

Case Study on Sea Level Rise

Tuvalu



The Commonwealth



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Case Study on Sea Level Rise

Tuvalu

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Acronyms and Abbreviations

BOM	Bureau of Meteorology (Australia)
CCA	climate change adaptation
DRM	disaster risk management
FAD	fish aggregating device
GCF	Green Climate Fund
GDP	gross domestic product
GEF	Global Environment Facility
IPCC	Intergovernmental Panel on Climate Change
JNAP	Joint National Action Plan
LDC	least developed country
LDCF	Least Developed Countries Fund
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
NSAPCC	National Strategic Action Plan for Climate Change
PACC	Pacific Adaptation to Climate Change
PSIDS	Pacific small island developing states
R2R	ridge to reef
RCP	Representative Concentration Pathway
SIDS	small island developing states
SLR	sea level rise
SPREP	Secretariat of the Pacific Regional Environment Programme
TC	Tropical Cyclone
TCAP	Tuvalu Coastal Adaptation Project
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

About the Commonwealth

The Commonwealth is a voluntary association of 56 independent and equal sovereign states and home to 2.7 billion people. The Commonwealth Secretariat is an independent organisation working with the 56 member countries and assists them together to promote prosperity, democracy and peace, amplify the voice of small states, and protect the environment.

The Commonwealth Secretariat's Climate Change and Oceans Directorate assists its member countries to sustainably manage their natural resources, in the ocean and on land, for the benefit of present and future generations. The Secretariat provides technical assistance and supports member countries in the development of policies, laws, and strengthening national institutions.

Executive Summary

Tuvalu is the world's fourth-smallest nation and a Pacific small island developing state (SIDS) and least developed country (LDC) with a total land area of 26 square kilometres (km²). Its climate change vulnerabilities centre around sea level rise and its compounding effects, with the average height of its atoll and reef islands above sea level being less than 3 metres, and a maximum elevation of 4.6 metres.

This case study provides an overview of the key vulnerabilities and impacts of sea level rise (SLR) and climate change in Tuvalu, examining the country's national adaptation strategies and reviewing the role of two main projects aligned with the National Adaptation Plans of Action: NAPA 1, 'Increasing resilience of coastal areas and community settlement to climate change' (2008–2013), and NAPA 2, 'Effective and responsive island-level governance to secure and diversify climate resilient marine-based coastal livelihoods and enhance climate hazard response capacity' (2013–2019). The Tuvalu Coastal Adaptation Project (TCAP), commenced in 2017 and financed by the Green Climate Fund with a total budget of US\$40.2 million, was completed in 2025. A second phase (TCAP-II), funded at US\$17.5m by Australia, New Zealand and the United States, commenced in 2024 to extend coastal protection on Funafuti.

Climate change adaptation responses in Tuvalu fall within the categories of protection (hard coastal infrastructure), accommodation (climate resilient crops), ecosystem-based adaptation (marine ecosystem protection), advance (land reclamation), and communications infrastructure or disaster risk management. The sea level rise of about 5 millimetres (mm) per year near Tuvalu exceeds the global average of 3.2 ± 0.4 mm per year, making adaptation and mitigation critical.

Each of Tuvalu's NAPA-related projects was ambitious in design, but basic challenges in implementation relating to communication and transportation have hindered progress. This review finds that successful implementation varies with location, and logistics issues associated with the outer islands must remain at the forefront of future planning. Tuvalu's prevailing environmental challenges, compounded by limited human resource and financial capacity, mean continuing reliance on international and regional support. The projected conversion of the TCAP project management unit into a Coastal Management Authority indicates formalising integration of adaptation into national planning and policy design.

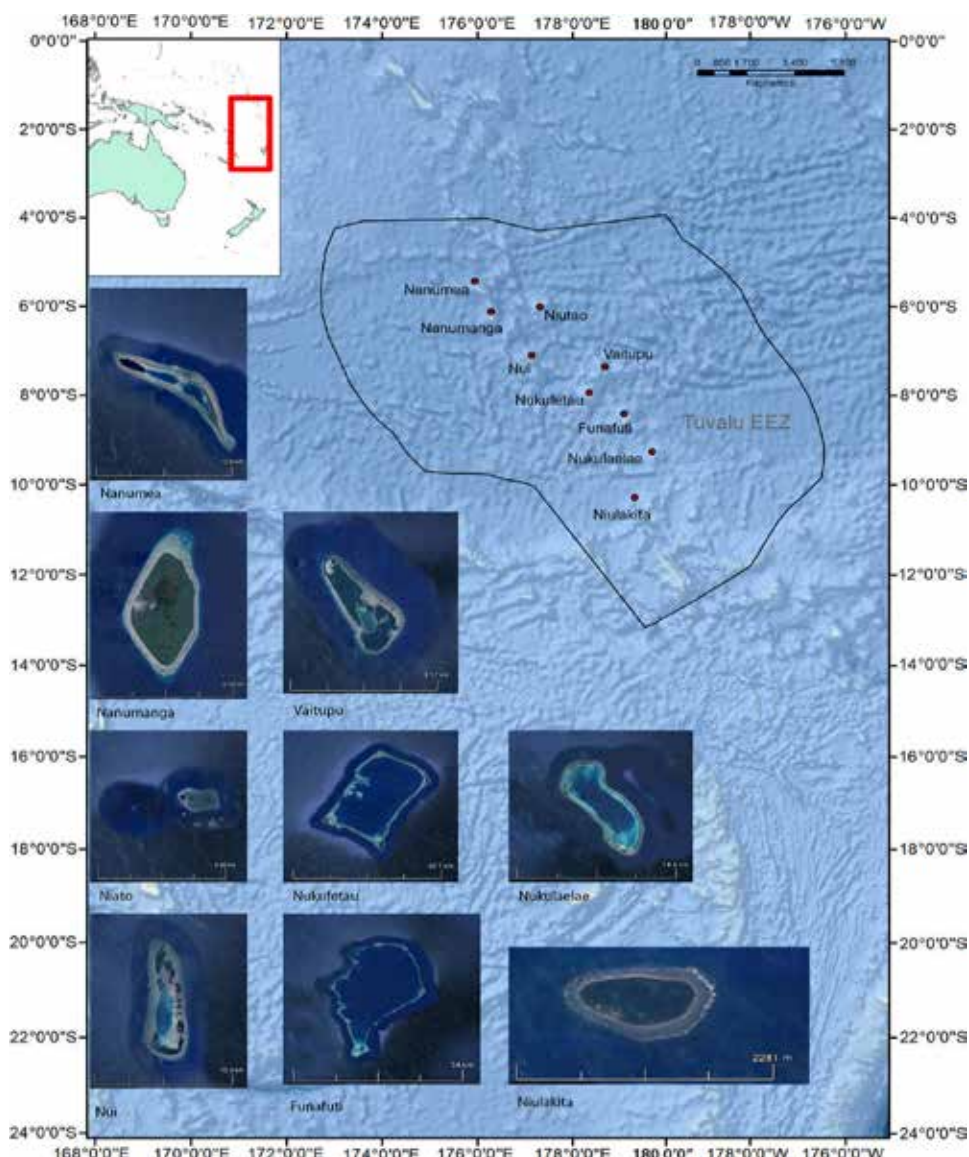
Country Profile

Geography, climate and natural hazard profile

The Polynesian island nation of Tuvalu, located in the west-central Pacific Ocean halfway between Australia and Hawaii, is the world's fourth-smallest nation. Tuvalu covers an oceanic area of approximately 900,000 km² and is made up of a chain of nine small islands covering a total land area of approximately 26km² stretching 1,000 km from north to south.

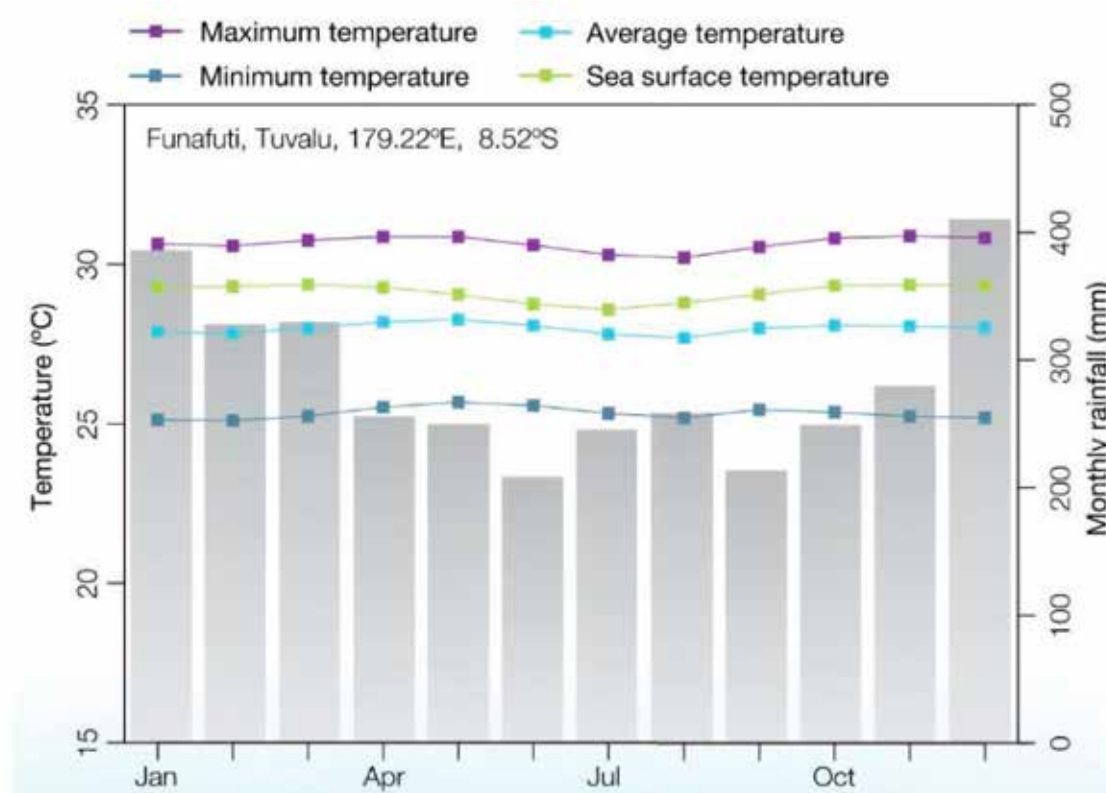
The nine atolls are a mix of three reef islands (Nanumaga, Niutao and Niulakita) and six low-lying atoll islands, known as *motu* (Nanumea, Nui, Vaitupu, Nukufetau, Funafuti and Nukulaelae). Reef islands are low-lying and highly exposed to climate and ocean processes, tending to rise no more than 3m above mean sea level. They are characterised by shorelines that change position faster than those of other island types and are composed of at least 80 per cent unconsolidated sediments

Figure 1. Map of Tuvalu atolls



Source: Ceccarelli 2019

Figure 2. Seasonal rainfall and temperature in Funafuti, Tuvalu



Source: Tuvalu Coastal Adaptation Project (TCAP) based on the Australian Bureau of Meteorology (BOM) and Commonwealth Scientific and Industrial Research Organisation (CSIRO) (2011)

(derived from adjacent offshore/underwater areas) that have accumulated on a shallow flat (shoal) and are commonly biogenic (reefal) in origin.

Each atoll island has numerous small islets surrounding lagoons of various depths, usually with at least one channel connecting the lagoon to the open ocean. These motu islands are composed of skeletal sands and/or coral rubble sourced from the adjacent reef or lagoon and are distinguished by a high seaward shingle ridge facing the ocean and a lower elevation sandy shoreline facing the lagoon (McLean 2011). The Niulakita atoll has the highest elevation at 4.6m above sea level, while Funafuti rises 1.9m above mean sea level (Figure 1).

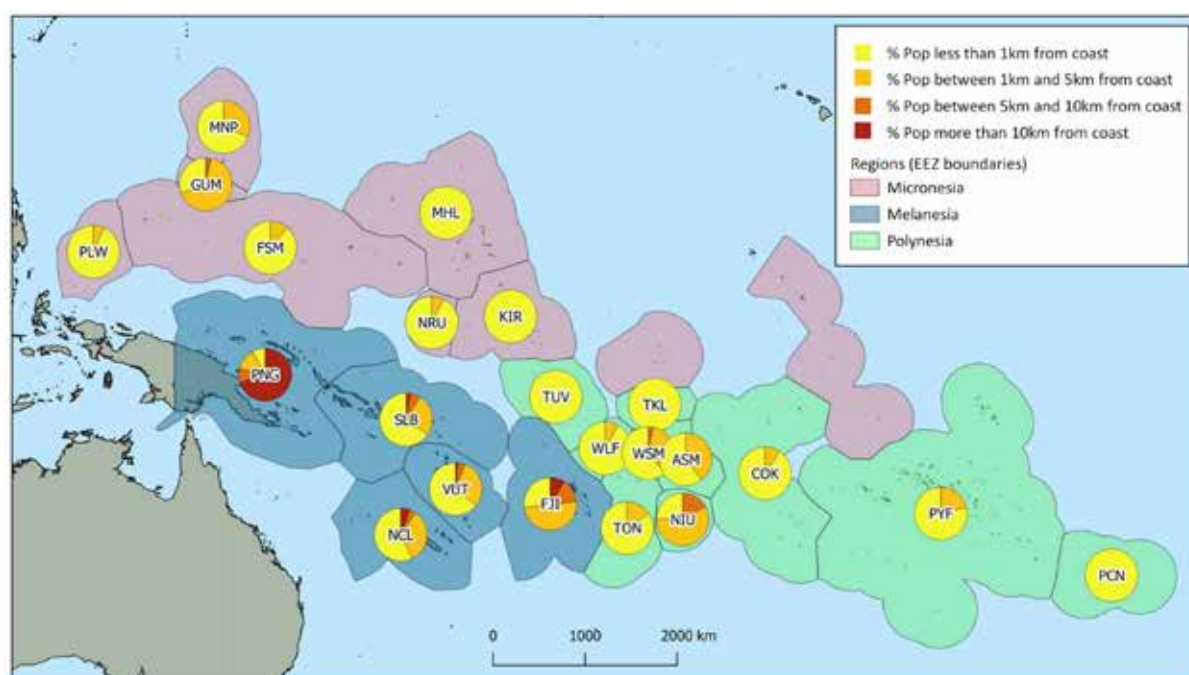
Temperatures in Tuvalu range between 26.0 and 32.0 degrees Celsius (°C). The wet season (October–March) brings tropical cyclones which inflict extensive damage on local infrastructure, agriculture and major food sources. The dry season (June–September) is characterised by an increasing number of droughts which contribute to the depletion of freshwater sources (Figure 2).

Tuvalu is prone to natural disasters. Between 1970 and 2020, 19 tropical storms and 1 drought have affected the small state. The 1972 Tropical Cyclone (TC) Bebe was the worst, striking down 90 per cent of the houses and trees and killing five people. In 1997, three TCs hit Tuvalu just week(s) apart – TCs Gavin, Hina and Keli; they caused severe coastal erosion on all nine atolls, washing about 6.7 per cent of the land into the sea, with total damage estimated at US\$2.23 million. In 2015, TC Pam devastated several islands with economic loss and damage estimated at US\$10.34 million, over a third of the country's gross domestic product (GDP) at the time. More recently, in 2023, the country experienced severe coastal flooding during king tide events, further underscoring its ongoing vulnerability.

Population and demographics

Tuvalu's population was 10,643 persons in 2022 (Pacific Community 2025; Tuvalu Central Statistics Division 2025) and is projected to increase to 19,600 by 2050 (Campbell and Warrick 2014).

Figure 3. Proportions of households within 1, 5 and 10 km from the coast in 22 Pacific island countries and territories. Acronyms are the three digit ISO country codes.



Source: Andrew et al. (2019)

Nearly 50 per cent of the population (about 6,320 people) live in the capital, Funafuti, which has a land area of 2.8km², 1.59km² of which is inhabited. Funafuti, a coral atoll, is approximately 7km long and 400m at its widest point, bordered by a lagoon on one side and open ocean on the other.

Across all the islands, estimates by Andrew et al. (2019) found that the entire population lives within 1 kilometre of the ocean (Figure 3). A study by Taupo and Noy (2016) found that a large proportion of households residing near areas prone to cyclones are low-income families living in informal and weak structured houses.

Economic context

Tuvalu is relatively remote from major markets and as a result, has a comparatively high cost of transportation for trade. The disparity between exports and imports causes reliance on foreign aid and overseas remittances to bridge the gap. Tuvalu has been classified as a least-developed country (LDC) since 1986. By United Nations (UN) definition, LDCs are low-income countries confronting severe structural impediments to sustainable

development. They are highly vulnerable to economic and environmental shocks and have low levels of human assets.

The country has few natural resources and is highly dependent on external aid. Employment opportunities are limited, as the primary economic activities are subsistence farming and fishing on the outer islands, while in Funafuti there is greater participation in the formal economy. The main agricultural sources people depend on include fish, shellfish and other seafoods, coconut, breadfruit, bananas, taro, pandanus, and other crops. Other main locally consumed foods include pork, chicken, seabirds and some wild plants, such as the bird's nest fern (laukatafa).

Governance and institutional structure

The decentralised nature of governance in Tuvalu allows local autonomy in governance and development. Local communities view traditional leaders and mechanisms as the most legitimate and effective institutions for representing interests and meeting their needs (Richardson 2009).

The role of central government is to set legislative parameters, assist local governments with financial and technical support, and link local planning and budgeting with national development priorities.

Local councils and administrators (*kapules* and *falekaupules*) can direct requests for specific development projects to national ministries and Members of Parliament. Approval of development projects by local leaders is also necessary for community ownership.

Sea Level Rise in Tuvalu

Local sea level rise observations (tide gauge data, satellite altimetry)

Historical records from the Australian Bureau of Meteorology recorded the mean sea level as 2.3m. The highest recorded water level of 3.44m was recorded on 28 February 2006, while the lowest recorded water level of 0.53m was recorded on 27 February 1998, covering the period March 1993 to July 2021 (Figure 4).

The sea level rise of about 5mm per year near Tuvalu is greater than the global average of 3.2 ± 0.4 mm per year and makes actions of adaptability and mitigation critical to maintain its physical presence.

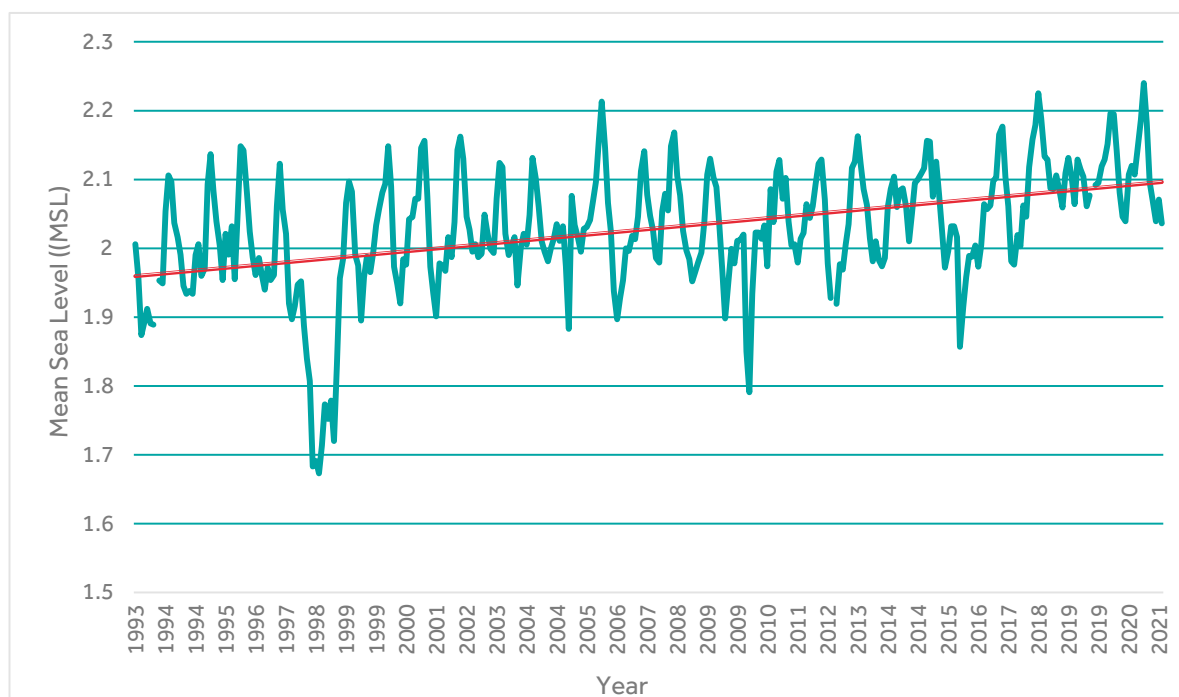
Projected local sea level rise

By 2030, under a high emissions scenario, the rise in sea level for Tuvalu is projected to be in the range 4–14cm; by 2090, under a high emissions scenario, the rise is expected to be in the range of 19–58cm (National Strategic Action Plan for Climate Change (NSAPCC), Government of

Tuvalu 2012). While the Intergovernmental Panel on Climate Change (IPCC) has not published SLR projections at a country level, projections from the Pacific Climate Change Science Program (PCCSP), which considers regional climate features including the South Pacific Convergence Zone (SPCZ), indicate a range of approximately 0–20 cm in the near term and 16–120 cm in the longer term. These projections suggest that the NSAPCC figures may be underestimates (Figure 5).

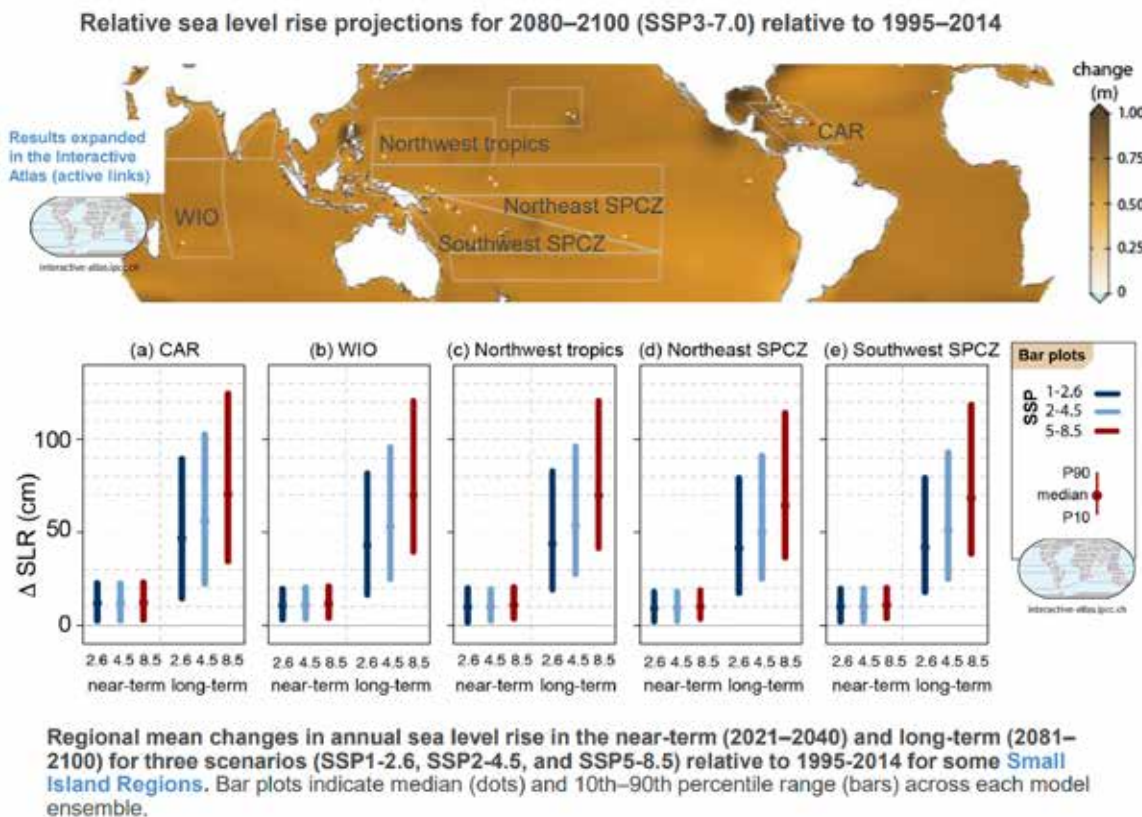
The IPCC (2021) states with high confidence that global mean sea level (GMSL) is rising and accelerating at a considerably higher pace than in previous periods. The latest advice from the IPCC report (2021) on sea level rise (1995–2014 baseline) projections for its best case scenario is a 0.28m increase by 2100 with very low emissions for Representative Concentration Pathways (RCP) 1, if carbon dioxide (CO₂) emissions are at net zero by 2050. At worst, SLR is at 1.01m for RCP8.5 if emissions have doubled by 2050 (Figure 6).

Figure 4. Mean sea level with linear trend line between March 1993 to July 2021



Source: Australian Bureau of Meteorology (BOM)

Figure 5. Relative sea level rise projections for 2080–2100 (SSP3–7.0) relative to 1995–2014



Note: SSP – shared socioeconomic pathway; SPCZ – South Pacific Convergence Zone; CAR – Caribbean; WIO – Western Indian Ocean.

Source: IPCC Sixth Assessment Report (AR6) 2021

It is projected that two-thirds of the global coastline will experience a ± 20 per cent of global mean increase by 2100. And over the next 2000 years, global mean sea level will rise by 2–3m if warming is limited to 1.5°C; 2–6m if limited to 2°C; and 19–22m with 5°C of warming.

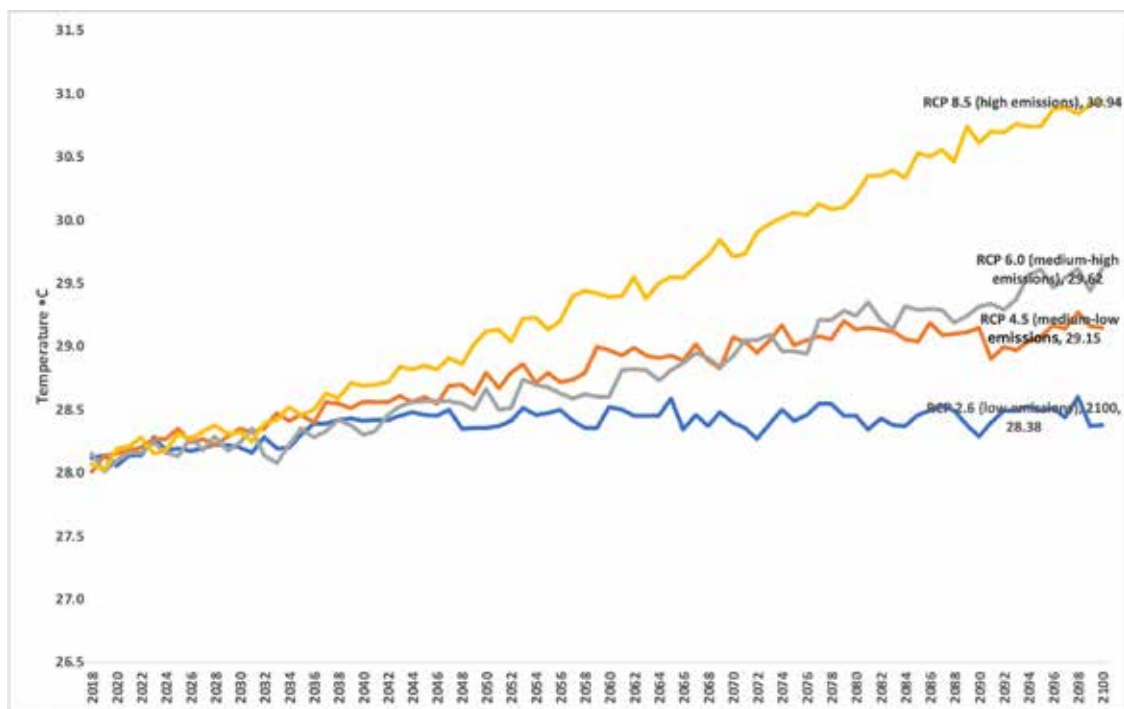
Even under low emissions scenarios, atoll nations will face high to very high risks (OPOC 2021). In Tuvalu, across all the islands, estimates by Andrew et al. (2019) found that the entire population lives within 1km of the ocean.

Contributing factors (subsidence, coastal erosion, land-use change)

Human actions can fragment wetland habitats and restrict landward migration, causing coastal ecosystems to progressively lose their ability to adapt to climate-induced changes and act as

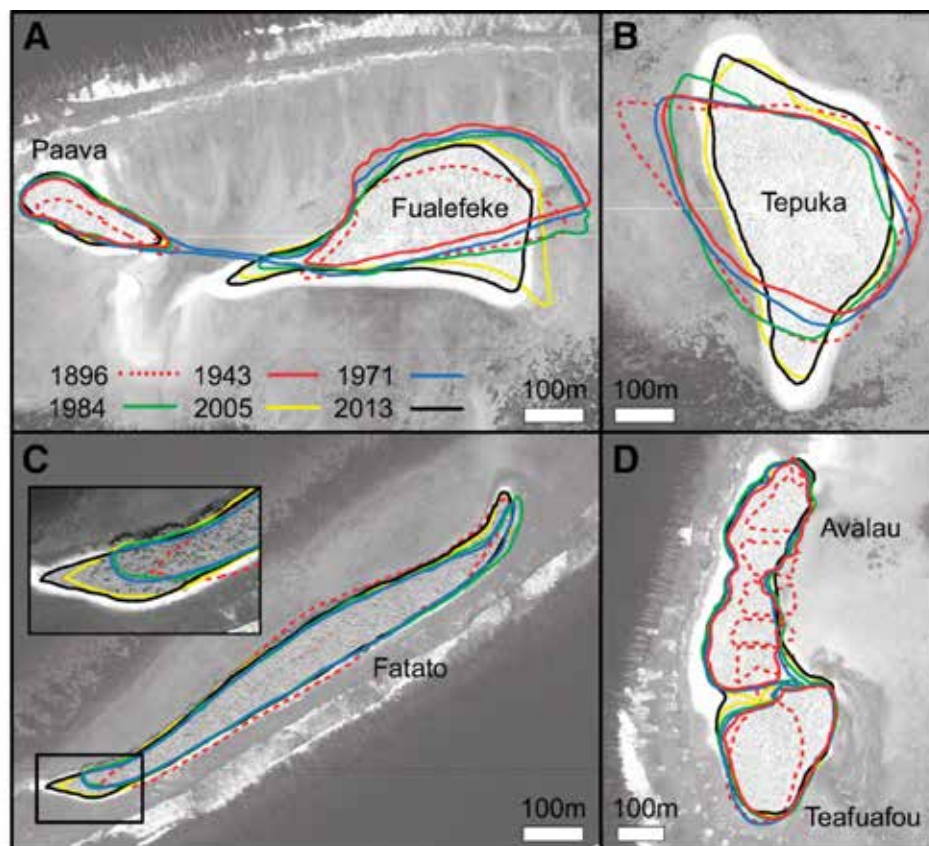
protective barriers. Vulnerabilities have resulted from urban development, which includes land reclamation and land clearance. As far back as the 1940s, there is evidence of United States (US) forces dredging shipping channels to enable access to Funafuti, Nukufetau and Nanumea during World War II. The extraction of large volumes of sand on Fongafale to reclaim land for the airstrip has left borrow pits scattered across the islet (Government of Tuvalu 2015a). In addition, the islands face challenges of sand mining. Although mining of sand from beaches is not permitted, a lack of proper enforcement has led to unmanaged mining (Ralston et al. 2004). There has also been the extraction of aggregates such as beach sand and reef coral, and blasting of reef passages for boat channels, which have contributed to coastal instability and beach erosion.

Figure 6. Temperature projections based on RCP scenarios



Source: <https://climateknowledgeportal.worldbank.org/download-data>

Figure 7. Changes in selected reef islands



Note: Changes in planform characteristics of selected reef islands in Funafuti Atoll, 1896–2013, showing different styles of island adjustment. A: Expansion of Paava and rotation of Fualefeke; B: Rotation of Tepuka.

The slow onset of sea level rise makes the islands highly susceptible to atoll inundation. Tuvalu's atolls and low-lying coral islands have been subject to constant change through continuing growth of living corals, erosion and accretion of wave action (Sauni 2021). Sea level changes are not spatially uniform, and topographical analysis demonstrates that wave currents, changes in weather, sea level and decadal variations change the size, shape and position of these islands, leading to accretion and secretion of land (Kench et al. 2015; Figure 7).

Tuvalu's second communication to the UN Framework Convention on Climate Change (UNFCCC) (Government of Tuvalu 2015a) noted that approximately 82 km of inhabited coastline had undergone rapid changes due to a combination of climate change and anthropogenic modification.

Impacts and Vulnerabilities

Coastal communities and human settlement

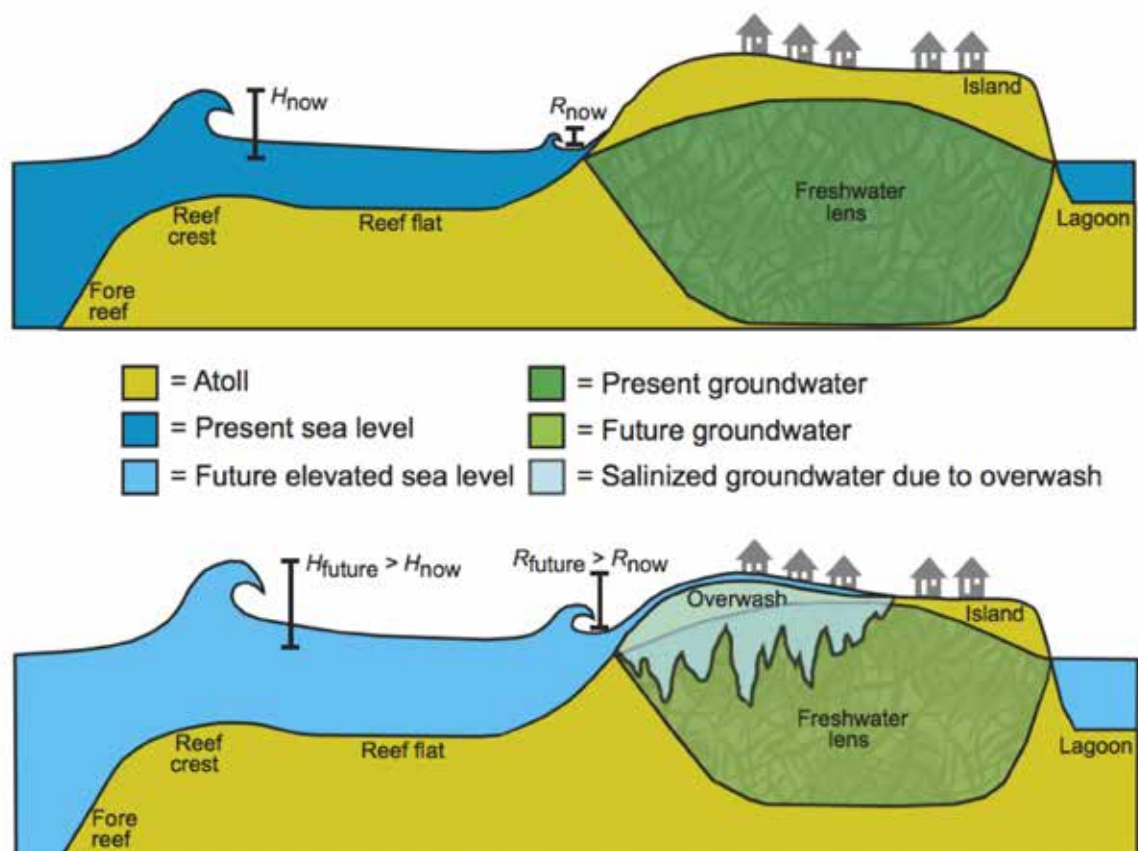
The main human vulnerabilities and livelihood impacts from sea level rise include reduced agriculture and fishery productivity, contributing to food security issues and further exacerbating human health and food security issues. Loss or degradation of land, as well as infrastructure damage from natural disasters and climate change, can also lead to the displacement of people and see human settlements destroyed.

With the islands of Tuvalu being only a few metres above sea level, a slight increase in sea level will have serious consequences for human health, food and water security, housing, infrastructure, land, and marine biodiversity. Due to its small geographical

size, insularity and remoteness, the concentration of economic activities and settlements along low-lying coastal areas, the narrow width of islands, the narrow natural resource base, and its heavy reliance on agriculture, small changes have a greater economic and social impact on Tuvalu than in many other countries.

These are exacerbated by high tides and storm surges. Changes already observed within Tuvalu include saltwater intrusions (Figure 8), collapsed seawalls, increases in salt-tolerant tree species and less productive land.

Figure 8. Conceptual diagram of land impact from SLR



Note: Conceptual diagram of the influence of sea level rise on wave heights, wave-driven run-up and flooding, and the resulting impact on atoll island groundwater – for current (top) and future (bottom) sea levels. H = wave length; R = wave-driven run-up.

Source: Storlazzi et al. 2018

Agriculture and food security

Seawater inundation on the islands causes saltwater contamination of the island vegetation. As sea level rises, it will affect the nation's ability to produce crops as the limited freshwater supplies will be displaced by seawater. Many trees, including coconut trees, that are important for food and livestock feed can be killed through saltwater contamination. Seawater inundation also fills the pits dug in the ground to grow swamp taro (known as *pulaka* in Tuvalu), a tuberous plant that is a major staple of Tuvaluans and is sensitive to seawater contamination. An increase in cyclones and storm surges as a result of climate change is also likely to severely limit the growing capability of this principal crop.

Agricultural impacts also affect food security as the diet of Tuvaluans is primarily marine based with a limited number of land-based food crops. The combination of natural events such as flooding and associated pressures on waste management and potable water sources means that pressing priorities can overtake longer-term planning.

The main source of freshwater in Tuvalu is rainwater. Groundwater resources are no longer suitable for human consumption due to pollution from saltwater intrusion caused by rising sea levels. Salinity intrusion enhanced by the porosity of soil in Tuvalu has also destroyed *pulaka* crops and decreased the yields of various other fruit trees.

Fisheries and marine resources

The coral reefs of Tuvalu cover 710km². A study by McLachlan et al. (2020) highlights that many coral species are highly vulnerable to heat stress. Scientists suggest that a 1°C increase in average water temperature will cause coral reefs to bleach and die. Although Tuvalu is currently only experiencing a small amount of coral bleaching, this is expected to rise as climate change challenges the world.

The Intergovernmental Panel on Climate Change (IPCC) predicts that in the next 30 to 50 years, coral bleaching events will occur every year. With coral dying, Tuvalu will lose part of its economic livelihood and protein sources as fish stocks will also dry up. It is also worth noting that hazardous weather events, such as storms and inundation, can disrupt food

supplies and contribute to increases in food prices, creating additional pressures on food security and household livelihoods.

Increased levels of carbon dioxide (CO₂) in the atmosphere are also causing more CO₂ to be dissolved in the ocean, causing acidification. Acidic seawater causes coral reefs to weaken and become more vulnerable to severe weather events, increases vulnerability to coral bleaching and weakens the shells of various shellfish, threatening their survival.

Rising sea temperatures are also contributing to coral bleaching and decreasing marine productivity. The marine ecosystem is a vital component of Tuvalu's economy, which is dependent on revenue provided by tuna fishing.

Coastal ecosystems (mangroves, coral reefs, wetlands)

Natural disasters, rising sea levels and climate change have led to vulnerabilities of natural coastal and marine ecosystems (for example, mangroves, non-mangroves, coral reefs). These ecosystems provide important services that include both coastal protection and habitat for diverse biota, as well as provide a vital component of Tuvalu's economy.

Drought, coral bleaching, ocean acidification and saltwater intrusion will affect food sources. Water resource scarcity becomes a risk with the dependence on groundwater and rainwater.

Infrastructure and critical services

During the king tides of 2013, substantial damage to government buildings, the airport and utility infrastructure occurred. In 2015, TC Pam devastated several islands, damaging houses, infrastructure, food gardens, graves and coastlines. In addition to the infrastructure damage, several islets in Funafuti permanently disappeared as a result of TC Pam.

Rising sea levels combined with extreme weather events are contributing to the inundation of low-lying areas. Coastal erosion is a major problem in Tuvalu, particularly on the western side of the islands. As most Tuvaluans live within coastal areas, additional stress is being placed on the already vulnerable marine ecosystem.

Economic costs and risks

In 1997, TCs Gavin and Hina caused a severe amount of coastal erosion on all the country's nine atolls, washing about 6.7 per cent of the land into the sea. Total damage from both cyclones was estimated at US\$2.23 million. Together with TC Keli, the three cyclones were responsible for about 50 hectares (120 acres) of land disappearing into the sea (Barkham 2013), with the Tepukasavilivili islet disappearing completely (Government of Tuvalu 2007).

It has been estimated that TC Pam inflicted economic losses and damage of approximately US\$10.34 million, equivalent to approximately 26.9 per cent of Tuvalu's GDP at the time (Government of Tuvalu, 2015a).

Policy and Governance Framework

National policies and strategies (NAPs, NAPAs, NDCs)

From a policy and governance perspective, Tuvalu has several key strategies/policies in place to deal with climate risks to coastal zones, which include measures to address sea level rise. These include national communications to the UNFCCC, National Adaptation Programmes of Action (NAPAs), a Climate Change Policy and a National Strategy for Sustainable Development. For the most part, these are interlinked and integrated into economic and environmental policies.

Tuvalu's Initial National Communication (NC1) in 1999 identified its needs and vulnerabilities, with its main priorities for adaptation being noted as human health, agriculture and water quality. Between NC1 and the creation of its first NAPA in 2007 (Government of Tuvalu 2007), Tuvalu embarked on a series of policy and strategy engagements to reduce vulnerability, achieve development priorities and address adaptation measures in response to multiple hazards. In its adaptation planning, the country reworked its national priorities to being coastal resilience, agriculture and water.

Tuvalu's National Strategy for Sustainable Development 2005–2015 (Te Kakeega II) established national climate change policy addressing both mitigation and adaptation as a goal, which set the stage for development of a National Adaptation Programme of Action (NAPA). Released in 2007 and formally endorsed by the Government of Tuvalu, the NAPA provided detailed information about the current and possible future impacts of climate change (ibid.).

Tuvalu's National Climate Change Policy created in 2012 by the Government of Tuvalu, United Nations Development Programme (UNDP), and the Secretariat of the Pacific Regional Environment Programme (SPREP), under the Pacific Adaptation to Climate Change (PACC) project. It spanned the period 2012 to 2021 and has since been succeeded by the broader policy framework under Te Kete (2021–2030) (Government of Tuvalu 2021).

Overall, where the Climate Change Policy sets the country's adaptation direction over the period 2012–2021, it is reaffirmed by priority areas and strategic actions set out in the National Strategies for Sustainable Development, the latest of which is Te Kete for the 2021–2030 period (ibid.). Te Kete carries on the policies from its predecessors, focusing on the key priority areas relating to long-term planning for SLR and climate, disaster risk management and building resilience. In September 2023, Tuvalu enacted constitutional amendments that formally declared the nation's statehood to be perpetual, notwithstanding any physical territorial loss due to climate change, and fixed its maritime zone baselines regardless of sea level rise. In November 2023, the Australia–Tuvalu Falepili Union Treaty was signed, providing a climate mobility pathway and formal recognition of Tuvalu's continuing sovereignty.

Two main projects were aligned with the National Adaptation Plans of Action (NAPAs): 'Increasing resilience of coastal areas and community settlement to climate change' (the NAPA 1 project implemented from 2008 to 2013) and 'Effective and responsive island-level governance to secure and diversify climate resilient marine-based coastal livelihoods and enhance climate hazard response capacity' (the NAPA 2 project implemented between 2013 and 2019).

Legal and institutional framework

Tuvalu is subject to international requirements and obligations as listed under the UN Convention on the Law of the Sea (UNCLOS; ratified in 2002). In terms of climate change, it ratified the UNFCCC in 1993, signed and ratified the Kyoto Protocol (as a non-Annex I country) in 1998, and ratified the Paris Agreement in 2016. Regarding biodiversity, it has ratified the Conservation of Biological Diversity (Aichi Targets) and the 2030 Agenda for Sustainable Development. In terms of waste and pollution, it adopted the International Convention for the Prevention of Pollution from Ships (MARPOL)

1973/1978; and accessioned the Basel Convention, the Vienna Convention for the protection of the ozone layer and the Stockholm Convention.

Key national legislation includes the National Development Management Act (2007), which defines disaster management structures; the Environmental Protection Act (2008), providing an overarching legislative framework for environmental protection and sustainable development; the Ozone Layer Protection Act (2008 Revised Edition); the Climate Change and Disaster Survival Fund Act (2015), which provides financial assistance to Tuvaluan citizens to adapt, recover or rehabilitate from the devastating impacts of climate change and natural disasters; and waste management regulations, including the Waste Management (Prohibition on the Importation of Single-Use Plastic) Regulation 2019.

the eight island communities on Funafuti, and seven counterparts in the outer islands. In all, more than 300 people were consulted, including more than 100 island leaders who were invited to the TKIII National Summit.

Sub-national and local governance

Pacific Island countries have taken steps through international obligations to develop and implement integrated action plans, or Joint National Action Plans (JNAPs), for climate change and disaster risk management (DRM). JNAPs are designed to support sustainable development and resilience outcomes through the national legislative and policy systems for climate change and DRM, including development of risk management plans and priorities, financial management, organisational arrangements, stakeholder-based decision-making processes, and the underlying enabling environment of knowledge, capacity and legislative frameworks.

Key factors observed behind efficient JNAP development and joint ownership include the presence of champions with interest and commitment to climate change, DRM and integration. Tuvalu has established 'formal' JNAP development governance arrangements, with a clearly identified lead agency, and supported by a committed inter-agency task force/or expert group (SPREP 2013).

Activities for outcome documents are derived from consultations with stakeholders, ministries and government departments. Staff from the Department of Planning and Budget, representatives from the Tuvalu Association of Non-Governmental Organisations (TANGO) and from the Ekalesia Kelisiano Tuvalu (EKT) met with

Adaptation Measures

Coastal protection (hard infrastructure)

NAPA 1, 'Increasing Resilience of Coastal Areas and Community Settlements to Climate' (2008–2013), was created to implement the country's most urgent and immediate adaptation needs identified among the first three priority strategies in its NAPA. The programme received US\$3.37 million in funding from the Least Developed Countries Fund (LDCF), with total project costs of US\$6.51 million, including approximately US\$3.14 million in co-financing. It was implemented by the Government of Tuvalu with support from the UNDP, the LDCF and the Global Environment Facility (GEF).

The Tuvalu Coastal Adaptation Project (TCAP - I) started in 2017 and was completed in 2025. A second phase (TCAP-II), funded with US\$17.5 million by the Governments of Australia, New Zealand and the United States, commenced construction in September 2024, with a scheduled completion by mid-2026. TCAP-I was financed by the Green Climate Fund (GCF), with total project financing of US\$38.9 million, comprising US\$36.0 million in GCF funding and US\$2.9 million in co-financing from the Government of Tuvalu. The project built coastal resilience in three of Tuvalu's nine inhabited islands, implementing measures for 2,780m of high-value vulnerable coastline. TCAP-II focuses on the southern lagoon shoreline of Fogafale Island, protecting 800m of vulnerable shoreline and reclaiming approximately 8 hectares of new raised land. Investments build upon existing initiatives, using a range of measures for coastal protection including eco-system initiatives, beach nourishment, concrete and rock revetments, and sea walls.

A Geotextile Synthetic Container seawall on Nukufetau was completed in 2017. On Funafuti, there has been reclamation and building of a sea wall. On Nanumea and Nanumaga, defences have been constructed using softer berm top barriers.

Ecosystem-based adaptation

Specific demonstration projects directly relevant to sea level rise included local communities on five atolls involved in mangroves being planted and trained in mangrove maintenance, and protection of plantations of *pulaka* from saline groundwater inundation.

NAPA 2 included community-based information collection and analysis, including GIS (Geographic Information System) mapping, collection of information about existing by-laws and local agreements, and ongoing management practices. The current ridge to reef (R2R) project includes a focus on marine ecosystems and ecosystem services, including engaging communities in monitoring methods and defining indicators for biodiversity; biodiversity monitoring training; conducting biodiversity baseline surveys in the nine islands; including endemic coastal vegetation and submerged marine ecosystems (seagrass/coral); and coral replanting activities.

Results from the first NAPA project included at least 12 plantations of *pulaka*, breadfruit and banana cultivation being protected from saline groundwater in at least three atolls (Nanumea, Nui and Nanumaga).

Accommodation and resilience building

NAPA 2 'Effective and Responsive Island-level Governance to Secure and Diversify Climate Resilient Marine-based Coastal Livelihoods and Enhance Climate Hazard Response Capacity' (2013–2019) aimed to increase the resilience of Tuvalu's outer island communities to future climate change-induced risks, such as declining marine resources and productivity and intensifying climatic hazards. The project was implemented by the Government of Tuvalu, UNDP and GEF, and received US\$4.2 million in funding, with US\$19.8 million in co-financing.

NAPA 2 included deploying three fish aggregating devices (FADs) in Funafuti (benefitting around 61 per cent of Funafuti households); demonstrations of traditional fishing methods and

post-harvest fish processing methods (benefitting around 38 per cent of Funafuti households); demonstrations of post-harvest fish processing methods (targeting women, youth and people with disabilities); and Secretariat of the Pacific Community (SPC)-led training in the rig and deployment of FADs.

NAPA 2 also focused on communication infrastructure. Successes included multiple communication lines for 100 per cent of the Tuvaluan population, technical training sessions/ refresher sessions for installation, use and maintenance of the communication equipment, and the development of videos on the deployment of the early warning system in Tuvalu. Existing materials on disaster preparedness were translated into Tuvaluan language. Awareness-raising materials were also produced and mock drill exercises were organised.

Planned relocation and retreat

Tuvalu's response to sea level rise is distinctive in that conventional planned retreat – the managed abandonment of land and inland relocation of communities – is not a feature of its current adaptation projects, which instead emphasise keeping the population in place wherever possible. With a total land area of only around 26km² spread across nine low-lying atolls that barely rise above sea level, the country has very limited higher ground to which residents could retreat internally. Tuvalu has therefore framed its strategy around 'advance' – raising and reclaiming land – together with legal and mobility measures that address national survival, rather than relocation away from the islands.

The principal physical response has been land reclamation and the creation of elevated, habitable land. Under the Tuvalu Coastal Adaptation Project, Phase II (TCAP-II) is reclaiming approximately 8 hectares of new raised land on the southern lagoon shoreline of Fogafale, intended to remain above projected sea levels and to accommodate settlement and critical functions as the surrounding environment changes. This 'advance' approach – building up land rather than withdrawing from it – has become the centrepiece of Tuvalu's adaptation model. The recommendations of this study call for reclamation and raised-land investments to be extended beyond the most populated areas to all islands, prioritised by site-specific vulnerability assessments.

Alongside these physical measures, Tuvalu has put in place legal and diplomatic instruments that address the longer-term, existential dimension of sea level rise. In September 2023, constitutional amendments declared the nation's statehood to be perpetual notwithstanding any physical loss of territory, and fixed its maritime zone baselines regardless of future sea level rise (Government of Tuvalu 2023). In November 2023, the Australia–Tuvalu Falepili Union Treaty established a voluntary climate-mobility pathway for Tuvaluans alongside formal recognition of Tuvalu's continuing sovereignty (DFAT 2024). Taken together, these instruments reframe what might elsewhere be described as 'retreat' as a managed and voluntary option that preserves national identity, sovereignty and choice, rather than as forced displacement.

The risk of displacement nonetheless remains real, as the loss or degradation of land and damage to infrastructure from climate-related hazards can force people from their homes and settlements. Planned relocation in the conventional sense continues to be the subject of wider Pacific small island developing states (PSIDS) policy work rather than a discrete national programme (Campbell and Warrick 2014). Tuvalu's experience illustrates the value of combining in-place adaptation, anticipatory legal measures and pre-arranged, dignified migration options well before any movement of people becomes unavoidable.

Climate finance and funding mechanisms

Tuvalu relies heavily on donor funding and most of its climate change adaptation projects have largely been supported by UNDP, GEF-LDCF and the Green Climate Fund (GCF), alongside donor agencies such as the Australian Agency for International Development (AusAID). One significant challenge highlighted in the projects is that the maintenance and sustainability will be an ongoing challenge for Tuvalu, as it relies on a small pool of funding sources tied to its status as an LDC.

As a small economy, Tuvalu relies heavily on international financial and capacity support to implement climate adaptation projects. The LDCF, which supports climate adaptation in countries classified as least developed countries (LDCs), has been an important source of funding. However, access to LDCF resources is linked to LDC status, which is determined using UN development criteria

relating to income, human assets and economic and environmental vulnerability. Countries that meet the graduation thresholds may eventually lose access to LDC-specific support. This was a particular concern for Tuvalu, which was identified as eligible for graduation in 2012, despite its extreme vulnerability to external shocks, including natural disasters.

TCAP is financed by the GCF, with total project financing of US\$38.9 million, comprising US\$36.0 million in GCF funding and US\$2.9 million in government co-financing. Annual funding allocations under the GCF are contingent on a 70 per cent completion rate of specified annual targets. The UNDP is managing the fund and projects, with GCF funds disbursed directly to suppliers engaged in the project through an international bidding process.

Recent initiatives have included a 2019 joint UNDP–UN Environment National Adaptation Plan Global Support Programme (NAP-GSP) to appraise climate change adaptation options and access climate finance. In conjunction with the NAPA 1 project, AusAID provided A\$1.07 million in funding targeting health and freshwater.

Assessment of Adaptation Effectiveness

Comprehensiveness and inclusiveness

Tuvalu's climate change adaptation responses fall within the categories of protection (hard coastal infrastructure in the form of sea defences), accommodation (introduction of climate-resilient drought and salt-resistant crops), ecosystem-based adaptation (protection of marine ecosystems, including fisheries and coral reef rehabilitation), advance (land reclamation), and communications infrastructure or disaster risk management.

The seven identified adaptation strategies in the NAPA form the basis of the main climate change adaptation projects implemented in country, addressing coastal areas, agriculture, freshwater, human health, fisheries, disaster risk reduction and marine ecosystems.

Tuvalu has placed considerable emphasis on addressing climate change vulnerabilities and implementing measures that enhance adaptive capacities in coastal protection, water resources, biodiversity, agriculture, energy, waste management and human health. However, constraints exist in the areas of technology transfer, climate change research, education, training and public awareness, capacity building, and data availability and gaps.

Implementability and integration

Consolidating implementation measures is not an easy task. Tuvalu's broad socio-economic and environmental dependence on ocean sustainability means that project outcomes must be aligned with wider environmental and ocean governance frameworks and progressively mainstreamed across other strategies to facilitate real change.

Generally, each of Tuvalu's National Adaptation Plans of Action (NAPA)-related projects was ambitious in nature and design; however, basic challenges in implementation relating to communication and transportation hindered progress and targets. Given that a clear signal

from the NAPA projects is that successful implementation varies with location, logistics issues associated with the outer islands must remain at the forefront of future planning, requiring the considerable expense associated with these missions to be fully costed within project finances and specifications.

The Terminal Evaluation for the NAPA 1 project (Jeffries 2016) concluded that the outcomes were mainly unsuccessful, highlighting significant challenges including a lack of sufficient capacity, lack of transparency around budget allocations and availability, and operational issues working in the outer islands.

The Terminal Evaluation of NAPA 2 (Bellamy 2019) found that the project had performed better than its predecessor, with project targets largely achieved. It concluded that the project had left island communities in Tuvalu better equipped to build resilience to climate variability and associated risks.

With the first phase of TCAP complete and TCAP-II underway, implementation has become considerably more agile than previous projects, and there is clear national will to apply lessons learned. The conversion of the TCAP project management unit into a Coastal Management Authority formalises the integration of adaptation into national planning.

Monitoring and evaluation

The monitoring, evaluation and learning (MEL) indicators used in reviewing the two projects included effectiveness, ownership, sustainability and relevance; in other words, whether the project continued to evolve in a positive way, if the situation changed further after the project was completed, and whether it brought any relevant transformations in support of self-sufficiency post-project.

Stronger institutional links forged between the project steering committee and relevant national meteorological services processes and other

regional and international climate information and modelling processes are accomplishments of the NAPA projects. Similarly, the review and updating of existing climate change scenarios and vulnerability assessments in coastal areas may have increased through improved ability of technical/sectoral planners to anticipate climate risks and plan for them.

While many of the benefits of the NAPA projects were challenging to untangle from those resulting from other projects or policies, at the end of the projects at least 1,000 households in Tuvalu were able to anticipate climate change-related risks and select the most effective risk reduction options.

Lessons Learned and Exemplars of Good Practice

This review of Tuvalu's SLR and climate change adaptation policies and projects highlighted several strengths and lessons for future projects. Ultimately, to facilitate real change, socio-economic and environmental dependence on the sustainability of the ocean means outcomes from these projects must be aligned with the country's wider environmental and ocean governance frameworks and progressively mainstreamed across other strategies.

The importance of local buy-in from local councils can be strongly identified with the need to link personal agency with *kaupule* and island and government action to fully understand vulnerability and provide effective adaptive efforts.

Policies and programmes must incorporate climate change adaptation (CCA), disaster risk reduction (DRR) and loss and damage (L&D). Streamlining adaptation and L&D policies is essential to protect the social and economic well-being and welfare of citizens and the economy. In Tuvalu, this has been addressed through the NAPAs and the National Strategic Action Plan for Climate Change and Disaster Risk Management (2012–2016).

Tuvalu remains dependent on donor aid for almost all its coastal adaptation, climate change and disaster risk-related projects. This leaves progress vulnerable to donor aid funding proclivities, as well as to ongoing government resource turnover. Maintenance and sustainability will be an ongoing challenge for Tuvalu, as it relies on a small pool of funding sources tied to its LDC status.

Generally, each of the NAPA-related projects was ambitious in nature and design; however, in implementation, basic challenges with communication and transportation have hindered progress and targets. One of the main differences between the NAPA 1 and NAPA 2 projects was the ability to consistently get expertise and equipment to the outer islands due to acquisition of a boat for NAPA 2.

Tuvalu's leadership has consistently prioritised climate change adaptation, with successive Prime Ministers highlighting the impacts of SLR on economic, environmental and social livelihoods. National policies and strategies have increasingly adopted more integrated approaches, mainstreaming climate adaptation into broader development priorities.

Responsibility for delivering policy outcomes from projects should be clearly documented, and a process for completing any outcomes left unfinished at the end of a project should be part of project planning. Best practices, methodologies and lessons learned from all projects should be made easily available and recommended for use.

Recommendations

Based on this review of Tuvalu's SLR and climate change adaptation policies and projects, the following recommendations are put forward.

- Future adaptation projects should build on the TCAP model of directly addressing sea level rise through hard infrastructure and land reclamation. This approach, first demonstrated at scale through TCAP, should be continued and expanded, building on the momentum of TCAP-II.
- Logistics and transportation challenges associated with the outer islands must be addressed as a core component of project design. Outer island mission costs must be fully budgeted within project finances, and the acquisition of a dedicated vessel, as with NAPA 2, should be replicated.
- Strategies to diversify Tuvalu's funding base beyond the narrow pool of donor sources tied to its LDC status should be explored. Sustainable financing mechanisms, such as those developed under TCAP, should be prioritised.
- Land reclamation and physical infrastructure investments should be extended beyond the most inhabited areas to all islands, prioritised by site-specific vulnerability assessments rather than solely by population concentration.
- Responsibility for delivering policy outcomes should be clearly documented, with a process for completing unfinished outcomes built into project planning. Outstanding outcomes from prior donor-funded projects should be incorporated into future programmes.
- Medium- to long-term capacity building is needed across climate change, project management, financial management and knowledge management. Capacity programmes should target beyond existing officials to ensure knowledge retention despite staff turnover.
- Best practices, methodologies and lessons learned from all projects should be made easily available and recommended for use. The conversion of the TCAP project management unit into a Coastal Management Authority should be supported as a means of institutionalising adaptation knowledge and ensuring continuity across project cycles.

Conclusions

Tuvalu faces an existential threat from sea level rise. With a maximum elevation of 4.6m and an average height above sea level of less than 3m, the nation's entire population lives within 1km of the ocean and is exposed to the compounding effects of rising seas, intensifying cyclones, saltwater intrusion, coastal erosion and ocean acidification. The local sea level rise rate of approximately 5mm per year exceeds the global average, and even under low emissions scenarios, atoll nations face high to very high risks.

Tuvalu has demonstrated sustained political commitment to addressing climate change, with consistent messaging from its leadership spanning more than two decades. This commitment is reflected in a coherent policy framework linking National Adaptation Programmes of Action, the National Climate Change Policy and successive National Strategies for Sustainable Development through to Te Kete (2021–2030). The alignment of JNAPs with national development strategies represents good practice in integrating climate adaptation into broader development planning.

The review of the NAPA 1, NAPA 2 and TCAP projects reveals a trajectory of improving project design and implementation. While NAPA 1 outcomes were assessed as mainly unsuccessful due to capacity constraints and operational challenges, NAPA 2 achieved greater success by addressing logistics barriers and strengthening island-level governance. TCAP represents a further step forward, being the first major project to directly tackle sea level rise through hard infrastructure and land reclamation. With Phase I complete and Phase II (TCAP-II) now underway, it reflects a substantially more agile implementation approach.

However, fundamental challenges persist. Tuvalu's limited human resource and financial capacity means continuing reliance on international and regional support for project implementation. Financial dependence renders progress vulnerable to donor aid funding inclinations and ongoing government resource turnover. Nonetheless, the conversion of the TCAP project management unit into a Coastal Management Authority offers an important institutional mechanism for sustaining adaptation efforts beyond individual project cycles.

Ultimately, to facilitate real change, Tuvalu's broad socio-economic and environmental dependence on ocean sustainability means that project outcomes must be aligned with wider environmental and ocean governance frameworks and progressively mainstreamed across other strategies. Adaptation cannot be absolute, as climate shocks change or compound, and previously successful strategies may fail. This underscores the need for policies and programmes that incorporate climate change adaptation, disaster risk reduction, and loss and damage in an integrated manner, supported by sustained international commitment to the most vulnerable nations.

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Annexes

Annex A. Country dashboard

COMMONWEALTH SEA LEVEL RISE CASE STUDY	MODEL
TUVALU	DASHBOARD

Country snapshot

Coastline ~82km	Coastal population 100% of total	Coastal elevation 1.9–4.6m above mean sea level (MSL)
GDP from coastal sectors ~100%	Coastal zone (% land) 100%	TC Pam Impact (2015) US\$10.34 million (~33% GDP)

Sea level rise indicators

Observed local SLR ~5mm/yr vs. global ~3.2 mm/yr	Projected rise by 2100 0.19–1.01m by 2100 (IPCC)	Land subsidence N/A (atoll accretion/erosion)
Asset exposure High (Entire pop. at risk)	Adaptation cost needed US\$40.2 million TCAP (GCF funded)	Tide gauge record 1993–2021 Funafuti (BOM)

Adaptation at a glance

Type	Key measures	Status
Coastal protection	Sea walls, revetments, berm barriers, land reclamation (TCAP)	Active; TCAP Phase I complete
Ecosystem based	Mangrove planting, coral replanting, R2R biodiversity	Active; community based
Accommodation	Salt-tolerant crops, FADs, early warning systems, island strategic plans (ISPs)	Ongoing; outer island challenges
Planned retreat	Not addressed in current projects	Subject of wider PSIDS work
Climate finance	GCF (US\$36 million), GEF-LDCF, UNDP, AusAID	Donor dependent; LDC status

Key milestones

1989	2007	2008	2013	2015	2017	2025
<i>Holdgate Report</i>	LCDS initiated	Major flood (~100% GDP)	National Strategic Action Plan for Climate Change and Disaster Risk Management implemented	NAP Developed	Offshore oil production	Kwakwani flood

Commonwealth Apia Ocean Declaration relevance

How does sea level rise in this country intersect with the **priorities set out in the Commonwealth Apia Ocean Declaration?**

	Ocean–Climate Nexus Primary Action Group for this series. Local SLR rate of ~5mm/yr exceeds global average of ~3.2mm/yr. Climate change intensifies cyclones and storm surges, threatening atoll inundation. Local SLR: ~5mm/yr (global: ~3.2mm/yr)		Marine Pollution Saltwater intrusion contaminates groundwater. Waste management is challenged by remoteness and limited infrastructure across nine atolls. Single-use plastics banned in 2019. Single-use plastic ban: 2019
	Sustainable Fisheries Coral reefs (710km ²) highly vulnerable to heat stress and acidification. Tuna fishing vital to economy. FADs deployed under NAPA 2 to support food security. Coral reef area: 710km ²		Blue Economy Tuvalu's economy is heavily marine dependent. Oceanic area of ~900,000km ² supports fisheries and potential for sustainable ocean economy development. Ocean area: ~900,000km ² LDC since 1986
	Marine Protection and Restoration: Coral reefs (710km ²) highly vulnerable to heat stress and acidification. Mangrove planting under NAPA 1 and coral replanting under R2R demonstrate community-based marine restoration. Marine ecosystem health is critical to food security and the tuna-based economy. Coral reef area: 710km ²		

Annex B. Legislative and policy framework summary

Category	Instrument / Framework	Year	Description	Relevance to SLR
International agreements	UNFCCC	1993	Ratified.	Framework for climate adaptation obligations and reporting.
International agreements	Kyoto Protocol	1998	Signed and ratified as non-Annex I country.	Supports global emissions reduction efforts.
International agreements	Paris Agreement	2016	Ratified.	Commits Tuvalu to adaptation planning and NDC submissions.
International agreements	UNCLOS	2002	Ratified; governs maritime zones.	Relevant to maritime boundary preservation under SLR.
International agreements	Basel Convention	Accessioned	Governs transboundary movement of hazardous wastes.	Relevant to waste management in climate-vulnerable context.
International agreements	Australia-Tuvalu Falepili Union Treaty	2023	Climate mobility pathway; recognition of Tuvalu's continuing sovereignty.	Provides climate migration option and sovereignty assurance under SLR.
Constitutional	Constitution of Tuvalu (Amendment) Act	2023	Declares statehood perpetual regardless of territorial loss; fixes maritime baselines.	Landmark legal response to existential SLR threat.
National strategy	Te Kakeega II (NSSD 2005–2015)	2005	National Strategy for Sustainable Development; established climate change policy as goal.	Set stage for NAPA development and climate mainstreaming.
National strategy	Te Kete (NSSD 2021–2030)	2021	Current national sustainable development strategy.	Continues focus on SLR planning, DRM and resilience building.
National policy	National Climate Change Policy	2012–2021	Developed under PACC project with UNDP and SPREP; succeeded by Te Kete framework.	Set adaptation direction for coastal resilience, agriculture and water.
National policy	National Adaptation Programme of Action (NAPA)	2007	Formally endorsed; detailed current and future climate change impacts.	Identified coastal resilience as top priority; informed NAPA 1 and 2 projects.
National policy	NAPA 1 Project	2008–2013	Increasing resilience of coastal areas and community settlements.	Directly addressed coastal SLR adaptation.
National policy	NAPA 2 Project	2013–2019	Island-level governance for climate-resilient marine-based livelihoods.	Focused on marine livelihoods and climate hazard response.
National policy	National Strategic Action Plan for Climate Change and DRM (NSAP)	2012–2016	Integrated CCA and DRM planning.	Streamlined adaptation and disaster risk approaches.
National policy	Nationally Determined Contribution (NDC)	Submitted	Commits to adaptation and mitigation actions under Paris Agreement.	Outlines national priorities for SLR adaptation.

Category	Instrument / Framework	Year	Description	Relevance to SLR
Legislation	National Development Management Act	2007	Defines disaster management structures.	Legal basis for disaster preparedness and response to SLR events.
Legislation	Environmental Protection Act	2008	Overarching framework for environmental protection and sustainable development.	Governs environmental governance relevant to coastal adaptation.
Legislation	Ozone Layer Protection Act	2008 (revised)	Protects ozone layer.	Part of broader environmental legislative framework.
Legislation	Climate Change and Disaster Survival Fund Act	2015	Financial assistance for citizens to adapt, recover or rehabilitate from climate impacts.	Directly funds citizen-level SLR adaptation and disaster recovery.
Legislation	Waste Management (Single-Use Plastic Prohibition) Regulation	2019	Prohibits importation of single-use plastics.	Reduces coastal and marine pollution exacerbated by flooding.
Institutional	JNAP governance arrangements	Established	Lead agency with inter-agency task force for CCA/DRM integration.	Co-ordinates national adaptation and DRM implementation.
Institutional	Climate Change Policy Unit (CCPU)	–	Technical unit for climate change policy co-ordination.	Supports policy development and implementation.

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