Commonwealth Marine Economies Programme

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Pacific Marine Climate Change Report Card 2018

This report card provides a summary of climate change impacts on coasts and seas in the Pacific island region, and how Pacific islands can respond.

Reliance on marine biodiversity is high across Pacific nations, thus reducing human pressures on habitats is vital to promote diverse and productive ecosystems which are more resilient to climate change.

Climate change is putting the fundamental needs of ocean dependent Pacific communities at risk, including living space and housing, food and water security, culture, health and wellbeing.

Pollution and marine waste, population growth, resource over-exploitation and overfishing, invasive species, damage to key ecosystems, and coastal development are all magnifying the effects of climate change.

Flexible management systems and adaptation projects which build climate resilience are urgently needed, that are adaptive over time, connect terrestrial and marine systems and link different sectors.

Engaging communities is a fundamental part of successful climate action and the intentional inclusion of social and cultural groups will benefit efforts to build climate resilience.

SPREP PROE
UN environment
USP THE UNIVERSITY OF THE SOUTH PACIFIC
Cefas Marine Climate Change Centre
IMPACT
Pacific Community Communauté du Pacifique

Climate change in the Pacific

Why should we worry?

For ocean-dependent Pacific islands, the connection between oceans and climate change is likely to be more vital than elsewhere and has a huge influence on people, culture and economies.

Most Pacific island communities are coastal, with some smaller island and atoll nations being overwhelmingly under five metres of elevation. Climate change puts communities, including fundamental needs such as housing, food availability and health, at risk.

Relocation threatens cultural identity and heritage. Climate change is forcing people to relocate within and between islands, away from land traditionally passed along family, kinship and village lines.

Different social and cultural groups are impacted differently by climate change. The poorest and most vulnerable tend to be disproportionately affected.

The impacts of climate change are generating acute stresses within communities across the Pacific region.

These effects are being experienced in the context of a wide range of interacting pressures already placed upon ocean and coastal systems which magnify the impacts of climate change. Population pressure and loss of traditional skills and cultures are creating additional challenges.

For ocean-dependent Pacific islands, the nexus between ocean and climate change is of critical importance; deteriorating marine and coastal biodiversity would have sizeable impacts upon livelihoods, health, culture, wellbeing and infrastructure.

The region is taking active steps to strengthen resilience of its systems to the foreseen impacts of climate change, innovating in many ways to adapt practices, develop new technologies, revisit traditional techniques, reinforce solidarity and exchange learning.

People are acting to conserve the biodiversity that sustains and ensures their lives against the shocks of climate change. It is clear that some Pacific communities are already reaching limits to adaptation and that the positive steps being made towards a resilient Pacific must be supported by rapid and deep cuts in global emissions.

Why is this report card of relevance to me?

This report card provides an easy-to-read, scientifically robust summary of what we know about marine and coastal climate change impacts in the Pacific, and explores some of the actions that are needed to respond to these impacts.

It can be used as evidence to support policy, programme and project development and is relevant to the following key initiatives:

- Sustainable Development Goals (SDG) for oceans (SDG14-life under water) and climate change (SDG13-climate action). The activities of the Pacific SDG Taskforce and development of the Pacific Roadmap for Sustainable Development.
- Regional policies such as the SAMOA pathway, the Framework for Pacific Oceanspace, the Framework for Pacific Regionalism and The Blue Pacific.
- The Fiji COP23-led initiative 'Ocean Pathway', which proposes a stronger integration of ocean into the United Nations Framework Convention on Climate Change (UNFCCC) processes, recognizing this intricate relationship of impact, mitigation solution and adaptation options between ocean and climate.
- Framework for Resilient Development in the Pacific (FRDP) 2017 – 2030, an integrated approach to address climate change and disaster risk management.
- Joint National Action Plans (JNAP), combining both climate change and disaster risk management strategies.

The evidence in this card can support these policies to ensure adaptation and resilience-building initiatives adopt collective and systematic cross-sectoral approaches which bring benefits across people, planet and prosperity.

The information provided is applicable to the wider Pacific island region, with specific case studies drawn from countries which fulfil criteria for the Commonwealth Marine Economies Programme. These countries are Fiji, Kiribati, Nauru, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu.

The supporting evidence behind this report card

This report card covers three themes: climate change drivers; impacts on biological diversity; and impacts on people. It is based on specially commissioned scientific reviews, covering the following key topics under these themes:

Climate change drivers
Sea temperature; ocean acidification; sea level rise; extreme events

Biological Diversity
Corals; mangroves; fish and shellfish; seagrass

People
Settlements and infrastructure; fisheries

The report card working group has tried to ensure that topics of greatest concern are addressed, and relevant regional experts identified to provide up-to-date, authoritative evidence. Wider issues, not covered by the topic papers listed above, are included in a broad overview paper. Additional papers on culture and gender, and differences in the scale of Pacific impacts at different global temperature thresholds (1.5 vs. 2 °C warmer) have also been published.

In total, thirteen specially commissioned review papers support this card, providing more detailed information to support action.

These papers include sections on past and future climate change impacts, confidence, knowledge gaps and for the biodiversity and society papers, socio-economic effects. Sixty authors and reviewers, principally drawn from the region, contributed to these papers, in addition to a dedicated report card working group.

These fully referenced, peer-reviewed papers, are available at **www.gov.uk/government/publications/commonwealth-marine-economies-cme-programme-pacific-marine-climate-change-report-card-and-scientific-reviews**

What's driving climate change impacts in the Pacific?

The ocean and atmosphere are already responding to rising greenhouse gas emissions, as evidenced by changes in sea temperature, extreme events (such as cyclones), sea level rise and ocean acidification. These changes are happening across the tropical Pacific and are having profound effects on marine ecosystems and people, as later sections of this report card will explore.

There are different projected climate change futures, which depend on the amount of greenhouse gas emissions that are released in the coming years. A future in which global air temperatures increase by 1.5 ˚C by 2100 will have different effects on the oceans than a future in which air temperature rises by 2 ˚C or more.

Sea temperature

Globally, the ocean has absorbed more than 90% of the additional heat from human-caused global warming, leading to an increase in sea temperature. In the Pacific, describing general patterns of change, both geographically and over time, is complex due to the influence of the El Niño/Southern Oscillation (ENSO), which dominates inter-annual variability in the region.

Currents in the region are complex. Here we specifically refer to the Warm Pool and the El Niño/Southern Oscillation (ENSO). Trade winds and westward ocean currents effectively push warm, surface, equatorial water into the western tropical Pacific, maintaining a warm volume of water - the Warm Pool - with sea surface temperatures nearing 30°C. ENSO has a strong impact on the region, with El Niño periods corresponding with an eastward movement of the Warm Pool as the trade winds weaken, and La Niña corresponding with a westward concentration of the Warm Pool as trade winds strengthen.

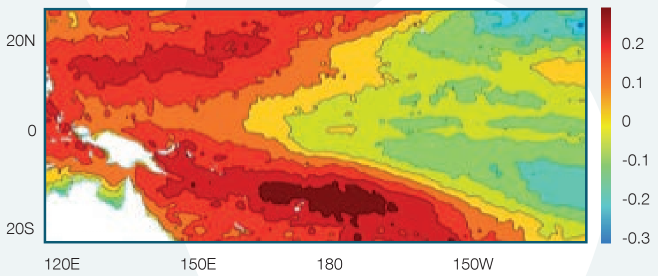
What is already happening?

Observations indicate that the western tropical Pacific has warmed, although the trends are hard to define owing to the high inter-annual and decadal variability, particularly associated with ENSO and Interdecadal Pacific Oscillation (IPO).

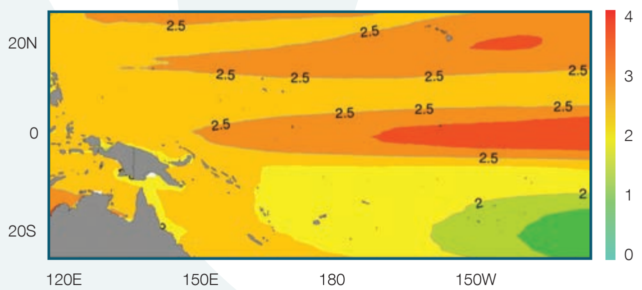
The Warm Pool area has expanded in recent decades. Since 1981 there has been a small warming of around 0.1°C per decade along the equator in the Warm Pool region. There is stronger warming to the north and south of the Warm Pool, with the highest trend of around 0.3°C per decade at ~12°S, 185°E (close to Samoa and Fiji), see left hand figure below.

What could happen?

It is expected that the overall warming in the region, and the warm pool expansion, will both continue into the future (see figure below). By the end of the century, warming of 1 to 3°C is expected in the region, depending on the emission scenario used. Models show a maximum warming in the central equatorial Pacific (i.e. around Kiribati, Tuvalu and Nauru), with less rapid warming in Papua New Guinea, Solomon Islands, Vanuatu, and New Caledonia, and especially around Fiji, Tonga and Samoa. Higher sea temperatures cause coral bleaching, alongside other negative effects on marine ecosystems. This warming, and associated increased rainfall could cause other changes in the ocean. One effect could be that the ocean becomes more strongly stratified (layered) because warm, fresh water is less dense than cold, saltier water. This layering would have an effect on biological productivity by reducing the mixing of nutrients from the deeper ocean into the shallow zone with implications for fisheries.



Trend in sea surface temperature since 1981, shown as change in degrees Celsius per decade. Figure based on satellite measurements provided by NOAA (NOAA OI SST V2 High Resolution Dataset).



Projected change in sea surface temperature in degrees Celsius, from an average of 1956-2005, to 2050-2099, under a high emissions scenario (RCP 8.5). From NOAA Climate Change Portal. www.esrl.noaa.gov/psd/ipcc/ocn.

Ocean Acidification

In the Pacific, ocean acidification has the potential to significantly impact marine ecosystems and the services they provide, particularly through combined impacts of sea temperature rise and coral bleaching. Any reduction in coral reef health could have serious consequences for public amenity, food security, tourism and economic development.

What is already happening?

Globally since the preindustrial era (~1850), the pH of the ocean has been declining and there has been more than a 26% increase in acidity in the global ocean. This is occurring as the ocean continues to take up carbon in response to rising atmospheric CO_2 levels.

The rates of ocean acidification in the Equatorial Pacific are also associated with large variability year-on-year. It is affected by changes in atmospheric CO_2 and ocean uptake, and ENSO.

What could happen?

In the future, as atmospheric CO_2 concentrations continue to rise, ocean pH will increasingly decline, and these changes will be very long lasting. Under a high greenhouse gas emissions scenario, the entire Equatorial Pacific will experience conditions that are very marginal for coral and it is likely coral reefs will disappear from most of the Equatorial Pacific region, with profound impacts for the richness and diversity of marine ecosystems.

When the impacts of ocean acidification are combined with ocean warming and other stressors (e.g. changes in nutrient supply and light, riverine input, storm damage, disease and human pressures), the effects are likely to be catastrophic. If greenhouse gas emissions are reduced, the effects could be less devastating, with pH levels that are more marginal for survival of some corals.

Ocean acidification appears to be occurring faster under El Niño than La Niña conditions. However, there is little consensus on future changes in El Niño frequency, so how this may influence future rates of ocean acidification remains unknown.

Sea-level rise

Sea-level rise is a major consequence of global warming. Sea-level rise is caused by a combination of thermal expansion of the ocean (because of warming), and an increase in run-off from the melting of continental glaciers (which adds water to the oceans). The amount of change experienced on Pacific islands can also be affected by vertical land movements or the effects of trade winds, which can locally act to either increase or decrease the effects of the rise in global mean sea level.

What is already happening?

Global mean sea-level rise has probably accelerated over the last century, and between 1993 and 2017, satellite measurements show that there has been a rise in sea level of 3-6 mm per year for the Pacific islands, but with some notable differences between islands (see figure right). Some islands in the Western Pacific (Solomon Islands, Papua New Guinea, Marshall Islands) have experienced a higher rate of sea level rise (up to 6 mm per year), compared to other islands further east (Samoa or Kiribati). This difference in sea-level rise is mainly attributed to large scale trends in trade winds.

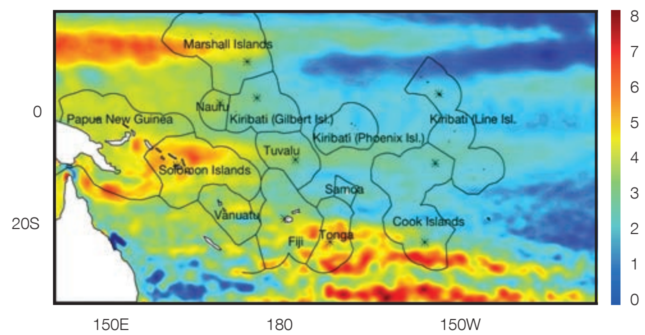
This recent rise in sea level means that extreme sea level events, that are usually caused by tropical storms and cyclones, are becoming more severe and frequent.

What could happen?

Further sea-level rise is expected globally. In the Pacific, the rate of sea-level rise is projected to be higher than in other parts of the world.

Projections suggest that sea level in the Pacific island region will rise by 40 to 80 centimetres by the end of this century. Some models project sea-level rise of more than one metre due to continued ice melt, if emissions do not stabilise soon. Even a small increase in sea level will make many low lying islands uninhabitable.

Coastal flood and inundation are caused by a combination of high waves, tides, storm surge, or ocean eddies. It is difficult to assess future changes in the number and severity of high waves and storms, but a rise in sea level will cause an increase in the frequency and severity of inundation in coastal areas (unless the number of storms significantly decreases). Throughout the tropical Pacific, even a 10 to 20 cm sea level rise would more than double the frequency of flooding. In low-lying Pacific atolls an increase in sea level of just a few centimetres would significantly increase the damage caused by storm surge and king tides, leading to repeated, damaging coastal inundation.



Rate of sea-level rise from 1993 to 2017 (in mm per year) from satellite altimetry (Data source: Delayed Time, all-sat-merged Global Ocean Gridded SSALTO/DUACS Sea Surface Height L4 product, CLS,CNES).

Extreme events

Tropical cyclones are considered the most significant extreme events in the Pacific island region, and are associated with heavy rains, strong winds, high storm surge, and large waves for all Pacific islands. Other extreme events include floods, droughts and extreme temperatures i.e. heatwaves. Extreme events impact water availability, fisheries, agriculture, energy, health, ecosystems, economy and finance, infrastructure, waste water and solid waste, human settlements and society, and cultural dimensions of Pacific islands.

One-off extreme events are not evidence of climate change, but the devastation caused by tropical cyclones in particular give us an understanding of how any future change in tropical cyclone intensity could impact the Pacific islands region. In Vanuatu in 2016, the estimated cost of tropical Cyclone Pam was approximately 64% of the country's GDP. In Fiji, tropical Cyclone Winston in 2016 killed 44 people, destroyed or damaged 40,000 houses, displaced 130,000 people and destroyed 500 schools, with total estimated damages of 1.4 Billion US dollars. Non-monetary consequences can also be great, for example 90% of the Niue National Museum collection was lost during tropical Cyclone Heta in 2004.

Estimated economic losses from average annual tropical cyclone activity and a 100-year tropical cyclone event for selected Pacific island countries are:

	Average annual cyclone activity		1 in 100 year event	
Country	**M US$**	**% of GDP**	**M US$**	**% of GDP**
Fiji	76.5	2.5	834.0	27.7
Kiribati	0	0	0.4	0.2
Nauru	0	0	0	0
PNG	22.7	0.1	432.0	4.6
Samoa	6.9	1.2	134.1	23.7
Solomon Islands	5.8	0.9	63.9	9.4
Tonga	9.5	2.7	126.0	35.2
Tuvalu	0.1	0.2	1.4	4.4
Vanuatu	36.8	5.0	311.8	42.8

Source: The World Bank (2013) PCFAFI Pacific Catastrophe Risk Assessment and Financing Initiative, Country Profiles NB since records have been kept, no tropical cyclones have affected Nauru.

What is already happening?

Some islands in the Pacific island region experience tropical cyclones and storms more often than others owing to their location in the Pacific. Nauru has only experienced one tropical storm in the past 30 years, whereas more than 70 tropical storms and cyclones have passed near Vanuatu.

Since 1981, there has been a significant increase in rainfall across most of the western pacific monsoon region, south and west of the South Pacific Convergence Zone (SPCZ) from Vanuatu to the southern Cook Islands. Rainfall has decreased north and east of the SPCZ at Nauru, Kiribati and Tuvalu.

What could happen?

There is still uncertainty around future changes to tropical cyclone activity. Research indicates that climate change is likely to lead to a decrease in overall tropical cyclone activity in the region, but the intensity of tropical cyclones is likely to increase. Under 2.5°C of global warming by 2100, the most devastating tropical storms are projected to occur up to twice as often as today in most cyclone-prone regions of the world. Irrespective of potential increases in storm intensity, the damage caused by tropical cyclones will be worse with climate change, because of intense precipitation and higher sea levels.

Models show that El Niño and La Niña events will continue to occur in the future, but it is not clear whether these events will change in intensity or frequency. Annual mean air temperatures and extremely high daily temperatures will also increase across the Pacific region.

More frequent extreme rainfall events are projected for Kiribati, Nauru, Papua New Guinea, Solomon Islands and Vanuatu. As temperatures increase, there could be an intensification of SPCZ events and an increase in average rainfall during the wet season, for the Solomon Islands and Tuvalu. An intensified seasonal cycle is projected for Vanuatu, Tonga, Samoa, Niue and Fiji, with a decrease in dry season rainfall and an increase in the wet season.

Impacts of climate change on marine and coastal biological diversity

In the Pacific, coral reefs, seagrass and mangroves form a mosaic of habitats which sustain a great diversity of life, and abundant fish productivity. These coastal and marine ecosystems, and the species they support, underpin a variety of key industries (such as fisheries and tourism), and together, more effectively protect coastlines against erosion and storms.

Health and biological diversity of coastal and marine ecosystems in the Pacific are threatened by human pressures from coastal developments, pollution and over-fishing. Reducing these pressures is critical to building resilience to climate change. Habitat degradation and declines will cause negative social and economic effects as Pacific islands are reliant on these resources for cultural reasons, income and food.

Ecosystem services: Seagrass, mangroves and coral reefs contribute significantly to the health, welfare and daily livelihoods of people who live by the coast. Fish habitat, fish nurseries, animal food, coastal protection, sediment stabilization and accretion, carbon sequestration, compost fertiliser, fuel, water purification, bequest value, education, recreation, research, spiritual values, tourism and pathogen reduction are all derived from these habitats. In Melanesia, the service values that these ecosystems provide have been estimated at: US$151.4bn for seagrasses; US$145.7bn for coral reefs; and US$109bn for mangroves.

Blue carbon: Seagrass habitats and mangrove forests are widely recognised globally as major organic carbon sinks, which are more stable than in terrestrial ecosystems. They absorb and store "blue carbon" over the long term. Mangroves and seagrasses are some of the most efficient habitats for natural carbon capture and storage, due to their high below-ground root biomass which effectively traps and buries organic carbon for thousands of years. Mangroves are beginning to be used in carbon credit schemes.

Fish and shellfish

Fishing effort is already high in the Pacific region, and in many places destructive fishing gears are used, such as small mesh nets. Human pressures on fish, shellfish and their habitats will be exacerbated by climate change, especially given that many species are already living close to their temperature limits.

What is already happening?

The main pressures on coastal fish habitats in the Pacific include coastal development, overfishing, and land-based pollution. These already degraded habitats are affecting fish and shellfish and highly degraded coral reefs support less than a third of the biodiversity of healthy reefs, making them more susceptible to impacts from climate change

What could happen?

The greatest impacts are likely to be from declines in productivity of demersal fish and invertebrates, and a more eastward distribution of some tuna species as a result of climate change. Changes in ocean temperature and water circulation are expected to impact coastal systems, reducing fish and shellfish productivity.

Warming temperatures and ocean acidification could also affect dispersal and settlement of larvae, affecting colonisation and connections between areas, fish behaviour and growth.

Shellfish such as trochus, green snails and pearl oysters could decline if a lower pH weakens their shells, reducing growth and causing greater mortality.

Declines in abundance of coastal fish and shellfish, exacerbated by climate change, will widen the gap between fish availability for growing island populations and sustainable harvests. Alternative sources of protein and income will be required.

Mangroves

Mangroves are highly valuable for Pacific island people. They provide food such as crabs and fish, are a source of wood for timber and fuel, and are important for coastal protection from waves and storms.

Promotion of mangrove substrate accretion will help enable mangroves to adapt to climate change and reducing non-climatic stressors will improve the health and condition of mangroves.

What is already happening?

In the Pacific region, mangrove losses are primarily due to coastal development and rubbish dumps, particularly in urban centres. There is some limited evidence that sea level rise is already causing mangroves to shift landward in the Pacific island region, and in some areas they are not keeping up with sea-level rise, leading to mangrove loss.

What could happen?

Mangroves are able to adapt to sea-level rise if they can accrete sediment and keep pace with rising waters. Sea-level rise will reduce mangrove cover where there is not enough sediment supply to support accretion. By 2070, mangroves with a low sediment supply and low tidal range could be submerged and die, including in Papua New Guinea and the Solomon Islands. While migration inland is possible, opportunities are often limited by topography, coastal developments, roads and sea defences.

In areas where long periods occur without rainfall, a reduction in mangroves is expected, creating dry saltpans in upper tidal zones. If climate change causes changes in the intensity of tropical cyclones, this is likely to cause more physical damage to mangroves.

A reduction in mangrove cover will reduce coastal protection, making coastal communities more vulnerable to storms, and reduce the availability of food and fuel that mangroves provide.

Seagrass

Seagrasses provide a wide range of services to Pacific island people including coastal protection, fish nursery grounds, and sediment stabilisation. Reducing anthropogenic impacts on seagrass beds will help to ensure resilience levels of local seagrass populations remain high, providing the best possible chance of survival under future climate change.

What is already happening?

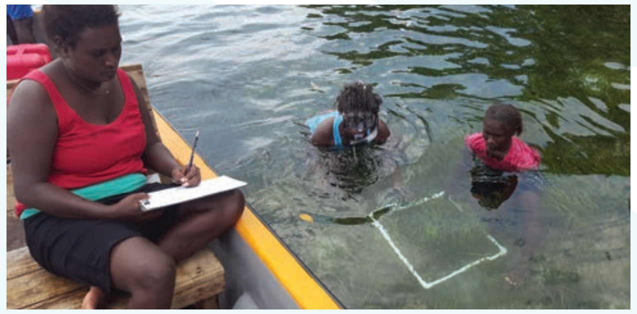
Coastal infrastructure development and pollution are currently placing more stress on seagrass habitats than climate change, causing loss of seagrass habitats and the services they provide to people.

What could happen?

Climate change will result in both gains and losses to seagrass beds. Increasing CO_2 is expected to enhance seagrass growth, but higher sea temperatures could reduce growth. Sea-level rise and the deepening of water over reefs would reduce the absorption of wave energy from the open ocean, altering the sheltered lagoonal conditions where seagrass live. In areas where seagrass thrive, they may become refuges for invertebrates and shellfish such as prawns, crabs, clams and sea cucumbers.

Changes in the magnitude of extreme weather events, such as heavy rainfall and tropical cyclones and storms, would cause direct physical damage and are likely to increase sedimentation and smothering, reducing seagrass growth.

Impacts from climate change will be exacerbated by urban expansion, pollution from rivers and coastal developments, and overfishing of key species. These will impact ecological function, reduce diversity of organisms and could prevent seagrass beds from adapting to climate change.



Communities in the Solomon Islands monitoring seagrass.

Corals

Coral reefs are the dominant coastal habitat in the tropical Pacific. Many Pacific islands have at least double the reef area to land area. Pacific communities depend heavily on these reefs for food, income and livelihoods.

What is already happening?

In the Pacific islands region, climate change is already impacting coral reefs through bleaching and by reducing calcification and growth rates. Tropical cyclones cause widespread coral damage, for example after Cyclone Winston struck Fiji in 2016, physical damage and severe declines in fish diversity were observed.

Non-climate pressures such as pollution, overfishing, sedimentation, eutrophication, crown of thorns starfish outbreaks and coral diseases are exacerbated by climate change, and together, these are changing Pacific coral reef communities.

What could happen?

Continued decline in reef health is expected, and by 2050, all Pacific nations may experience severe annual bleaching as a result of ocean warming. By 2100, live coral cover could be reduced by 90%. Large seaweeds could become a dominant feature of reefs, outcompeting corals.

Climate and non-climate pressures together are expected to increase the frequency and severity of coral bleaching, disease and mortality, and the time taken for a reef to recover will lengthen.

Such sustained pressure will cause a reduction in live coral, increased algal cover, more diseases, a weakened reef structure and a less diverse faunal community. Degraded reefs would also affect fisheries, tourism and reduce the coastal protection provided by reef structures, increasing the risk of property damage during storms.

Assessment of the vulnerability of Pacific islands to the impacts of ocean acidification on coral reefs and their services to livelihoods, food security, tourism and coastal protection. The vulnerability score is based on country characteristics including future ocean chemistry projections (to 2050), reliance on fish for food and earnings and jobs from coastal fisheries.

Country or Territory	Vulnerability score	Reef area (km^2)	Land area (km^2)
Solomon Islands	1.32	8535	27,556
Kiribati	1.31	4320	810
Papua New Guinea	1.30	22,200	462,243
Tonga	1.27	5811	699
Tuvalu	1.24	3175	26
Samoa	1.23	466	2935
Fiji	1.22	10,000	18,272
Vanuatu	1.22	1244	11,880
Nauru	1.15	7	21

Source: Johnson, J.E. Bell, J.D., Sen Gupta, A. (2016) Pacific Islands Ocean Acidification Vulnerability Assessment. SPREP, Apia, Samoa.

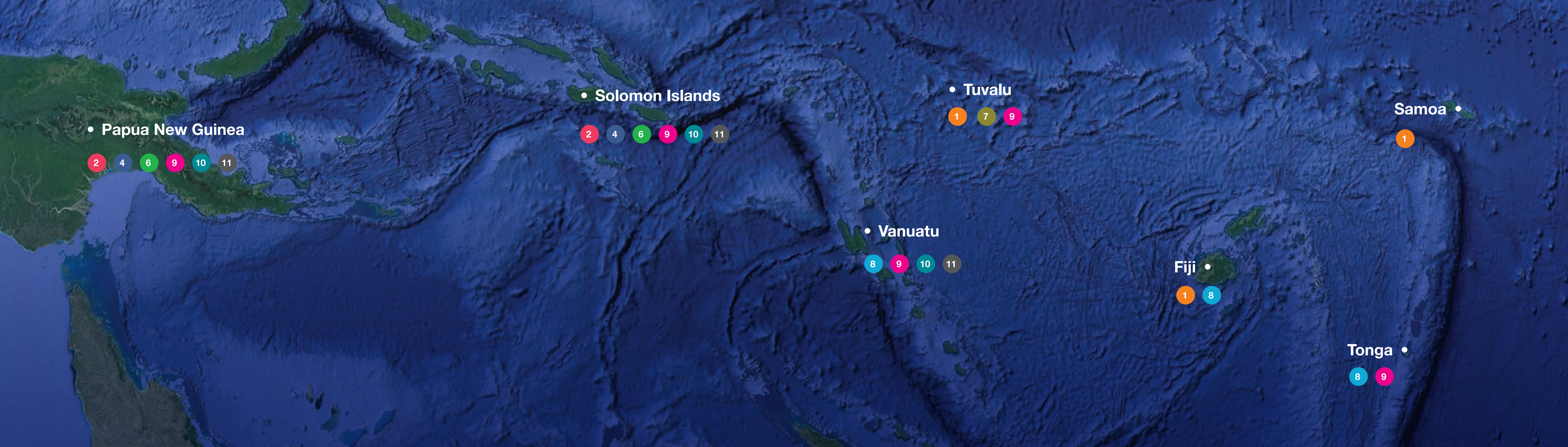
Wider impacts on biological diversity

In addition to the key issues identified here, there are many other important wider impacts on biological diversity. Further information on some important impacts are provided in the broad overview paper that supports this card.

For example, turtles tend to nest just above the high-water mark but cyclones, rising seas, storm surges and heavy rainfall can inundate nests or erode sand dunes resulting in significant damage to nests and eggs. Temperature during incubation is expected to affect hatchling sex ratios, size and quality, leading to population changes. Impacts on seabirds and marine mammals are thought to be mostly indirect through the effects of warming on their prey.

Climate change impacts at the country level

Whilst many climate change impacts will be common to all Pacific islands, vulnerability and adaptive capacity may differ within islands and from one island to another because of the Pacific islands' diverse physical and climatic environments and human pressures. This diversity must be recognised, and accounted for, in climate change and sustainable development planning.



1. Climate change is likely to contribute to urban migration and put greater pressure on degraded marine ecosystems, such as seagrass. Low-lying urban areas, such as in **Tuvalu**, **Kiribati**, **Fiji**, and **Samoa**, are particularly at risk because of the high-density, relatively poor migrant populations.

2. Displacement, relocation, and migration to higher islands has begun in **Solomon Islands**, **Papua New Guinea**, and low-lying atolls as land becomes uninhabitable. This can also lead to loss of language and cultural practices.

3. Low-lying atolls are particularly exposed to sea-level rise. **Kiribati** has 32 low-lying atolls that rise to no more than 2-3 metres above sea level. Such atolls already face loss of land to coastal erosion and saline inundation which can damage agricultural land and pollute water sources.

4. With rising sea levels, mangroves with low tidal range and low sediment supply could be submerged as early as 2070, including northern **Papua New Guinea** and the **Solomon Islands**.

5. Higher sea temperatures will cause some islands to experience severe annual coral bleaching before 2040 (e.g. **Nauru**) with all nations experiencing severe annual bleaching this century, even under the lowest emissions scenarios, unless emissions are reduced.

6. Declines in coastal fish and shellfish will widen the gap between fish available for growing human populations and sustainable harvests, with shortages expected in some Pacific nations (e.g. **Papua New Guinea**, **Solomon Islands**) by 2035.

7. Modelling suggests there could be increases in tuna abundance in the east and decreases in the west. This could be advantageous for countries like **Kiribati** and **Tuvalu**.

8. **Vanuatu**, **Fiji** and **Tonga** have experienced the most tropical cyclones in the past 30 years. In the future, the overall number of tropical cyclones may decrease in the Pacific region, but maximum intensity is likely to increase.

9. **Solomon Islands**, **Kiribati**, **Papua New Guinea**, **Tonga** and **Tuvalu** have been found to be the most vulnerable reef-dependent communities to the effects of ocean acidification. This will impact food security and livelihoods based on fishing, aquaculture and tourism.

10. Mean rainfall is projected to increase along with more extreme rainfall events for **Kiribati**, **Nauru**, **Papua New Guinea**, **Solomon Islands** and **Vanuatu**.

11. The population of some countries in Melanesia (e.g. **Papua New Guinea**, **Solomon Islands**, **Vanuatu**) are projected to almost double by the year 2050, exacerbating climate change impacts on already endangered coastal habitats, such as seagrass, mangroves, corals and coastal communities.

Google Earth
Image landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Case studies are drawn from the Commonwealth Marine Economies Programme countries, but are applicable to the wider region.

Climate change impacts on people and livelihoods

In the Pacific islands region over the past half century, there has been significant migration to coastal towns and cities, where flat land is available for agriculture, tourism and urban growth. This has put pressure on water resources and agriculture, led to the clearance of mangroves, polluted lagoons, reduced the habitat of coastal fisheries, increased coastal erosion, and put communities at greater risk from flooding. Climate change is expected to exacerbate these pressures and have profound effects on human settlements. In many cases, it is the poor that suffer most, as they live on land prone to coastal flooding and pollution, and are most reliant on the sea for food.

Resilience to extreme events can be enhanced when traditional knowledge is integrated with science. In the Pacific, it has been recognized that communities that make effective use of traditional knowledge are more resilient to extreme events.

Coastal fisheries

The degradation of coral reefs, exacerbated by climate change, is thought to be the greatest threat to coastal fisheries. Fish and invertebrate species are harvested in the Pacific islands for subsistence, sale at local markets and/or export. Women harvest over half of small-scale fisheries catches in the region, much of it through gleaning on the reef flat at low tide.

What is already happening?

Coastal development, overfishing, demand for resources and land-based pollution are already impacting coastal habitat condition, with indirect impacts on the demersal fish and invertebrates that depend on these habitats. Fishing effort is high due to rapidly growing human populations. Currently, impacts from targeting spawning aggregations and destructive fishing practices and gears, are considered to be greater than impacts from climate change.

What could happen?

The effects on coastal fisheries will largely be from climate change impacts on the extent and condition of coastal fish habitats. Resulting declines in coastal fish and shellfish populations will further reduce sustainability of harvests, with shortages expected in some Pacific nations (e.g. Papua New Guinea, Solomon Islands) by 2035. Alternative incomes will be needed where fishing operations are negatively affected, and ecosystem-based fisheries management to support sustainable fishing.

Changes in storm and cyclone severity could cause an increase in damage to coastal housing, fisheries infrastructure, ports, boats and fishing gear, with resulting loss of fishing days and cost implications for replacing and repairing these.

Settlements and infrastructure

The impacts of climate change will vary to some degree between states, because of differences in island types and topography, population and infrastructure. In most Pacific islands, almost all the population live on or near the coast. Tourism, many industries and most infrastructure are also coastal.

What is already happening?

Sea-level rise, storm surges, and high tides and flooding, combined with informal housing causing pollution of freshwater lenses, disease problems and fresh water scarcity are placing coastal communities and properties at increasing levels of risk. Only Papua New Guinea has significant infrastructure, industry and population centres away from coasts.

Beach extent is declining because of human development. Many of the region's coastlines have been affected by sea-level rise, tidal and wave action, storms, deforestation, sand mining and housing, wharf and causeway construction. To date, human impacts have had a greater influence on erosion and coastline changes than climate change.

The Papua New Guinea drought of 2015-16 indicates how droughts can affect every part of Pacific states. For a year, most of the country was badly affected by drought which reduced water supply, affected health, food production and some transport, closed some schools (since no water was available), and some women couldn't work because they had to walk long distances for water. Recovery was slow because crops could not be planted until adequate rain was available.

What could happen?

Stresses will be most acute on coral atoll states. Further increases in sea level will make much land in these atoll states more vulnerable to flooding. As sea level rises, freshwater lenses are expected to become increasingly affected by saltwater intrusion, making islands uninhabitable.

A greater incidence of drought is expected in some areas in the future, as well as severe tropical cyclones and more frequent flooding. This threatens coastal people further, especially in urban areas, with negative impacts on national economies. Along with housing, airports, power stations, factories, roads, landfill sites and hotels will be severely affected by climate change. Coastal cemeteries, archaeological and cultural heritage sites will be heavily impacted. Climate change is expected to put greater pressure on coastal urban areas, especially where marine ecosystems are already degraded, such as coastal sites with inadequate environmental management. Sea-level rise is expected to increase erosion and cause further coastal land loss.

The likelihood of damage to port infrastructure during storms and cyclones will increase as the intensity of storms increases, exacerbated by the decreasing coastal protection mangroves, seagrass and coral reef decline. Increased intensity of winds may make operations unsafe and increased rainfall may impede road transport to and from ports.

Waste management in Pacific islands will be affected by climate change. Most landfill sites are at the coasts, and many are at high risk from overtopping by high seas. These sites need to be climate-proofed to ensure that waste does not enter the seas or rivers during storms and high tides. Cyclones also generate large amounts of waste, including hazardous waste, when buildings and equipment are destroyed, and disaster relief supplies also create waste. The Cleaner Pacific 2025 project is aiming to improve waste and pollution management across the Pacific, incorporating these aspects.

Oceanic fisheries

Offshore tuna fisheries make critical contributions to economic development, government revenue and livelihoods in many Pacific islands.

Taking 2013/2014 as an example, some countries received 10-84% of their government revenue from tuna access fees and associated licences. Onshore processing of tuna contributes significantly to employment and GDP and more than 23,000 jobs have been created in American Samoa, Fiji, Marshall Islands, Papua New Guinea and Solomon Islands, through tuna processing operations. Movement of tuna away from these countries could affect employment and income.

What is already happening?

The distribution and abundance of tuna stocks are influenced by natural climate variability, such as the El Niño Southern Oscillation (ENSO) at inter-annual scales, and the Pacific Decadal Oscillation (PDO) on decadal time scales.

What could happen?

The four main Pacific tuna species, and their prey, will respond directly to changes in water temperature, oxygen, ocean currents and stratification causing knock-on effects for the fishers that catch them. Fishing grounds may need to move further east along the equator and at higher latitudes to follow tuna stocks, and there could be more tuna in international waters. This will likely benefit Kiribati, Tuvalu, Cook Islands and French Polynesia that may be able to increase fees from foreign fishing vessels and benefit through processing and export industries.

For islands in the Western Pacific, the projected eastward shift of tuna would reduce jobs for many Pacific islanders, and potentially reduce the government income from fishing fees.

Fish processing facilities in vulnerable coastal areas may need to be climate-proofed or relocated as sea-level rises, and more intense storms and extreme rainfall events occur.

Wider impacts on people and livelihoods

In addition to the key issues identified here, some important wider impacts on people and livelihoods are provided in the broad overview paper that supports this card.

Tourism is a major contributor to the economy of the region. The net contribution of the tourism industry to Pacific GDPs in 2016 ranged from 1.9% for Papua New Guinea to 44.5% for Vanuatu. Tourism infrastructure is mainly located along the coastal fringe of many Pacific islands, making the sector particularly vulnerable to extreme tides, waves, surge and sea-level rise. Climate change is expected to have negative impacts on tourism revenue for Pacific islands. Sea-level rise and erosion may also reduce the recreational value of beaches as they get narrower. Loss or degradation of coral reefs due to acidification and bleaching are also expected to devalue destinations for scuba divers and snorkelers.

With rainfall patterns and extreme weather events expected to change, it may be that the climate of some islands becomes less appealing to tourists.

As well as the direct **health impacts** caused by climate change drivers, such as risk of injury or death due to increased intensity of extreme weather events, there are also indirect effects on physical and mental health. Flooding creates risks associated with food and water security, and vector borne diseases. Increasing sea temperatures can alter host-pathogen interactions, affecting infectious disease outbreaks, such as Ciguatera, which can have severe human health implications.

There could be significant impacts from climate change on non-communicable diseases, such as heart disease and cancer, via interaction between climate change phenomena and other factors such as physical inactivity, food insecurity, and poor nutrition.

Responding to climate change impacts in the Pacific islands

This report card has highlighted some of the key impacts that Pacific islands face from climate change. By drawing together information from a range of regional experts in a policy context, the card shows that to respond in an effective, and appropriate manner, further understanding of these impacts at a local scale is needed, along with actions that are realistic and achievable.

Many anticipated climate change impacts are described in this report card, but the future is far from certain. The nature and extent of these impacts will be shaped by future global emissions levels. All indications show that only by rapidly reducing greenhouse gas emissions to levels consistent with stabilising global temperatures below 1.5˚C we can avoid reaching critical tipping points and the worst impacts of climate change in the Pacific region. Global mean temperature rise will determine the state of future ocean-based ecosystems and livelihoods. Climate change projections are improving all the time and can help us to understand future impacts on ecosystems and the people they support, by mid-to-end century. However, many climatic changes will be incremental, and start to manifest before then.

To fully understand the changes taking place, monitoring and evaluation of physical and ecosystem changes is needed which must feed into, and assess progress against model projections, and link information to government decision makers. It is imperative that climate change adaptation begins now. Flexible management systems, that are adaptive over time, are urgently needed which connect terrestrial and marine systems, link different sectors of government and industry and provide long-term planning solutions. These systems must address other stressors as well, such as habitat destruction and pollution, which exacerbate climate change impacts.

Engaging social and cultural groups is a fundamental part of successful climate action and their inclusion will benefit efforts to build climate change resilience. Communities should be involved in research and knowledge collection, in decision-making, and in actions and programme and project outputs. Enduring engagement of culture and traditional knowledge will help ensure the effectiveness of resilience strategies.

Working together and uniting in addressing climate change at the international level is the strength of the Pacific islands. The cost of climate change is far too high for any island to address alone. National actions on the ground also have regional links, with different Pacific islands learning from each other as they forge a path forward. The challenges of policy development and adaptation in one island nation may help another as they journey into similar waters.

A number of potential responses are highlighted in the supporting topic papers. Some overarching examples include:

- developing future Pacific climate projections that can be used at local scales through investment in new, improved data collection and analysis and build research capacity in these areas.
- building resilience to unavoidable climate change impacts on coral reefs, mangroves and seagrass, by substantially reducing multiple non-climate threats. This should include culturally sensitive collective endeavours and cooperative action, including protected areas and creating new space for mangroves.
- providing support for biological, social and economic assessments on the status, and future projections of, seagrass and mangroves to support appropriate evidence-based adaptation planning.
- assessing how fisheries' livelihoods will need to be diversified on some islands. Communities can adapt by catching fish which are more resilient to climate change, and conserving and restoring important fish habitats.
- optimising the sustainable economic benefits from tuna through regional management, in light of shifting location and productivity of tuna resources across the Pacific.

The topic papers linked to this report card provide more detail on responding to climate change impacts, along with further research priorities and examples of successful adaptation projects for the Pacific. **www.gov.uk/government/publications/commonwealth-marine-economies-cme-programme-pacific-marine-climate-change-report-card-and-scientific-reviews**

Whilst we Pacific islanders may be amongst the most vulnerable to the impacts of climate change, we are empowered enough to do what we can to play our part as responsible global citizens and to help our island communities adapt.

This report card is based on an original concept developed by the UK Marine Climate Change Impacts Partnership (MCCIP) **www.mccip.org.uk**.

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