UNIVERSITY OF TECHNOLOGY SYDNEY

INSTITUTE FOR SUSTAINABLE FUTURES &
WORLD HEALTH ORGANIZATION COLLABORATING CENTRE FOR NURSING MIDWIFERY AND HEALTH DEVELOPMENT

PROJECTED CLIMATE CHANGE IMPACTS IN THE PACIFIC

2012

Institute for Sustainable Futures
WORLD HEALTH ORGANIZATION COLLABORATING CENTRE FOR NURSING, MIDWIFERY & HEALTH DEVELOPMENT
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Projected Climate Change Impacts in the Pacific

Prepared for: National Climate Change Adaptation Facility (NCCARF)

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EXECUTIVE SUMMARY

Climate change is expected to have significant implications on emergencies and disasters in the Pacific. Observations of altered climate and weather patterns are already happening in Pacific Island Countries (PICs) and are expected to continue in coming years, potentially changing the face of emergencies and disasters.

Detailed scientific projections for the Pacific were released in 2011 and are summarised in this report. Projections of warming temperatures, rising sea levels and more acidic oceans are generally consistent across the Pacific region, while those for rainfall, drought and tropical cyclones carry greater regional variation and higher degrees of uncertainty. All climate change projections are highly dependent on which emission scenario is selected for projections.

This report also highlights the context in which the research is situated, including:

- the breadth of expected climate change impacts;
- the criticality of emergency assistance;
- issues of climate change and health;
- the need for enhanced adaptive capacity;
- the need for commitment to addressing climate change impacts and
- the need for better climate information.

Next steps of the research will involve stakeholder consultation with the Pacific emergency and disaster response sector, with particular focus on current capacity and their potential to adapt to changing conditions as a result of climate change. The aim is to produce research outcomes that provide the means for practitioners and policy makers to enhance their adaptive capacity to climate change in Pacific disaster management.

1 INTRODUCTION

1.1 THIS RESEARCH

This report is part of a broader research project focused on the adaptive capacity of Pacific Island Countries (PICs) and Australia's emergency response to disasters in the Pacific in the face of climate change. Climate change impacts are likely to affect global stability, health, resources and infrastructure. In the Pacific, the impacts of climate change are expected to be severe, particularly the possibility of increased frequency and intensity of extreme events.

This research project is conducted through a partnership of two leading institutes from the University of Technology Sydney (UTS) – the Institute for Sustainable Futures (ISF) and the World Health Organization Collaborating Centre (WHO CC), and funded by the National Climate Change Adaptation Research Facility (NCCARF).

The research seeks to understand the adaptive capacity of both PICs and Australia's emergency response to a potential increase in disasters driven by climate change in PICs.

With a focus on the immediate humanitarian needs post-disaster, including health care; food and nutrition; water and sanitation and psychosocial needs, the primary objectives of the research are:

- To provide recommendations to policy makers and practitioners in the Pacific and Australian disaster and emergency response sectors on current adaptive capacity of PICs to climate related disasters (e.g. tropical cyclones, floods, droughts, storm surge), and identify the resources, policies and systems needed in the coming years to enhance this capacity;
- To inform improved planning and more effective response through analysis of the Australian emergency services and related organisations' capacity, role and obligations to assist PICs in times of disaster

1.2 THIS REPORT

The purpose of this report is to set the context of climate change in the Pacific by outlining some of the implications of climate change to the people of PICs and in turn, for Australian emergency response systems. This report also summarises the latest science on how the Pacific climate is projected to change over coming years as a result of climate change.

1.3 SETTING THE CONTEXT

Several factors are important to consider in the context of the PICs, climate change and expected impacts, and emergency response:

Breadth of the expected impacts of climate change: PICs are inherently vulnerable to climate change given their small size, insularity and remoteness and limited disaster mitigation capacity (Pelling and Uitto, 2001; Kaly et al., 2002; Meheux et al., 2007) with implications likely across social, economic, environmental and importantly health contexts.

Social impacts of climate change in the Pacific are likely to include implications for water and food security (Government of Tuvalu, 2011); and land rights issues and migration (Farbotko, 2010). Economic impacts are likely to have severe consequences on infrastructure (MNRE, 2005), tourism (Farbotko, 2010) and exports and imports (FAO,

2008). The environmental impacts of climate change have implications for flora and fauna, with seasonal changes in temperature and rainfall threatening the timing and shifts in species across the region (Hoegh-Guldberg et al. 2009). Corals are increasingly stressed as a result of warmer temperatures, more acidic conditions and sea level rise, with sea grasses, mangroves and coastal environments – all key ecosystems in the Pacific – also highly vulnerable (Eakin et al., 2009).

Impacts of climate change on health and well-being will inevitably affect the basic human health needs (clean air and water, food, nutrition and adequate shelter), challenges to the control of infectious diseases, and subsequent health impacts from acute shocks such as natural disasters or epidemics (WHO, 2009). The above-mentioned shifts, both in terms of trends and shocks, threaten the very existence of traditional cultures of the people of the Pacific, many of whom live subsistence lifestyles.

Criticality of external assistance: In many instances, developing countries like PICs will require the assistance of developed countries in meeting the costs of adaptation and emergency response (Maclellan 2011). Many small island developing states may lack the resources and personnel, resulting in poor or unachievable preparedness. In many cases, this results in dependence upon international collaboration for emergency response and management in the face of large-scale disasters (Bar-Dayan 2008). Climate change therefore challenges Australia's significant investment in development in PICs, including in response to emergencies. The UNFCCC has committed several developed countries to provide assistances, as well as several other bilateral agreements exist, such as Australia's International Climate Change Adaptation Initiative (ICCAI) and Australia's International Climate Change Adaptation Initiative (ICCAI) and International Forest Carbon Initiative (IFCI).

However, PICs report that they still encounter major obstacles in accessing sufficient resources to address the adverse effects of climate change on their food security, water supply, coastal management and public health (Maclellan 2011). In the case of PICs, key humanitarian and disaster response agencies work in collaboration with the respective national authorities to prepare and respond to emergencies and climate related disasters. These include mechanisms to coordinate general aspects of disaster response in the region and mechanisms to coordinate the more specific health aspects of disaster response (Thompson et al. 2011).

Climate change and health: The World Health Organization suggests that the impacts of current and future emergency and disasters could be reduced if the health sector takes the necessary steps to define integrated measures that address the root causes of vulnerability, and plan for effective emergency and disaster responses (Campbell-Lendruma et al. 2007). While there is growing political commitment to integrate health considerations into climate change mitigation and adaptation efforts at national and regional levels, these are still limited in the Pacific region (WHO/SEARO 2007).

Adaptive capacity is needed: The ability for political and social systems to adapt and respond to climate-related changes depends upon their adaptive capacity, and is a function of vulnerability and existing levels of resilience. According to Brooks and Adger (2004): "*Adaptive capacity is the ability to design and implement effective adaptation strategies, or to react to evolving hazards and stresses so as to reduce the likelihood of the occurrence and/or the magnitude of harmful outcomes resulting from climate-related hazards.*" (Brooks & Adger 2004:168).

Commitments to address climate change in PICs: The Pacific Islands Forum meeting in Cairns in 2009, called for immediate action to address climate change issues, because if left unaddressed the threats from climate change may further aggravate conflicts over increasingly scarce resources in PICs (UNDP 2009). The governments of Asia and the Pacific region have therefore agreed that there is an urgent need for incorporation of health concerns in inter-sectoral plans for mitigation and adaptation to climate change

Availability of new information on predicted climate changes in Pacific: Limited scientific information (data and scientific studies) in the Pacific has in the past restricted our understanding of potential Pacific climate changes (Australian Bureau of Meteorology and CSIRO, 2011). The Pacific Climate Change Science Program (PCCSP) – a partnership between Australian science organisations and partner Pacific countries and regional organisations is addressing the urgent need for better scientific knowledge and country specific projections for Pacific Island Countries (PICs).

This summary draws from PCCSP country reports released in 2011, in addition to other relevant references to provide the projected changes in the coming years. A map of the Pacific (Figure 1) is provided to further provide context.

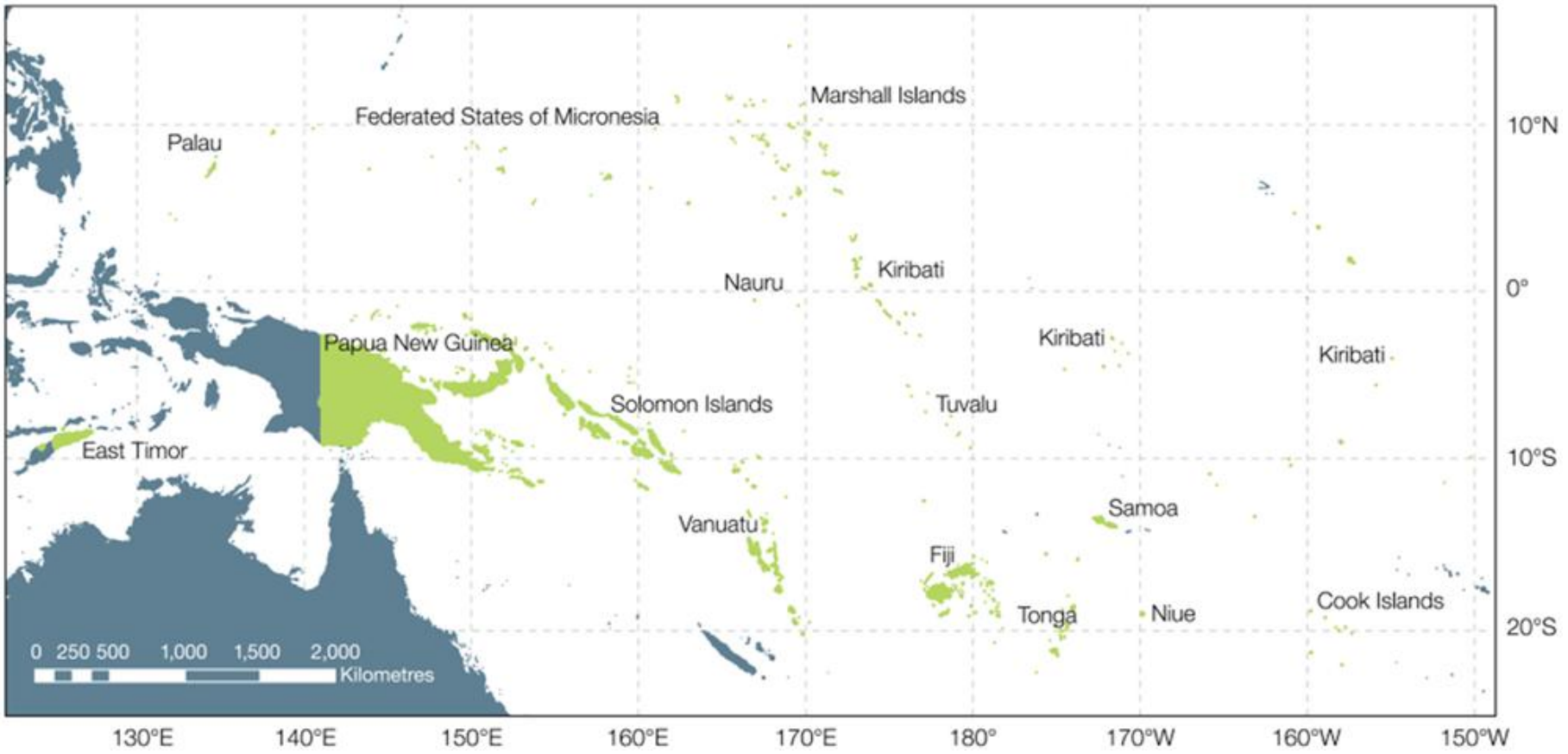

Figure 1: Map of the Pacific

(Source: Australian Bureau of Meteorology & CSIRO, 2011)

1.4 SUMMARY OF PACIFIC CLIMATE CHANGE PROJECTIONS

A summary of significant future projections, relevant across the Pacific region, is listed below.

Table 1: **Summary of Pacific climate change projections**

TEMPERATURE	Increase in average temperatures across the region More very hot days, less cool weather
RAINFALL	More extreme rainfall days; some regional reductions in drought frequency
TROPICAL CYCLONES	Less frequent tropical cyclones Some regional increases in proportion of intense storms
SEA LEVEL RISE	A rise in sea level across the region

(Source: Australian Bureau of Meteorology & CSIRO, 2011)

2 CURRENT CLIMATE OF THE PACIFIC

To gain an understanding of potential climate changes in the region, it is important to consider the major features defining the current climate of the Pacific. Weather events during the tropical cyclone season cause a significant proportion of disasters in the Pacific via their destructive nature (extreme winds, flooding, storm surge and high seas, landslips, erosion and related impacts). Average climatic conditions for the Pacific in November to April are shown in Figure 2, representing the wet / tropical cyclone season for the region. Figure 2 highlights relevant features of the regional climate during this season, including the Inter-tropical and South Pacific Convergence Zones (blue shading), where converging moist air masses result in high rainfall. Yellow arrows represent near surface winds, while the West Pacific Warm Pool – a region of warm sea surface water is shown in red dashed oval. Sub-tropical high pressure zones are also seen. This figure provides the baseline upon which climate change is occurring.

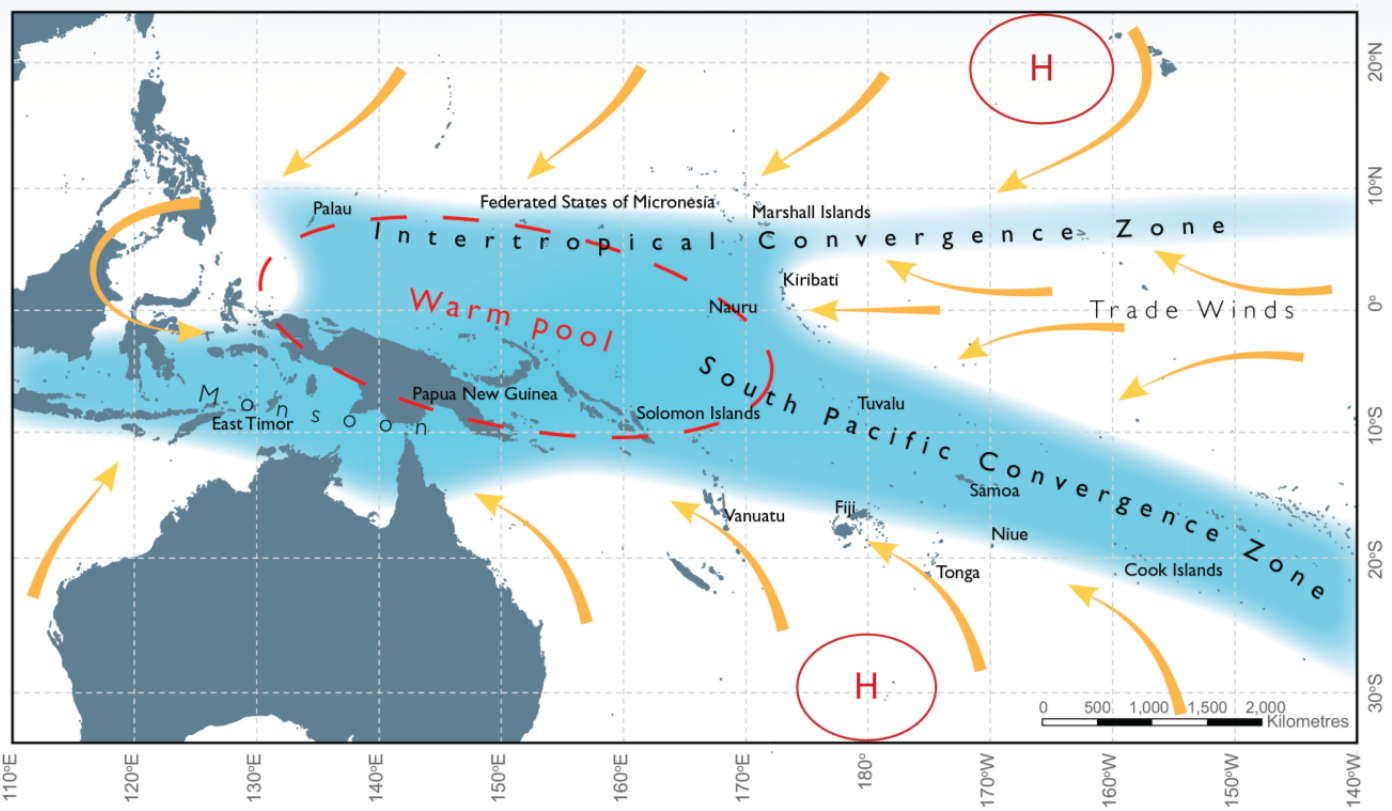

Figure 2: The average positions of the major climate features in November to April.
(Source: Australian Bureau of Meteorology & CSIRO, 2011)

3 PACIFIC CLIMATE CHANGE PROJECTIONS

This section outlines projections for temperature, rainfall, severe weather, sea level rise and ocean acidification for PICs.

3.1 TEMPERATURE

In line with global temperature trends, average temperatures across the Pacific region have increased over the second half of the 20th century, with more frequent hot days and less frequent cool nights (Australian Bureau of Meteorology & CSIRO, 2011). **A continuation of this warming trend is expected** across the Pacific region. The extent of warming is dependent on the emission scenario model used. See Figure 2 for the projected temperature ranges for the low and high emissions scenarios for 2030 and 2090[1].

Each vertical grey bar in Figure 3 represents the uncertainty range for each single PIC (seen in Figure 1) in terms of projected temperature increase. For the low emissions scenario (light grey), this Figure shows there is to be little variation in projected temperature trends across the Pacific (short length of the grey bars), and little increase from 2030 to 2090. The high emissions scenario (dark grey) shows a larger uncertainty range, as the vertical bars are longer. This scenario also shows a much greater projected increase in temperature from 2030 to 2090, from around 1.5°C in 2030 to approximately 2.75°C in 2090. It is also worth mentioning that nearer term climate projections are likely to be more accurate, as uncertainty increases with time.

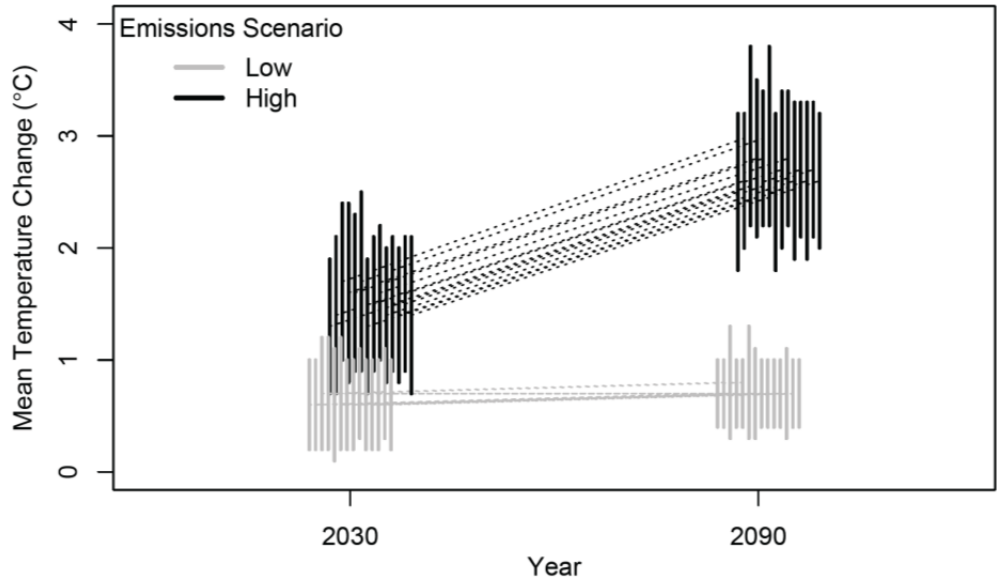

Figure 3: Projected temperature ranges for high and low emission scenarios for 2030 and 2090.

(Source: Australian Bureau of Meteorology & CSIRO, 2011)

[1] Emission scenarios were developed by the Intergovernmental Panel on Climate Change (IPCC) to represent different scenarios of demographic, social, economic, technological and environmental developments which drive greenhouse gas emissions and therefore different outcomes (IPCC, 2000). The Low Emission Scenario represents a best case outcome, while the High Emission Scenario represents a worst case outcome in terms of greenhouse gas emissions and resulting climate changes.

3.2 RAINFALL

Rainfall projections are inherently more difficult to make than those for temperature, being more complex in input variables and resulting in inconsistent and uncertain model results. On a global scale, average annual and seasonal rainfall is projected to increase over the 21st Century (Australian Bureau of Meteorology & CSIRO, 2011). This comes as a result of the enhanced hydrological cycle driven by human-induced climate change, as a warmer lower atmosphere is capable of storing more water vapour (Bindoff et al. 2007; Emori and Brown 2005; Meehl et al. 2007; Trenberth et al. 2007).

El Nino Southern Oscillation (ENSO) plays a major role as a driver of year-to-year variability of weather and climate in the Pacific region, with El Nino and La Nina events significantly affecting rainfall patterns and temperature (Australian Bureau of Meteorology & CSIRO, 2011). Currently, there is no consistency of projections of frequency and intensity of ENSO events from Global Climate Models, however scientists predict that in El Nino affected countries, the warming trends will be higher than trends experienced in the past (Australian Bureau of Meteorology & CSIRO, 2011).

A projected intensification of the South Pacific Convergence Zone, the West Pacific Monsoon and the Inter-tropical Convergence Zone are likely to result in wet season and dry season increases in rainfall in some countries (Australian Bureau of Meteorology & CSIRO, 2011).

While limited rainfall projection certainty due to inconsistent model results exists for most of the Pacific, some specific projections for rainfall are listed in Figure 4, with implications for agriculture, health outcomes, tourism and the overall resilience of people living in PICs.

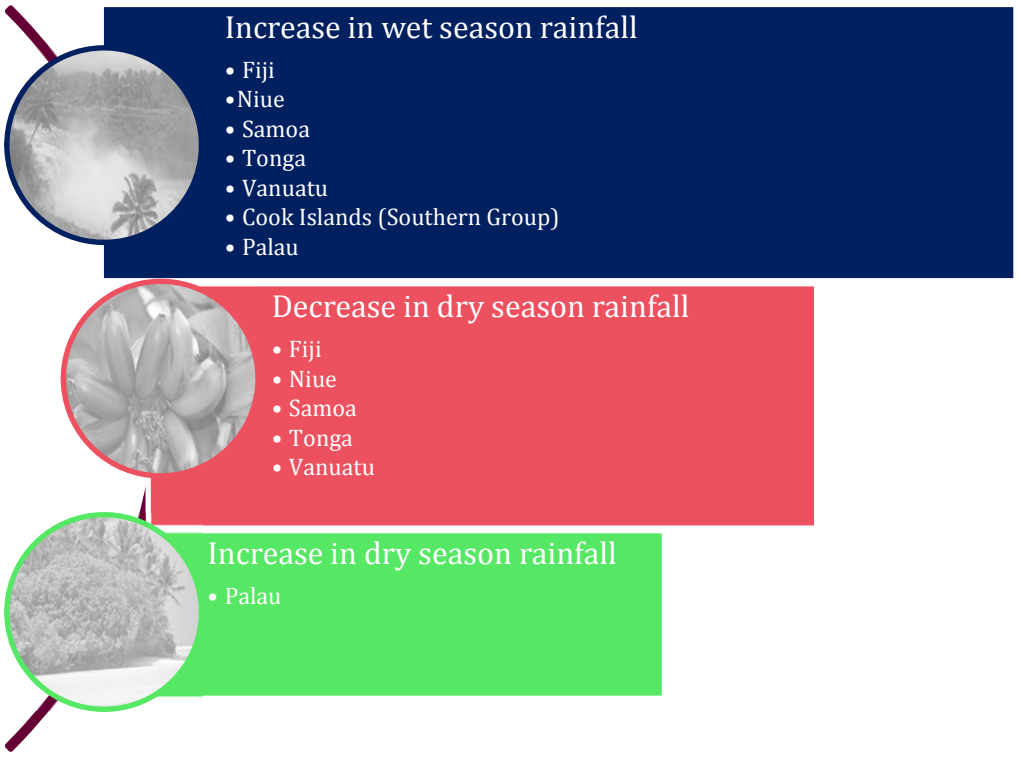

Figure 4: Projected changes in rainfall for some PICs.
(Source: Australian Bureau of Meteorology & CSIRO, 2011)

3.3 SEVERE WEATHER

Across the Pacific region, **an increase in extreme rainfall days is likely**, driven by the enhanced hydrological cycle (Australian Bureau of Meteorology & CSIRO, 2011). This in turn can cause flash flooding, damage to crops and infrastructure, erosion and inundation. In terms of drought frequency, limited certainty exists for most regions; however there is some agreement for those countries expected to have less frequent drought events. See Figure 5 for details.

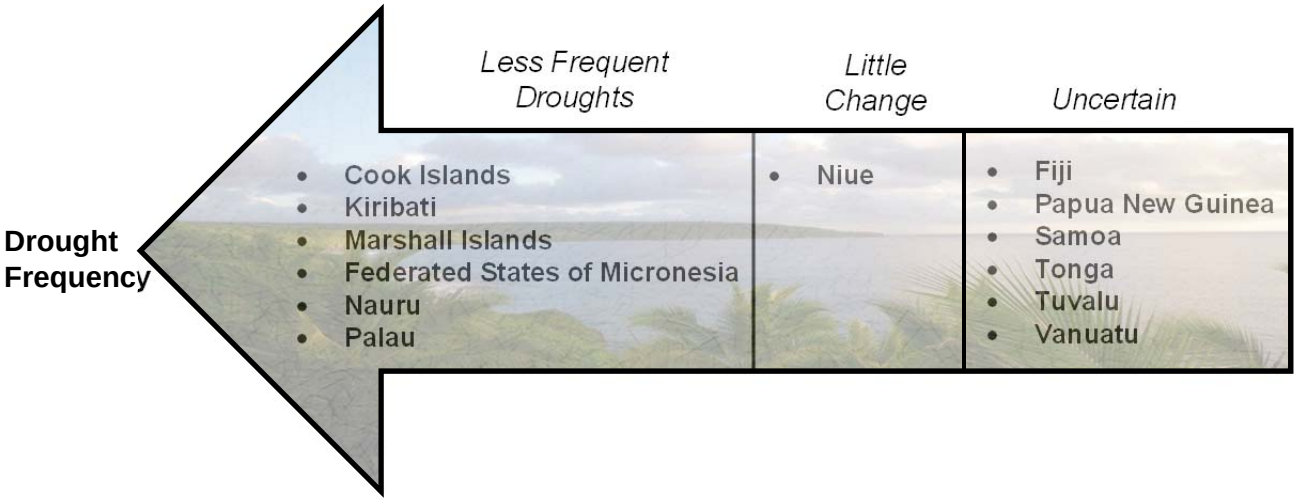

Figure 5: Projected change in drought frequency.
(Source: Australian Bureau of Meteorology & CSIRO, 2011)

Globally, tropical cyclone frequency is likely to decrease by the end of the 21st century. A warmer climate, however, is likely to drive an increase in average maximum wind speed of tropical cyclones between 2-11% (Australian Bureau of Meteorology & CSIRO, 2011). Rainfall intensity within 100km of the centre of the cyclone is also likely to increase in intensity by 20% (Australian Bureau of Meteorology & CSIRO, 2011).

Projections for tropical cyclone frequency for the Pacific follow global trends – i.e. **less frequent tropical cyclones** by the end of the 21st century. However, there is an expected change in the relative **proportion of severe storms**. Some countries will experience a greater number of severe storms, while for others, the proportion of severe storms will decrease, as shown in Figure 6.

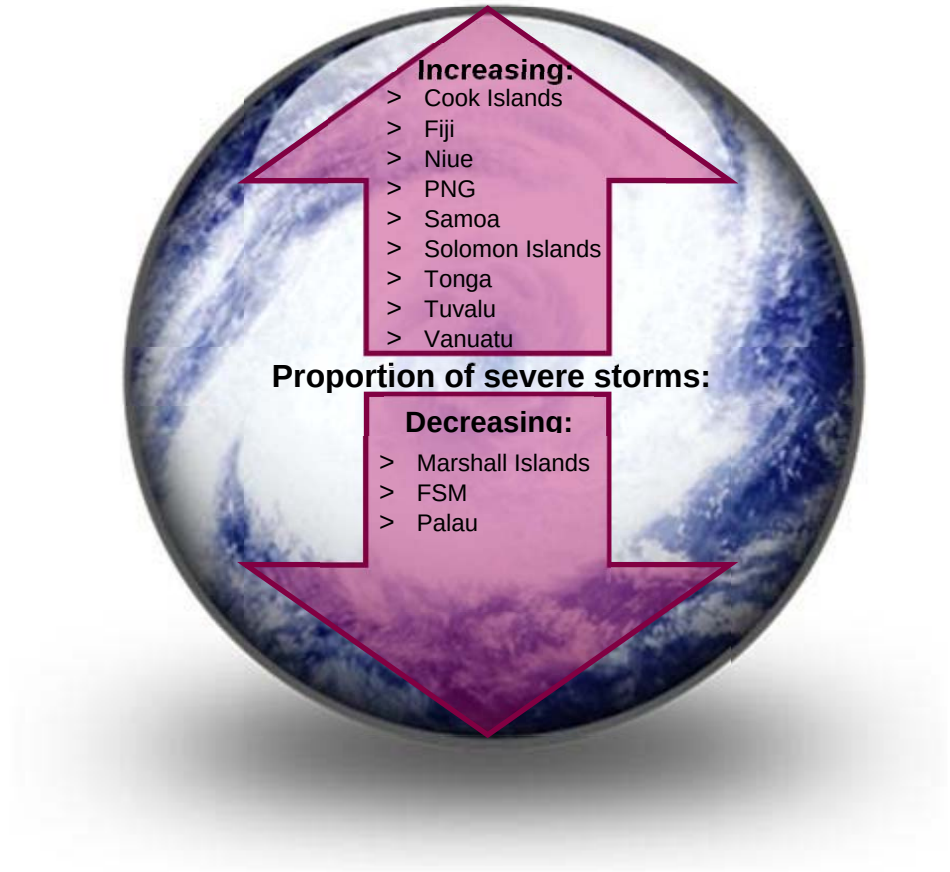

Figure 6: Expected change in the proportion of severe storms.

Note: Kiribati and Nauru are excluded given their proximity to the equator and general lack of tropical cyclone risk. Source: Australian Bureau of Meteorology & CSIRO, 2011. FSM: Federated States of Micronesia

3.4 SEA LEVEL RISE

Sea level rise (SLR) is expected to **continue its increasing trend**, the rate dependent on the emission scenario drawn upon in the climate models. SLR occurs concurrently with natural variability driven by El Nino Southern Oscillation (ENSO) circulation and can be highly locally specific in magnitude. See Figure 6 for specific projections for both low and high emission scenarios for 2030 and 2090.

As for Figure 3, each vertical grey bar in Figure 7 represents the uncertainty range for each PIC, this time in terms of projected SLR. For both the low and high emissions scenarios, this Figure shows there to be little variation in projected SLR trends across the Pacific in 2030, with both the trends overlapping considerably. In 2090, the uncertainty range (length of the vertical bars) is much greater, and as is expected, the projections are much higher for the high emissions scenario (dark grey). The reason for similarity of projected SLR for the low and high emissions scenario in 2030 is due to the length of time the ocean takes to warm compared to the air, with thermal expansion of ocean water the predominant cause of rising sea levels (Trenberth et al. 2007). It is important to note that SLR projections are based on a conservative estimate of temperature increase (2C°), and some scientists are calling for more urgent action to better communicate the risks of dangerous SLR that may occur as temperature projections increase beyond 2°C (Hansen, 2007).

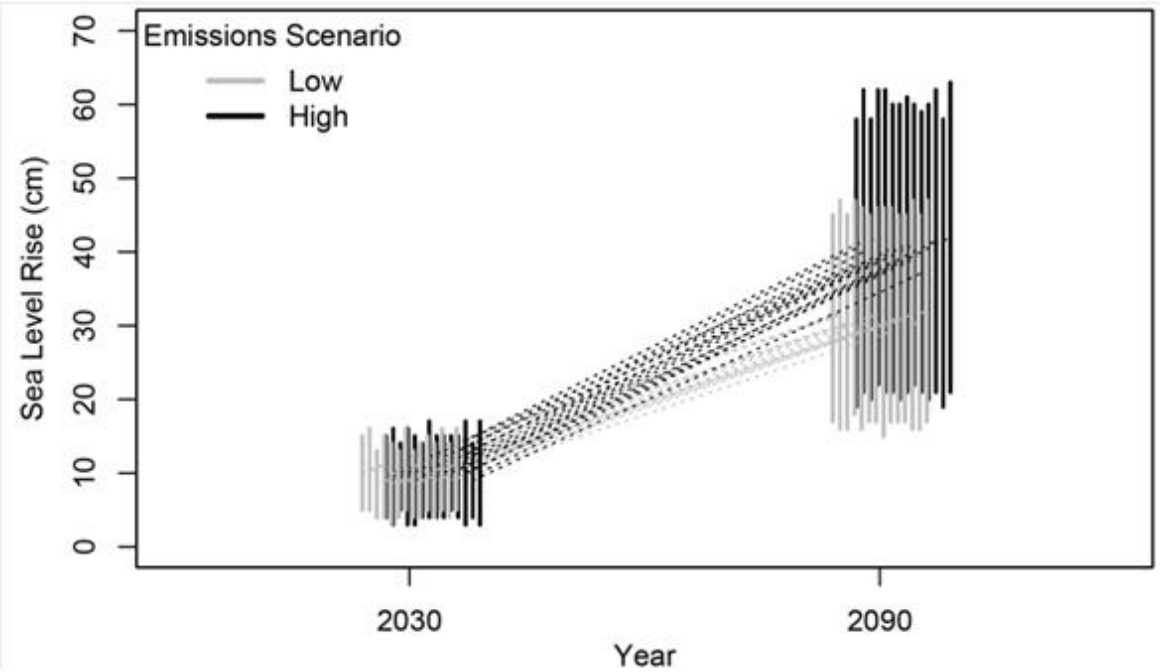

Figure 7: Projected sea level projections for high and low emission scenarios for 2030 and 2090.

(Source: Australian Bureau of Meteorology & CSIRO, 2011)

3.5 OCEAN ACIDIFICATION

The acidification of the ocean is occurring as higher concentrations of carbon dioxide from the atmosphere are absorbed and dissolved by ocean waters, leading to a greater amount of carbonic acid present in the ocean. Implications of ocean acidification include degradation of the reef system health, which may be particularly severe if occurring alongside coral bleaching, storm damage and overharvesting of fish (Australian Bureau of Meteorology & CSIRO, 2011).

4 SUMMARY AND CONCLUSION

It is clear from this recent scientific information on climate change in the PICs that there is cause for concern about changed patterns of disasters. Table 2 provides an overall summary of the projected climate changes for the Pacific, both in terms of regional wide projections and those varying across the PICs.

Table 2: Climate projections for the Pacific.

	CONSISTENT PROJECTIONS ACROSS PACIFIC REGION	VARIABLE PROJECTIONS ACROSS PACIFIC REGION
TEMPERATURE	o Increase in average air temperature o Increase in average sea surface temperature o Increase in number of hot days and warm nights o Decline in cool weather	o Temperature increase vary slightly across the region (see Figure 1)
RAINFALL	o Extreme rainfall days more likely across the region	o Rainfall changes: more difficult to predict and dependent on region o Drought predictions vary – generally predicted to be less frequent or inconsistent model results
TROPICAL CYCLONES	o Decrease in frequency of tropical cyclones by late 21st C	o Variable change of proportion of intense storms
SEA LEVEL RISE	o Increase in sea level across region	o Variable rate of sea level rise, combined with natural variability (see Figure 2)
OCEAN ACIDIFICATION	o Acidity will increase, greatest with high emission scenarios	

Source: Australian Bureau of Meteorology & CSIRO, 2011.

Table 3 provides more detail with projections for each of the variables described for each PIC.

Table 3: Specific climate projections for PICs.

PIC	Temp. Projection (increase in °C)*		Rainfall Projection	Drought	Tropical Cyclone (expected change in proportion of severe storms)	Sea Level Rise (increase in cm)*	
	2030	2090				2030	2090
Cook Islands	1	3.2	Incr. wet season (Southern Group)	Less frequent	Increasing	15	58
Fiji	1	3.2	Incr. wet season Decr. dry season	Uncertain	Increasing	16	62
Kiribati	1.3	3.8		Less frequent	N/A	14	58
Marshall Islands	1	3.5		Less frequent	Decreasing	16	62
FSM	1	3.4		Less frequent	Decreasing	15	62
Nauru	1.3	3.8		Less frequent	N/A	14	60
Niue	1.1	3.2	Incr. wet season Decr. dry season	Little change	Increasing	17	60
Palau	1	3.4	Incr. wet season Incr. dry season	Less frequent	Decreasing	15	61
Papua New Guinea	1	3.4		Uncertain	Increasing	15	60
Samoa	1	3.3	Incr. wet season Decr. dry season	Uncertain	Increasing	15	59
Solomon Islands	1	3.3			Increasing	15	60
Tonga	1.1	3.3	Incr. wet season Decr. dry season	Uncertain	Increasing	17	62
Tuvalu	1	3.3		Uncertain	Increasing	14	58
Vanuatu	1	3.2	Incr. wet season Decr. dry season	Uncertain	Increasing	17	63

Source: Australian Bureau of Meteorology & CSIRO, 2011.

* Note for both temperature and SLR, projections pertain to the high end of the high emission scenario, thus represent “worst case” or the biggest change in climate conditions. Blank cells represent lack of data.

This report sets the context for the broader research project which focuses on the adaptive capacity of Pacific Island Countries (PICs) and Australia's emergency response to disasters in the Pacific in the face of climate change. As described in this report, the climate of PICs is projected to change considerably over the coming years, in terms of temperature, rainfall, severe weather, sea level rise and ocean acidification – all of which affect the adaptive capacity of PICs. In turn, these changes will have implications for emergency and disaster response of PICs and in Australia.

Several multilateral and government agencies in PICs are involved in climate change mitigation and adaptation planning and several policies have been developed (Urbano et al. 2010). However, there is need for an understanding of what currently exists, who are the actors and institutions involved, what the gaps are and where there is need for collaboration for more effective response to address basic human needs. With the foregoing in mind, there is an obvious need to clearly understand the existing adaptive capacity of PICs and how this will influence their response to climate related disasters/emergencies.

The next steps of the research involve analysis of stakeholders involved in Pacific emergency and disaster response, with particular focus on current capacity and their potential to adapt to changing conditions as a result of climate change. Four PICs will become the focus for more detailed analysis, with in-depth research being conducted to better understand the specific situations in each country. The aim is to produce research outcomes that provide the means for practitioners and policy makers to enhance their adaptive capacity to climate change in Pacific disaster management.

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