



TORRES STRAIT CLIMATE CHANGE STRATEGY

2014-2018



Australian Government



TSRA
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Foreword

The message from the scientific community is clear that climate change poses one of the most significant threats to humanity and the planet's natural systems over the years and decades ahead. The unique cultures and environments of the Torres Strait that have weathered change over many millennia, now face a very uncertain future. Our island communities, ecosystems, infrastructure, livelihoods, wellbeing, culture and identity are all threatened by the many impacts of climate change.

Our low-lying island communities are already experiencing the direct impacts of sea level rise. Every year during Spring tides these islands suffer inundation from the seas that surround them, a tidal event that is increasingly exacerbated as sea levels march steadily upwards. The resultant flooding and erosion, particularly around ancestral burial sites, is a source of significant community distress.

Despite these challenges we are pleased to reflect on the progress that has been made in implementing the actions identified in the first (2010–2013) edition of the Strategy. Significant progress has been made in securing the knowledge and information needed to inform future decisions and actions.

Through constructive collaboration between local, state and federal governments, communities and research partners, the Torres Strait now has a much clearer understanding of local climate change projections, sea level rise and associated inundation and erosion risks as well as a growing body of baseline information on key species and ecosystems.

The next phase of the Strategy implementation is to identify and take appropriate adaptation actions that will help to reduce climate change risks and build regional and community resilience. This will require even greater collaboration across all agencies and sectors given the complex and multi-faceted nature of climate change impacts. In parallel we will need to keep monitoring the changes around us and continue to build our understanding to inform a flexible and adaptive approach for responding to future uncertainties.

In this updated version of the Strategy, we have built on the solid foundations of the first version, updated the climate change projections and action plan, and included a specific section on knowledge gaps and monitoring.

As ever, it is our hope that we can work with the Australian and Queensland Governments to implement this Strategy in a spirit of collaboration and determination to achieve the best outcomes for current and future generations. Torres Strait Islander and Aboriginal people of our region are here for the long term, and will continue to demonstrate our capacity to respond to whatever challenges we face. Climate change will test our determination, ingenuity and capacity to work as one for a common purpose; there is too much at stake for us not to rise to the challenge.

Acknowledgements

This Strategy was developed with the input of members of the Torres Strait Coastal Management Committee, the Land and Sea Management Unit of the Torres Strait Regional Authority (TSRA), and external experts. This document should be referenced as: TSRA (2014) Torres Strait Climate Change Strategy 2014–2018. Report prepared by the Land and Sea Management Unit, Torres Strait Regional Authority, 2014, 22p. Printed on 50% recycled and 50% managed plantation paper.

¹Intergovernmental Panel on Climate Change (2013) Climate Change 2013: The Physical Science Basis. Working Group I Contribution to the IPCC 5th Assessment Report – Changes to the underlying Scientific/Technical Assessment. IPCC Secretariat, Geneva, Switzerland.

²Australian Human Rights Commission (2008) Native Title Report, Aboriginal and Torres Strait Islander Social Justice Commissioner Report No. 2/2009.

Executive Summary

Human-induced climate change is now unequivocal, with impacts already being observed in societies and ecosystems around the world¹. The extent of the predicted effects of climate change in the Torres Strait region, along with the geographic, ecological, social and cultural characteristics make Torres Strait communities amongst the most vulnerable in Australia.

The effects of climate change threaten the islands themselves as well as marine and coastal ecosystems and resources, and therefore the life, livelihoods and unique culture of Torres Strait Islanders.

Indigenous communities are more vulnerable to climate change because of the social and economic disadvantages they already face. If strong action is not taken to address these threats, there is the potential for climate change impacts in Torres Strait to create a human rights crisis².

The degree of vulnerability of Torres Strait communities to climate change, and sea level rise in particular, needs to be fully appreciated by governments and policy makers. Even small increases in sea level due to climate change will have an immense impact on Torres Strait communities, potentially threatening their viability. Large increases would result in several Torres Strait islands being completely inundated and uninhabitable.

To date, the Torres Strait Regional Authority (TSRA), in partnership with relevant local Councils, Queensland and Australian Government departments, has undertaken a number of activities to support Torres Strait Islanders to make informed decisions about adaptation to sea level rise and other climate change impacts in implementing the 2010–2013 Strategy. However, much of this effort will be lost if funding does not support continued implementation of the strategic priorities identified in this 2014–2018 Strategy.

This Torres Strait Climate Change Strategy (Strategy) outlines some of the observed and potential future impacts of climate change on Torres Strait ecosystems and communities, and identifies priority responses through an Action Plan. The Action Plan incorporates and builds on existing efforts under the 2010–2013 Strategy, focused around appropriate adaptation and management solutions. Key research and monitoring gaps to support effective adaptation are also identified.

The Strategy recognises that the complex and multifaceted nature of climate change means that individual studies or measures cannot address all potential climate change challenges. The approach adopted by this Strategy involves the application of specialist assessments integrated across sectors using existing knowledge frameworks and management practices where possible. The Strategy is intended to guide whole-of-government efforts to manage the impacts of climate change, and facilitate adaptation to future change. It is also designed to support grass-roots, community-based planning and local decision-making, enabling communities to respond to these challenges in the most culturally appropriate and locale-specific way.

The key themes of this Strategy include:

- Culture and Traditional knowledge;
- Environment and Ecosystems;
- Settlements and Infrastructure;
- People and Communities;
- Research and Monitoring (to support actions and policy); and
- Communication and Capacity Building.

Implementation of the Action Plan will depend on the commitment of government agencies, the research sector and the international community to support, resource and further develop the approaches put forward in this Strategy. These actions will also depend on consultation with and commitment by Torres Strait Islander communities.

The causes of climate change, the resultant impacts and required mitigation actions are beyond the capacity of agencies and people in the Torres Strait region to manage along; they are also not the sole responsibility of the region. Strong political will, sufficient funding, technical support, and coordinated, collective effort will be required in the immediate future to effectively deliver this Strategy and minimise the potential impact of climate change on Torres Strait communities and ecosystems.

“Many impacts on small islands are generated from processes well beyond the borders of an individual nation or island and generally they have negative effects.”

United Nations IPCC, AR5, 2013

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Introduction

Each year many Torres Strait Island communities are impacted by inundation during high tides. These events inundate houses, infrastructure including roads and sewage systems, community facilities, cultural sites including cemeteries, traditional gardens and coastal ecosystems. Often these events have also caused severe coastal erosion and reconfiguration of island shorelines, further threatening community infrastructure. The implications of sea level rise associated with climate change are thus of immense and potentially devastating significance.

Indigenous Island communities are recognised to be at the front line of climate change impacts due to their remoteness, often low topography and limited capacity to respond, and adapt to additional social, financial and ecological stressors. Torres Strait people are sea people and impacts on the marine environment pose a significant threat to both livelihoods and culture.

Since the Torres Strait Climate Change Strategy was first released in 2010, there has been increased certainty in the scientific community around the timing and scale of changes to the Earth's climate system driven predominately by human activity. Besides sea level rise, other impacts of climate change on Torres Strait communities and environments are likely to result from ocean warming, hotter weather, changed wind and rainfall patterns, and more intense weather events. Ocean acidification and changes to ocean currents are also likely to become apparent over time, affecting marine ecosystems, and impacting communities and the region in a multitude of ways¹.

Climate change is widely acknowledged as a serious threat to the long-term health of coral reefs; the reefs of the Torres Strait, the northern extent of the Great Barrier Reef ecosystem, are no exception. Coral bleaching and ocean acidification have far-reaching implications for the region's reef ecosystems. Corals are fundamental to the region's marine biodiversity and productivity, and provide food and income for many Torres Strait Islanders. For low-lying cay islands they also provide coastal protection from waves, as well as the sediments from which the islands are composed. Even on the high islands, beach sediments are often largely derived from the surrounding reef.

The Torres Strait is also home to globally significant dugong and green turtle populations and some of the world's most extensive seagrass meadows. Seagrass meadows provide nursery areas and habitat for many species of marine fish and invertebrates, feeding grounds for many species of adult fish and green turtles as well as being the only food source for dugong. As such, climate change impacts on seagrasses have potentially devastating implications for dugong and turtle populations. Turtles are also threatened by warmer temperatures and loss of nesting beaches from enhanced erosion and sea level rise.



Besides the direct impacts of climate change (e.g. extreme weather impacts on ecosystems, health and wellbeing), there are likely to be a multitude of indirect or flow on impacts (e.g. consequential impacts upon traditional hunting and cultural practices due to changes in ecosystems and marine species).

Combined, these impacts will present significant social, cultural and economic challenges, such as loss of access to traditional land and sea country and loss of, or changes to, cultural practices; impacts on infrastructure, housing, land-based food production systems and marine industries; and health issues such as increased disease and heat-related illness.

Other less direct but nonetheless significant impacts of climate change may be felt by communities through the introduction of carbon price mechanisms and other external drivers, such as increasing costs of fuel and transporting goods and services from the mainland. Already, fuel costs have significantly raised the cost of living and impacted heavily on the lower-than-average standard of living for the majority of the Indigenous community. Without the introduction of alternative power sources such as wind, solar or tidal energy, increasing diesel fuel costs are likely to impact on the local economy and directly impact the capacity of communities to adapt to climate change.

Broader regional and international border issues also have the potential to significantly affect Torres Strait communities as health and food security in the wider region are impacted. Much of the Western Province of Papua New Guinea experiences significant inundation issues, and is likely to be significantly affected as sea levels rise, impacting communities and their capacity to maintain food production. The result could be increased reliance on resources in the Torres Strait.

The close proximity of Torres Strait to adjacent tropical regions, and the potential for the transfer of malaria, dengue fever and other water and vector borne diseases more prevalent in hotter and wetter conditions, are also of concern.

The need to properly and thoroughly consider the potential impacts of climate change, the associated risks to communities, as well as ways of adapting to this change is fundamental to the intent of this Strategy.

The Strategy is accompanied by an Action Plan for responding to climate change. This has been divided into the following elements:

- Culture and Traditional knowledge;
- Environment and Ecosystems;
- Settlements and Infrastructure;
- People and Communities;
- Research and Monitoring (to support actions and policy); and
- Communication and Capacity Building.

These elements take into consideration the regional context including existing management and governance arrangements, Ailan Kastom and the physical complexity of the area. They also encompass uncertainty and accepted management principles.

Context

Setting

The Torres Strait is a broad stretch of shallow water between the tip of Cape York and the south-western coast of Papua New Guinea. The region includes over 200 islands and cays, and numerous coral reefs and sand banks (Figure 1).

The region is home to 18 Island communities with a total population of around 8,700 people. The region is classified by the Australian Bureau of Statistics as an Indigenous Region; approximately 91 percent of inhabitants are Torres Strait Islander and Aboriginal people (ABS 2010 census). A further 42,000 Torres Strait Islanders live outside the region.

The region's inhabited islands vary significantly in their geography:

- The low-lying mud islands of Boigu and Saibai close to the Papua New Guinea coastline;
- The western continental islands which have similar geomorphology to the Australian mainland;
- The central coral cays of Poruma, Warraber and Masig; and
- The eastern volcanic islands of Mer, Erub and Ugar.

The communities that inhabit the region have strong cultural, economic, social and spiritual connections with their land and sea country, and maintain their distinct *Ailan Kastom* (Island custom).

The Torres Strait region is known for its ecological complexity, biodiversity and relatively pristine marine and island environments, providing a multitude of habitats and niches for the highly diverse Indo-Pacific marine fauna, including dugongs (listed as vulnerable) and marine turtles (listed as endangered). It has extensive continuous areas of seagrass meadows, significant areas of coral reefs with high diversity and extensive areas of coastal mangroves.ⁱⁱ

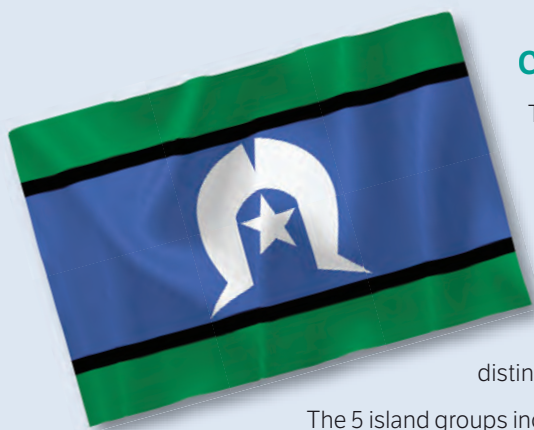
To the north of the region is the international border with Papua New Guinea. The Torres Strait Treaty, signed in 1978 between Australia and Papua New Guinea and ratified in 1985, allows for traditional visitation between the inhabitants of the Torres Strait and specific villages on the coast of Papua New Guinea, and traditional fishing and hunting by both groups. The Treaty recognises the importance of the Torres Strait environment and the traditional way of life and livelihood of traditional inhabitants, and includes provision for protection of native flora and fauna, amongst other things.

The proximity of Torres Strait to Asia and Papua New Guinea has meant that the region has long been recognised by health and biosecurity authorities as a potential route for the entry of exotic weeds, pests and diseases into Australia, including mosquito borne diseases. This is managed by strict quarantine regulations concerning the movement of high-risk products out the region to mainland Australia.

The Torres Strait is also an important international shipping route and is classified as a Particularly Sensitive Sea Area by the International Maritime Organisation.

Figure 1: The Torres Strait Region





Culture (Ailan Kastom)

The Indigenous peoples of the Torres Strait have a distinct culture that includes influences from Papua New Guinea, Indigenous Australia and Austronesian elements. Traditionally, islanders are seafaring people who rely heavily on local marine resources, island gardens and trade with Papua New Guinea villages. There are two main languages groups, Kala Lagaw Ya of the western, southwestern, central and northern island groups, and Miriam Mir of the eastern islands. Torres Strait islanders also have distinctive dance and arts practices.

The 5 island groups include:

- Northern Division (Boigu, Dauan, Saibai);
- Eastern Division (Erub, Mer, Ugar);
- Western Division (St. Pauls, Kubin, Badu, Mabuiag);
- Central Division (Masig, Poruma, Warraber, Iama); and
- Southern Division (Thursday, Horn, Prince of Wales & Hammond Islands, NPA).

Mer Island in the Torres Strait was also the first place in Australia to secure Native Title recognition.

Existing management arrangements

More than 25 government agencies and departments are represented in the Torres Strait because of its unique political features and strategic location for defence, surveillance and monitoring. These agencies are primarily based on Thursday Island, the administrative centre for the region.

Local government authorities in the region include the Torres Strait Island Regional Council (TSIRC), Torres Shire Council (TSC) and Northern Peninsula Area Regional Council (NPARC). The Queensland Government also has a key role in funding and delivering other services in the region, such as policing, health care, housing and infrastructure supply and maintenance.

The TSRA is a Commonwealth statutory authority that provides regional coordination of policies and programs of benefit to Torres Strait Islander and Aboriginal people living in the region. This is the only such regional Indigenous body in Australia. The TSRA consists of an elected arm and an administrative arm. The elected arm is comprised of 20 elected representatives who are Torres Strait Islander and Aboriginal people living in the Torres Strait regionⁱⁱⁱ. The TSRA is administered by a Chief Executive Officer and staff who implement and manage TSRA programs. The TSRA Land and Sea Management Unit is the Regional Natural Resource Management (NRM) body for the Torres Strait and delivers the TSRA's Environmental Management Program.

The TSIRC was established in 2008, in line with the Queensland Government's amalgamation of Community Councils direction. The TSIRC is the entity responsible for fulfilling local government service delivery requirements for the 15 Torres Strait outer islands. The TSC also operates under the *Local Government Act 1993* to deliver local government services to the inner islands, including Thursday (Waiben), Horn (Nurupai) and Prince of Wales (Muralug) Islands.

The NPARC operates under the *Local Government Act 1993* to deliver local government services to five mainland communities including the two Torres Strait Islander communities of Bamaga and Seisia which had previously been administered within the Torres Strait jurisdictional boundary.

Coastal management and climate change issues in the Torres Strait are managed through the Torres Strait Coastal Management Committee, which was established by the TSRA in 2006. The TSRA Chairperson is the chair for the committee with secretarial supports provided by the LSMU. This Committee comprises representatives from the communities worst affected by coastal erosion and inundation, including Boigu, Saibai, Iama, Warraber, Masig and Poruma, as well as local, State and Australian government agencies and various research institutions. From time to time, other communities are represented. The Committee aims to enable a whole-of-government, coordinated response and policy advice to coastal and climate change issues in the Torres Strait region.

Work undertaken by the Torres Strait Coastal Management Committee has to date focused on coastal erosion issues and, to a lesser extent, sea level rise. The Committee has noted that inundation and other climate change impacts are also very significant issues for Torres Strait communities and has expanded its focus to take on these priority areas, including the development and implementation of regional and local adaptation and resilience planning.

Studies undertaken for the Committee include the Queensland Department of Environment coastal erosion assessments for Boigu, Saibai, Warraber, Masig, Iama and Poruma, research by James Cook University (JCU) on erosion and inundation across the region, downscaled climate change modeling by CSIRO and extreme water level modeling by Systems Engineering Australia. Reports on erosion and mitigation costs and options for Boigu, Saibai, Iama and Poruma have also been undertaken by AECOM. These studies have been conducted in full collaboration with communities to identify preferred management strategies, including protection works, for several island communities.

Complexity of the area

Administration

The jurisdictional and administrative arrangements over the Torres Strait environment are extremely complex, involving two countries, Local, Queensland and Commonwealth governments and multiple agencies. There are also many island communities, each with their own distinct languages and customs, and different priorities and concerns for community development and environmental managementⁱⁱ.

Weather patterns, currents, tidal data and dynamics

The weather of the Torres Strait region is dominated by two main influences, the summer northwest monsoon and the winter southeast trade winds. However detailed knowledge of the region's weather and oceanographic patterns are still in a state of development. Longer-term observations of climate have been disrupted through weather station relocation and/or discontinuation, making interpretation of past changes in factors like temperature and wind problematic. A regional network of new tide gauges supplemented with tide boards to monitor sea level and surge is currently being installed, with gauges at Kubin (Moa), Iama, Ugar and Boigu deployed and National Tidal Centre sea level gauge to be installed on Thursday Island. The two Bureau of Meteorology weather stations (at Horn Island and Poruma Island) have recently been supplemented by two real-time marine monitoring stations off of Thursday and Masig Islands with meteorological capabilities as part of a marine monitoring program between TSRA and the Australian Institute of Marine Science.

The predominantly marine nature of the region means potential impacts from changes to ocean currents is high, and although these processes are not well resolved in global climate models, recent downscaling for the Torres Strait region has provided projections for surface temperatures (air and sea), rainfall, sea level, humidity and storm surge, wind speed and solar radiation.

In relation to the impacts of sea level rise and inundation processes, tidal data is limited to gauge sites close to Thursday Island which are maintained by the Australian Maritime Safety Authority for shipping purposes. Short-term tidal surveys have greatly improved the previous very inaccurate datums, but data from the new tide gauges will further increase datum accuracy. The highly complicated tidal dynamics of the region are likely to mean that some potential uncertainty will remain as to the exact tidal planes in each community.

Tidal dynamics are amongst the most complex in any region in Australia and result from the complicated interaction of tides in the Coral Sea and the Arafura Sea/Gulf of Carpentaria. Tidal phase and amplitude varies significantly east to west across the Torres Strait, with particularly strong gradients in tidal coefficients around the Western Island chain, which results in significant differences in tidal patterns over short distances of a few kilometers.

Ecological diversity

Gradients also exist in ecology, both east-west and north-south across the Torres Strait, influenced by local geological, climatic and topographic variability. Baseline information with respect to ecosystems and their various components is still in development, but significant progress has been made in this area over the past three years for both terrestrial, mangrove and coral reef ecosystems. Biodiversity assessments are highlighting the regional and international significance of the Torres Strait as an important centre of unique and intact biodiversity.

General management principles

The management of the potential effects of climate change involves the management of risk, for which there is a generally accepted management approach.

AS/NZS 4360 *Risk Management*^{iv} provides a generic framework for risk management. The framework specifies a process for supporting better decisions and providing greater insight into risks and their consequences. The framework involves systematically identifying, analysing, evaluating, treating, monitoring and communicating risks.

In adopting such an approach, it is essential that all possible foreseeable impacts of climate change are assessed. For example, it is not sufficient to simply consider that impacts will be limited to a conservative sea level rise scenario.

The general approach adopted in the application of this Strategy is one of risk management, with the following principles used to guide decision-making in relation to specific impacts of climate change, acceptable levels of risk and treatment options:

- **The Torres Strait is a special place:** the unique characteristics of the region and its people should be explicitly recognised and protected. Adaptation options should be culturally appropriate;
- **Sustainable:** Adaptation responses should support the development of ecologically, socially and financially sustainable communities in the Torres Strait;
- **Holistic outlook:** management of climate change is complex, multi-faceted and needs to address complex inter-relationships between physical, biophysical, socio-economic and cultural factors. The interactions between climate and non-climate stressors also need to be considered;
- **Local decision-making:** Torres Strait Islander and Aboriginal peoples as Traditional Owners of the region have an inherent right to self-determination including deciding upon the acceptability of potential risks;
- **Short and long term thinking:** management needs to consider both immediate, medium and long term implications, and should serve the needs of both current and future generations;
- **Robust and adaptive management (flexibility):** it is preferable to adopt robust solutions that allow for potential uncertainties ('no regrets') together with adaptive approaches that involve monitoring and review as circumstances, conditions and knowledge change (the 'precautionary principle');
- **Natural limits:** management actions should consider critical thresholds (e.g. regarding survival of coral reef ecosystems);
- **Responsiveness to local conditions:** management actions should take into account local variations in the physical, ecological, social and economic characteristics of specific communities;
- **Participatory planning:** objectives and actions should reflect community and stakeholder opinions and values with appropriate investment in awareness, education, consultation and mediation;
- **Multi-faceted solutions:** the most effective response to any one problem will often involve a combination of possible actions;
- **Relocation as a last resort:** Island communities do not want to leave their ancestral homelands as the islands and the sea that surround them are an inseparable part of their physical and spiritual identity;
- **Traditional Owner input and ownership:** Traditional Owners are familiar with seasonal weather patterns, variations and historic climate and sea level events, and have much to contribute to the process of planning for climate change and building community resilience; and
- **Evidence-based:** adaptation options should make full use of the latest research, data and practical experience so that decision-making is well supported and informed.

The complex and multi-faceted nature of the climate change issue means that no one study or solution will address climate change impacts. The approach adopted in this Strategy involves the application of specialist assessments within different sectors and integration of these with existing policies and management practice where possible.

Current climate trends

The Torres Strait region experiences a tropical climate with a mean maximum temperature of around 29°C and a mean minimum temperature of about 24°C. The seasonal range is relatively small, varying between 28 and 31°C. The mean temperature has increased by 0.25°C per decade between 1960 and the mid-1990s, and by 0.51°C per decade from the mid-1990s to 2009, consistent with global trends¹.

Annual rainfall is around 1750mm, which occurs mainly during summer months. The region experiences a distinct dry season between May and November, characterised by low rainfall and strong southeast trade winds commonly known locally as 'Sager', and a wet season between December and April characterised by higher rainfall and humidity, and north-west monsoon winds commonly known locally as 'Kuki'.

The transition from the dry to the wet is characterised by lighter northerly winds that blow intermittently from October until December, known locally as 'Naigai'. This is the period of the year when heat and humidity peak. Southerly winds that blow randomly throughout the year are commonly known as 'Zay'.

Sea surface temperature in the region averages about 28°C with little variation throughout the year. The long-term average for summer is 28.3°C and for winter is 27.4°C. Average annual sea surface temperatures in the region have been observed to increase by about 0.16 to 0.18°C per decade from 1950 to the present, consistent with global trends¹.

Cyclone occurrence in the region is lower than in other parts of Queensland, but nevertheless poses a significant hazard. Records of historical cyclone impact are scant; however significant impacts were associated with cyclonic events in 1923, 1948 (with significant inundation at Saibai and Boigu), 1952, 1959, 1970 and 1972.

In the Torres Strait region, sea level has been rising at ~0.6cm per year from 1993-2010 (compared to global average of 3 mm/yr). The rate of sea level rise since the mid-19th century has been larger than the mean rate during the previous two millennia¹.

Climate dynamics

Climate – or the average weather over many years – differs in regions of the world that receive different amounts of sunlight and have different geographic factors, such as proximity to oceans and altitude. The amount of solar radiation (heat) received at any location on Earth will affect the amount of precipitation and evaporation. The tropics receive more sunlight than higher latitudes and as a result tend to have higher temperatures, more rainfall and less seasonal variation.

Greenhouse gases play a major role in determining the balance between incoming and outgoing solar radiation – the greenhouse effect keeps the Earth's surface about 33°C warmer than it would otherwise be. The main greenhouse gases are water vapour, carbon dioxide (CO₂), methane, nitrous oxide, ozone and a suite of synthetic gases, mainly chlorofluorocarbons (CFCs). Human activity has significantly increased concentrations of some greenhouse gases (CO₂, methane, nitrous oxide and ozone), which have caused the Earth's atmosphere and oceans to warm, resulting in increased water vapour levels and further warming, known as the Enhanced Greenhouse Effect (Figure 2). The extra heat in the climate system has other impacts such as affecting atmospheric and ocean circulation, which influences rainfall and wind patterns.

The Earth's climate has varied naturally over hundreds of millions of years. However, comparisons with past changes between glacial and interglacial periods help us to understand how unusual the current warming is. For example, the linear warming trend over the past 50 years of 0.13°C per decade is much more rapid than the rate of warming between ice ages and warm interglacial periods of around 0.01°C per decade. Human influence on the climate system is clear¹. Current climate change models generally do not factor in some significant feedbacks that have the potential to further exacerbate the scale and speed of climate change (such as melting of sub-arctic permafrost – a significant store of carbon). Therefore, current predictions should be considered relatively conservative.

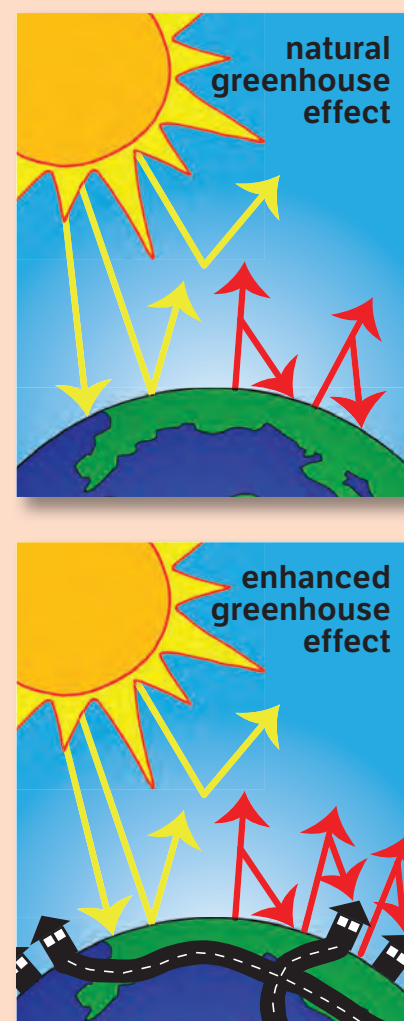
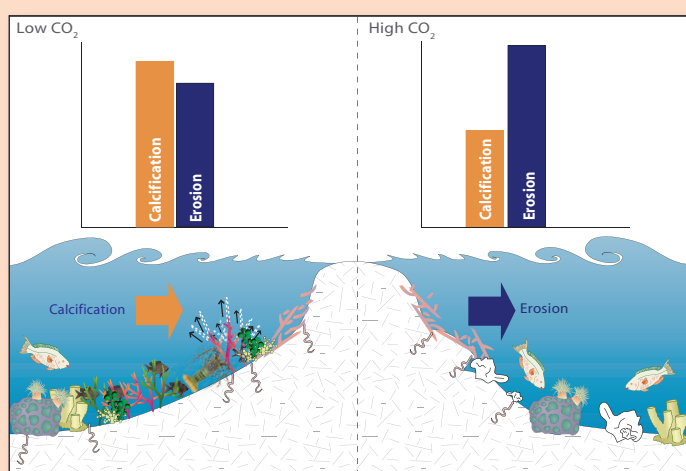
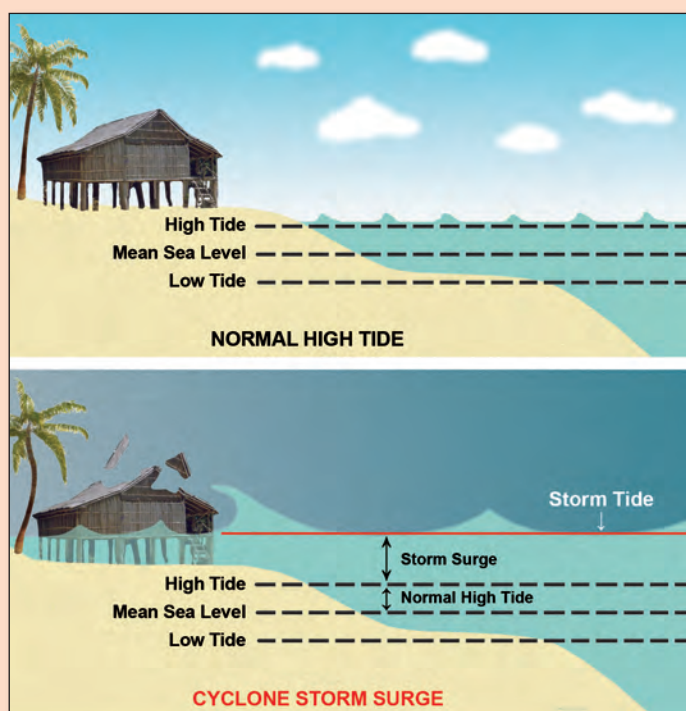
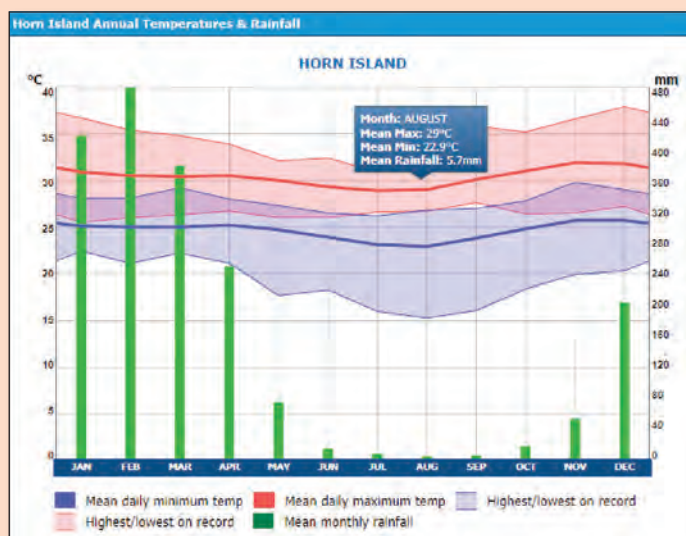


Figure 2: Enhanced Greenhouse Effect – human activity such as burning fossil fuels (coal, oil and natural gas) and land clearing is creating more greenhouse gases that trap more heat, warming the earth



Projected climate change

Climate change in the Torres Strait is expected to involve a warming of air and sea temperatures, rising sea levels, more intense cyclones, ocean acidification, and changes to rainfall, evaporation, wind and ocean currents.

The results of modelling predict that climate change in the Torres Strait is expected to result in:

- An increase in mean surface temperatures of between 0.62 and 1.27 °C by 2030, and 1.65 and 3.01°C by 2070^v;
- An increase in annual average rainfall of 1.46% by 2030, and 3.78% by 2070^v;
- An increase of sea level of between 5 and 15cm by 2030^{vi}, and 52 to 98cm by 2100ⁱ relative to 1990 levels;
- An increase in the maximum wind speed of tropical cyclones of between 2 and 11% by 2100^{vii};
- A decrease in ocean pH (ocean acidification) of between 0.2 and 0.3 units by 2100^{iv,i}; and
- Potential changes to seasonality, wind regimes, waves, ocean currents and salinity etc.

In general, the nature of projected climate change involves a slow and steady change over time, although more abrupt change is possible. Rates of change are predicted to increase over time. For sea level, changes tend to be modest for the next few decades but increase significantly under high emissions scenarios towards the latter half of the century. For example, the projected 5 to 15cm sea level rise over the next two decades is unlikely to be significant but could be 98cm (or potentially even higher) by the end of the century (Figure 4).

Whilst 52-98cm may seem small compared with the tide range of around 4–5m, island geomorphology is finely adjusted to current sea level with many sections of villages located only marginally above current high tide and in many cases below current annual inundation levels. Under this projected future, five communities

Figure 3: Mean maximum temperature and rainfall, and projected changes for Torres Strait (top panel); demonstrated effect of rising sea level and storm surge on coastal communities (middle panel); ocean acidification threatens reef-building corals as well as other marine animals that build calcium carbonate skeletons, such as crustaceans (Source: SPC)(bottom panel)

that are already regularly affected by seawater inundation – Saibai, Boigu, Masig, Warraber and Iama – will be more severely impacted by sea level rise, and increased flooding and erosion will be issues for Poruma, Erub and Mabuiag communities^{viii, ix}.

IPCC modelling and the inherent time lags in the climate system suggest that global mean sea level will continue to rise during the 21st century and the rate of rise will very likely exceed that observed during 1971–2010 due to increased ocean warming and increased melting of glaciers and ice sheetsⁱ.

In the long term, ongoing sea level rise is inevitable over the coming centuries, irrespective of the success of emission reduction strategies. As the IPCC 2013 Physical Science Basis says, “*Most aspects of climate change will persist for many centuries even if emissions of CO₂ are stopped. This represents a substantial multi-century climate change commitment created by past, present and future emissions of CO₂*”ⁱ. This indicates that management and adaptive responses need to address both the short- and long-term impacts, and give serious consideration to strategies that best manage longer term inevitable impacts.

“Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system.”

United Nations IPCC, AR5, 2013

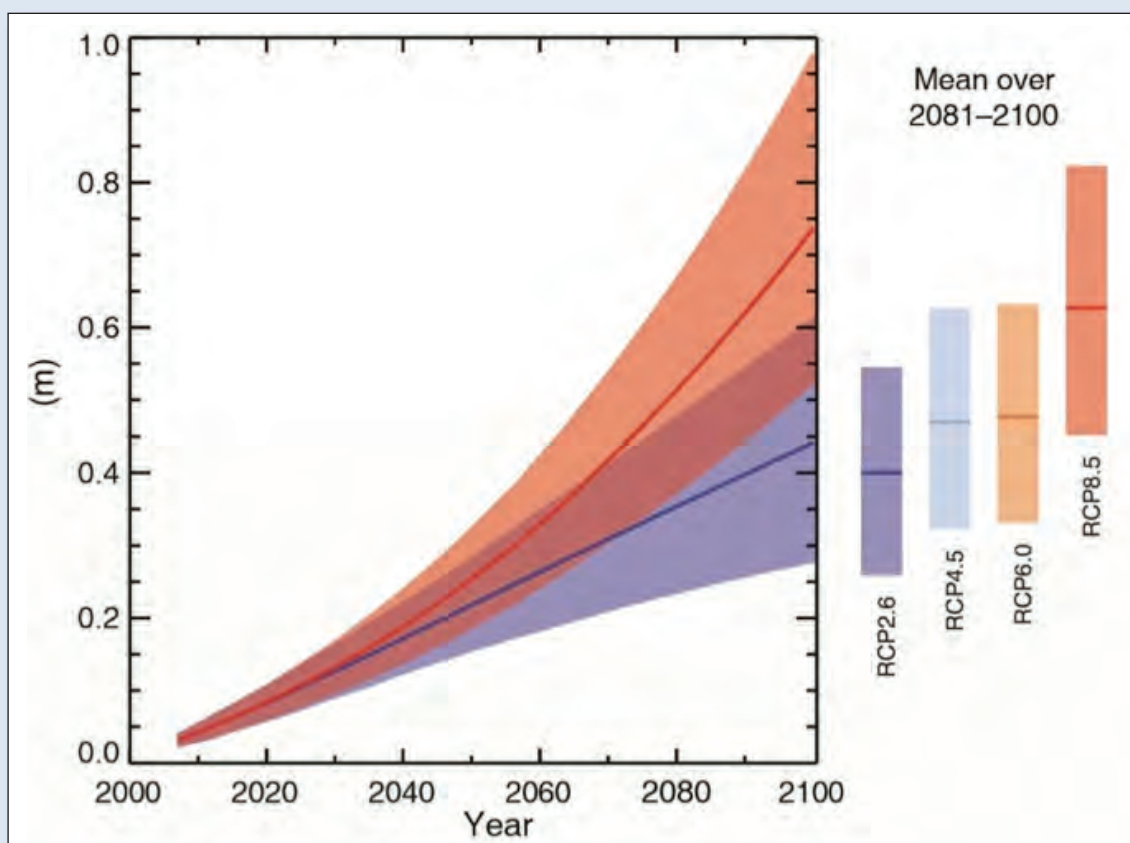


Figure 4: Projected global mean sea level rise (Source: IPCC AR5 The Physical Science Basis, 2013)



Climate Change Impacts, Risk and Vulnerability

Uncertainty

These complexities generate considerable uncertainty as to the exact nature and extent of the potential changes to climate as well as their impacts on the Torres Strait. This is further compounded by the general uncertainty concerning future emissions, and the lack of resolution about key processes (e.g. ocean currents, cyclones etc.) in global climate models. However, overall climate change predictions are getting increasingly more refined, narrowing the range of uncertainty associated with expected changes to key meteorological variables such as temperature. In dealing with risk it is prudent to consider legitimate worst-case scenarios to ensure mitigation strategies are capable of responding to the suite of potential impacts. Dealing with uncertainty is a key management consideration, for which standard risk management practice is well established.

Impacts

The impacts of climate change in the Torres Strait will be felt across all communities, sectors and ecosystems in the region. Impacts are already being experienced, with coral bleaching observed on Torres Strait reefs in 2010, and the impacts of sea level rise on the frequency and extent of inundation observed with major flood events in 2005, 2006, 2009 and 2010.

The implications of climate change in the Torres Strait will be the result of both direct and indirect impacts of increasing temperatures, changing rainfall patterns, sea level rise, ocean acidification and more extreme weather events, including tropical cyclones and storms. The impacts of these changes will manifest in natural ecosystems and resources, island morphology, island economies, and settlements and infrastructure (Figure 5).

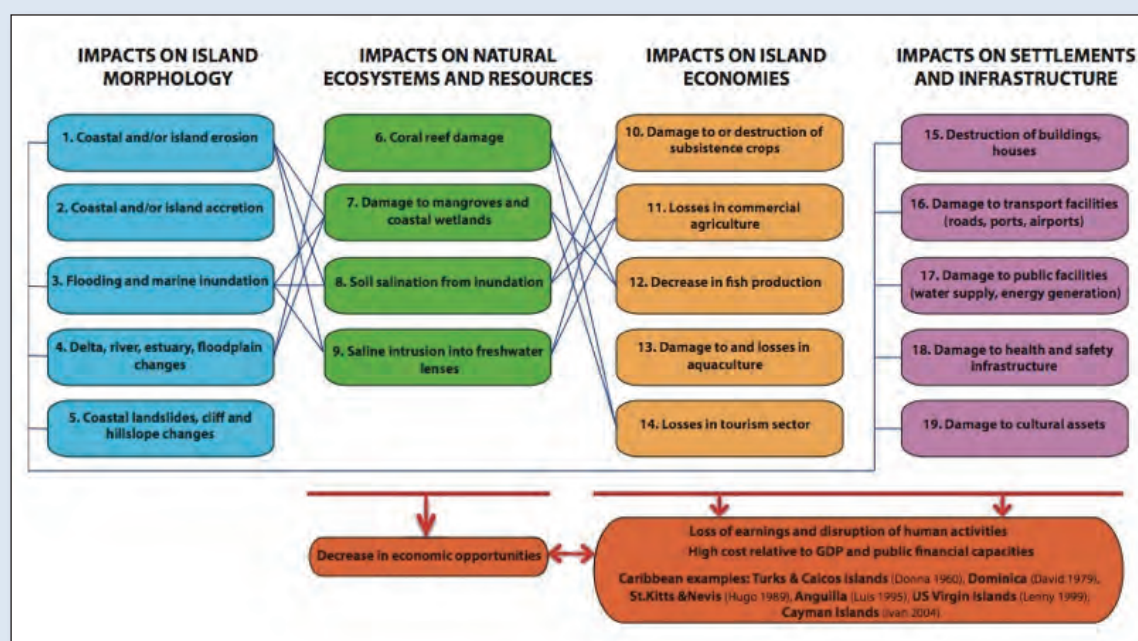


Figure 5: Tropical cyclone and storm impacts on the coasts and communities of small islands (IPCC WGIIAR5 Chapter 29, in press).

The impact of climate change in the Torres Strait can be broadly categorised as follows:

What is happening

Culture and Traditional knowledge

Sea level rise	Impacts of inundation and erosion events on low-lying communities and sites of cultural significance
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Environment and Ecosystems

Increased sea surface temperatures	Coral bleaching due to thermal stress
Sea level rise	Enhanced salt water intrusion into coastal ecosystems
Increased land temperatures and evaporation	
More intense storms and cyclones	
Ocean acidification	

Settlements and Infrastructure

Sea level rise	Impacts from sea level rise leading to increased frequency and extent of inundation
More intense storms and cyclones	Enhanced erosion and inundation of low-lying communities
More intense rainfall	Coastal erosion events threatening existing island infrastructure
Ocean acidification	Damage to roads, houses

People and Communities

Increased surface temperatures	Reduced catchability of tropical rock lobster during periods of elevated sea surface temperatures
Shifts in seasons and rainfall patterns	
Species and Habitat declines	
Extreme weather events	

Likely impacts /What is going to happen

Impacts of inundation and erosion events on low-lying communities

Inundation of sacred sites and cemeteries

Current island communities becoming uninhabitable

Impacts on Ailan Kastom - traditional customs, knowledge and practices (e.g. hunting of dugongs and turtle, knowledge of seasonal variations)

Declines in marine and terrestrial ecosystem goods and services

Loss of coral reef ecosystems due to direct and indirect changes in ocean temperature and acidity

Reduced area of seagrass due to increasing ocean temperature, reduced solar radiation and more intense storms and cyclones

Direct impacts on species (e.g. turtles, dugongs, seabirds), including changes in distribution, abundance and seasonality, and in some cases the loss of species

Movement of mangrove communities inland with advancing water

Salt water intrusion into groundwater systems

Changes in island vegetation communities (composition and distribution)

Increased fires

Increased spread of weeds and pest species

Impacts from sea level rise leading to increased frequency and extent of inundation, as well as permanent inundation of lower lying areas/islands

Increased frequency and extent of coastal erosion events potentially threatening existing island infrastructure

Loss of land, accretion or creation of land, and potentially increased shoreline fluctuation

Impacts from more intense storms and cyclones

Impacts on surface and groundwater supplies

Damage to roads, ports, power supplies, housing etc.

Impacts on cement based maritime infrastructure

Physical and mental health impacts due to increases in temperature, prevalence of vector borne, water borne and respiratory diseases and stress

Impacts on food and water availability

Livelihoods and industry affected by climate change impacts on fishery resources

Increases in the cost of living due to higher fuel and transport costs due to climate change impacts on broader Australian and global economy

Changes to rainfall and ground water impacting on community water supplies

The nature of these impacts and their onset is likely to vary significantly, with potential for very rapid change – particularly to ecological systems – when critical thresholds are breached. Therefore, a small change in climate or ecosystem condition, could lead to significant impacts if a critical threshold is passed. Some impacts are very direct (e.g. impacts of inundation and extreme events, and impacts on ecosystems), while others are likely to be the consequence of complex interactions between physical, ecological and social systems, both locally and regionally. These indirect but still significant impacts could include, for example, effects from increased fuel cost on the costs of goods and services from the mainland, and increasing demand from neighbouring countries for health and food resources as the broader region is impacted.

Risk (Exposure & Sensitivity)

Communities in the Torres Strait are already subject to significant coastal hazards associated with erosion and inundation that directly threaten housing, infrastructure (including roads, water supply systems, power stations, and community facilities), cultural sites, cemeteries, traditional gardens, ecosystems, industries and food security.

Given the low-lying nature of several islands, and the extent of current inundation problems, communities are highly exposed to the impacts of sea level rise. This is particularly so for Boigu and Saibai, but also for the central coral cay islands and several other communities located on low-lying coastal flats.

Even small increases in sea level due to climate change are likely to result in increasing frequency and extent of inundation in these communities; although for the coral cay islands there is some potential, under lower sea level scenarios at least, for the islands to build up as this occurs. The process of overtopping to create island growth would however be very difficult to live with and this sediment may be exhausted in the longer term.

Studies of extreme seawater inundation in Torres Strait at present show that based on a 5-year return period five communities are particularly vulnerable to inundation – Saibai, Boigu, Masig, Warraber and Lamavii. Future sea level rise will exacerbate this existing issue, with inundation events likely to occur more frequently and the possibility that several Torres Strait islands are completely inundated. Whilst it remains unclear what level

“The more benign possibilities from a failure of effective global mitigation are likely to require the relocation a long way from their homes of hundreds of thousands living in and adjacent to the Torres Strait.”

Professor Ross Garnaut, James Cook University Mabo Lecture, 2009)

of inundation will be tolerable for communities over the longer term, the probable worst-case scenario is the relocation of several communities, incurring considerable cultural, spiritual and economic costs.

Other potential impacts of climate change, including more intense storms that will increase island erosion, changes to rainfall patterns, hotter weather, spread of diseases, and changes to ecosystems, are also expected to significantly affect Torres Strait Island communities, whose culture, subsistence and livelihoods involve traditional and commercial fishing, hunting and gardening.

It is clear that climate change presents a significant and potentially devastating threat to Torres Strait communities. However a comprehensive understanding of the nature and extent of this risk is

lacking due to inadequate knowledge of key climatic, oceanographic and ecological processes. One of the objectives of the Action Plan delivered as a part of this Strategy is to provide a more comprehensive understanding of climate risk to enable appropriate adaptation options to be considered. Understanding the risks and vulnerability of communities and ecosystems to climate change over various time horizons will help to develop strategies to bolster resilience and assist adaptation and management actions.



Vulnerability

The potential impacts of climate change are a product of both how exposed individuals, communities or ecosystems are to the impacts of climate change, as well as the individual's or community's response to those impacts (sensitivity). Existing social and economic disadvantages of Indigenous peoples tends to heighten their sensitivity (Figure 6). The capacity of communities and ecosystems to adapt to these potential impacts can temper the extent of vulnerability, however the geographic, social, cultural and spiritual factors of the region combine to make Torres Strait communities amongst the most vulnerable in Australia to climate change. These factors, combined with the nature of the connections between island life, culture and customs, the islands and surrounding sea country, means Torres Strait Islanders are likely to be particularly affected by climate change.

The interconnection between Ailan Kastom (Island custom) and healthy land and sea are integral to spiritual and cultural identity, making the potential threat of climate change to both the islands and the surrounding ecosystems all the more significant to the region's traditional inhabitants.

The extent of vulnerability of the region and its peoples to climate change together with the human rights implications are highlighted in the 2008 Native Title Report by the Aboriginal and Torres Strait Islander Social Justice Commissioner which, along with submissions to Senate and House of Representatives inquiries by the TSRA, emphasise the need for immediate and comprehensive action to address climate change concerns in the region.

Social and economic disadvantage further reduces the capacity to adapt to rapid environmental change; this problem is compounded on many of the islands that lack adequate infrastructure, health services and employment opportunities. On the positive side, island culture and community cohesion are still strong in the Torres Strait and the region has some of the most intact ecosystems in the world with comparatively few anthropogenic stressors.

“The scope of these problems – and the action required to treat them – reach beyond previous human challenges. Yet in the years since the UNFCCC was signed, global negotiations have proceeded at a glacial pace. We have collectively failed to grasp the scale and urgency of the problem.”

Mary Robinson, former UN High Commissioner for Human Rights (International Council for Human Rights Policy, 2008)

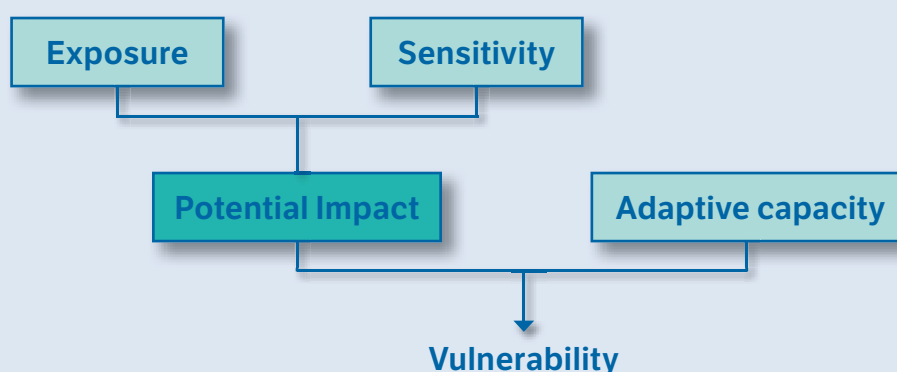


Figure 6: Framework for assessing vulnerability of species or habitats to climate change (adapted from Schroter et al. 2004^{xii}, Schneider et al. 2007^{xiii})

Adaptation & Resilience

Adaptation to the effects of climate change will require a broad array of activities and actions to both minimise the impacts on communities and to build resilience to deal with inevitable change.

Adaptation, as broadly defined by the Intergovernmental Panel on Climate Change, is an adjustment in natural or human systems in response to actual or expected climatic changes or their effects, which moderates harm or exploits beneficial opportunities. Adaptive capacity is the capacity of species, ecosystem or people to adapt to the consequences of change (including climate change). Due to the cross-cutting nature of climate change across sectors, development of adaptation strategies requires a high level of collaboration between agencies, communities and researchers to ensure strategies are appropriate, not mal-adaptive (i.e. further exacerbate climate change), effective and achievable.

Resilience is the amount of change a species, ecosystem or society can withstand without fundamental alteration or loss. For example, the resilience of an ecosystem is its capacity to absorb shocks and to then regenerate and re-organise to maintain key functions, without undergoing a 'phase shift' (moving into another state controlled by different processes). By considering the attributes of resilient systems and applying them to local communities, local resilience to negative impacts can be considerably enhanced.

Whilst extremely vulnerable in many ways, Torres Strait communities also have a number of key strengths that will assist them to confront the challenges ahead, including a very healthy and intact natural environment, a strong cultural connection to, and traditional knowledge of, that environment, relatively good community cohesion and leadership, and, through the support of various western science-based programs focusing on the region, access to good information designed to provide early warnings for weather related events.

Key vulnerabilities and strengths of Torres Strait island communities

Vulnerability	Strength
High exposure of low-lying islands and coastal communities to sea level rise, flooding and erosion, often with limited or no options for retreat	Healthy intact ecosystems and environment
Limited financial and human resources	Strong traditional culture and connection to country
High community reliance on local marine resources for protein and cultural maintenance	Strong sense of community and strong leadership
High dependence on and highly influenced by external drivers over which they have little or no control	Good access to scientific information
Indigenous disadvantage	Strong focus on regional unity
Geographically remote	Independent approach to resolving local problem-based issues

For sea level rise, coastal erosion and inundation, adaptation options include undertaking coastal zone management activities like coastal planning, implementing setbacks for new development, managing berms and dunes (commonly known locally as boeywadh) and their vegetation to build them higher and wider, raising housing, raising and filling inundation prone areas, building seawalls, bunds, levees and groynes, beach nourishment, relocation, and emergency planning.

For other impacts of climate change, adaptation is likely to involve a variety of activities to bolster community resilience and sustainability. This could include, for example, programs to explore alternative livelihood options (e.g. ecotourism, aquaculture) to broaden the income base and promote resilience, the installation of infrastructure that is better suited to a variable climate and has lower operational and maintenance costs,

the revival of traditional management strategies for natural resources, as well as the enhancement of existing programs for health and management of vector borne diseases.

Identification of appropriate coastal management options is well progressed for some communities and implementation of options identified to date is a priority, along with emergency planning and completion of land use planning currently underway. For other communities, management options to deal with inundation and sea level rise are yet to be assessed and will require detailed modelling. For the low-lying communities, consideration of contingency planning for worst case sea level rise scenarios and how to best manage the effects on communities, culture and identity is required.

The actions outlined in the next section are designed to build on current projects, giving urgent priority to the implementation of identified actions. These actions also assess in a comprehensive manner, the risks associated with inundation and sea level rise, as well as the other potential impacts of climate change and identify ways to adapt to these changes. The assessment of risks (or vulnerability) will inevitably lead to further projects and hence budgetary needs.

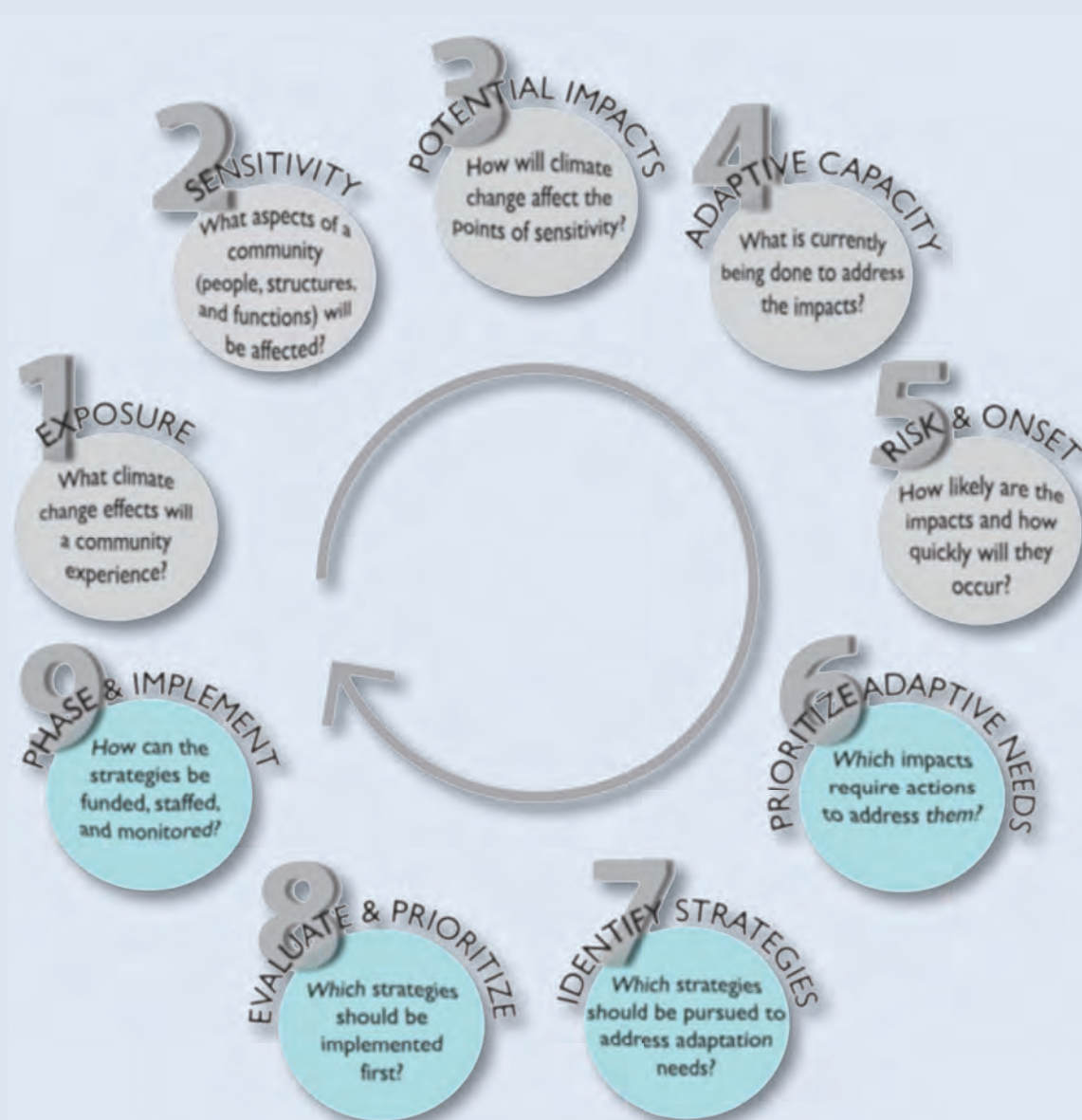


Figure 7: Adaptation process (Planning for Adaptive Communities – California Adaptation Planning Guide 2012^{xiv})

Traditional knowledge and climate Change

There has been increasing recognition in recent years of the significance of Indigenous traditional ecological knowledge and observations as a key source of information about historic climate systems, seasonal weather patterns and events. Torres Strait Islanders have an intimate knowledge of their islands and sea country that is vitally important in allowing them to maintain their culture and livelihoods. Traditional knowledge of seasonal variations, climatic events and natural cycles, built upon over many generations, allows for appropriate decision-making about hunting and harvesting of natural resources to ensure sustainability .

Already islanders are noticing changes in the timing of seasons, rainfall, temperatures and in the behavior of key species^{xvi}. The capacity of Indigenous people to adapt to historic changes in weather patterns (including extreme events and sea level rise) and environmental change associated with natural causes is reasonably well documented. More recently, the application of ancestral and local knowledge in the context of dealing with anthropogenic change has been recognised as a key element in national and international climate change policy development. Traditional knowledge informs community understanding of environmental change, use of natural resources and their worldview, all of which play an important role in how communities adapt to climate change . Incorporation of Indigenous knowledge in climate change adaptation strategies can lead to more cost-effective, locally relevant, sustainable approaches being identified, and increased Indigenous ownership and engagement in culturally appropriate adaptation planning processes and outcomes.

A Traditional Ecological Knowledge (TEK) project is being facilitated by TSRA to support community members and Rangers to record and manage local cultural information. The project will give Rangers the capability to record TEK about climate change in the Torres Strait, including seasonal variations, weather patterns and changes in resource distribution and abundance. The database system will potentially allow for contemporary environmental research and monitoring data for Torres Strait to be depicted geospatially, and considered alongside cultural and historic datasets, providing an additional tool to assist in adaptive planning. The TEK project and the Torres Strait E-Atlas will both improve communities' access to relevant environmental information and data in a user friendly format to support community-based management and adaptive planning.

Action Plan

This action plan provides a systematic and coordinated pathway for responding to climate change in the Torres Strait region over the next five years. It identifies general and targeted actions for adapting to and mitigating climate change impacts, under five key themes: Culture and Traditional Knowledge, Environment and Ecosystems, Settlements and Infrastructure, People and Communities, and Research and Monitoring. There is also a section that identifies supporting communication and capacity building tasks to facilitate effective engagement and delivery of information to communities and stakeholders that can inform decision-making.




The Action Plan complements and builds on existing adaptation and mitigation efforts lead by the TSRA and Queensland Government agencies under the previous 2010–2013 Strategy. It captures those actions that require further progress and identifies important information gaps that need to be filled to inform decision-making.

Progress since 2010




The focus since the Strategy was launched in 2010 has been on procuring critical research and modelling to inform coastal works prioritisation and to progress urgent coastal works. In addition, progress has been made on completing key research required to identify climate risks and to inform adaptation options. Achievements over this period include:

- Down-scaled climate change modelling for the Torres Strait region (*Observed and Future climates of the Torres Strait Region* CSIRO, 2011^{xviii});
- Torres Strait Extreme Sea Level Study^{xix} that provides detailed information on extreme sea levels in the region, factoring in storm surge and climate change (*TSRA 2011*);
- An assessment of renewable energy options and the carbon footprint of the Torres Strait region^{xix};
- Coastal erosion and inundation research on all islands in the Torres Strait, also including flood hazard mapping (*Torres Strait: Climate change driven coastal erosion and inundation*, Parnell *et al.* 2013);
- Establishment of a regional sea surface temperature monitoring program and coral reef monitoring program (funded through the National Environmental Research Program www.nerptropical.edu.au);
- Sand nourishment works at Warraber and Masig Islands;
- Installation of two real-time meteorological and marine monitoring stations with real-time data available remotely (Australian Institute of Marine Science www.aims.gov.au);
- Detailed coastal engineering studies for key communities identify by the coastal works program^{xx,xxi};
- Assessment of the vulnerability of key fisheries to future climate change^{xxii};
- Various research projects investigating climate change impacts on green turtles and seagrass (JCU);
- Adaptation and resilience workshops in Cairns, Masig and Erub (funded through the National Environmental Research Program www.nerptropical.edu.au);
- Torres Strait ocean circulation model developed^{xxiii};
- Mapping and assessment of cumulative impacts on marine and coastal habitats (*Grech et al.* 2012) (JCU); and
- A study into the limits to climate change adaptation for two lying island communities (NCCARF 2012)^{xxvi}.

Status of actions as of December 2013:

-  Action not yet initiated
-  Action initiated but less than 75% complete
-  Action more than 75% complete or finalised






Priority of actions:

-  Action critical to future adaptation/mitigation to climate change
-  Action important to future adaptation/mitigation to climate change
-  Action desirable if possible

* An updated version of this table included more detailed status information can be found at www.tsra.gov.au/...

1. Culture and Traditional Knowledge

Goal: to ensure that mitigation and adaptation options identified respect Ailan Kastom, acknowledge native title rights, and promote cultural maintenance and revitalisation of traditional knowledge, where possible.

Action			Lead agency supporting agencies	Timeframe
1a	Support Rangers and community members to record and access traditional ecological knowledge about climate change in the Torres Strait, including seasonal variations, weather patterns and historic sea levels.		 TSRA	Ongoing
1b	Support Torres Strait communities to access and interpret environmental research and monitoring data, including modelling and mapping of projected climate change and sea level rise scenarios, and to consider this data alongside cultural and historic datasets.		 AIMS, JCU, RRRC, TSRA, Tagai College	Ongoing
1c	Facilitate opportunities for community-based monitoring of climate change impacts on ecosystems and ecosystem services, combining traditional knowledge and science in the training of rangers and students in monitoring techniques.		 AIMS, JCU, TSRA, Tagai College	2015
1d	Identify and document adaptive strategies that island communities have adopted in response to historic climate change or impact events.		 CSIRO, JCU, TSRA	2015
1e	Document traditional knowledge and cultural practices relevant to climatic and seasonal variations to inform adaptation planning.		 TSRA	2015

2.1 Environment and Ecosystems

Goal: to protect the unique natural resources and processes of the Torres Strait region and provide for future generations of Islanders to enjoy and sustainably utilise their environmental assets.

Action			Lead agency supporting agencies	Timeframe
2.1a Map and model climate change sensitivity, known threats, biogeographic characteristics and areas of high value to prioritise investment and management effort (e.g. identify and protect refugia for thermally tolerant coral species that will provide genetic stock for recovery).	☹️	■	AIMS, JCU, TSRA	Dec 2015
2.1b Identify key marine species and ecosystems at risk from climate change, and potential shifts in community composition and distribution.	☹️	■	AFMA, AIMS, JCU, TSRA	Dec 2014
2.1c Identify key terrestrial species (flora and fauna) at risk from climate change, potential shifts in community composition and distribution, and bush fire risk.	☹️	■	CSIRO, JCU, TSRA	2015
2.1d Document potential climate change impacts on coastal ecosystems, including geophysical changes to island profiles due to erosion and sea level rise (in particular coral cays).	☹️	■	DSITIA, JCU, TSRA	2015
2.1e Research institutions and partners coordinate research projects that target species vulnerable to climate change (e.g. corals, fishes, crayfish, marine turtles, dugongs, seagrasses, pelagic foragers) to optimise the effectiveness of resilience-based management.	☹️	■	AFMA, AIMS, CSIRO, JCU, RRRC, TSRA	2016
2.1f Synthesise emerging scientific and traditional knowledge to underpin effective management decisions and improve capacity to adapt to climate impacts.	☹️	■	RRRC, TSRA	2016
2.1g Identify thresholds beyond which climate change causes irreversible damage to vulnerable species (e.g. seabirds, marine turtles, dugongs, corals, fishes and plankton), habitats (e.g. seagrasses, mangroves and pelagic) and processes (e.g. productivity and connectivity).	☹️	■	AFMA, AIMS, CSIRO, DITSIA, DoE, JCU, RRRC, TSRA	June 2015
2.1h Assess and document implications of climate change for terrestrial weeds and feral animal distribution and abundance.	☹️	■	DNRM, TSRA, JCU	2016
2.1i Implement strategies that ensure local fishing and hunting is undertaken in a sustainable way that takes into account the vulnerability of fisheries to climate change and future resource changes.	☹️	■	AFMA, QDAFF, DoE, TSRA, PNG DEC	Dec 2014
2.1j Assess synergies between climate and non-climate stressors on critical processes (such as productivity, connectivity, calcification and recovery potential) and synthesize results as the basis for revising management policies and targets.	☹️	■	TSRA, AFMA, AIMS, JCU, RRRC, CSIRO, DITSIA	2018
2.1k Develop local coastal management plans, including management of boeywadh (berms/dunes) and their vegetation, to reduce possible community impacts and build coastal resilience.	☹️	■	TSRA, TSC, TSIRC	2015
2.1l Investigate the feasibility of utilising a dredge for accessing offshore sand resources for beach re-nourishment.	☹️	■	QTMR, TSRA, TSIRC, TSC	2016

2.2 Environment and Ecosystems – Monitoring

Action			Lead agency supporting agencies	Timeframe
2.2a Establish long-term monitoring program to track climate change related changes to ecosystems and key bio-physical variables and processes (including ground water intrusion, ocean acidification, sea surface temperatures, tides, salinity, shoreline erosion, changes in fauna distribution, abundance, breeding success and behavior, changes in flora composition and distribution, fire frequency, soil moisture and standard meteorological variables).	😊	■	TSRA, JCU, AIMS	Dec 2015
2.2b Monitor regional changes to ocean pH, SST, currents and ocean circulation and likely impacts on marine ecosystems.	😊	■	CSIRO, BoM, TSRA, JCU, AIMS, AMSA	Dec 2014
2.2c Coordinate and implement ecological monitoring that targets species and ecosystems vulnerable to climate change, including turtles, dugong, coral reefs, fisheries species and seagrasses, and can detect change over time.	😊	■	TSRA, JCU, AIMS, AFMA, QDAFF	2015
2.2d Monitor salinity intrusion into groundwater systems on cays and other sites vulnerable to salt water intrusion, including potential changes to island water tables and implications for water supply.	😞	■	TSIRC, DNRM	2015
2.2e Work with partners to develop improved tools (e.g. operational remote sensing products, improved regional projections, predictive models) for predicting, measuring and monitoring effects of climate change on ecosystems and vulnerable species.	😊	■	TSRA, AIMS, BoM, JCU, CSIRO	2016

3.1 Settlements and Infrastructure

Goal: to implement adaption works and strategies that protect existing infrastructure and allow for future climate projections when upgrading or constructing new infrastructure.

Action			Lead agency supporting agencies	Timeframe
3.1a	Finalise Torres Strait Regional Disaster Management Plan and local disaster plans for local communities.	☹️	EMQ, TSC, TSIRC, TSRA	2014
3.1b	Ensure Disaster Management Planning is integrated into regional and local adaptation and resilience planning process.	☹️	TSRA, TSIRC, TSC	2015
3.1c	Develop and implement sustainable land use planning that incorporates hazard mapping, sea level rise and storm surge for new developments in all planning regions.	😊	QDIP, TSC, TSIRC, TSRA, JCU, DSITIA	July 2014
3.1d	Manage boeywadh (berms/dunes) and their vegetation with the intention of building them higher and wider, to ensure that natural defenses against inundation are maintained.	☹️	TSC, TSIRC, TSRA, DNRM	2015
3.1e	Document current housing capacity to withstand cyclonic winds and develop climate-appropriate and culturally sensitive house design.	☹️	QHPW, CSIRO, TSRA	2015
3.1f	Identify and encourage ways of reducing the regional carbon footprint through increased uptake of clean energy and improvements in transport efficiency.	☹️	DTMR, TSRA, Ergon	2016
3.1g	Reduce reliance on desalination through water conservation and efficiency, and alternate technologies.	☹️	TSIRC, TSC, TSRA	2015
3.1h	Where appropriate, manage shorelines for long-term stability and avoid infrastructure placement in vulnerable areas.	☹️	TSRIC, TSC, TSRA, QHPW	2015
3.1i	Secure funding and implement Torres Strait Major Coastal Works program to progress coastal defenses for Saibai, Boigu, Poruma, Iama, Warraber and beach replenishment for Masig.	☹️	TSIRC, TSRA, DIP, DPaC	2017
3.1j	Assess the implications of increased ocean acidity on marine cement infrastructure.	☹️	DSDIP, QHPW	2016
3.1k	Investigate the impacts of climate change on water quality and security, energy demand and water/energy infrastructure.	☹️	TSIRC, Ergon, DSDIP	2015

3.2 Settlement and Infrastructure – Monitoring

Action		Lead agency supporting agencies	Timeframe
3.2a	Monitor sea level, tides and frequency and extent of inundation through installation of a regional network of tide gauges supplemented with tide boards in individual communities.	😊 TSRA, BoM, DSITIA, TSIRC, AMSA	Ongoing

4.1 People and Communities

Goal: to facilitate community adaptation, build community resilience, and encourage efforts to reduce greenhouse gas emissions to enable Torres Strait communities to become more sustainable in the long-term.

Action			Lead agency supporting agencies	Timeframe
4.1a	Queensland Health to partner with research organisations and TSRA to identify specific future health risks associated with climate change in the Torres Strait (e.g. heat-related illness, increased disease incidence, new disease vectors and extreme weather events).	☹️	Queensland Health, CSIRO, JCU, TSRA, ADH	Dec 2014
4.1b	Queensland Health and partners develop appropriate socio-economic programs and services to address impacts on community health and wellbeing caused by, or associated with, climate change.	☹️	Queensland Health, CSIRO, JCU, ADH, TSRA	Dec 2014
4.1c	Investigate the physical and psychological health impacts of frequent coastal inundation events on Torres Strait communities.	☹️	Queensland Health, ADH	2015
4.1d	Work with communities on contingency planning for worst-case sea level rise scenarios.	☹️	TSRA, TSIRC, TSC, NPARC, QHPW, DFAT	2016
4.1e	Undertake regional climate change vulnerability and adaptation assessment, including assessment of adaptation capacity, resilience building, detailed assessment and evaluation of adaptation options over various time horizons.	☹️	TSRA, TSIRC, TSC, NPARC	2015
4.1f	Explore alternative livelihood options (e.g. tourism, aquaculture) to broaden the income base to promote resilience.	☹️	TSRA, CSIRO, JCU, AIMS	2016
4.1g	Benchmark regional and local community resilience in order to help assess the value and impact of adaptation and resilience actions and strategies.	☹️	TSRA, JCU, CSIRO	2015
4.1h	Work with all communities to develop medium-term adaptation plans addressing sea level rise and other potential climate change issues. The process of developing these plans will involve detailed consideration of adaptation options (e.g. seawalls, house raising, levees, filling, relocation, social and cultural programs, emergency planning etc.), as well as social, cultural, economic, and environmental assessment over various time horizons and appropriate risk management and contingency planning.	☹️	TSRA, TSIRC, TSC, NPARC, CSIRO, JCU	2016
4.1i	Facilitate information sessions and adaptation and resilience workshops for each community to build their understanding of climate change, to identify appropriate community-based adaptation options and actions to build local resilience.	☹️	TSRA, TSIRC, TSC, JCU, RRRRC, EMQ	2016
4.1j	Support communities and Councils to identify, adopt and create more sustainable systems, technologies and industries to reduce operational and maintenance costs to Councils, minimise their ecological and carbon footprint and promote increased self-sufficiency.	☹️	TSIRC, TSC, NPARC, Ergon, TSRA, DTMR	Ongoing

Action			Lead agency supporting agencies	Timeframe
4.1k	Promote local water conservation and recycling, waste reduction and recycling and community gardening initiatives.	☹️	TSIRC, TSC, NPARC, TSRA	Dec 2014
4.1l	Identify and encourage ways of increasing energy conservation and efficiency (e.g. installing insulation, applying green building codes, renewable technologies), including installation of alternative and renewable energy sources for Torres Strait communities.	☹️	Ergon, TSRA, TSIRC, TSC, NPARC	2015
4.1m	Encourage linkages between Torres Strait Islands and other Indigenous coastal communities and small island nations globally.	☹️	TSRA, TSIRC, TSC, DFAT, DoE	2017
4.1n	Investigate the implications of increased migration of displaced PNG nationals seeking better food and water security, and a higher standard of living on the natural, economic and social resources of the Torres Strait region.	☹️		2016

4.2 People and Communities – Monitoring

Action			Lead agency supporting agencies	Timeframe
4.2a	Establish monitoring of climate related impacts on health including incidence of heat stress, asthma and allergies, water and food-borne diseases, vector-borne diseases and health impacts of extreme weather events.	☹️	Queensland Health, ADH	2016
4.2b	Establish monitoring and evaluation framework for adaptation actions and strategies.	☹️	TSRA	2015

5 Communication and Capacity Building

Action			Lead agency supporting agencies	Timeframe
5a	Provide communities with the best possible information about likely climate change impacts and scenarios, uncertainties and adaptation options and their advantages and disadvantages.	☹️	TSRA, CSIRO, JCU	2015
5b	Coordinate and synthesise emerging scientific knowledge and traditional knowledge to underpin effective management decisions and improve the capacity to adapt to climate impacts.	☹️	RRRC, TSRA, CSIRO, JCU	2016
5c	Continue to speak out about the vulnerability of Torres Strait communities and ecosystems to the impacts of climate change and the need to minimise greenhouse gas emissions.	☹️	TSRA, TSIRC	Ongoing
5d	Offer training for communities to build their capacity to undertake and implement adaptation and resilience planning.	☹️	TSRA, CSIRO	2015
5e	Develop appropriate climate change communication materials for local and national audiences.	☹️	TSRA, RRRC	2015

References

- ⁱ IPCC [Intergovernmental Panel on Climate Change] (2013) Climate Change 2013: The Physical Science Basis. Working Group I Contribution to the IPCC 5th Assessment Report – Changes to the underlying Scientific/ Technical Assessment (eds Solomon, S. et al.) Cambridge Uni Press, Cambridge, UK, and New York.
- ⁱⁱ Torres Strait NRM Reference Group (2005) Land and Sea Management Strategy for Torres Strait. www.tsra.gov.au.
- ⁱⁱⁱ Torres Strait Regional Authority (2009) Torres Strait Development Plan 2009-2013. www.tsra.gov.au.
- ^{iv} Standards Australia (2004) Risk Management AS/NZS 4360.
- ^v Suppiah, R., Bathols, J., Collier, M., Kent, D. and O’Grady, J. (2010) Observed and future climates of the Torres Strait region. CSIRO report for the Torres Strait Regional Authority. www.tsra.gov.au.
- ^{vi} [Australian] Bureau of Meteorology and CSIRO (2011) Climate Change in the Pacific: Scientific Assessment and New Research. Volume 1: Regional Overview. Volume 2: Country Reports, 273 p.
- ^{vii} Knutson, T.R., McBride, J.L., Chan, J., Emanuel, K., Holland, G., Landsea, C., Held, I., Kossin, J.P., Srivastava, A.K. and Sugi, M. (2010) Tropical cyclones and climate change. *Nature Geoscience*, 21: 157-163.
- ^{viii} Parnell, K.E., Smithers, S.G. and Ischenko, L. (2012) Understanding climate change driven coastal erosion and inundation impacts on Torres Strait communities and the development of adaptation options. Report for the Department of Climate Change and Energy Efficiency, Australia.
- ^{ix} Harper, B. 2011. Torres Strait Extreme Water Level Study. Systems Engineering Australia. www.tsra.gov.au.
- ^x Climate Commission Secretariat (2013) The Critical Decade: Extreme Weather. Department of Climate Change and Energy Efficiency, Australian Government, Canberra, 12 p.
- ^{xi} Australian Human Rights Commission (2008) Native Title Report, Aboriginal and Torres Strait Islander Social Justice Commissioner Report No 2/2009.
- ^{xii} Schroter and the ATEAM consortium (2004) Global Change Vulnerability – Assessing the European Human-Environment System. Potsdam Institute for Climate Impact Research, Potsdam, Germany.
- ^{xiii} Schneider, S.H., Semenov, S., Patwardhan, A., Burton, I., Magadza, C.H.D., Oppenheimer, M., Pittock, A.B., Rahman, A., Smith, J.B., Suarez, A. and Yamin, F. (2007) Assessing key vulnerabilities and the risk from climate change. p 779–810. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (Eds) Cambridge University Press, Cambridge, UK.
- ^{xiv} California Adaptation Planning Guide 2012, http://resources.ca.gov/climate_adaptation/docs/1APG_Planning_for_Adaptive_Communities.pdf.
- ^{xv} Green, D., Alexander, L., McInnes, K., Church, J., Nicholls, N. and White, N. (2010) An assessment of climate change impacts and adaptation for the Torres Strait Islands, Australia. *Climatic Change*, 102: 405-433.
- ^{xvi} McNamara, K.E., Smithers, S.G., Westoby, R. and Parnell, K. 2011. Limits to climate change adaptation for low-lying communities in the Torres Strait. Final report to the National Climate Change Adaptation Research Facility.
- ^{xvii} Leonard, S., Parsons, M., Olawsky, K. and Kofo, F., The role of culture and traditional knowledge in climate change adaptation: Insights from East Kimberly, Australia. *Global Environmental Change*, 23 (2013) 623-632.
- ^{xviii} Suppiah, R., Bathols, J., Collier, M., Kent, D. and O’Grady, J., Observed and Future Climates of the Torres Strait Region. CSIRO. www.tsra.gov.au.
- ^{xix} Centre for Appropriate Technology, 2012. Torres Strait - Options to Reduce Regional Carbon Footprint. www.tsra.gov.au.
- ^{xx} AECOM, 2012, Inundation Management on Saibai, Boigu and Ima Islands – Drainage and Seawalls. www.tsra.gov.au.
- ^{xxi} AECOM, 2011, Poruma Seawall Feasibility Study. www.tsra.gov.au.
- ^{xxii} Welch, D and Johnson, J., 2013. Assessing the vulnerability of Torres Strait fisheries and supporting habitats to climate change. www.afma.gov.au.
- ^{xxiii} Wolanski, E., Lambrechts, J., Thomas, C., Deleersnijder, E., 2013. The net water circulation through Torres Strait. *Continental Shelf Research* 64 (2013) 66-74.

Acronyms

ADH	Australian Department of Health
AFMA	Australian Fisheries Management Authority
AIMS	Australian Institute of Marine Science
AMSA	Australian Maritime Safety Authority
BoM	[Australian] Bureau of Meteorology
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DoE	[Australian] Department of Environment
DEHP	[Queensland] Department of Environment and Heritage Protection
DFAT	[Australian] Department of Foreign Affairs and Trade
DNRM	[Queensland] Department of Natural Resources and Mines
DSDIP	[Queensland] Department of State Development, Infrastructure and Planning
DSITIA	[Queensland] Department of Science, Information Technology, Innovation and the Arts
EMQ	Emergency Management Queensland
EMS	Environmental Management System
IPCC	Intergovernmental Panel on Climate Change
JCU	James Cook University
LSMU	[TSRA] Land and Sea Management Unit
MTSRF	Marine and Tropical Sciences Research Facility
NCCARF	National Climate Change Adaptation Research Facility
NPARC	Northern Peninsula Area Regional Council
PNG DEC	Papua New Guinea Department of Environment and Conservation
QDAFF	Queensland Department of Agriculture, Fisheries and Forestry
QHPW	Queensland Department of Housing and Public Works
QTMR	Queensland Department of Transport and Main Roads
RRRC	Reef and Rainforest Research Centre
TEK	[TSRA] Traditional Ecological Knowledge
TSC	Torres Shire Council
TSIRC	Torres Strait Island Regional Council
TSRA	Torres Strait Regional Authority

Notes

