and disease from contaminated water[2].
- 4.7 million people in PNG have been affected by El Niño related droughts, erratic rains and frosts resulting in cases of hunger, poverty, and disease[2].
- Rainfall in PNG has been below average and frost and invasive pests in the Highlands have contributed to destroyed crops and livestock leading to food insecurity and people being forced to cut down on meals and eat less compounding the issue with risk of malnutrition[2].
- The damage to water resources of a projected two to four degree Celsius rise in temperature is estimated to cause economic losses amounting to USD1billion per year[21].
- ENSO-related drought and flooding are prevalent and continue to impact the socio-economic livelihood of people of PNG[3].
- More intense rainfall has the potential to increase flooding, damage crops and move pollutants into coastal waters[3].
- In the last 20 years, climatic changes have worsened the effects of malaria; with rising temperatures, the parasite has established itself in the highlands where it was not previously present[20].
- Additional increases in temperature over the next 20 years will introduce malaria to previously risk-free regions and could worsen the impact of malaria for those living in low-risk zones[20].
- Increases in sea surface temperatures and ocean acidification may over time destroy PNG's coral reefs, which are the fifth largest in the world[20].
- Domestic and international surveys reveal widespread illiteracy, malnutrition, poor health and vulnerability to natural hazards, many of which will become more salient with climate change[18].
- Pacific island countries are among the most vulnerable in the world to the health impacts of climate change[22].
- Groups such as women, children, the elderly, disabled, and refugees/displaced persons who already face challenges in PNG may find themselves more adversely impacted by disasters and be less able to rebound after an event[2].

MITIGATION & ADAPTATION TO CLIMATE CHANGE

- It is critical that PNG understands how and where climate change is likely to impact on its shores to assist in making decisions for adapting to and mitigating against these impacts[21].
- PNG is a developing country that has not been responsible for most of the greenhouse gas emissions of the world[18].
- Deforestation accounts for 17% of global emissions and PNG is the world's ninth largest greenhouse gas emitter with respect to deforestation[21].
- PNG has a national target of becoming carbon free by 2030 target date in the electricity sector[18].
- PNG can make a significant contribution to reducing global greenhouse gas emissions with good forest management and through the development of its enormous hydroelectricity potential, which is a zero emissions source of electricity[21].
- Resource management and conversation are essential for healthy and stable communities on islands with limited resources because overexploitation could damage or permanently destroy natural resources[17].
- Research has shown that climate-driven health risks from the spread of infectious disease, loss of settlements and infrastructure, and decline of ecosystems that affect small island economies and livelihoods, and human well-being are under researched[15].
- The National Food Security Policy (2016-2025) is currently the only sectoral strategy to include adaptation concerns[2].
- Its position along the Pacific Ring of Fire and the specific challenges of the country's terrain and remote villages and islands have contributed to make disaster risk reduction, disaster risk management and climate change adaptation a priority for PNG and its partner nations and agencies[2].
- The National Climate Compatible Development Management Policy focuses on sustainable development and key policy areas for climate change mitigation and adaptation and provides monitoring and evaluation of these activities[20].

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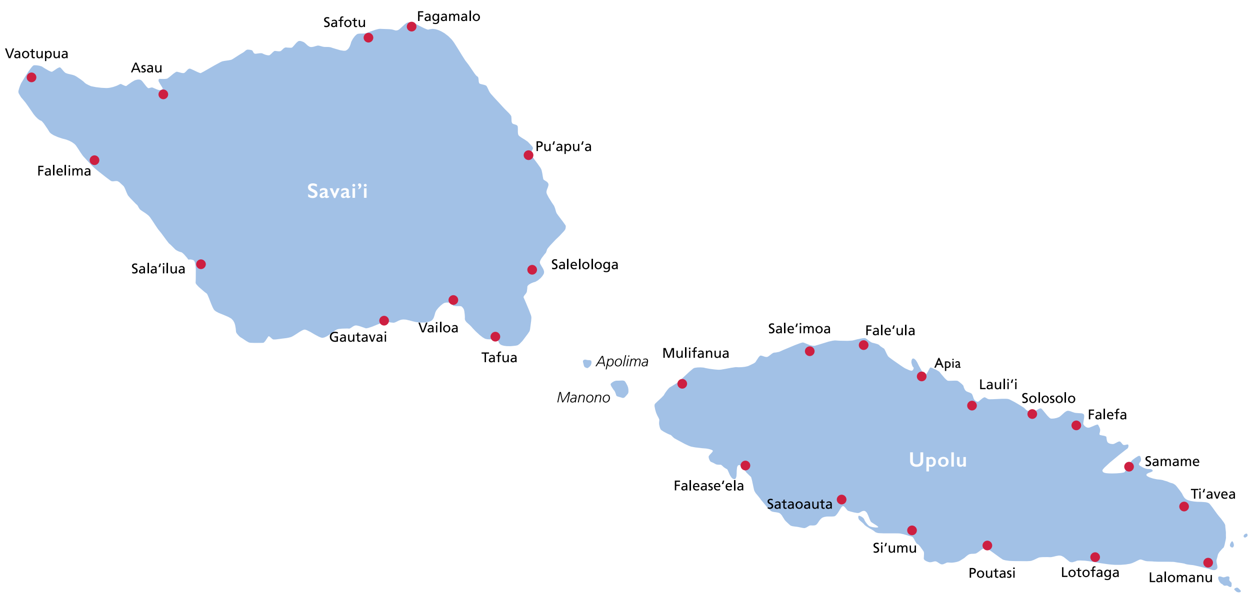
SAMOA



GEOGRAPHY

GLOBAL CLIMATE CHANGE

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GEOGRAPHY

SAMOA

- The country of Samoa is located in the western South Pacific Ocean between 13°S - 14°S latitude and 170° - 173°W longitude[1].
- Samoa consists of four main inhabited islands (Upolu, Savai'i, Manono and Apolima) and six smaller uninhabited islands[1].
- The capital of Samoa, Apia, is in the northern part of the Island of Upolu[2].
- Samoa has a total land area of 2,934 km^2[(1)].
- On Upolu, the central mountain range runs along the length of the island with some peaks rising more than 1,000 m above sea level[1].
- Savai'i has central volcanic peaks reaching 1860 m[1].
- Samoa is a parliamentary democracy where the Parliament is elected through universal suffrage every five years[3].
- Samoa administrative organization consists of 11 districts; A'ana, Aiga-i-le-Tai, Atua, Fa'asaleleaga, Gaga'emauga, Gagaifomauga, Palauli, Satupa'itea, Tuamasaga, Va'a-o-Fonoti, Vaisigano[5].
- The total population of Samoa is 201,316 and 81.8% is considered rural (2018 est.)[5].
- Samoa has a nominal Gross Domestic Product (GDP) of USD844 million (2018 est.)[5].
- Samoa per capita income is USD5,770 (2017 est.)[5].
- Samoa's economy has traditionally depended on development aid, family remittances from overseas, agriculture and fishing[4].
- Remittances represents about 21.6% of GDP (2015 est.)[3].
- Agriculture and fishing products have traditionally provided the bulk of Samoa's commodity exports including coconut oil, coconut cream, bananas, taro, kava and fish[1].
- Two-thirds of Samoa's potential labor force is absorbed by subsistence village agriculture, a dominant sector in the Samoan economy[4].
- The fisheries sector is not only a source of food for the local population it also injects considerable foreign revenue into Samoa's economy[2].
- Tourism is an expanding sector, and now accounts for 25% of GDP[4].
- Currently, about 80% of Samoa has access to electricity and water, and the whole country is served by tar-sealed roads.
- Approximately 70% of Samoa's population and infrastructure is located along the coastline[2].
- As of 2010 there were eight operational climate stations in Samoa's climate monitoring network[1].
- The primary meteorological station is located in Apia[1].
- Apia, Faleolo and Maota stations take multiple observations within 24-hour period.

GEOGRAPHY

- The other stations (Afiamalu, Nafanua, Alafua, Togitogiga on Upolu and Asau on Savali) record rainfall once a day[1].
- Monthly average sea level data are available form Pago Pago (American Samoa) 1948-present[1].
- The Köppen-Geiger Climate Classification of Samoa is generally categorized as equatorial, fully, humid (Af)[6].
- The annual range in average monthly maximum temperature in Samoa is small1.
- Samoa has two distinct seasons: Dry/Cool season (May to October) and Wet/Warm season (November to April)[1].
- The annual rainfall is about 3,000 mm, with about 75% of the precipitation occurring between November and February[4].
- Average wet season rainfall in Samoa amounts to 350 mm per month[1].
- The seasonal cycle is strongly affected by the South Pacific Convergence Zone (SPCZ), which is most intense during the wet season[1].
- The close proximity of the SPCZ to Samoa during the summer results in heavy rainfall throughout the country[1].
- Samoa's topography has a significant effect on rainfall distribution[1].
- Year-to-year natural climate variability is high in Samoa and is explained by the El Niño Southern Oscillation (ENSO)[1].
- There are significant correlations between ENSO indices and both rainfall and air temperature in Samoa[1].
- El Niño years also bring lower than normal rainfall during the wet season as the SPCZ usually moves away from Samoa to the north-east[1].
- In La Niña Years the SPCZ moves closer and so wet season rainfall increases[1].
- Generally, El Niño years are drier and cooler than average in Samoa while La Niña years are wetter and warmer than average[1].
- Annual rainfall in Samoa during the drier years can be approximately half of the observed in wettest years[1].
- The tropical cyclone (TC) season in Samoa is usually between November and April but occasionally in October and May during El Nino Years[1].
- Between 1969-200, 71 TC's passes approximately 52 km of Apia (19 cyclones per decade)[1].
- Tropical cyclones are most frequent during El Niño years[1].
- 1990 and 1991, Samoa was struck by successive cyclones Ofa and Val where, high winds, storm surges and heavy rains severely damaged 90% of Samoa's infrastructure, including the coast of the capital Apia[2].

GLOBAL CLIMATE CHANGE

TEMPERATURE

- The 2018 average global temperature across land and ocean surface areas was 0.84˚C above the 20th century average[7].
- 2018 was the fourth warmest year in the 1880–2018 record, behind 2016 (highest), 2015 (second highest), and 2017 (third highest)[7].
- 2018 was the second warmest year on record without an El Niño present in the tropical Pacific Ocean[7].
- 2018 marks the 42nd consecutive year (since 1977) with global land and ocean temperatures above 20th century average[7].
- Nine of the 10 warmest years have occurred since 2005[7].
- The 2018 globally averaged sea surface temperature was 1.19°F (0.66°C) above the 20th century average[7]. This was the fourth highest among all years in the 1880-2018 record, again behind 2016 (highest) and 2015 (second highest) and 2017 (third highest)[7].

SEA LEVEL RISE

- In 2017 global sea level was 77mm above the 1993 average, which is the highest annual average in the satellite record[8].
- 2017 was the sixth consecutive year, and the 22nd out of the last 24 years in which global mean sea level increased relative to the previous year[8].
- Global average sea level rises at a rate of just over 3.1 mm per year due to a combination of melting glaciers and ice sheets and from the thermal expansion of seawater[8].
- The rate of sea level rise has doubled since 1993 compared to the 20th century average[8].

OCEAN ACIDIFICATION AND TEMPERATURE

- Oceans are absorbing about 25% of the carbon dioxide emitted to the atmosphere annually and as a result are becoming more acidic[9].
- The world's oceans have absorbed about 93% of the excess heat caused by greenhouse gas warming since the mid-20th century[10].
- Ocean heat content has increased at all depths[10].
- Increasing sea surface temperatures, rising sea levels, changing patterns of precipitation and winds, and ocean circulation are contributing to overall decline oxygen concentrations in the oceans[10].

REGIONAL CLIMATE CHANGE

SAMOA

TEMPERATURE

- Averaged as a whole, Oceania had its third warmest year in 2018 since regional records began in 1910[7].
- Much warmer than average temperatures occurred in equatorial western Pacific encompassing the geographic area of containing the country of Samoa[7].
- In the Pacific region, land-surface temperatures have been rising at the rate of +0.17°C (0.31°F) per decade since the 1980s, slightly ahead of the global trend[11].
- An upward trend in temperature at Apia (+0.14°C per decade) has been observed (between 1950 to 2009)[1].
- In Fua'amoto a 0.32°C per decade increases in temperature has been observed since 1980 (1980-2013)[12].
- Ocean temperatures have risen gradually since the 1950s with the rate increasing over time and since the 1970s the rate of warming has been approximately 0.12°C per decade[1].
- At regional scales natural variability plays a large role in determining sea-surface temperature making it difficult to identify long-term trends[1].

PRECIPITATION

- No significant changes in average annual rainfall have been observed over the period 1950-2009[1].

SEA LEVEL RISE

- Sea level rise near Samoa measured by satellite altimeters since 1993 is over 6 mm per year compared with the global average of 3.2 ± 0.4 mm per year[1].
- Seasonal sea levels are significantly lower during El Niño conditions and higher during La Niña conditions[1].
- The sea surface temperatures near Samoa indicate a warming trend of 0.06˚C/decade[1].


To Sua ocean trench in Lotofaga -Upolo, Samoa

MARINE SYSTEMS

- Coral reefs face threats at multiple scales ranging from global increases in oceanic temperature and ocean acidification, to local factors such as point and non-point source pollution, increased disturbance, and fishing pressure[13].
- Species diversity for both fished and non-fished species groups have been shown to decrease as human population increases[13].
- In Samoa maritime boundaries, the aragonite saturation state has declined from 4.5 in the late 18th century to 3.9 in 2000 (which negatively impacts the development of corals)[1].

FUTURE CLIMATE PROJECTIONS

SAMOA

- Surface air temperature and sea surface temperature are projected to continue to increase in Samoa over the course of the 21st century[1,14].
- Beyond 2030 the projected warming in Samoa diverges depending on the greenhouse gas emissions pathway that humanity follows (see table below)[1]. NOTE: Climate projections have been derived for Samoa by the Australian Bureau of Meteorology using the Coupled Model Intercomparison Project (CMIP3) database for up to three greenhouse gas emission scenarios: B1 (low emissions), A1B (medium emissions) and A2 (high emissions)[1].

Projected change in surface air temperature (°C) for 2030 (2020–2039), 2055 (2046–2065) and 2090 (2080–2099), relative to 1990 (1980–1999) base period for the three emission scenarios are shown below[1].

EMISSION SCENARIO	2030	2055	2090
LOW B1	+0.6 ± 0.4	+1.0 ± 0.4	+1.4 ± 0.6
MEDIUM: A1B	+0.8 ± 0.4	+1.4 ± 0.5	+2.2 ± 0.7
HIGH: A2	+0.7 ± 0.3	+1.4 ± 0.4	+2.6 ± 0.7

The CMIP3 scenarios are a product of the Inter-Governmental Panel on Climate change (IPCC) forth Assessment Report (AR4) but are considered equivalent to the more recent CMIP5 scenarios from the AR5. In regards to air temperature CMIP3 and CMIP5 have been shown to produce similar results and ranges of uncertainty by the end of the century[14]. The newest regional climate projections which are part of the CMIP6 are currently in development and result will be officially released in 2022 with the IPCC AR6.

- Wet season rainfall is projected to increase across the country over the century[1].
- The majority of CMIP3 models simulate little change (-5% to 5%) in wet season rainfall by 2030, however by 2090 the majority simulate an increase (>5%), with approximately one third simulating a large increase (>15%) under the A2 (high) emissions scenario[1].
- The models disagree in the dry season with projections in annual rainfall ranging from -5 to +15%[1].

FUTURE CLIMATE PROJECTIONS

SAMOA

- The intensity and frequency of days of extreme heat are projected to increase over the course of the 21st century[1].
- The intensity and frequency of days of extreme rainfall are projected to increase over the course of the 21st century[1].
- Little change is projected in the incidence of drought over the course of the 21st century[1].
- Projections from all analyzed CMIP3 models indicate that the annual maximum aragonite saturation state will reach values below 3.5 by about 2035 and continue to decline thereafter[1].
- The impact of acidification change on the health of reef ecosystems is likely to be compounded by other stressors including coral bleaching, storm damage and fishing pressure[1].
- Acidity levels of the ocean are expected to increase across Samoa over the course of the 21st century[1].
- Best estimates of long-term, systematic changes in the average climate for Samoa indicate that by 2050, sea level is likely to have increased by 36 cm, rainfall by 1.25%, extreme wind gusts by 7% and maximum temperatures by 0.7°C[2].
- The CMIP3 models simulate a rise in sea-level in Samoa between approximately 5-15 cm by 2030, with increases of 20-60 cm indicated by 2090 under the high emission scenarios[1].
- Frequency of cyclone activity in the region of Samoa is projected to decline but the intensity of the most severe cyclones is projected to increase[1,14].
- Global sea surface temperature is projected to continue to increase through the 21st century under all emissions scenarios[14].
- Elevated sea temperatures and CO2 concentrations from climate change are already contributing to large-scale ecological change across the globe[14,15].
- Devastating impacts on coral reefs between 2030 and 2050 are expected in the region as bleaching level stress is reached annually under all emission scenarios[14].
- Severe degradation and potential loss of corals from most global locations is expected by 2050 under current warming trajectories[14].
- Regional ocean oxygen levels are projected to decrease by as much as 3.5% by the end of the century under a low mitigation scenario relative to pre-industrial levels[10].

IMPACTS OF CLIMATE CHANGE

- Samoa is a Small Island Developing State and is at the forefront of efforts to address issues associated with impacts of climate change[16].
- Samoa's contribution to GHG emissions are negligible[16].
- Samoa has a target of generating 100% of its electricity from renewable energy sources by 2017 and continue through 2025 in anticipation of the increasing electricity demand[16].
- Like other islands in the region the impacts of climate change on the environment are already quite evident and will continue to pose significant treats in the future[16].
- In 2018, Samoa was ranked 76 out of 172 countries with the highest disaster risk in the world[17].
- High priority climate sensitive health effects risks in individual Pacific Island countries include the direct impacts of extreme weather events and the indirect effects of water security and safety (including water-borne diseases) and food security and safety (including malnutrition and percentage of people affected by food-borne diseases)[18].
- Increased frequency and intensity of extreme climatic events is recognized as a key vulnerability issue for Samoa[16].
- Water resources are particularly vulnerable to the effects of climate change[16].
- Significant problems associated with climate change include: periods of low rainfall, resulting in water shortages; heavy rains that cause flooding and subsequent damage to water infrastructure, quality and supply; enforced water rationing to compensate for inconsistent rainfall; rapid water evaporation, caused by higher temperatures and salt water despoiling ground water and coastal springs as sea levels rise[16].
- Samoa has experienced frequent floods from extreme rainfall events causing unreliable supply and poor quality of water that impact greatly on the health of the people[19].
- Professionals consulted as part of the vulnerability and adaptation assessment confirm that outbreaks of diseases such as typhoid and dengue fever correlate closely with changes in Samoa's climate[2].
- Current health sector vulnerabilities are expected to increase over time, particularly given the projected changes in Samoa's climate[2].
- Climate change threatens the physical, biological, and human elements necessary for Pacific Island cultures to sustain their way of life[20].
- Agricultural production in Samoa is particularly vulnerable to climatic change as crops can be damaged or destroyed by extreme climate conditions like drought and prolonged heavy rainfall, as well as by isolated extreme events, like cyclones and tropical storms[2].
- Variations in climate can also expose crops and livestock to more pests and diseases[2].

IMPACTS OF CLIMATE CHANGE

- Climate-related stresses cause farmers in Samoa significant financial hardship and disrupt food supply for local and export markets[2].
- Warmer sea-surface temperatures have been linked to lower catches in Samoa[2].
- In recent years, higher sea-surface temperatures have damaged marine ecosystems, thus affecting near-shore fishing stocks[2].
- Coral bleaching has been of particular concern in Samoa, and increasingly heavy rainfall has boosted sedimentation levels in coastal waters which affecting fishing stocks[2].
- Marine species in Samoa and their habitats are significantly affected by rising sea levels and sea temperatures and by changes in wave action[2].
- Samoa's biological resources are already under stress from a range of factors unrelated to climate change and change in the climate may exacerbate these stresses and cause irreversible damage in the medium to long-term through species loss and changes to the ecosystem[2].
- The 'status of wildlife' in Samoa shows that many forest birds have declined in numbers even to the extent that some bird species populations have been 'decimated'[19].
- There is anecdotal evidence of growth in vector borne and water borne diseases that reconfirms the already changing climate and the impact it has on the health sector in Samoa[19].
- The impacts of climate change on the tourism sector widely include loss of beaches, inundation, and degradation of the coastal ecosystems, saline intrusion and damage to critical infrastructure[19].

MITIGATION & ADAPTATION TO CLIMATE CHANGE

SAMOA

- The adverse effects of climate change and sea level rise present significant risks to the sustainable development of small island developing states and the long-term effects threaten the very existence of some small islands[21].
- Samoa recognizes that the adverse effects of climate change will have significant impact on the country particularly in sectors such as agriculture, coastal infrastructure, health, forestry, meteorology, tourism, and water[16].
- Resource management and conversation are essential for healthy and stable communities on islands with limited resources because overexploitation could damage or permanently destroy natural resources[20].
- Current monitoring and surveillance systems cannot provide precise data on disease incidences, and so it is almost impossible to gather and analyses long-term data on how climate change affects human health[16].
- Local research into the links between climate-related extreme events and water- and vector-borne diseases has been minimal[16].
- Samoa's intended Nationally Determined Contribution highlights the need to build on work that has been undertaken to ensue actions that have been identified during the implementation of previous adaptation objects are addressed at a future stage[16].
- The assessment conducted as part of the Second National Communication identified higher temperatures, changing rainfall conditions, heavier winds and sea level rise as key challenges associated with climate change, which will increase the vulnerability of Samoa's agriculture sector[2].
- Adaptation in the agriculture sector will depend on national policies, planning for projected climatic changes and developing appropriate response measures[2].
- Adaptation measures include managing fisheries resources, establishing marine protected areas and reserves, restoring vital habitats like mangroves and coral reefs, improving public education and devising and implementing sound policy and regulation[2].
- The most important adaptation measures involve improving surveillance systems, early response systems and developing sustainable prevention and control programes[2].
- The Strategy for Development of Samoa highlights the key strategies for development across the priority sectors[4]. The Strategy highlights the importance of the environment as a priority area and has identified the mainstreaming of climate change across all sectors and increased investment in renewable energy as some of the main strategic outcomes[4].
- Climate and disaster resilience planning and implementation actions will be integrated into all sector plans and Implementing agency corporate plans ensuring adoption of Samoa's climate and disaster policies[3].

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SOLOMON ISLANDS

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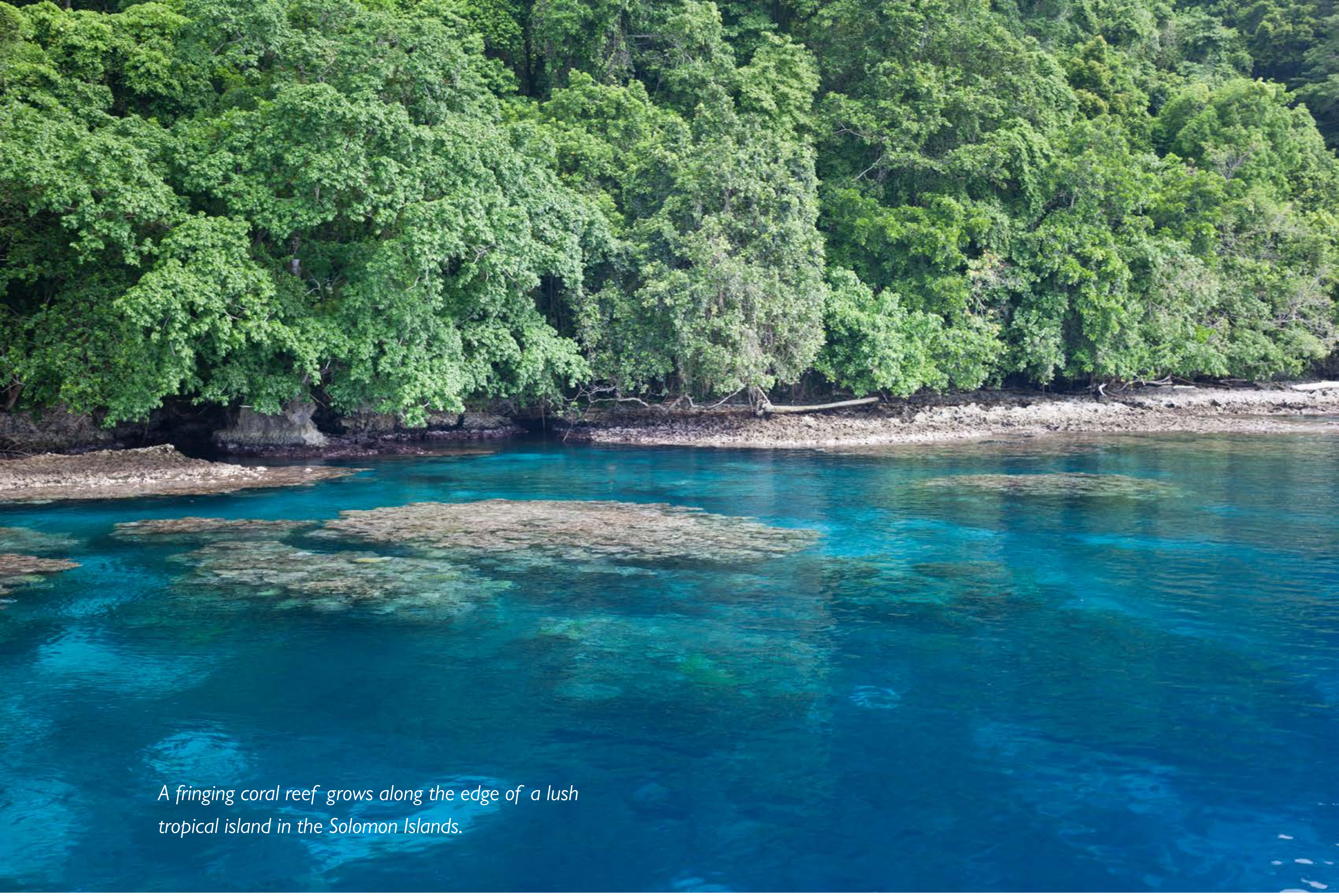
SOLOMON ISLANDS

- The Solomon Islands are located just south of the equator, in the western South Pacific Ocean, between 5 – 13 °S latitude and 155 – 169 °E longitude[1].
- The Solomon Islands archipelago is composed of approximately 1000 islands of which 350 are inhabited[2].
- Solomon Islands has a total land area of 28,785 km^2 and an Exclusive Economic Zone of 1.34 million Km^2[(3)].
- The Islands range from small low-lying atolls to large, volcanic islands with high peaks[1].
- The islands are grouped into three Geological provinces; the Pacific Geological Province (including Malaita, Ulawa and North Eastern part of Santa Isabel island); Central Geological Province (Makira, Guadalcanal and the Florida Islands, South -Western part of Isabel and Choiseul) and the Volcanic Geological Province (New Georgia, Russell Islands, Shortland Islands and North Western tip of Guadalcanal and Savo)[4].
- The capital city of Honaria, is located on the island of Guadalcanal and is the only major area of economic activity[4].
- The Solomon Islands location within the earthquake belt, or Ring of Fire, makes earthquakes a normal occurrence and makes the country extremely vulnerable to the effects and impacts of earthquakes[4].
- The Solomon Islands economy heavily depends on agriculture, forestry and fishing and other natural resources, both for the sustenance of its people and future economic expansion like many other less-developed Pacific Island Countries[4].
- The country's terrestrial biodiversity is outstanding with 4,500 species of plants and is recognized as one of the world's great centers of plant diversity[4].
- The reefs surrounding the islands contain one of the highest diversities of coral and fish found anywhere in the world placing the country in the coral triangle of the World's most important marine biodiversity areas[4].
- Total estimated population of Solomon Islands (based on 2015 estimate) is 583,6002.
- Approximately 80% of the population live in rural areas and rely on a subsistence economy with supplementary income from agriculture, forestry and fishery and remittances from relatives working off-island[4].
- The 2017 Gross Domestic Product (GDP) of Solomon Islands was USD1,518 milion[2].
- The key economic sectors are agriculture, forestry, fishing, mining and exploration, manufacturing, electricity and water, construction, transport and communication, retail and wholesale trade and finance[3].

GEOGRAPHY

SOLOMON ISLANDS

- Major environmental concerns are the impact of forest degradation through large scale logging operations, land clearing for subsistence agriculture as a result of rapid population growth, and the unsustainable harvesting of marine resources[3].
- As of 2012 there were six operational observation meteorological stations in the Solomon Islands[1].
- Multiple observations within a 24-hr period are taken at several stations (Taro, Munda, Auki, Honiara, Henderson and Santa Cruz), the station on Kirakia records a single observation of rainfall daily[1].
- Air temperatures are relatively constant throughout the year and are closely related to sea surface temperatures[1].
- Annual daytime temperatures range from 25 °C (77 °F) to 32 °C (90 °F)[4].
- The country has two distinct seasons: Dry season (Ara) from May to October and Wet season (Komburu) from November to April[1].
- The rainfall distribution across the Island chain is quite varied with annual average rainfall raging between 3,000 to 5,000 mm annually[3].
- Rainfall in the Solomon Islands (especially in the eastern part of the island chain) is strongly influenced by the position and strength of the South Pacific Convergence Zone (SPCZ), which is strongest during the wet-season[1].
- Most rain falls from January to March when the West Pacific Monsoon is most active in the region[1].
- Topography also plays a role, where rainfall is higher on the east facing (windward) sides of the Island and drier on the west facing (leeward) sides of the islands[1].
- The tropical cyclone season in the Solomon Islands region is between November and April and occurrences outside of this period are rare[1].
- The Solomon Islands are just north of the latitudinal belt of greatest-seasonal cyclone activity in the southern hemisphere (10-20°S) thus, occasionally experience extreme cyclone related weather events[1].
- Total area of Solomon Islands receives between 1-2 cyclones per year[5].
- Tropical cyclones pose a serious threat to the people, economy and environment and result in flooding and wind damage[4].
- The main influence of year-to-year natural climate variability in the Solomon Islands is the El Niño Southern Oscillation (ENSO)[1].


A fringing coral reef grows along the edge of a lush tropical island in the Solomon Islands.

- There are significant correlations between ENSO indices and both rainfall and air temperature in the Solomon Islands[1].
- El Niño events tend to bring a late start to the wet season and lower rainfall in both the wet and dry seasons, as well as cooler conditions in the dry season1. Opposite impacts are usually observed during La Niña Events[1].
- The wettest years in the Solomon Islands can be twice as wet as the driest years1.
- The Solomon Islands remain, after a period of several years, one of the top countries whose populations are threatened by natural disasters, and whose government is incapable of protecting, or barely even helping its citizens[6].
- In 2016, the Solomon Islands was ranked the sixth most at-risk country to natural disasters in the world, primarily because of its extremely high exposure to disaster events and the frequency which these events occur[6].

GLOBAL CLIMATE CHANGE

SOLOMON ISLANDS

TEMPERATURE

- The 2018 average global temperature across land and ocean surface areas was 0.84˚C above the 20th century average[7].
- 2018 was the fourth warmest year in the 1880–2018 record, behind 2016 (highest), 2015 (second highest), and 2017 (third highest)[7].
- 2018 was the second warmest year on record without an El Niño present in the tropical Pacific Ocean[7].
- 2018 marks the 42nd consecutive year (since 1977) with global land and ocean temperatures above 20th century average[7].
- Nine of the 10 warmest years have occurred since 2005[7].
- The 2018 globally averaged sea surface temperature was 1.19°F (0.66°C) above the 20th century average[7]. This was the fourth highest among all years in the 1880-2018 record, again behind 2016 (highest) and 2015 (second highest) and 2017 (third highest)[7].

SEA LEVEL RISE

- In 2017 global sea level was 77 mm above the 1993 average, which is the highest annual average in the satellite record[8].
- 2017 was the sixth consecutive year, and the 22nd out of the last 24 years in which global mean sea level increased relative to the previous year[8].
- Sea level rises at a rate of just over 3.1 mm per year due to a combination of melting glaciers and ice sheets and from the thermal expansion of seawater[8].
- The rate of sea level rise has doubled since 1993 compared to the 20th century average[8].

OCEAN ACIDIFICATION AND TEMPERATURE

- Oceans are absorbing about 25% of the carbon dioxide emitted to the atmosphere annually and as a result are becoming more acidic[9].
- The world's oceans have absorbed about 93% of the excess heat caused by greenhouse gas warming since the mid-20th century[10].
- Ocean heat content has increased at all depths[10].
- Increasing sea surface temperatures, rising sea levels, changing patterns of precipitation and winds, and ocean circulation are contributing to overall decline oxygen concentrations in the oceans[10].

REGIONAL CLIMATE CHANGE

SOLOMON ISLANDS

TEMPERATURE

- Averaged as a whole, Oceania had its third warmest year in 2018 since regional records began in 1910[7].
- Much warmer than average temperatures occurred in equatorial western pacific encompassing the geographic area of containing the Solomon Islands[7].
- In the Pacific region, land-surface temperatures have been rising at the rate of +0.17°C (0.31°F) per decade since the 1980s, slightly ahead of the global trend[11].
- Warming trends of a similar magnitude are evident in both annual and seasonal mean air temperatures in the Solomon Islands (1950-2009) with the strongest trend found in the wet-season mean air temperature (+0.18° C per decade)[1].
- Ocean temperatures have risen gradually since the 1950's with the rate increasing over time and since the 1970a the rate of warming has been approximately 0.13°C per decade[1].

PRECIPITATION

- Annual and seasonal rainfall trends for Honiara for the period 1950-2009 are not statistically significant[1].

SEA LEVEL RISE

- The sea level rise near the Solomon Islands is measured by satellite altimeters and since 1993 is about 6 mm per year, which is larger than the global average of 3.2 mm per year[1].
- Seasonal sea levels are significantly lower during El Niño conditions and higher during La Niña conditions[1].
- In the waters around the Solomon Islands, aragonite saturation state has declined from 4.5 in the late 18th century to 3.9 in 2000 (which is not optimal for coral growth)[1].

EXTREME EVENTS

- Between 1969 and 2010, 41 tropical cyclones passed through the region of the Solomon Islands (10 cyclones per decade)[1].
- The probability of changes to the frequency and intensity of extreme rainfall events and storm surges remains poorly understood for small islands[12].

FUTURE CLIMATE PROJECTIONS

SOLOMON ISLANDS

- Surface air temperature and sea-surface temperature are projected to continue to increase over the course of the 21st century[1,13].
- Beyond 2035 the projected warming in the Solomon Islands diverges depending on the greenhouse gas emissions pathway that humanity follows (see table below)[1]. NOTE: Climate projections have been derived for the Solomon Islands by the Australian Bureau of Meteorology using the Coupled Model Intercomparison Project (CMIP3) database for up to three greenhouse gas emission scenarios: B1 (low emissions), A1B (medium emissions) and A2 (high emissions)[1].

Projected change in surface air temperature (°C) for 2030 (2020–2039), 2055 (2046–2065) and 2090 (2080–2099), relative to 1990 (1980–1999) base period for the three emission scenarios are shown below[1].

EMISSION SCENARIO	2030	2055	2090
LOW B1	+0.6 ± 0.4	+1.1 ± 0.4	+1.5 ± 0.6
MEDIUM: A1B	+0.8 ± 0.4	+1.4 ± 0.5	+2.3 ± 0.8
HIGH: A2	+0.7 ± 0.3	+1.4 ± 0.4	+2.7 ± 0.6

The CMIP3 scenarios are considered equivalent to the more recent CMIP5 scenarios. In regards to air temperature CMIP3 and CMIP5 have been shown to produce similar results and ranges of uncertainty by the end of the century[13]. The newest regional climate projections which are part of the CMIP6 are currently in development and result will be officially released in 2020 with the Inter-governmental Panel on Climate Change (IPCC) Six Assessment Report.

- The majority of CMIP3 models simulate little change (-5% to 5%) in wet season rainfall by 2030, however, by 2090 under the A2 (high) emissions scenario, the majority simulate an increase (>5%) in wet-season rainfal[11].
- The intensity and frequency of days of extreme heat are projected to increase over the course of the 21st century[1].
- The intensity and frequency of days of extreme rainfall are projected to increase over the course of the 21st century[1].

FUTURE CLIMATE PROJECTIONS

SOLOMON ISLANDS

- Incidence of drought over the course of the 21st century are expected to decrease[1].
- Acidity levels of the ocean are expected to increase across the Solomon Islands over the course of the 21st century[1].
- Projections from all analyzed CMIP3 models indicate that the annual maximum aragonite saturation state will reach values below 3.5 by about 2035 and continue to decline thereafter[1].
- The impact of acidification change on the health of the reef ecosystems is likely to be compounded by other stressors including coral bleaching, storm damage and fishing pressure[1].
- The CMIP3 models simulate a rise of between approximately 5-15 cm by 2030, with increases of 20-60 cm indicated by 2090 under the high (A2) emission scenarios[1].
- Frequency of cyclone activity in the region of the Solomon Islands is projected to decline but the intensity of the most severe cyclones is projected to increase[1,13].
- Global sea surface temperature is projected to continue to increase through the 21st century under all emissions scenarios[13].
- Elevated sea temperatures and CO2 concentrations from climate change are already contributing to large-scale ecological change across the globe[12,13].
- Devastating impacts on coral reefs between 2030 and 2050 are expected in the region as bleaching level stress is reached annually under all emission scenarios[13].
- Severe degradation and potential loss of corals from most global locations is expected by 2050 under current warming trajectories[13].
- Mean sea level is projected to continue to rise over the course of the 21st century[1]. Between 5-15 cm by 2030 and 20-60 cm by 2090 under high (A2) emission scenarios[1].
- Ocean oxygen levels are projected to decrease by as much as 3.5% by the end of the century under a low mitigation scenario relative to pre-industrial levels[10].

SOLOMON ISLANDS

IMPACTS OF CLIMATE CHANGE

- Climate change threatens the physical, biological, and human elements necessary for Pacific Island cultures to sustain their way of life[14].
- The Solomon Islands have experienced the globes highest rates of warming[15].
- Severe flooding from storm events has been observed in Guadalcanal, Malaita, Makira and Santa Isabel in recent years with a number of lives lost, and severe damage to agriculture and Infrastructure[16].
- The 97/98 El Nino caused severe drought conditions in many parts of the country and one of the major prolonged droughts occurred in the eastern part of the country in the Temotu province in 2004 causing food and water shortages[16].
- Climate change will also adversely affect water and sanitation, food shortages leading to poor nutrition, reduced immunity and enhanced distribution of bacteria and parasites. Increased rainfall and increased humidity lead to more breeding sites for malaria mosquito's survival and transmission. From a household perspective, such changes to health and diseases place additional burden on women and children[3].
- There is evidence that water quality and quantity in Solomon Islands is reducing but the rate of reduction is not well understood due to lack of data and limited understanding of local hydrological systems and water resources[3].
- More intense rainfall has the potential to increase flooding, damage crops and move pollutants into coastal waters[1].
- Rising sea levels, coastal erosion cause damage to water supply infrastructure and salt water intrusion into groundwater lens on low-lying and atoll islands[3].
- The recent sea level rise in the Solomon Islands has in some cases led to substantial coastal change and displacement of indigenous communities[15].
- Pacific island countries are among the most vulnerable in the world to the health impacts of climate change[17].
- In Solomon Islands specific diseases have been linked to climate and or weather patterns including malaria, mental illness, malnutrition, diarrhea, acute respiratory infections, micronutrient deficiency, parasitic diseases due to poor sanitation, tuberculosis, leprosy and non-communicable diseases[3].
- Overall health impacts from climate change are not well understood in a Solomon Islands context and more research and data collection is needed to plan, prepare and build commitment to the issues across stakeholders[3].
- In 2015, Category 5 Tropical cyclone Pam impacted an estimated 4,600 people in the Solomon Islands and destroyed, over 1,000 homes and severely damaged crops[18].

MITIGATION & ADAPTATION TO CLIMATE CHANGE

SOLOMON ISLANDS

- Climate change is the most important environmental and developmental issue for Solomon Islands[3].
- Solomon Islands is committed to reduce emissions by: 12% below 2015 level by 2025 and 30% below 2015 level by 2030[16].
- With a high vulnerability to climate change impacts, Solomon Islands has placed equal importance on mitigation of and adaptation to climate change and recognizes the need for developing low carbon economy to achieve its sustainable development objectives[16].
- Change Policy (2012-2017) which is linked to National Development Strategy (2011-2020) provides a policy framework for developing and describing ongoing and planned actions (changes in institutions, modified policies and measures, major projects/programs, planning processes, and financial investments) using international and country resources[16].
- Solomon Islands has committed to continuing its participation and interface with the UNFCCC Conference of the Parties process[19].
- The relocation of population because of climate change presents a complex challenge to the communities displaced, facing a loss of land and connection to ancestral heritage and to the governments responsible for protecting climate-vulnerable populations[15].
- Although the Solomon Islands government views climate relocation as a critical issue, there is currently no effective policy or legislation to guide relocation of human settlements[15].
- Community-based adaptation has been identified as a national strategy to improve food security and well-being and build adaptive capacity to climate change in the context of other pressures[20].
- Resource management and conversation are essential for healthy and stable communities on islands with limited resources because overexploitation could damage or permanently destroy natural resources[14].
- Research has shown that climate driven health risks from the spread of infectious disease, loss of settlements and infrastructure, and decline of ecosystems that affect small island economies and livelihoods, and human well-being are under researched[12].

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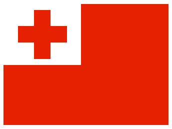

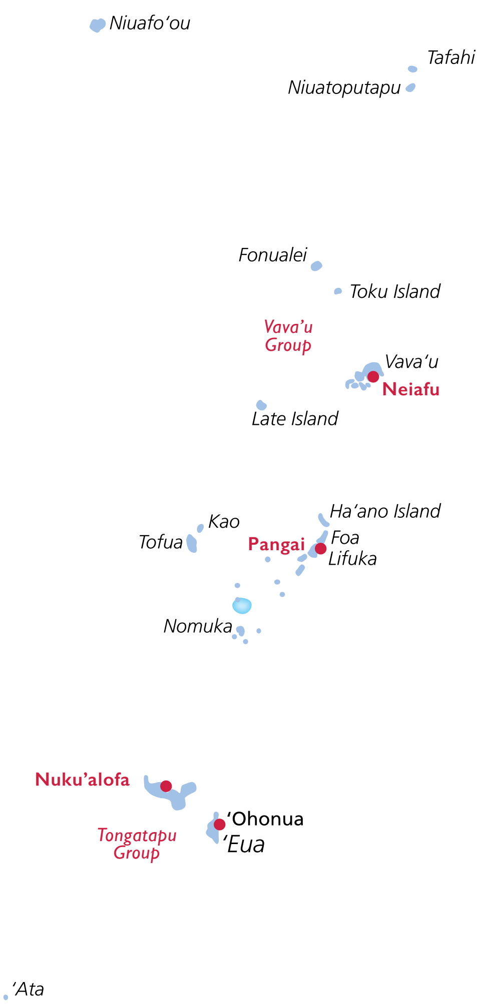

GEOGRAPHY

GLOBAL CLIMATE CHANGE

REGIONAL CLIMATE CHANGE

FUTURE CLIMATE PROJECTIONS

IMPACTS OF CLIMATE CHANGE

MITIGATION & ADAPTATION TO CLIMATE CHANGE

GEOGRAPHY

- The island Kingdom of Tonga is located in the western South Pacific Ocean between 15°S - 23°S latitude and 173° - 177°W longitude[1].
- The Tonga archipelago is spread over 800km in a north-south direction[1].
- Tonga has a total land area of 686 km^2 and an exclusive economic zone of 720,000 km^2[(1)].
- The Kingdom of Tonga consists of 172 islands situated in four island groups; Tongatapu (260 km^2) and ʻEua (87 km^2) in the south, Haʻapai (109 km^2) in the middle, Vavaʻu (121 km2) in the north, and Niuafoʻou and Niuatoputapu (72 km^2) in the far north[2].
- Thirty-six of the islands in the Tonga archipelago are inhabited[3].
- Tongatapu, the main island, is a raised coral atoll and is distinctively flat and low lying[4].
- The Vavaʻu group is mostly raised coral atolls with some low-lying island, whereas Haʻapai is typically flat with some islets and sand cays[4].
- Kao and Tofu are volcanic Islands in the Haʻapai group and the two Niuas are high volcanic islands surrounded by fringing and barrier reefs[4].
- Most of Tonga's atoll islands, including the main island, Tongatapu, are flat with an average elevation of 2-5 meters[2].
- Tonga is situated at the subduction zone where the Australian and Pacific Tectonic plates meet and where most seismic activities occur[4].
- Tonga is also vulnerable to earthquakes and the resultant tsunami waves due to its location within the Pacific Ring of Fire[4].
- The total land area of Tonga is 686.87 square kilometers[3].
- Coconut (grassland, shrubland and cropland) account for 74%, of the total land cover[3].
- Woodlands account for 9%, mangroves and wetlands accounted for 3%, coniferous and non-coniferous plantations accounted for 1% and other classification of lands accounted for the remaining balance[3].
- Indigenous forest area has been estimated at between 4-11% of the total land area[3].
- The two main sources of water in Tonga are from the rainwater captured and stored in the water tanks and also from the underground water aquifers[3].
- Tonga's government is comprised of a Constitutional Monarchy with the King in Privy Council, the other three main government bodies are the Parliament, the Cabinet and the Judiciary[5].
- The capital Nukuʻalofa, is situated on Tongatapu, which is the largest in the south[1].
- The total population in Tonga (based on 2016 census) is 100,651[6].
- The urban population (23% of the total population) includes the villages of Kolofʻou, Maʻufanga and Kolomotuʻa, which make up Tongatapu[6].

GEOGRAPHY

TONGA

- Most of the urban area of Nuku'alofa is only 1-2 meters above sea level[5].
- Average annual population growth is -0.5% (or 520 people per year) due to out migration6.
- Tonga's Gross Domestic Product (GDP) is USD398.3 million[7].
- Tonga's economy is very much dependent on remittances (50-60%), agricultural export (10-15%) with squash as the leading export, and the rest from fisheries, tourism and foreign assistance[3].
- Agriculture is primarily a subsistence activity[4].
- Subsistence crops include yam, taro, sweet potato and cassava[4].
- Tonga's per capita income at approximately USD3,818[7].
- Approximately 22.5% (2009 est.) of the Tongan population lives below the national poverty line[8].
- The percentage of the population living below the poverty line grew from 16.2% in 2001 to 22.5 in 2009 with the greatest increases occurring on the outer islands[8].
- Tonga's economy is highly dependent on remittances flow and donor grants, with agriculture and tourism being the main exports which pose sustainability risks[5].
- Women make up 42.3% of the labor force in Tonga[4].
- As of 2010 there were seven climate stations in Tonga's climate monitoring network[1].
- Multiple daily observations are taken at Fuaʻamoto, Lupepauʻu, Niuatoputapu, Haʻapai and Niuafoʻou and single day observations are taken at Nukuʻalofa and Kaufana[1].
- Climate records with data available from 1944 are available at the primary stations located on the northern and southern side of Tongatapu[1].
- Oceanographic records are not as extensive and monthly-averaged sea-level data are available from 1993 at Nukuʻalofa[1].
- The Köppen-Geiger Climate Classification of Tonga is generally categorized as equatorial, fully, humid (Af)[9].
- The annual range in average monthly maximum temperature in Tonga shows some variation due to its proximity to the sub-tropics with Nukuʻalofa showing the largest variation (about 5˚C) between the warmest month (February) the coolest month (July-August)[1].
- Tonga has two distinct seasons: Dry/Cool season (May to October) and Wet/Warm season (November to April)[1].
- Almost two-thirds of Tonga's rainfall falls in the wet season[1].

Swallow Cave - Vava'u Island, Tonga.

- The seasonal cycle is strongly affected by the South Pacific Convergence Zone (SPCZ), which is most intense during the wet season[1].
- Year-to-year natural climate variability is high in Tonga and is explained by the El Niño Southern Oscillation (ENSO)[1].
- Both Nukuʻalofa and Lepupauʻu receive about three times as much rain in the wettest years as in the driest years[1].
- There are significant correlations between ENSO indices and both rainfall and air temperature in Tonga[1].
- Generally, El Niño years are drier and cooler than average in Tonga while La Niña years are wetter and warmer than average[1].
- The tropical cyclone season in Tonga is usually between November and April but occasionally in October and May during El Nino Years[1].
- From 1970-2015 a total of 73 cyclones passed through Tonga waters[4].
- Tropical cyclones are most frequent during El Niño years[1].
- In February 2018, Tropical Cyclone Gita was the most intense tropical storm to impact Tonga since reliable records began and caused 2 fatalities, 41 injuries, destroyed 171 homes, damaged 1,100 homes and caused an estimated USD61 million in damages (equivalent to 37.8% of the nominal GDP)[10].

TONGA

GLOBAL CLIMATE CHANGE

TEMPERATURE

- The 2018 average global temperature across land and ocean surface areas was 0.84˚C above the 20th century average[11].
- 2018 was the fourth warmest year in the 1880–2018 record, behind 2016 (highest), 2015 (second highest), and 2017 (third highest)[11].
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SEA LEVEL RISE

- In 2017 global sea level was 77mm above the 1993 average, which is the highest annual average in the satellite record[12].
- 2017 was the sixth consecutive year, and the 22nd out of the last 24 years in which global mean sea level increased relative to the previous year[12].
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- Oceans are absorbing about 25% of the carbon dioxide emitted to the atmosphere annually and as a result are becoming more acidic[13].
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- Ocean heat content has increased at all depths[14].
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TONGA

REGIONAL CLIMATE CHANGE

TEMPERATURE

- Averaged as a whole, Oceania had its third warmest year in 2018 since regional records began in 1910[11].
- Much warmer than average temperatures occurred in equatorial western Pacific encompassing the geographic area of containing the country of Tonga[11].
- In the Pacific region, land-surface temperatures have been rising at the rate of +0.17°C (0.31°F) per decade since the 1980s, slightly ahead of the global trend[15].
- An upward trend in temperature at Nukuʻalofa (+0.16°C per decade) has been observed (between 1950 to 2009)[1].
- In Fuaʻamoto a 0.32°C per decade increases in temperature has been observed since 1980 (1980- 2013)[4].
- Ocean temperatures have risen gradually since the 1950s with the rate increasing over time and since the 1970s the rate of warming has been approximately 0.12°C per decade[1].
- At regional scales natural variability plays a large role in determining sea-surface temperature making it difficult to identify long-term trends[1].

PRECIPITATION

- No significant changes in average annual rainfall have been observed over the period 1950-2009[1].
- Severe droughts of 1983, 1998, 2006 and 2015 have caused stunted growth of annual crops such as squash, vegetables, yams, sweet potatoes, root crops and coconuts[4].
- In the 1998 drought squash export was reduced by 52%[4].

SEA LEVEL RISE

- Sea level rise near Tonga measured by satellite altimeters since 1993 is over 6 mm per year compared with the global average of 3.2 ± 0.4 mm per year[1].
- Seasonal sea levels are significantly lower during El Niño conditions and higher during La Niña conditions[1].
- The sea surface temperatures near Tonga indicate a warming trend of 0.06˚C/decade[1].

Humpback Whale Calf, Pacific Ocean - Vava'u, Tonga

MARINE SYSTEMS

- Coral reefs face threats at multiple scales ranging from global increases in oceanic temperature and ocean acidification, to local factors such as point and non-point source pollution, increased disturbance, and fishing pressure[16].
- Species diversity for both fished and non-fished species groups decreases as human population increases[16].
- In Tongan maritime boundaries, the aragonite saturation state has declined from 4.5 in the late 18th century to 3.9 in 2000 (which negatively impacts the development of corals)[1].

FUTURE CLIMATE PROJECTIONS

TONGA

- Surface air temperature and sea-surface temperature are projected to continue to increase in Tonga over the course of the 21st century[1,17].
- Beyond 2030 the projected warming in Tonga diverges depending on the greenhouse gas emissions pathway that humanity follows (see table below)[1]. NOTE: Climate projections have been derived for Tonga by the Australian Bureau of Meteorology using the Coupled Model Intercomparison Project (CMIP3) database for up to three greenhouse gas emission scenarios: B1 (low emissions), A1B (medium emissions) and A2 (high emissions)[1].

Projected change in surface air temperature (°C) for 2030 (2020– 2039), 2055 (2046–2065) and 2090 (2080–2099), relative to 1990 (1980– 1999) base period for the three emission scenarios are shown below[1].

EMISSION SCENARIO	2030	2055	2090
LOW B1	+0.6 ± 0.4	+1.0 ± 0.5	+1.4 ± 0.6
MEDIUM: A1B	+0.7 ± 0.5	+1.3 ± 0.6	+2.1 ± 0.8
HIGH: A2	+0.7 ± 0.4	+1.4 ± 0.4	+2.6 ± 0.7

The CMIP3 scenarios are a product of the Inter-Governmental Panel on Climate change (IPCC) forth Assessment Report (AR4) but are considered equivalent to the more recent CMIP5 scenarios from the AR5. In regards to air temperature CMIP3 and CMIP5 have been shown to produce similar results and ranges of uncertainty by the end of the century[17]. The newest regional climate projections which are part of the CMIP6 are currently in development and result will be officially released in 2022 with the IPCC AR6.

- Wet season rainfall is projected to increase across the country over the century[1].
- The majority of CMIP3 models simulate little change (-5% to 5%) in wet season rainfall by 2030, however by 2090 the majority simulate an increase (>5%), with approximately one third simulating a large increase (>15%) under the A2 (high) emissions scenario[1].
- The models disagree in the dry season with projections in annual rainfall ranging from -5 to +15%[1].

FUTURE CLIMATE PROJECTIONS

TONGA

- The intensity and frequency of days of extreme heat are projected to increase over the course of the 21st century[1].
- The intensity and frequency of days of extreme rainfall are projected to increase over the course of the 21st century[1].
- Projections from all analyzed CMIP3 models indicate that the annual maximum aragonite saturation state will reach values below 3.5 by about 2035 and continue to decline thereafter[1].
- The impact of acidification change on the health of reef ecosystems is likely to be compounded by other stressors including coral bleaching, storm damage and fishing pressure[1].
- Acidity levels of the ocean are expected to increase across Tonga over the course of the 21st century[1].
- The CMIP3 models simulate a rise in sea-level in Tonga between approximately 5-15 cm by 2030, with increases of 20-60 cm indicated by 2090 under the high emission scenarios[1].
- Frequency of cyclone activity in the region of Tonga is projected to decline but the intensity of the most severe cyclones is projected to increase[1,17].
- Global sea surface temperature is projected to continue to increase through the 21st century under all emissions scenarios[17].
- Elevated sea temperatures and CO2 concentrations from climate change are already contributing to large-scale ecological change across the globe[17,18].
- Devastating impacts on coral reefs between 2030 and 2050 are expected in the region as bleaching level stress is reached annually under all emission scenarios[17].
- Severe degradation and potential loss of corals from most global locations is expected by 2050 under current warming trajectories[17].
- Regional ocean oxygen levels are projected to decrease by as much as 3.5% by the end of the century under a low mitigation scenario relative to pre-industrial levels[14].

TONGA

IMPACTS OF CLIMATE CHANGE

- The geographical location, geological composition and socioeconomic features of Tonga greatly determine its susceptibility to the impacts of climate change as they fundamentally affect the environment, the people of Tonga and their livelihoods[3].
- In 2018, Tonga was ranked second out of 172 countries with the highest disaster risk in the world[19].
- Sea level rise is already causing loss and damages of not only agricultural lands but lands on the low-lying coastal areas of the islands of Tonga[5].
- Tonga's agriculture remains vulnerable to the impacts of climate change and natural disasters[4].
- Increased weather variability makes farming less predictable and Increasing trends in storm frequency and intensity threaten crops[4].
- Tonga has experienced a considerable loss of coastal agricultural land and increased salinity of groundwater lens, with lesser amounts of groundwater available today for irrigation[4].
- Increased heavy rainfall events can increase soil erosion and increase the weathering of soil[3].
- Rising sea levels stand to exacerbate the contamination and increase the impact on communities relying on these ground water supplies[4].
- Total loss of coastal agricultural land due to sea level rise has been estimated at 43 Km2 or 8% of total land for Tongatapu and 15% for the Haʻapai group[4].
- Increasing sea surface temperatures, ocean acidification, and loss of important habitats like coral reefs, sea grass beds, mangroves and intertidal flats are expected to have a dramatic impact on the fish and shellfish that support many coastal communities[5].
- By 2030, projections for the thermal stress and ocean acidification suggest that the number of reefs assessed as being at the highest risk will increase from 10% to nearly 40% especially reefs around Tongatapu and Vavaʻu (the two most populated islands)[5].
- High priority climate sensitive health effects risks in individual Pacific Island countries include the direct impacts of extreme weather events and the indirect effects of water security and safety (including water-borne diseases) and food security and safety (including malnutrition and percentage of people affected by food-borne diseases)[20].
- With increasing rainfall and increased settlement of Tongans from outer islands to swampy areas of Nuku'alofa, the spread of dengue fever reached epidemic proportions in 2014 and 2016[4].
- Heavy rainfall events increase erosion and increases the amount of freshwater, sediments and pollutants (pesticides and herbicides from farming) that enter coastal waterways[4].
- Sediments produced from heavy rainfall events smother and poison intertidal and subtidal areas, affecting ecosystem health, fisheries productivity and threatening important food sources, especially for those people residing around such areas[4].

IMPACTS OF CLIMATE CHANGE

TONGA

- Climate change will enhance the spread of pests, and disease which puts pressure on crop production[4].
- The recent rise in sea temperature warming around Tonga's coastal waters have caused widespread coral bleaching and increased algae blooms, both of which impact on fishery species and importantly the complex ecosystem of bays, inlets and coral reefs where they live[4].
- The average disaster losses from cyclones, earthquakes and tsunami is estimated by the World Bank to be equivalent to 4.4 percent of GDP[21].
- Tropical Cyclone Ian, in 2014, affected some 5,500 people (nearly 70 percent of the population of Ha'apai), destroying or severely damaged about 75% of their housing stock[21].
- Climate change threatens the physical, biological, and human elements necessary for Pacific Island cultures to sustain their way of life[22].

MITIGATION & ADAPTATION TO CLIMATE CHANGE

- The adverse effects of climate change and sea level rise present significant risks to the sustainable development of small island developing states and the long-term effects threaten the very existence of some small islands[23].
- Tonga makes a negligible contribution to global greenhouse gas emissions, with low per capita emissions of 2.95 tCO2e[2].
- Tonga has set ambitious goals to reduce GHG emissions by generating 50% of electricity from renewable sources by 2030 and 70% by 2030[2].
- Tonga will double the number of Marine Protected areas by 2030[2].
- Tonga will use the new Climate Change Policy (2015-2020)[21].
- The Government of Tonga has raised its climate change authority to the ministerial level, establishment of the Legislative Assembly Standing Committee for Climate Change, developing of National Climate Change Policy, revision of the Joint National Action Plan to Integrate Climate Change and Disaster Risk Reduction, and development of the third Climate Change National Communication[2].
- Extensive coastal erosions across the Kingdom has prompted Government to direct over 30 percent of mobilized development assistance to address it during the last six years (2010-2015), and lack of climate proofing investments further risks Government's poverty alleviation commitments and national development[2].
- The purpose of the new Tonga Climate Change Policy is to provide a clear vision, goal, and objectives to direct responses to climate change and disaster risk reduction over the next five years[21].
- This Tonga Climate Change Policy provides a supporting framework that is aligned with the Tonga Development Plan 2015-2025 and encourages alignment with all relevant sector policies and plans to ensure that proactive measures are taken to build a resilient Tonga[21].
- The protection of health facilities against climate change and disaster impacts throughout Tonga is crucia[14].
- The purpose of this Tonga Climate Change Policy is to provide a clear vision, goal, and objectives to direct responses to climate change and disaster risk reduction over the next five years[21].
- Resource management and conversation are essential for healthy and stable communities on islands with limited resources because overexploitation could damage or permanently destroy natural resources[22].

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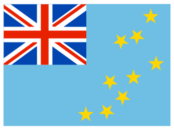
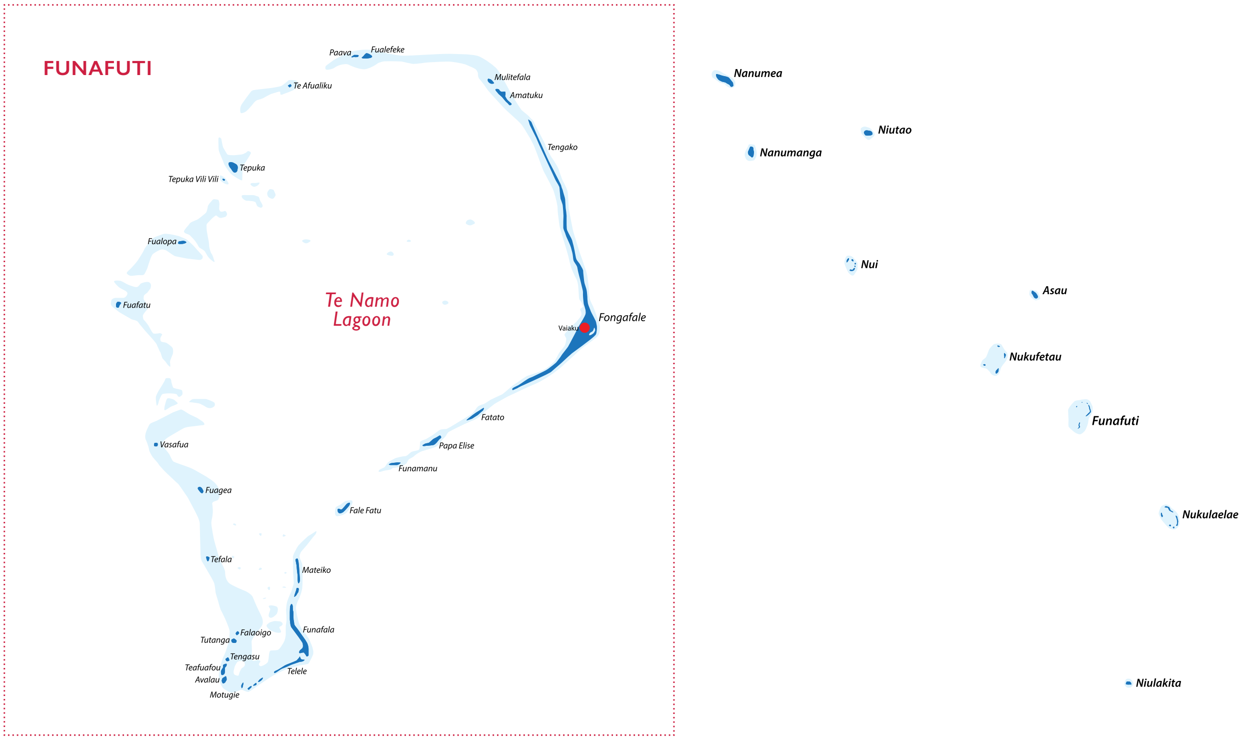
TUVALU





GEOGRAPHY

GLOBAL CLIMATE CHANGE

REGIONAL CLIMATE CHANGE

FUTURE CLIMATE PROJECTIONS

IMPACTS OF CLIMATE CHANGE

MITIGATION & ADAPTATION TO CLIMATE CHANGE

GEOGRAPHY

TUVALU

- The island nation of Tuvalu lies south of the equator in the western South Pacific Ocean between 5 -11°S latitude and 176 - 180°E longitude[1].
- The Tuvalu archipelago consist of nine small islands, six of them are atoll islands with ponding lagoons (Nanumea, Nui, Vaitupu, Nukufetau, Funafuti and Nukulaelae) and the remaining three islands (Nanumaga, Niutao, and Niulakita) are raised limestone reef islands[2].
- The name Tuvalu means "eight islands in unity" and although there are nine island that make up the nation today, only eight were initially inhabited so the ninth (Niulakita) is not included in the name[1].
- Tuvalu is the fourth smallest nation in the world with a combined land area of 26 km[2,3].
- Tuvalu is surrounded by 1.3 million km2 of ocean, including an Exclusive Economic Zone of 719,174 km[2,1] .
- All of the islands and atolls are low lying with an average elevation of less than 3 meters above sea level. The highest point is 4.6 m above sea level found on the island of Niulakita (4.6 m)[1].
- Tuvalu's inhabited coastline of 82 km has undergone rapid changes due to exploitation of aggregates such as beach sand and reef coral, and blasting of reef passages or boat channels, predominantly during World War II[1].
- Total estimated population of the Tuvalu (based on the 2017 mini-census) is 10,645. Funafuti, the capital, is the most populated atoll with 63% of the country's population[4].
    - Funafuti Island population = 6,7164
    - Outer Island population= 3,9294
- In a five year period (2012-2017) total population decreased by -1.3% which was attributed to out-migration of residents in the working age group (30-54)[4].
- Tuvalu's population is forecasted to reach 13,300 by 2025 and 15,600 by 2030[1].
- Subsistence agriculture is the predominate form of economic activity in Tuvalu, however, compared to other countries in the Pacific region, agricultural productively in Tuvalu is low due to poor soil and water retention capacity, low levels of organic material, scarcity of arable land and freshwater, and lack of agricultural technology[1].
- A higher proportion of the outer island population is engaged in subsistence agriculture, fishing and domestic duties compared to the population on Funafuti[1].
- 18,000 ha (60% of the country's land) is occupied by agriculture[5].
- Air temperatures are relatively constant throughout the year and are closely related to sea surface temperatures[6].
- Temperatures range between 26°C and 32°C the year round, with the water temperature averaging 28–29°C[7].

GEOGRAPHY

TUVALU

- The country has two distinct seasons[6].
    - Dry-season from May to October[6].
    - Wet-season from November to April[6].
- The strong seasonal cycle is driven by the strength of the South Pacific Convergence Zone (SPCZ), which is strongest during the wet-season[6].
- Annual rainfall varies considerably from north to south with the southern atolls (including Funafuti) receiving 340 mm/yr. and the northern atolls (including Nanumea) receiving 290 mm/yr[6].
- During the wet-season the West Pacific Monsoon can also bring high rainfall[6].
- Sixty-percent of the rain in Tuvalu occurs during the wet-season[7].
- Dry periods are more severe in the northern than the southern islands, notably in the months of August to October[8].
- Tropical cyclones and spring tides ae the main extreme events that affect Tuvalu[6].
- In addition to the high winds and heavy rainfall associated with tropical cyclones, storm surge and swell generated by these storms result in land inundation which causes damage to buildings and roads along the coast as well as agricultural losses (especially taro)[6].
- The tropical cyclone season in Tuvalu is from November to April. On average eight cyclones pass through the region each year[6].
- The northern islands have higher exposure indices (compared to the central and southern islands). The central islands have the highest percentage of households residing in narrow parts of the islands which are prone to disasters. On the capital Funafuti, 13% of households reside in narrow parts of the island which are exposed to storms, while 9.3% of households live beside pits and ponds which are prone to flooding during king tides[9].
- As of 2012 there were nine operational observation meteorological stations in the Tuvalu[6].
    - Multiple observations taken at four stations (Nanumea, Nui, Funafuti and Niulakita) and single observation rainfall stations Nanumaga, Niutao, Nukfetau, Vaitupu and Nuklaelae[6].
- The main influence of year-to-year natural climate variability in Tuvalu is the El Niño Southern Oscillation (ENSO)[6].
- Temperatures in Tuvalu are typically warmer during El Niño events and cooler during La Niña Events[6].
- In an El Niño year the SPCZ tends to move to the north-east over Tuvalu which results in higher rainfal[6].
- In La Niña Years the SPCZ shifts to the southwest which can bring about severe drought[6].

Aerial of the Island of Tuvalu

- In 2011 La Niña event triggered a severe drought and a subsequent state of emergency in Tuvalu[10].
- During the 2011 drought, families did not have enough water for basic household needs, feeding livestock, or tending to gardens, and food-bearing trees died, so local food availability declined[3].
- Tuvalu is highly reliant on rainfall as the main source of fresh water[3].
- There are no rivers on the islands and groundwater is extremely limited[1].
- Rainwater is harvested and stored in household tanks, island community and church tanks and cisterns and a large government cistern[3].
- Funafuti's water harvesting system is inherently sensitive to dry spells because it is completely dependent on rainfall. This reflects the timing, frequency, and intensity of rainfall[3].
- Groundwater resources are very limited and if available, are brackish and exposed to saltwater intrusion from flooding and rising sea level and exposed to contamination from human and animal waste[1].
- In Funafuti groundwater is only used for feeding pigs, washing pig pens and flushing toilets, however, during a drought, its use extends to washing clothes, bathing and flushing toilets[1].
- The 2011 drought resulted in widespread sickness due to a decrease in handwashing, low household water reserves that increased pathogen concentrations, and a switch to untreated or less hygienic water sources[10].

GLOBAL CLIMATE CHANGE

TEMPERATURE

- 2019 was the second warmest year in the 140-year record globally[11].
- Global land and ocean surface temperature departure were +0.95°C (+1.71°F) above the long-term average[11], which is only 0.04°C (0.07°F) less than the record high value of +0.99°C (+1.78°F) set in 2016 and 0.02°C (0.04°F) higher than the now third highest value set in 2015 (+0.93°C / +1.67°F)[11].
- The five warmest years in the 1880–2019 record have all occurred since 2015, while nine of the 10 warmest years have occurred since 2005[11].
- The year 2019 marks the 43rd consecutive year (since 1977) with global land and ocean temperatures, at least nominally, above the 20th century average[11].

SEA LEVEL RISE

- Global mean sea level has risen about 21–24 centimeters (8–9 inches) since 1880, with about a third of that coming in just the last two and a half decades[12].
- The rising water level is mostly due to a combination of meltwater from glaciers and ice sheets and thermal expansion of seawater as it warms[12].
- In 2019, global mean sea level was 87.61 mm centimeters (3.4 inches) above the 1993 average- the highest annual average in the satellite record (1993-present)[12].
- From 2018 to 2019, global sea level rose 0.24 inches (6.1 millimeters)[12].
- The rate of sea level rise has doubled since 1993 compared to the 20th century average[12].

OCEAN ACIDIFICATION AND TEMPERATURE

- Oceans are absorbing about 25% of the carbon dioxide emitted to the atmosphere annually and as a result are becoming more acidic[14].
- The world's oceans have absorbed about 93% of the excess heat caused by greenhouse gas warming since the mid-20th century[15].
- Ocean heat content has increased at all depths[15].
- Increasing sea surface temperatures, rising sea levels, changing patterns of precipitation and winds, and ocean circulation are contributing to overall decline oxygen concentrations in the oceans[15].

TUVALU

REGIONAL CLIMATE CHANGE

TEMPERATURE

- Averaged as a whole, Oceania had its warmest year in the 140-year record in 2019[11].
- Record warmest temperatures occurred in 2019 in the equatorial western pacific encompassing the geographic area of containing the Tuvalu[11].
- In the Pacific region, land-surface temperatures have been rising at the rate of +0.17°C (0.31°F) per decade since the 1980s, slightly ahead of the global trend[16].
- Since 2005, nearly all surface stations have seen annual temperature anomalies above the long-term average[16].
- Warming trends of a similar magnitude are evident in both annual and seasonal mean air temperatures in Tuvalu (1950-2009) with the strongest trend found in dry-season mean air temperature (+0.24C per decade)[6].
- Ocean temperatures have risen gradually since the 1950's with the rate increasing over time and since the 1970a the rate of warming has been approximately 0.13°C per decade.
- Rates of sea-level rise are not uniform across the globe, and as a result the western tropical Pacific has experienced rates up to four times the global average between 1993 and 2009[17].
- Funafuti Atoll is located in the southwest Pacific Ocean, which has experienced some of the highest rates of sea-level rise (~5.1 ± 0.7 mm/yr) from 1950 to 2009 due to regional variability and vertical ground motion. The rate is nearly three times the global mean, and corresponds with a total increase in sea level of ~0.30 ± 0.04 m[17].
- Over the last decade (2006 to 2017), the high spatial resolution imagery indicated a 0.13% decrease in net island area in Funafuti Atoll[17].

PRECIPITATION

- Annual and seasonal rainfall trends for Funafuti and Nanumea for the period 1950-2009 are not statistically significant[6].

SEA LEVEL RISE

- Tuvalu is the world's second lowest-lying country and sea level rise poses a fundamental risk to its very existence[2].
- The sea-level rise near Tuvalu measured by satellite altimeters and since 1993 is about 5 mm per year, larger than the global average of 3.2 ± 0.4 mm per year[6].
- Seasonal sea levels are significantly lower during El Niño conditions and higher during La Niña conditions[6].

REGIONAL CLIMATE CHANGE

TUVALU

CORAL REEFS

- Human interference, namely urban development, habitat fragmentation, dredging and extraction of coastal aggregates have led to the destruction of coral reef systems[1].
- In Tuvalu aragonite saturation state has declined from 4.5 in the late 18th century to 4.0 in 2000 (which is not optimal for coral growth)[6].

EXTREME EVENTS

- The probability of changes to the frequency and intensity of extreme rainfall events and storm surges remains poorly understood for small islands[18].
- Predictions of cyclone risks have been underestimated in the Pacific, particularly for low lying atoll islands[19].

FUTURE CLIMATE PROJECTIONS

TUVALU

- Surface air temperature and sea-surface temperature are projected to continue to increase over the course of the 21st century[6].
- Beyond 2035 the projected warming in Tuvalu diverges depending on the greenhouse gas emissions pathway that humanity follows (Table 1)[6]. Climate projections have been derived for Tuvalu by the Australian Bureau of Meteorology using the Coupled Model Intercomparison Project (CMIP3) database for up to three greenhouse gas emission scenarios: B1 (low emissions), A1B (medium emissions) and A2 (high emissions)[6].

Projected change in surface air temperature (°C) for 2030 (2020–2039), 2055 (2046–2065) and 2090 (2080–2099), relative to 1990 (1980–1999) base period for the three emission scenarios are shown below[6].

EMISSION SCENARIO	2030	2055	2090
LOW B1	+0.7 ± 0.4	+1.1 ± 0.4	+1.5 ± 0.6
MEDIUM: A1B	+0.8 ± 0.4	+1.5 ± 0.5	+2.3 ± 0.8
HIGH: A2	+0.7 ± 0.4	+1.4 ± 0.4	+2.7 ± 0.6

The CMIP3 scenarios are considered equivalent to the more recent CMIP5 scenarios. In regards to air temperature CMIP3 and CMIP5 have been shown to produce similar results and ranges of uncertainty by the end of the century[20]. Assessment Report 4 (AR4) scenarios are used here due to the lack of availability of AR5 scenarios for Tuvalu.

- The majority of global climate models simulate little change in rainfall by 2030 (-5% to 5%)[6].
- By 2090 there is expected to be a greater than 5% increase in rainfall[6].
- The majority of models project that mild drought will occur approximately eight to nine times every 20 years in 2030 under all emission scenarios, decreasing to six to seven times by 2090[6].
- The frequency of moderate and severe drought is expected to stay the same[6].
- Frequency of cyclone activity in the region of Tuvalu is projected to decline but the intensity of the most severe cyclones is projected to increase[6].
- Global sea surface temperature (SST) is projected to continue to increase through the 21st century under all emissions scenarios[20].

FUTURE CLIMATE PROJECTIONS

- Devastating impacts on coral reefs between 2030 and 2050 are expected in the region as bleaching level stress is reached annually under all emission scenarios[20].
- Severe degradation and potential loss of corals is expected for most global locations by 2050 under current warming trajectories[20].
- Acidity levels of the ocean are expected to increase across Tuvalu[6].
- The impact of acidification change on the health of the reef ecosystems is likely to be compounded by other stressors including coral bleaching, storm damage and fishing pressure[6].
- Mean sea level is projected to continue to rise over the course of the 21st century[6]. Between 5-15 cm by 2030 and 20-60 cm by 2090 under high emission scenarios[6].
- Ocean oxygen levels are projected to decrease by as much as 3.5% by the end of the century under a low mitigation scenario relative to pre industrial levels[15].

IMPACTS OF CLIMATE CHANGE

- Tuvalu is at extreme high risk for the following climate change impacts and associated disasters: Intense storms and tropical cyclones and associated damages to livelihoods and infrastructure, negative impacts on biodiversity, and erosion and inundation[8].
- The Cook Islands and Tuvalu appear to face the highest disaster losses in the Pacific[21].
- Tuvalu was significantly affected by Tropical Cyclone Pam (TC Pam) in 2015 even though the islands were a great distance away from the cyclone path[19].
- The loss and damages for Tuvalu as result of TC Pam are equivalent to 10% of GDP[19].
- Estimated loss and damage due to drought in 1998 to Tuvalu was $2,072,045, around 4% of 2011 GDP[19].
- The overall risk to welfare for Tuvalu was determined to be higher than all other countries measured by the World Bank[19].
- Elevated sea temperatures and CO2 concentrations from climate change are already contributing to large-scale ecological change across the globe[1,18,20].
- The climate change threats of immediate concern include sea level rise in combination with storm surges causing flooding, accelerated coastal erosion and saline intrusion into freshwater lenses; periodic droughts associated with ENSO events and coral bleaching resulting from increased temperature and ocean acidification in combination with extreme low tides[1].
- Small island communities are at greater risk from sea level rise in comparison with other geographic areas because most of their population and infrastructure are in the coastal zone[1].
- Tuvalu is considered one of the nations in the world most vulnerable to sea level rise. It is already regularly affected by king tide events, which raise the sea level higher than a normal high tide and cause flooding of low-lying areas[7].
- These high tide events are compounded when sea levels are further raised during storms; baseline sea level rise will further add to the problem. It is estimated that a sea level rise of 20–40 cm in the next 100 years could make Tuvalu uninhabitable[7].
- In low-lying atoll nations such as Tuvalu there is extremely high vulnerability to the impacts of climate change[1].
- Sea level rise, coastal erosion, impacts on plants and animals and changes in rainfall patterns make climate change an environmental sustainability issue, exacerbate development pressure and pose a threat to security[18].
- Tuvalu's people are among the most vulnerable in the world to the impacts of climate change and many of these impacts are already occurring, inflicting damage and imposing substantial costs on the Tuvalu government and people[1].

TUVALU

IMPACTS OF CLIMATE CHANGE

- Future water security in Tuvalu will likely be affected by projected changes in rainfall patterns, since water harvesting systems are dependent on consistent moderate rainfall to maintain a sufficient water supply[3].
- Heavy precipitation events quickly exceed water tank storage capacity[3].
- More intense rainfall has the potential to increase flooding, damage crops and move pollutants into coastal waters[6].
- The ability to grow crops (notably pulaka, or swamp taro), maintain food-bearing trees and rear livestock will be constrained by increases in droughts and by more intense storms[3].
- Rising sea-levels will further limit food production by exacerbating stress to pulaka plantations and gardens from saltwater intrusion[3].
- Subsistence fishing in the lagoon will be further constrained as sea surface temperature and ocean acidification continue to increase and adversely affect marine systems[3,20,22].
- Higher sea-surface temperatures, will contribute to increases in coral bleaching leading to a change in coral species composition, coral disease, coral death, and habitat loss[23].
- Open ocean fisheries in the Pacific will be affected negatively over the long term[23].
- The impact of increased acidification on the health of the reef ecosystem is likely to be compounded by other stressors including coral bleaching, storm damage and fishing pressure[6].
- It is unclear whether climate change will lead to an increased frequency in storms, however there is a wide agreement that the intensity of storms will increase as ocean waters warm[20].
- Climate change threatens the physical, biological, and human elements necessary for Pacific Island cultures to sustain their way of life[23].
- Climate driven health risks from the spread of infectious disease, loss of settlements and infrastructure, and decline of ecosystems that affect small island economies and livelihoods, and human well-being are under researched[18].
- Climate change related migration is particularly relevant to low island communities in the pacific and presents significant practical, cultural and legal challenges[14].

MITIGATION & ADAPTATION TO CLIMATE CHANGE

- Tuvalu's contribution to climate change has always been marginal (<0.000005% of global emissions)[2].
- Tuvalu has no conventional energy resources and is heavily reliant on imported oil fuels for transport, electricity generation and household use[2].
- As of 2012, 50% of Tuvalu's electricity was derived from renewables, mainly solar and this number is expected to rise to 75% by 2020 and 100% by 2025[2].
- Resource management and conversation are essential for healthy and stable communities on islands with limited resources because overexploitation could damage or permanently destroy natural resources[23].
- Since the release of the First National Communication, Tuvalu has placed considerable emphasis on addressing climate change vulnerabilities and implementing measures that enhance adaptive capacities by collaborating with different development partners in key sectors including coastal protection, water resources, biodiversity, agriculture, energy, waste management and human health[1].

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REPUBLIC OF VANUATU

GEOGRAPHY

GLOBAL CLIMATE CHANGE

REGIONAL CLIMATE CHANGE

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GEOGRAPHY

VANUATU

- The Island nation of Vanuatu lies south of the equator, in the western South Pacific Ocean, between 12 - 23°S latitude and 166 - 173°E longitude[1].
- The Vanuatu archipelago consist of 83 islands and stretches 1,300 km from north to south[2].
- Vanuatu has a total land area of 12,120 km^2 and an Economic Exclusion Zone of 710,000 (km^2)[2].
- The large islands in the chain are characterized by rugged volcanic peaks and lush tropical rainforests[2].
- The highest peak (1877 meters above sea level), Mount Tabwemasana is found on the largest island of Espiritu Santo.
- The capital, Port Vila, is located on the island of Efate and is home to the Vanuatu Government[2].
- Almost 74% of the land area in Vanuatu is covered by natural vegetation, with around one third covered by forest[1].
- Vanuatu is located in a seismically and volcanically active region and has high exposure to geologic hazards, including volcanic eruptions, earthquakes, tsunamis and landslides[1].
- Vanuatu's economy heavily depends on natural resources, both for the sustenance of its people and future economic expansion like many other less-developed Pacific Island Countries[1].
- Vanuatu has some 108 known species of amphibians, birds, mammals and reptiles; of these 21.3% are endemic (meaning they exist in no other country) and 13% are threatened[1].
- The islands are grouped into six provinces each with their own provincial councils[1].
- Total estimated population of Vanuatu (based on the 2016 mini-census) is 272,495 and the Shefa province (which contains the capital city of Port Vila) is the most populated with 35% of the country's population[3].
    - Torba Province population = 10,1613
    - Samma Province population = 54,1843
    - Penama Province population = 32,5343
    - Malampa Province population =40,9283
    - Shefa Province population = 976023
    - Tafea Province population =37,0503
- Approximately 75% of the population live in rural areas[3].
- Vanuatu's population is forecasted to fall within the range of 428,000 to 695,000 (depending on fertility assumptions) by 2050, with the most likely figure being approximately 480,000 people[4].
- Population growth, particularly in urban areas, has already placed pressure on water resources and supply services. Climate change is likely to increase demand for water while impacting on the quality and availability of water resources[5].

GEOGRAPHY

- Vanuatu is experiencing increased population pressures due to the high rate of population growth which is clearly impacting the availability of land for agriculture and sustenance, and has serious implications for food security, nutrition and health[5].
- Vanuatu's main primary industries are agriculture, fishing and forestry[1].
- Approximately 81% of the population engages in agriculture which represents 10% of the economy[1,3].
- Most ni-Vanuatu (indigenous peoples of Vanuatu) earn their living from subsistence or small scale agriculture and fishing largely outside of the cash economy[1].
- The 2017 Gross Domestic Product (GDP) of Vanuatu was USD772 million[6].
- In 1995 Vanuatu was admitted to the group of Least Developed Countries (LDCs) and is still part of that group today (although its GDP is higher than the LDC threshold)[5].
- As of 2012 there were 47 operational observation meteorological stations in Vanuatu[2].
- Multiple observations within a 24-hr period are taken at several stations (Sola, Pekoa, Saratamata, Lamap, Bauerfield, Whitegrass and Analgauhat), other stations record a single observation of rainfall daily[2].
- Air temperatures are relatively constant throughout the year and are closely related to sea surface temperatures[2].
- Annual temperatures range from 20 °C (68F) to 30 °C (86F)[1].
- The country has two distinct seasons: dry season from May to October and wet season from November to April[2].
- Rainfall in Vanuatu is strongly influenced by the position and strength of the South Pacific Convergence Zone (SPCZ), which is strongest during the wet season[2].
- Topography also plays a role, where rainfall is higher on the east facing (windward) sides of the island and drier on the west facing (leeward) sides of the islands[2].
- Aneityum, which is located in the southern part of the island chain, also receives rainfall from extra-tropical influences such as cold fronts during the dry season[2].
- Low pressure systems embedded in the SPCZ can often become tropical cyclones during the cyclone season[2].
- The tropical cyclone season in the Vanuatu region is between November and April and occurrences outside of this period are rare[2].
- Tropical cyclones and depressions are also common, which can be responsible for high and destructive winds in the hot season[1].
- Total area of Vanuatu receives 2-3 cyclones in a cyclone season, 20-30 cyclones per decade with 3-5 causing severe damage[1].

Nanda Blue Hole, Espiritu Santo, Vanuatu

- The main influence of year-to-year natural climate variability in Vanuatu is the El Niño Southern Oscillation (ENSO)[2].
- There are significant correlations between ENSO indices and both rainfall and air temperature in Vanuatu[2].
- El Niño events tend to bring a late start to the wet season and lower rainfall in both the wet and dry seasons, as well as cooler conditions in the dry season2. Opposite impacts are usually observed during La Niña Events[2].
- In Vanuatu, the wettest years receive up to three times the amount of rainfall than the driest years[2].
- Almost 81% of its land mass and 76% of the population of Vanuatu is exposed to two or more potential hazards including volcanic eruptions, cyclones, earthquakes, droughts, tsunamis, storm surge, coastal and river flooding and landslides[2].
- Vanuatu remains, after a period of several years, at the top of the list of countries whose populations are threatened by natural disasters, and whose government is incapable of protecting, or barely even helping, its citizens[7].
- In 2016, Vanuatu was ranked the most at-risk country to natural disasters in the world, primarily because of its extremely high exposure to disaster events and the frequency which these events occur[8].
- According to the international disaster database, 37 disaster reported in Vanuatu during 1950-2004 resulted in significant economic loss (approximately USD384.4 million) and social costs (loss of life, livelihood, homes, roads, relocation job losses etc.)[1].

GLOBAL CLIMATE CHANGE

TEMPERATURE

- The 2018 average global temperature across land and ocean surface areas was 0.84˚C above the 20th century average[9].
- 2018 was the 4th warmest year in the 1880–2018 record, behind 2016 (highest), 2015 (second highest), and 2017 (third highest)[9].
- 2018 was the second warmest year on record without an El Niño present in the tropical Pacific Ocean[9].
- 2018 marks the 42nd consecutive year (since 1977) with global land and ocean temperatures above 20th century average[9].
- Nine of the 10 warmest years have occurred since 2005[9].
- The 2018 globally averaged sea surface temperature was 1.19°F (0.66°C) above the 20th century average[9]. This was the fourth highest among all years in the 1880-2018 record, again behind 2016 (highest) and 2015 (second highest) and 2017 (third highest)[9].

SEA LEVEL RISE

- In 2017 global sea level was 77 mm above the 1993 average, which is the highest annual average in the satellite record[10].
- 2017 was the sixth consecutive year, and the 22nd out of the last 24 years in which global mean sea level increased relative to the previous year[10].
- Sea level rises at a rate of just over 3.1 mm per year due to a combination of melting glaciers and ice sheets and from the thermal expansion of seawater[10].
- The rate of sea level rise has doubled since 1993 compared to the 20th century average[10].

OCEAN ACIDIFICATION AND TEMPERATURE

- Oceans are absorbing about 25% of the carbon dioxide emitted to the atmosphere annually and as a result are becoming more acidic[11].
- The world's oceans have absorbed about 93% of the excess heat caused by greenhouse gas warming since the mid-20th century[12].
- Ocean heat content has increased at all depths[12].
- Increasing sea surface temperatures, rising sea levels, changing patterns of precipitation and winds, and ocean circulation are contributing to overall decline oxygen concentrations in the oceans[12].

REGIONAL CLIMATE CHANGE

TEMPERATURE

- Averaged as a whole, Oceania had its third warmest year in 2018 since regional records began in 1910[9].
- Much warmer than average temperatures occurred in equatorial western pacific encompassing the geographic area of containing the Vanuatu[9].
- In the Pacific region, land-surface temperatures have been rising at the rate of +0.17°C (0.31°F) per decade since the 1980s, slightly ahead of the global trend[13].
- Warming trends of a similar magnitude are evident in both annual and seasonal mean air temperatures in Vanuatu (1950-2009) with the strongest trend found in the wet-season mean air temperature (+0.17° C per decade)[2].
- Ocean temperatures have risen gradually since the 1950's with the rate increasing over time and since the 1970a the rate of warming has been approximately 0.13°C per decade[2].

PRECIPITATION

- Annual and seasonal rainfall trends for Port Vila and Aneityum for the period 1950-2009 are not statistically significant[2].

SEA LEVEL RISE

- The sea level rise near Vanuatu is measured by satellite altimeters and since 1993 is about 6 mm per year, which is larger than the global average of 3.1 mm per year[2].
- Seasonal sea levels are significantly lower during El Niño conditions and higher during La Niña conditions[2].

MARINE SYSTEMS

- The coastal fisheries sector however is trending towards overexploitation , with several fisheries near collapse (e.g. green snail, trochus etc.)[1].
- The reef fisheries are particularly over-fished in some areas, notably in the vicinity of Efate and Santo[1].
- In Vanuatu aragonite saturation state has declined from 4.5 in the late 18th century to 3.9 in 2000 (which is not optimal for coral growth)[2].

REGIONAL CLIMATE CHANGE

VANUATU

EXTREME EVENTS

- Between 1969 and 2010, 94 cyclones passed through the region of Vanuatu (23 cyclones per decade) making Port Vila the most impact capital city in the Pacific[2].
- The probability of changes to the frequency and intensity of extreme rainfall events and storm surges remains poorly understood for small islands[14].

FUTURE CLIMATE PROJECTIONS

VANUATU

- Surface air temperature and sea surface temperature are projected to continue to increase over the course of the 21st century[2,15].
- Beyond 2035 the projected warming in Vanuatu diverges depending on the greenhouse gas emissions pathway that humanity follows (see table below)[2]. NOTE: Climate projections have been derived for Vanuatu by the Australian Bureau of Meteorology using the Coupled Model Intercomparison Project (CMIP3) database for up to three greenhouse gas emission scenarios: B1 (low emissions), A1B (medium emissions) and A2 (high emissions)[2].

Projected change in surface air temperature (°C) for 2030 (2020–2039), 2055 (2046–2065) and 2090 (2080–2099), relative to 1990 (1980–1999) base period for the three emission scenarios are shown below[2].

EMISSION SCENARIO	2030	2055	2090
LOW B1	+0.6 ± 0.4	+1.0 ± 0.5	+1.4 ± 0.7
MEDIUM: A1B	+0.7 ± 0.6	+1.4 ± 0.5	+2.2 ± 0.9
HIGH: A2	+0.7 ± 0.3	+1.4 ± 0.3	+2.6 ± 0.6

The CMIP3 scenarios are considered equivalent to the more recent CMIP5 scenarios. In regards to air temperature CMIP3 and CMIP5 have been shown to produce similar results and ranges of uncertainty by the end of the century[15]. The newest regional climate projections which are part of the CMIP6 are currently in development and result will be officially released in 2020 with the Inter-governmental Panel on Climate Change Six Assessment Report.

- The majority of CMIP3 models simulate little change (-5% to 5%) in wet season rainfall by 2030, however, by 2090 under the A2 (high) emissions scenario, the majority simulate an increase (>5%) in wet-season rainfall[2].
- Dry season rainfall is expected to decrease over the course of the 21st century[2].
- The intensity and frequency of days of extreme heat are projected to increase over the course of the 21st century[2].
- The intensity and frequency of days of extreme rainfall are projected to increase over the course of the 21st century[2].

FUTURE CLIMATE PROJECTIONS

- Little change is projected in the incidence of drought over the course of the 21st century[2].
- Acidity levels of the ocean are expected to increase across Vanuatu over the course of the 21st century[2].
- Projections from all analyzed CMIP3 models indicate that the annual maximum aragonite saturation state will reach values below 3.5 by about 2035 and continue to decline thereafter[2].
- The impact of acidification change on the health of reef ecosystems is likely to be compounded by other stressors (e.g. coral bleaching, storm damage and overfishing[2].
- The CMIP3 models simulate a rise of between approximately 5-15 cm by 2030, with increases of 20-60 cm indicated by 2090 under the high emission scenarios[2].
- Frequency of cyclone activity in the region of Vanuatu is projected to decline but the intensity of the most severe cyclones is projected to increase[2,15].
- Global sea surface temperature is projected to continue to increase through the 21st century under all emissions scenarios[15].
- Elevated sea temperatures and CO2 concentrations from climate change are already contributing to large-scale ecological change across the globe[14,15].
- Devastating impacts on coral reefs between 2030 and 2050 are expected in the region as bleaching level stress is reached annually under all emission scenarios[15].
- Severe degradation and potential loss of corals from most global locations is expected by 2050 under current warming trajectories[15].
- Mean sea level is projected to continue to rise over the course of the 21st century[2]. Between 5-15 cm by 2030 and 20-60 cm by 2090 under high emission scenarios[2].
- Ocean oxygen levels are projected to decrease by as much as 3.5% by the end of the century under a low mitigation scenario relative to pre industrial levels[12].

IMPACTS OF CLIMATE CHANGE

- Climate change threatens the physical, biological, and human elements necessary for Pacific Island cultures to sustain their way of life[17].
- Climate change and changing weather patterns are already having a negative impact on all the priority sectors in Vanuatu[1].
- Climate change is likely to impact on all sectors that are pertinent to the sustainable development of Vanuatu[5].
- Potential impacts of climate change on Vanuatu's agriculture, fisheries, forestry, tourism, health, transport and infrastructure sectors include: a reduction of fresh water resources; shifts in crop seasonality of harvest, planting and fruiting; increase in pests and disease for animals, crops and trees; saltwater inundation and intrusion of coastal and land groundwater; compromised food security; coral reef deterioration; reduced fisheries productivity; increased risk of human disease and health problems, including vector-borne disease transmission and heat related illness; damage to infrastructure; loss and coastal land; and Reduced economic growth and revenue generation[16].
- Climate change is likely to increase demand for water while impacting on the quality and availability of water resources[5].
- ENSO-related drought and flooding are prevalent and continue to impact the socio-economic livelihood of people of Vanuatu[2].
- More intense rainfall has the potential to increase flooding, damage crops and move pollutants into coastal waters[2].
- A flood event during the 2011 La Niña event washed through several villages on Emae Island completely inundating agricultural land in Middle Bush, Tanna, Such occurrences are rare but can be devastating[2].
- Climate related disasters are one of the main hindrances to economic development in Vanuatu and this will certainly continue[1].
- In 2015, Category 5 Tropical cyclone Pam impacted an estimated 18,000 people and displaced 65,000 people[8].
- For the Ni-Vanuatu, their livelihood and social structure are inextricably linked to the natural environment and its resource base therefor any perturbations to this availability of natural resources will have a direct bearing on the poverty levels and the very survival of the people. Changes to the traditional social system, coupled with any decrease in food security and water availability, could lead to deterioration of social systems and law and order[5].

IMPACTS OF CLIMATE CHANGE

VANUATU

- Pacific island countries are among the most vulnerable in the world to the health impacts of climate change[18].
- Changes in climate are likely to impact the health sector in Vanuatu due to Tropical and vector borne diseases such as malaria and dengue as well as water related diseases such as dysentery and diarrhea. Other problems associated with increased temperatures such as food contamination and heat stress are likely to be exacerbated[5].

MITIGATION & ADAPTATION TO CLIMATE CHANGE

- Vanuatu has positioned itself as regional leader in the fields of climate change and disaster risk reduction (DRR) and has been widely applauded for its initiative to establish a National Advisory Board for Climate Change and DRR as means of improving coordination and governance around the two issues[1].
- In 2007, Vanuatu completed its National Adaptation Programme of Action. Its priorities include: agriculture and food security; sustainable tourism development; community based marine resource management; sustainable forest management and integrated water resource management[5].
- The National Climate Change and DRR Policy identifies five key adaptation efforts and build resilience across sectors which include the need for: climate change vulnerability and multi sector impact assessments; integrated climate change and disaster risk reduction; community based adaptation; loss and damage and ecosystem based approaches[16].
- The Government of Vanuatu has undertaken major reform of national climate and disaster risk governance by establishing the Ministry of Climate Change and the National Advisory Board on Climate Change & DRR. Adaptation to climate change and risk management of natural hazards is one of the core development issues for Vanuatu[1].
- Vanuatu has a target of transitioning to 100% renewable energy in the electric sector by 2030[19].
- Traditional knowledge remains highly valued and well used in Vanuatu. Traditional coping and early warning mechanisms contribute to existing community resilience, which must be built on, promoted and empowered through climate change and disaster risk reduction initiatives[16].
- Resource management and conversation are essential for healthy and stable communities on islands with limited resources because overexploitation could damage or permanently destroy natural resources[17].
- Agro-forestry and improved farming systems are being promoted as means to reduce soil degradation[5].
- Research has shown that climate driven health risks from the spread of infectious disease, loss of settlements and infrastructure, and decline of ecosystems that affect small island economies and livelihoods, and human well-being are under researched[14].

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