SPREP
Secretariat of the Pacific Regional Environment Programme

Pacific Community
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INTERNATIONAL COURT OF JUSTICE

Request for an Advisory Opinion on Obligations of States in respect of Climate Change

Expert Report for the Melanesian Spearhead Group prepared by the Pacific Community (SPC) and the Secretariat of the Pacific Regional Environment Programme (SPREP)

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Disclaimer

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I. INTRODUCTION AND EXPERTISE

The Pacific Community (SPC) is an intergovernmental organization that supports Pacific countries and territories with scientific and technical solutions to address the region's greatest challenge, climate change. SPC is one of the Pacific region's scientific and technical intergovernmental organisations working alongside its Pacific Island country and territory (PICT) members[1] to understand and develop effective solutions to the challenges they face. In this case, SPC's core technical abilities to provide the objective science behind observed impacts of the adverse effects of climate change will help provide further expertise for the Melanesian Spearhead Group's (MSG) submission with focus on Fiji, Papua New Guinea, and Solomon Islands.[2]

SPC's mandate and work programme addresses the many facets of climate change and its impacts on the region, including but not limited to, marine ecosystems, fisheries,[3] coastal hazards, and human rights protections.[4] Additionally, SPC is the regional lead for the implementation of many climate change mitigation and adaptation programmes, including on sea-level rise as well as loss and damage, and it sustainably manages Pacific maritime zones, ecosystems, and resources from 'ridge to reef' for current and future generations.[5] Its expertise in global and regional analyses of the impacts of climate change on the marine environment is why it was granted leave to intervene in the advisory opinion proceedings at the International Tribunal for the Law of the Sea in Case No. 31.[6]

SPC is also a consultative and advisory body to participating governments in matters affecting the economic and social development of its members within its scope, and the welfare and advancement of their peoples.[7] SPC sustainably manages social and environmental risks and impacts of all its activities in an inclusive manner, with a people-centred approach to maximise whole-of-society benefits. SPC is committed to openness and transparency, maintaining the highest ethical standards, and, as such, the statements contained in this report are factually correct and materially complete.

The Secretariat of the Pacific Regional Environment Programme (SPREP) is the regional organisation established by the governments and administrations of the Pacific charged with protecting and managing the environment and national resources. SPREP's mandate is to promote cooperation in the Pacific region and provide assistance to protect and improve its environment as well as ensure

[1] SPC has 27 members, including 22 PICTs: American Samoa, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Nauru, New Caledonia, Niue, Northern Mariana Islands, Palau, Papua New Guinea, Pitcairn Islands, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu and Wallis and Futuna.
[2] Vanuatu is not included, only because SPC has completed an expert report specific to its state submission.
[3] Note that, under the United Nations Convention on the Law of the Sea (UNCLOS), fishing is singled out among the legitimate uses of the sea that are negatively affected by pollution ('pollution of the marine environment means the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities'), UNCLOS, 10 December 1982, 1833 United Nations Treaties Series (U.N.T.S.) 397 (entered into force 1 November 1994) at Article 1(1)(4).
[4] Article IV, §§ 6-10, of the Canberra Agreement establishing the South Pacific Commission (U.N.T.S., vol. 97, 227).
[5] For the full range of SPC's implementation for mitigation and adaptation programming, *see* Pacific Community Strategic Plan 2022-2031 (available at: https://purl.org/spc/digilib/doc/uzzya).
[6] See Request for an Advisory Opinion submitted by the Commission of Small Island States on Climate Change and International Law (Request for an Advisory Opinion submitted to the Tribunal).
[7] See note 3 at para. 6.

sustainable development for present and future generations.[8] SPREP is guided by its vision for the future: 'A resilient Pacific environment, sustaining our livelihoods and natural heritage in harmony with our cultures.'[9]

SPREP provides its 21 Pacific Island Members with technical advice and support for capacity building for the region's environmental and development priorities. It also promotes sustainable development and cooperation in the region. With the support of the SPREP, much progress has been made by Members to address environmental concerns. Pacific Island leaders have long recognised climate change as the biggest threat facing the region, with serious implications for sustainable development and the environment that has nurtured the Pacific's unique cultures. As such, Pacific Islands Forum (PIF) Leaders established the Council of Regional Organisations of the Pacific (CROP) in 1988, of which both SPREP and SPC are members, that work with other peer CROP agencies to serve the region's people and governments.

II. METHODOLOGY

MSG requested that this expert report include the full scope of climate-related losses and damages experienced, including environmental, human health, socio-economic, and cultural impacts. From this request, several of SPC's largest and most relevant divisions provided the necessary science to put together this report, compiled by an international lawyer with a scientific background to ensure proper competencies.[10] SPC also worked closely with SPREP to ensure the best possible science was included in this report, so where SPREP's competencies were required, it provided relevant data in line with the request.[11]

The report builds upon the best available science, including the Sixth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC).[12] It covers climate impacts that have already been observed as well as those currently occurring, including extreme weather events such as cyclones, changing rainfall patterns and drought, ocean warming, acidification and deoxygenation, and others.

It concludes that (i) MSG countries have experienced significant harm because of anthropogenic climate change, and (ii) future losses and damages are bound to occur, with the extent of future harm depending on actions taken to avert, minimize, and address such losses and damages.

III. CLIMATE CHANGE–RELATED IMPACTS

Small island developing states, due to their geographical circumstances and level of development, are specially affected and particularly vulnerable to the adverse effects of climate change. For MSG countries, these well-documented climate change–related impacts include, but are not limited to, sea-level rise; extreme weather events (tropical cyclones); rainfall; temperature rise; and sea surface

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[8] SPREP Agreement, 1993 (available at: https://www.sprep.org/governance/agreements-establishing-sprep).
[9] Secretariat of the Pacific Regional Environment Programme, Strategic Plan 2017–2026, available at: library.sprep.org/sites/default/files/strategic-plan-2017-2026.pdf, p.5.
[10] SPC's relevant divisions include Human Rights and Social Development (HRSD), Geoscience Energy and Maritime (GEM), Fisheries, Aquaculture and Marine Ecosystems (FAME), Land Resources Division (LRD), and Climate Change and Environmentally Sustainability (CCES) programme.
[11] For example, **s**pecific science on the Kikori River Basin and coral health were provided by SPREP experts on those topics. Inputs from SPREP provided by Jessica Rodham and Everett Sioa.
[12] Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2022: Impacts, Adaptation, and Vulnerability*. Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 2022 (available at: https://report.ipcc.ch/ar6/wg2/IPCC_AR6_WGII_FullReport.pdf).

temperature effects on coral and ocean health.[13] These impacts are described under the progression of time and corresponding increased temperature projections, and where possible, include climate impacts likely to occur at 2.8°C—the level of warming projected to occur if nationally determined contributions (NDCs) submitted under the Paris Agreement are fully implemented. To keep this report focused and brief, it will describe the most relevant climate change–related impacts that best characterise the harm this region faces.

At the outset, it is pertinent to recognise that Melanesian countries—Papua New Guinea (PNG), Fiji, New Caledonia, Solomon Islands and Vanuatu—represent 90% of the total Pacific Island population and 85% of its total land area. MSG countries also hold between them some of the most biodiverse ocean areas in the world. While PNG, Solomon Islands, and Fiji are within the same region, they do have distinct elements that affect how climate change interacts with each of them. Parsing each of the overall climate change–related impacts with the data specific to each country, as highlighted at the front of each paragraph, is vital.

Most notably distinct is PNG with a total land area of 462,840 km^2 and an exclusive economic zone (EEZ) of 2.4 million km^2, which make it the world's third-largest island nation. It is also home to the third-largest tropical rainforest on the globe and contains 7% of the world's total number of biodiverse species. It forms part of the Coral Triangle, which is the centre of biodiversity for the world's marine life. PNG is the largest carbon sink in the Pacific (outside the ocean itself). Located at the equatorial/tropical South Pacific, it is also home to several major rivers, including the Sepik River. Its profile is unlike that of other Pacific countries; its unique climate includes mountain glaciers, humid tropical rainforests, swampy wetlands, and coral reefs. Many of the impacts of climate change on PNG have the potential to translate into global issues if these pockets of biodiversity and carbon-storage are harmed beyond repair.

Sea-level rise

Rising sea levels remain an existential threat to the Pacific, to which MSG countries are well acquainted. Figure 1 depicts sea-level rise for the Melanesian region from 1993 to 2020. PNG, Solomon Islands, and Fiji are all located in parts of the Pacific that have seen some of the most drastic rises in sea levels, above those of global averages.

PNG: The highest sea levels in PNG typically occur in the months of November–February, with the majority in December/January. La Niña brings noticeably higher sea levels in December and January, In 2021 alone, almost half of the exceedance hours in the 27-year record were represented. Sea-level rise within PNG's EEZ, measured by satellite altimeters from 1993 to mid-2020, ranges from about 2.5 to 5.0 mm per year, with the highest estimates in the east and southwest. Tidal analysis of Lombrum sea-level data shows that it experiences a diurnal tide, meaning only one high and one low tide per day, with the highest tides predicted to occur mostly in December and January. La Niña years typically have higher sea levels in December and January. In January and December 2021 alone, PNG exceedances accounted for almost half of all exceedance hours in the entire record. In other words, of the number of

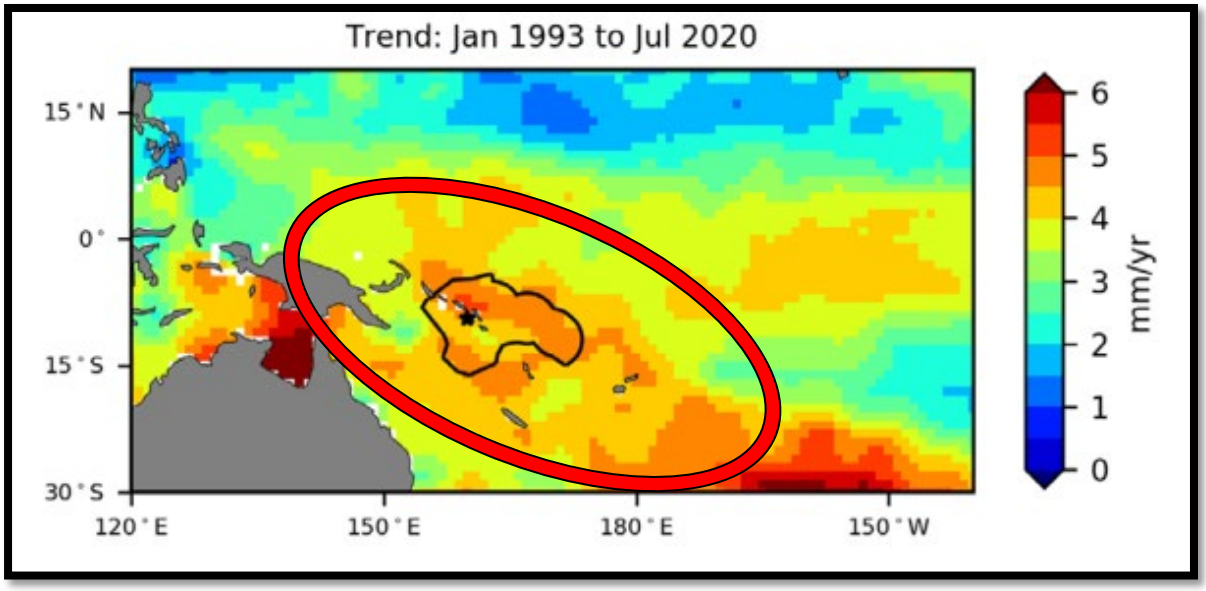
[13] *See mainly*, McGree, Simon, Grant Smith, Elise Chandler, Nicholas Herold, Zulfikar Begg, Yuriy Kuleshov, Philip Malsale and Mathilde Rittman, SPC. *Climate Change in the Pacific 2022: Historical and recent variability, extremes and change.* Chapters 4, 10 and 12, 'Fiji', 'Papua New Guinea', and 'Solomon Islands', respectively; SPC also received data on *Coral Reefs* and on *Biodiversity* from experts at SPREP in consultation with Melanesian Spearhead Group representatives.

hours in the 99th percentile (1.29 metres) that exceeded the sea-level threshold, nearly half of them were measured in the first and last months of 2021.[14]

Solomon Islands: Honiara experiences a mixed tidal cycle, meaning it can be both diurnal and semidiurnal depending on the time of month, meaning sometimes there are two high and low tides a day, and sometimes there is only one high and low tide per day. The highest predicted tides of the year typically occur during the wet season months of November–January and also April/May. Sea level within the EEZ, measured by satellite altimeters since 1993, has risen between 3.5 and 5.5 mm per year, with a confidence interval of up to ±1.2 mm across the islands, higher than the global average of 3.1 ± 0.4 mm per year. It is important to note a high uncertainty estimate in the numbers, which means that the trend could be as low as 2.3 mm/year or as high as 6.7 mm/year. Trend estimates at the Honiara tide-gauge over a shorter time period are provided in the Pacific Sea Level and Geodetic Monitoring (PSLGM) Project, which provides numbers that are updated on a monthly basis.[15]

Fiji: Fiji experiences a semidiurnal tidal cycle, meaning two high and two low tides per day. The highest predicted tides of the year typically occur during the wet season months of December–February and the highest sea levels typically occur in the months from October to March. La Niña brings noticeably higher sea levels outside the austral summer, specifically March/April and September/October. Sea-level rise within Fiji's EEZ, as measured by satellite altimeters from 1993 to mid-2020, ranges from 4 to 5 mm per year, with highest trend estimates in the far north, also higher than the global average. Since approximately 2009, the number of hours where sea level exceeds the 2.39 m sea-level threshold has increased steadily. This is due to a combination of sea-level rise, and subsidence occurring in Fiji.[16]

Figure 1. Satellite altimetry annual trend for the Pacific from 1993 to 2020, with the Melanesian Spearhead Group of countries highlighted (in red circle) and the Solomon Islands EEZ highlighted (in black).[17]



[14] McGree et al., *Climate Change in the Pacific 2022*, 144.
[15] *Ibid.*, 157.
[16] *Ibid.*, 55.
[17] Figure adapted from McGree et al., *Climate Change in the Pacific 2022*, 158.

Case Study: Kikori River Basin and Delta (Papua New Guinea)

PNG is ranked as the tenth most vulnerable country in the world to the risk of climate change. PNG's highlands region is susceptible to extreme weather such as heavy rainfall, which may increase the occurrence of landslides and inland flooding. The coastal regions, the islands and the low-lying atoll areas are mostly vulnerable to extreme weather events, storm surge, sea-level rise, and coastal inundation. The sea level surrounding PNG has risen by approximately 7 mm per year since 1993, which is higher than the global average of 2.8–3.6 mm per year. Projections anticipate a continued rise. Under a high emissions scenario, the sea is expected to rise between 4–15 cm by 2030. This will impact storm surges and flooding to coastal regions. Risk of flooding (both coastal and inland flooding) is ranked amongst the highest level of climate risks in PNG.[18]

The Kikori River is 445 km in length and is PNG's fifth-largest river. The Kikori River is included in the Kikori River Basin, a nominated World Heritage Area because of its biodiversity and cultural diversity values. Climate change impacts in the Kikori Delta, Gulf Province of PNG, include the rise of sea levels, increased flooding, and increased intensity of storm surges. A number of villages have already relocated as the villages have become unable to sustain the human population. Freshwater sources have become more saline as salt intrusions enter into water sources. June and July are the peak months for storm surges in the Gulf of Papua, and many villages have faced the destruction of these storms. Villagers have moved themselves up the river to the small township of Kikori. Due to climate change impacts, this forced migration is already causing friction among the tribes as settlers and traditional landowners argue overfishing and food resources (See Picture 1).[19]

Picture1. Dohumo settlement-Kikori Urban where villagers have relocated themselves from the coast of the Kikori Delta to settlements near Kikori Town.[20]

[18] Government of Papua New Guinea (2020), *Papua New Guinea's Enhanced Nationally Determined Contribution 2020*, available at https://unfccc.int/sites/default/files/NDC/2022-06/PNG%20Second%20NDC.pdf, 19.
[19] Piku Biodiversity Network (2020), *Climate Change Impacts in the Kikori River Delta*, available at https://www.ohchr.org/sites/default/files/documents/issues/climatechange/cfi-promotion-and-protection/non-states/2022-07-06/Environmental-Defenders-Office-2-cfi-promotion-and-protection.pdf.
[20] *Ibid.*, 9.

Coastal erosion

The loss of land due to coastal erosion can pose a significant threat to coastal infrastructure and threaten the livelihoods of coastal communities. Coastal erosion decreases the space available for much-needed community facilities and development initiatives. For example, most of PNG experiences flooding during the monsoons. The highlands—where average rainfall can reach 10,000 mm—have a long history of severe flooding. In the coastal plains, floods cause erosion and heavy sedimentation that impact agricultural productivity and downstream settlements.[21] This has been best documented in Fiji. Compounding factors like sea-level rise, wave inundation, and extreme weather, mean that Fiji's coast has undergone significant change over time. Over 80 coastal towns have had to relocate due to rising sea levels and subsequent coastal erosion.[22] And, at present, close to 50 Fijian villages have been earmarked for potential relocation in the next five to ten years, owing to the impacts of climate crisis. A Climate Relocation of Communities (CROC) Trust Fund has been established for planned relocation in Fiji.[23]

Tropical cyclones

A large number of tropical cyclones pass through the Melanesia region of the Pacific Ocean each year. Tropical cyclones cause major economic harm to the region. In Fiji, tropical cyclones cost around 5% of its GDP every year, with a 65% probability that it will experience a storm every year.[24] While the complexity of the science behind cyclone hazard and climate change is developing,[25] known risks include the adverse effects that sea-level rise has on increasing the damage caused by cyclone-induced storm surges, and intensified wind and rainfall. While the number of cyclones passing through MSG EEZs may be somewhat decreasing, there is significant evidence that the cyclones that do pass are more extreme.

PNG: Tropical cyclones usually affect PNG between November and April. Over the period 1969–2018, an average of 16 cyclones passed within the PNG EEZ per decade. Tropical cyclones were most frequent in neutral El Niño–Southern Oscillation years and least frequent in La Niña years. Interannual variability in the number of tropical cyclones in the EEZ is large, ranging from zero in some seasons to six in 1971/1972 and five in 2013/2014.[26] PNG has been affected by devastating cyclones on multiple occasions. In November 2007, tropical cyclone Guba resulted in at least 164 fatalities and caused severe damage across southeastern PNG, including displacing over 13,000 people. A state of emergency was

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[21] World Bank, Climate Knowledge Portal: Climate Risk and Adaptation Country Profile, *Vulnerability, Risk Reduction, and Adaptation to Climate Change Papua New Guinea,* April 2011 available at https://climateknowledgeportal.worldbank.org/sites/default/files/2018-10/wb_gfdrr_climate_change_country_profile_for_PNG.pdf.

[22] See Storymap ArcGIS, Fiji Climate Impacts: Rising Sea Level available at https://storymaps.arcgis.com/stories/f0168f19be45481792f85fc7a8dde8f7.

[23] Office of the Prime Minister, Climate Change Division, Fiji Climate Change Portal, *Information Sharing Session on Climate Relocation of Communities Trust Fund*, 19 January 2024 (accessed 5 March 2024) available at https://fijiclimatechangeportal.gov.fj/information-sharing-session-on-climate-relocation-of-community-croc-trust-fund/.

[24] Climate Investment Fund Factsheet, *Nature, People & Climate Partner Countries Program Overviews* (2022) available at https://cif.org/sites/cif_enc/files/knowledge-documents/NPC%20Countries%20announcement.pdf.

[25] Records of tropical cyclones exist from the late 1800s in some countries in the Southwest Pacific, but trends in tropical cyclones have only been presented from 1981/1982. Satellite-based observations began in the Southwest Pacific in the early 1970s, but consistent coverage and reliable intensity estimates have only been available since the early 1980s. Confidence in tropical cyclone trends is moderate as the definition of a tropical cyclone has changed and satellite observation methods have continued to improve over the last 40 years.

[26] McGree et al. 2023, *Climate Change in the Pacific 2022*, 129.

declared as torrential rains and high tides caused extensive flooding that destroyed over 13 bridges and numerous roads as a result of landslides and floodwater.[27]

Solomon Islands: Tropical cyclones usually affect Solomon Islands during the southern hemisphere tropical cyclone season, which is from November to April, but also occasionally occur outside the tropical cyclone season. The Southern Hemisphere Tropical Cyclone archive indicates that between the 1969/1970 and 2017/1918 seasons, 138 tropical cyclones passed within the EEZ. This represents an average of 28 cyclones per decade. Tropical cyclones were most frequent in El Niño years (42 cyclones per decade), followed by neutral years (25 cyclones per decade) and least frequent in La Niña years (20 cyclones per decade).[28] The most recent tropical cyclone, Jasper (category 4), affected Solomon Islands in December 2023, compromising water supplies in the Western Province, disrupting shipping routes in the Central Province, and suspending domestic air travel,[29] totalling a conservatively estimated US$675 million in damage to the region.[30]

Fiji: Tropical cyclones usually affect Fiji during the southern hemisphere tropical cyclone season, which is from November to April. Tropical cyclones also occasionally occur in October and May of El Niño years. The tropical cyclone archive of the southern hemisphere indicates that between the 1969/1970 and 2017/2018 seasons, 135 tropical cyclones passed within its EEZ, representing an average of 28 cyclones per decade.[31] In 2016, Tropical Cyclone Winston—one of the strongest tropical storms on record in the southern hemisphere—hit Fiji causing massive destruction. Winston is one of the deadliest storms in Fiji's history, causing 44 deaths and affecting more than 60% of Fiji's total population,[32] and an estimated US$1.4 billion (approximately 31% of Fiji's GDP) in damages, the second costliest cyclone ever in the South Pacific basin. The cyclone damaged at least 495 schools and 88 health facilities, disrupted basic public services, and destroyed crops and livelihoods.[33]

Subsistence agriculture and food security

MSG countries are distinct in their land cultivation capabilities, so agriculture is very important to them. However, it also leaves them vulnerable to the impacts of climate change on that sector. More intense rainfall events exacerbate soil erosion and nutrient loss. Rising sea levels have increased the incidence of soil and groundwater salinization, which also impacts water security. In fact, saltwater intrusion into agricultural lands has devastating effects on food production that PNG, Solomon Islands and Fiji have all witnessed.

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[27] United Nations Office of the Coordination of Humanitarian Assistance (OCHA), *Papua New Guinea: Cyclone Guba OCHA Situation Report No. 2* (26 November 2007) available at https://www.unocha.org/publications/report/papua-new-guinea/papua-new-guinea-cyclone-guba-ocha-situation-report-no-2 (this report is based on information from U.N. Agencies, the Government of Papua New Guinea, and other responders and donors).

[28] McGree et al., *Climate Change in the Pacific 2022*, 155.

[29] Radio New Zealand, Tropical cyclone Jasper impacts Solomon Islands as it slowly moves away, 8 December 2023 available at https://www.rnz.co.nz/international/pacific-news/504209/tropical-cyclone-jasper-impacts-solomon-islands-as-it-slowly-moves-away (accessed 11 March 2024: data based on Solomon Islands Meteorological Services update at the time).

[30] Nicholson, Dylan (31 December 2023). "Cyclone Jasper damage bill estimated to hit $1 billion". *The Cairns Post*. Archived from the original on 2 January 2024 (accessed 15 March 2024).

[31] McGree et al., *Climate Change in the Pacific 2022*, 53.

[32] Australian Government, Department of Foreign Affairs and Trade, *Tropical Cyclone Winston Education Response Evaluation*, October 2017 available at https://www.dfat.gov.au/sites/default/files/tropical-cyclone-winston-education-response-evaluation.pdf.

[33] Government of Fiji, *Fiji Post-Disaster Needs Assessment – Tropical Cyclone Winston (*2016) available at, https://reliefweb.int/report/fiji/fiji-post-disaster-needs-assessment-may-2016-tropical-cyclone-winston-february-20-2016.

The effects of climate change can influence food security via direct and indirect effects on crop growth processes. Direct effects include alterations to carbon dioxide availability, precipitation, and variable temperatures. Indirect effects include impacts on water resource availability, soil organic matter transformation, soil erosion, changes in pest and disease profiles, the arrival of invasive species, and declines in arable areas due to the submergence of coastal lands. The following section will discuss the impacts of changing rainfall and drought conditions as well as temperature rise since these factors directly affect the agricultural industry, and, by extension, food security for MSG countries.

PNG: The agriculture sector and subsistence farming employs a majority of PNG's population (around 85%) and accounts for approximately 30% of the national GDP.[34] The majority of PNG receives more than 2500 mm of rainfall annually, so both subsistence and commercial farming depends on rainfall. Primary cultivated crops include sweet potatoe, taro, yam, cassava, banana, breadfruit, sugarcane, and *aibika* (a type of Pacific cabbage), while a diverse range of vegetables are produced for local consumption, including pumpkins, corn, carrots, peppers, beans, and tomatoes. Higher temperatures resulting from climate change result in more heat stress and increased humidity with negative consequences for agricultural production. Rising temperatures could lead to faster rates of crop deterioration after harvesting, with significant implications for food security.[35] PNG is among the group of PICTs where the estimated sustainable production of fish and invertebrates from coastal and freshwater habitats is unable to supply the national population with the number of fish needed per person per year for good nutrition.[36]

Solomon Islands and Fiji: In Solomon Islands, 75% of its labour force is engaged in subsistence farming and/or fishing. As with the other Melanesian countries, agriculture and fishing are an especially important source of income for rural households in Fiji, and changes in rainfall, more extreme weather events, higher average temperatures, sea-level rise, and ocean acidification all negatively affect yields of crops, fisheries stock and livestock health, and particularly affect subsistence farmers in remote locations.[37]

Changing rainfall and drought

Annual rainfall across the Melanesia region varies significantly making crop yields less predictable as climate change-related impacts intensify and become more frequent. This is especially true in the case of prolonged drought. The 2015–2016 drought seriously reduced food security in PNG. For areas with very high elevations (2200 to 2800 m), the effects of the drought were compounded by the effects of frost on crops. The drought and frost affected around 700,000 people and approximately 450,000 people

[34] *Pacific Adaptation to Climate Change Papua New Guinea Report of In-Country Consultations*. GEF, UNDP, SPREP, available at https://www.sprep.org/attachments/Climate_Change/PACC_Report_of_in-country_consultations_Papua_New_Guinea.pdf.
[35] Facts taken from the World Bank Climate Knowledge Portal, Climate Risk and Adaptation Country Profile for Papua New Guinea, available at: https://climateknowledgeportal.worldbank.org/sites/default/files/2018-10/wb_gfdrr_climate_change_country_profile_for_PNG.pdf.
[36] Johann D. Bell, Johanna E Johnson, and Alastair Hobday (eds). *Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change Summary for Pacific Island Countries and Territories. Secretariat of the Pacific Community, Noumea, New Caledonia,*186.
[37] See generally, Aditi Kapoor et al., *Climate Change Impacts on Health and Livelihoods: Fiji Assessment*, April 2021 available at https://www.climatecentre.org/wp-content/uploads/RCRC_IFRC-Country-assessments-FIJI.pdf. See also, Climate Resilient Food Systems Alliance, *Fiji: A case study*, December 2022 available at https://unfccc.int/sites/default/files/resource/CRFSA_Fiji_Case_Study.pdf.

faced critical food shortages.[38] Droughts also affect the livelihood of people by destroying economic crops. In Fiji, the 1997–1998 El Niño event is an example where losses in the sugar cane industry were around US$53 million, while other agriculture losses including livestock death amounted to US$8 million. In the 1998 drought, Fiji lost approximately US$63 million in the agriculture sector.[39]

With changes in precipitation, rainfall, and temperature patterns predicted to occur, a range of follow on impacts are foreseeable. For example, forests (particularly applicable to PNG) will become more susceptible to invasive species and fire, resulting in broad ecosystem shifts such as loss of ecosystem services and loss of habitats for certain species. In the Solomon Islands, annual rainfall is projected to increase slightly with more extreme rain events, including increased rainfall intensity of around 20% within 100 km of the cyclone centre. Projections show extreme rainfall days are likely to occur more often and be more intense.[40]

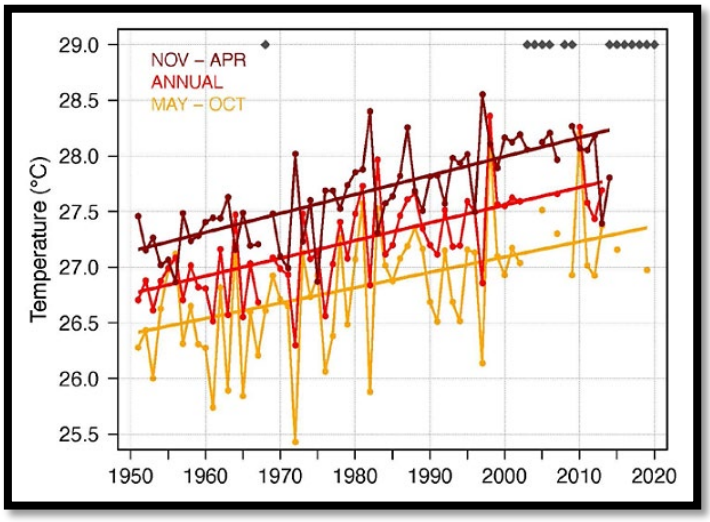
Increased frequency of high-temperature days

Temperature rise and global warming caused by climate change are wreaking havoc across the planet and have particular climate effects for small island developing states like PNG, Solomon Islands, and Fiji.

PNG: Annual and seasonal air temperatures at Port Moresby increased over the period 1951–2019. The annual number of hot days and warm nights has increased, while the number of cool days and cold nights has decreased. The energy required for cooling indoor environments has increased and the difference between daytime and night-time temperatures has decreased.[41] Coastal locations on the PNG mainland and offshore islands experience small seasonal variations in temperature, the largest of which is a maximum temperature range of 1.3°C at Port Moresby for the 1961–1990 climatology period and 1.2°C for the 1991–2020 period. There is a peak in maximum temperature during the wet season and a minimum during the dry season months of June–August. There has been a clear shift towards warmer average minimum monthly temperatures between the climatology periods of 1961–1990 and 1991–2020.[42] Average annual and seasonal temperatures have increased significantly at Port Moresby (Figure 2) and daily minimum temperatures are increasing faster than daily maximum temperatures.

[38] Iese, Viliamu, Anthony S. Kiem, Azarel Mariner, Philip Malsale, Tile Tofaeono, Dewi GC Kirono, Vanessa Round et al. "Historical and future drought impacts in the Pacific islands and atolls." *Climatic Change* 166, no. 1 (2021), 19. doi:10.1007/s10584-021-03112-1.
[39] Iese, Viliamu. , Pajiliai Dobui, Helene Jacot des Combes, Morgan Wairiu, John Walenenea Jr, Moses Asitarau, Tapulolou Tuailemafua et al., *Community-based loss and damage assessment toolkit for the tourism and agricultural sectors*, Pacific Centre for Environment and Sustainable Development, Fiji (2016).
[40] See Pacific-Australia Climate Changes Science and Adaptation Planning Program, *Current and future climate of the Solomon Islands Update,* 2011 available at https://www.pacificclimatechangescience.org/wp-content/uploads/2013/06/13_PACCSAP-Solomon-Islands-11pp_WEB.pdf, 7–8.
[41] McGree et al., *Climate Change in the Pacific 2022,* Chapter 10 'Papua New Guinea', 123.
[42] *Ibid*., 127.

Figure 2. Average annual November–April and May–October temperatures at Port Moresby, PNG.[43]



Solomon Islands: Average annual and seasonal temperatures have increased significantly at Honiara (Table 1). Air temperatures throughout the year show only small seasonal variations as they are strongly linked to the surrounding ocean temperatures. The most significant variation in air temperatures is in July and August, when cooler air blows in from the south. This change is most evident in the average minimum temperatures at Munda, which has a minimum temperature range of 1.6°C for the 1961–1990 climatology period. Both Honiara and Munda display a clear rise in average minimum temperatures between the 1991–2020 climatology period and the 1961–1990 period for all months throughout the year.[44]

Table 1. Trends in annual and seasonal air temperatures for Honiara.[45]

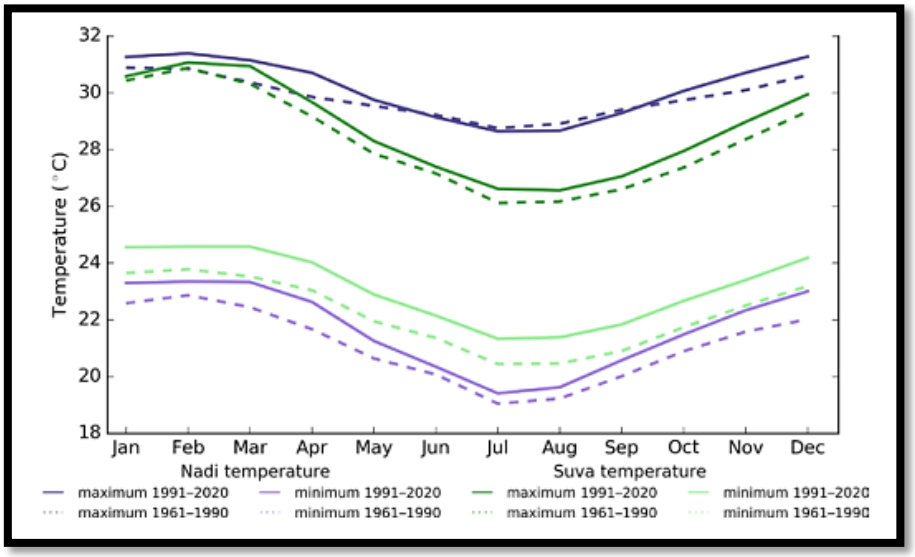
	Honiara Tmax (°C/decade)	Honiara Tmin (°C/decade)	Honiara Tmean (°C/decade)
	1951–2020		
Annual	**+0.23** (+0.17, +0.28)	**+0.19** (+0.14, +0.24)	**+0.21** (+0.17, +0.25)
November–April	**+0.26** (+0.19, +0.31)	**+0.20** (+0.15, +0.27)	**+0.23** (+0.19, +0.27)
May–October	**+0.22** (+0.16, +0.27)	**+0.18** (+0.13, +0.22)	**+0.19** (+0.16, +0.23)

Fiji: The range in average monthly maximum temperatures throughout the year is about 5°C for Suva and 3°C for Nadi Airport. The average monthly minimum temperature range is about 3°C for Suva and 4°C for Nadi Airport for 1991–2020. There has been a clear shift towards warmer average monthly temperatures between the climatology periods of 1961–1990 and 1991–2020 (Figure 3), with warmer

[43] Figure from McGree et al., *Climate Change in the Pacific 2022*, 127. Straight lines indicated linear trends and the diamonds indicate the years with insufficient data for one or more variables.
[44] McGree et al., *Climate Change in the Pacific 2022*, 153.
[45] *Ibid*., 154. The 95% confidence intervals are shown in parentheses and trends significant at the 95% level are shown in bold.

average temperatures occurring in all months throughout the year for both Suva and Nadi Airport, except for average maximum temperatures at Nadi Airport between June and September.

Figure 3. Maximum and minimum air temperatures in Fiji for different periods of time.[46]



Biodiversity

As mentioned earlier, Melanesia is one of the richest biodiverse regions on the planet. Although consisting of just over one percent of the earth's total land area, Melanesia contains a disproportionately high percentage of the planet's terrestrial and marine biodiversity. Numerous studies show that the island of New Guinea (the country of Papua New Guinea and Indonesia's Papua province) and its associated archipelagos as well as the major Melanesian islands (located in the countries of Solomon Islands, Vanuatu, Fiji, and the French Pacific territory of New Caledonia) are major global priorities for conservation.[47]

PNG: Data shows that ocean acidification around PNG has slowly been increasing since the 18th century, impacting the growth of corals and organisms that require carbonate minerals to develop. This damage will impact the health and viability of PNG's marine ecosystems, including the coral reefs that provide ecosystem services to communities. There are 15 coastal provinces in PNG with a population of approximately 4.5 million people who rely on the food, shelter and livelihoods sourced from coral reefs. Not only do the reefs contribute to livelihoods, but they also protect the coastlines from storms and loss of land.[48]

Solomon Islands: Seagrass, mangrove and coral reef ecosystems perform important ecosystem services and support high levels of biodiversity. Ideally, these ecosystems are monitored by recording percentage

[46] Figure from McGree et al., *Climate Change in the Pacific 2022*, 50. Purple represents the air temperatures for Nadi Airport (West) and green represents Suva (East) for the periods of 1961–1990 (dotted lines) and 1991–2020 (full lines).
[47] Stephen J. Leisz, J. Burke Burnett, and Allen Allison, *Consensus Report Climate Change and Biodiversity in Melanesia: What do we know?* available at http://www2.bishopmuseum.org/ccbm/areas/melanesia/papers/consensus_report-what_do_we_know-final.pdf
[48] See note 17, p.22.

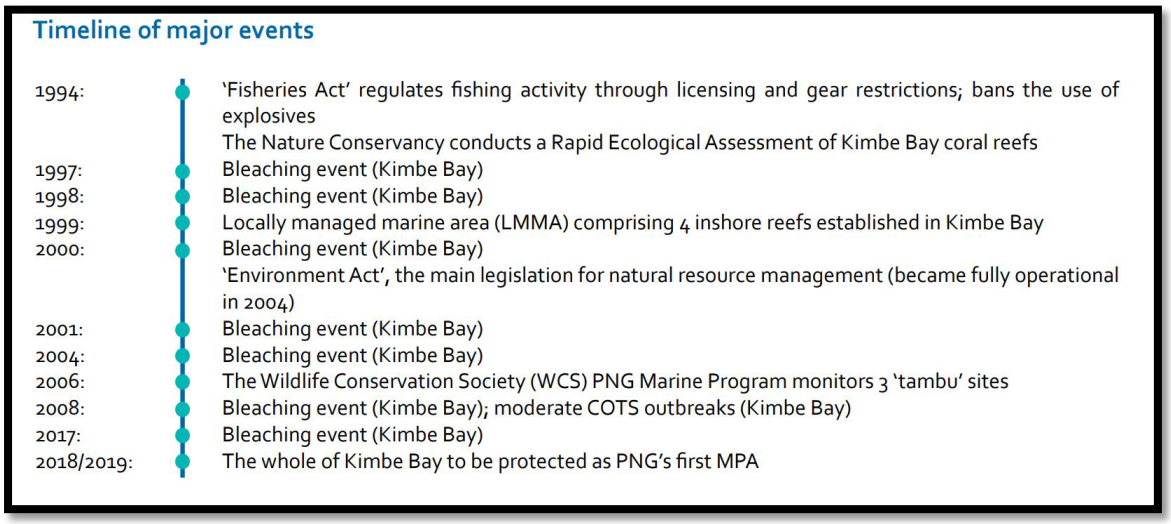
cover over time and a target trend is stable or increasing. These ecosystems (particularly coral reef ecosystems) are vulnerable to changes in sea temperatures.[49]

Coral reef health

Coral reefs are unique ecosystems that also provide habitats for other species (fish, turtle, dugong) as well as having other benefits such as providing protection/resilience against wave action and supporting tourism. Each of these habitats is vulnerable to pollution, loss of water quality and sedimentation from land-based activities. They are also vulnerable to changes in sea temperature and pH, as well as extreme weather events, associated with climate change.[50]

PNG: Most of PNG's reefs are fringing or patch reefs which dominate the northern coast and islands, and barrier reefs, which occur along the south coast. Included within the Coral Triangle of biodiversity, which contains the highest marine biodiversity in the world, these reefs are extremely rich in marine species. For example, there are an estimated 400 species of coral and 860 species of fish on the coral reefs of Kimbe Bay on the island of New Britain. Many local communities in PNG are highly dependent on natural resources for food security, with an estimated 85% of the population reliant on subsistence activities to meet daily needs.[51] As atmospheric CO_2 concentrations continue to rise, oceans will warm and continue to acidify. Under all three emissions scenarios, ocean acidification is projected to increase in the waters surrounding PNG.[52] Figure 4 provides a timeline of major events on PNG coral reefs.

Figure 4. A timeline of major events on PNG coral reefs.[53]



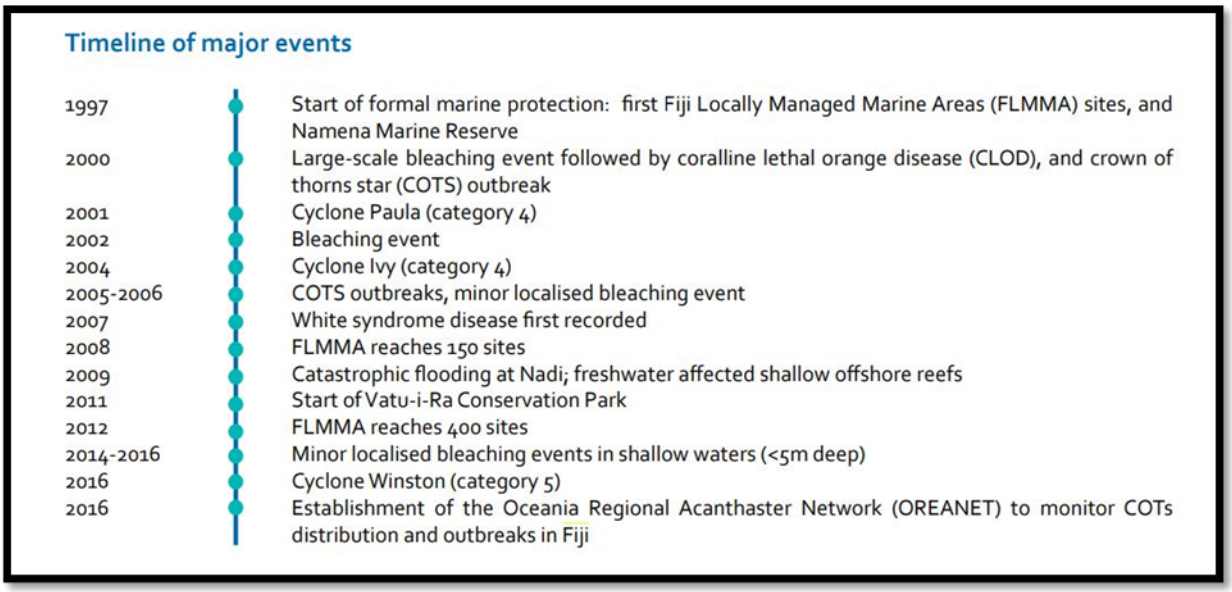
Solomon Islands: Extensive coral reef surveys were conducted in Solomon Islands in 2004 across 113 sites around the major islands and a total of 485 described species belonging to 76 genera were recorded. This is the second highest species diversity in the world, second only to the region of the Raja Ampat

[49] *Solomon Islands State of the Environment Report 2019*, available at https://www.sprep.org/sites/default/files/documents/publications/soe-solomon-islands-2019.pdf, 68.
[50] *Ibid*., 91.
[51] Moritz, Charlotte, Jason Vii, Warren Lee Long, Jerker Tamelander, Aurélie Thomassin, Serge Planes (eds.). (2018) Status and Trends of Coral Reefs of the Pacific. Global Coral Reef Monitoring Network, 212, available at https://gcrmn.net/wp-content/uploads/2022/06/Status-and-Trends-of-Coral-Reefs-of-the-Pacific-2018.pdf, 194.
[52] See note 17, 22.
[53] Moritz et al., Status and Trends of Coral Reefs of the Pacific: Papua New Guinea, 194.

Islands of eastern Indonesia. Seven coral community types were recognised and those found in very sheltered inlets were of particular interest as they had high species richness, usually high living coral cover (32% average live coral cover) and were generally in good health. Overall, reefs and coral communities of the Solomons were in good condition and, with the exception of some localised areas, impacts and reef degradation were low to moderate at most sites. Crown of thorns starfish damage was the most widespread threat and significant at some locations. Damage from the 2000 coral bleaching event was noted at some locations; however, sediment-associated impact was rare.[54]

Fiji: Over half the population is rural with many communities relying on small-scale commercial and subsistence fishing. About 75% of the dietary protein is sourced from the ocean. Tourism is the major source of foreign income, with most tourist activity concentrated on the beaches and reefs of the coast of the main islands and smaller adjacent islands. Reef biodiversity is high, with at least 422 taxa of marine algae, 342 species of hard corals, 253 species of marine molluscs and 1075 recorded reef-associated fish species. Fiji also has mangrove forests and seagrass beds, with eight species of mangrove and six species of seagrass.[55] Figure 5 provides a timeline of major events on Fiji's coral reefs.

Figure 5. A timeline of major events on Fiji's coral reefs.[56]



Health and social impacts, particularly on children, and especially rural youth

Food shortages caused by drought and other climate change impacts affect peoples' health and social well-being. For example, the 2015–2016 drought in PNG, reported an increase in the death rate for some locations. People were reduced to eating unusual foods or famine foods in abnormally large quantities. The drought caused water shortages and forced many women and girls to walk long distances to obtain drinking water, often from sources that they would not normally use. Women reported experiencing increased harassment on the journey to and from water collection points. Women and girls also reported an increased share of the workload as they were involved in collection of water from

[54] Solomon Islands State of the Environment Report, 2019, 69. See also Alison Green, Paul Lokani, William Atu, Peter Ramohia, Peter Thomas and Jeanine Almany (eds.) 2006. *Solomon Islands Marine Assessment: Technical report of survey conducted May 13 to June 17, 2004*. TNC Pacific Island Countries Report No. 1/06.
[55] Moritz et al., Status and Trends of Coral Reefs in the Pacific: Fiji, 132.
[56] *Ibid*., 132.

distant sources as well as being charged with the reestablishment of familial gardens, particularly in rural areas. Other social and health impacts were also reported (e.g., theft, high consumption of alcohol, increased incidences of gut and skin diseases).[57] The impacts of climate change are affecting all aspects of life for Fijians—the environment, economy, social development, as well as cultural practices and traditional ways of life. Fiji is facing loss and degradation of vital ecosystems and natural resources, including its coral reefs, coasts and catchments, on which key sectors of its economy such as agriculture and fisheries are dependent.[58]

IV. CONCLUSION

Climate change is causing significant harm to PICTs, including those in the Melanesian region. This harm materialises in the form of sea-level rise, threats to some of the world's most biodiverse regions, extreme weather events, prolonged drought, and other impacts. Projections indicate that these impacts are bound to intensify. In line with IPCC AR 6, the reduced habitability of small islands from a combination of these factors poses significant risk, even under the global scenario of 1.5°C (*high confidence*), which at its current trajectory, the planet is certain to exceed. Key risks that face the Melanesian region in this regard include increased intensity and intensification rates of tropical cyclones, marine and coastal biodiversity, submergence of reef islands, water security, degradation of health and well-being, economic losses, and non-economic losses related to culture, custom, and traditional knowledge. The extent to which this existential threat materialises will heavily depend on actions taken to curb anthropogenic greenhouse gas emissions—the vast majority of which are generated outside its borders—and the measures to adapt to climate change and respond to the loss and damage it causes.

[57] *See* Papua New Guinea National Disaster Centre, *El Niño 2015/2016 Post Drought Assessment: report of the interagency post drought assessment in Papua New Guinea*, 2016, available at https://reliefweb.int/report/papua-new-guinea/el-ni-o-20152016-post-drought-assessment-report-inter-agency-post-drought.

[58] Fiji's Updated Nationally Determined Contribution 2020, https://unfccc.int/sites/default/files/NDC/2022-06/Republic%20of%20Fiji%27s%20Updated%20NDC%2020201.pdf, 16.