
Overview of Climate Change Impacts on Human Health in the Pacific Region

Report to:

COMMONWEALTH OF AUSTRALIA

Department of Climate Change and Energy Efficiency

Prepared by:

Dr E.G. Hanna: RN, RCCN, BA (Hist & Phil of Sc), MPH, PhD , FRCNA; Convenor Climate Change Adaptation Research Network – Human Health.

Associate Professor D. Harley: BSc (Zoology, Hons I), MBBS, PhD, FAFPHM, MMedSc (Clin Epid); Associate Professor of Epidemiology.

Ms C. Xu: BA (Intel Journalism), MPH, Research Assistant.

Professor A.J. McMichael: MBBS, PhD; Professor of Population Health, and NHMRC Australia Fellow.

National Centre for Epidemiology & Population Health
College of Medicine, Biology & Environment
Australian National University



1 December, 2011



Australian Government

**Department of Climate Change
and Energy Efficiency**

AusAid



© Commonwealth of Australia 2012

ISBN 978-1-922003-96-6

This report was supported by funding from the Australian Government under the Pacific Australia Climate Change Science and Adaptation Planning (PACCSAP) program.

The material in this publication is provided for general information only, and on the understanding that the Australian Government is not providing professional advice. Before any action or decision is taken on the basis of this material the reader should obtain appropriate independent professional advice.

Contents Page

Contents Page	3
ACKNOWLEDGEMENTS	5
EXECUTIVE SUMMARY	6
KEY FINDINGS	7
Glossary of terms	8
Key definitions	9
SCOPE OF SERVICES.....	10
KEY QUESTIONS.....	11
METHODS.....	12
Part 1: CONTEXT OF CLIMATE CHANGE IN THE PACIFIC REGION.....	14
1.1 Current Knowledge and Understanding.....	14
1.2 Introduction.....	15
1.3 Existing Health Challenges	23
1.3.1 Health Status	23
1.3.2 Non-communicable diseases.....	26
1.3.3 Communicable Diseases.....	29
1.3.4 Population and demographics	31
1.3.5 Health Infrastructure.....	32
1.4 Projections.....	40
Part 2: CLIMATE CHANGE IMPACTS ON HUMAN HEALTH	43
2.1 Extreme weather events and disasters.....	45
2.1.1 Heat Waves	47
2.1.2 Storms and cyclones.....	52
Case Study 1 – Cyclone Heta Niue.....	52
2.1.3 Coastal Inundation	55
2.1.4 Flooding.....	56
2.2 Vector-borne Infectious Disease.....	58
Case Study 2 - Malaria in Papua New Guinea	60
2.3 Food Security and Food-borne disease.....	62
2.3.1 Food-borne Disease.....	65
Case Study 3 - Food Security and Child Health.....	65
Food insecurity – a climate change risk	66
Food insecurity through economic vulnerability.....	67
Child health	69
Climate and food and health.....	71
2.4 Water security, Water-borne Disease and Sanitation	73
2.4.1 An overview of water supply issues in the Pacific Island Nations.....	74
2.4.2 An overview of water-borne disease and sanitation in the Pacific.....	75
2.5 Chronic (non-communicable) Health Conditions.....	81
Part 3: IDENTIFIED CHALLENGES AND HEALTH INTERVENTIONS.....	85
3.1 Challenges and Gaps	85
3.2 Recommendation for health interventions	86
3.2.1 Recommendation 1: Research	87

Overview of Climate Change Impacts on Human Health in the Pacific Region

3.2.2	Recommendation 2: Expand Population Health Programs.....	88
3.2.3	Recommendation 3: Emergency Response Programs	89
3.2.4	Recommendation 4: Data Management / Surveillance	89
3.2.5	Recommendation 5: Education	90
3.2.6	Recommendation 6: Governance.....	90
REFERENCES	.....	91
APPENDIX	.....	107
Appendix 1: Map of Pacific Island Countries	.....	107

ACKNOWLEDGEMENTS

We thank Marijia Apostoloska (medical student, University of Tasmania), Hayley Engel, Haiyao He, Jana Li, Agnes Luty, Rajivi Prematunga, and Paris Ramrakha (medical students, Australian National University). Their project work on climate change and human health in the Pacific region has contributed background information to the preparation of this report. We also acknowledge the valuable input provided during the Noumea workshop by regional stakeholders, the Secretariat of the Pacific Communities (SPC), World Health Organization (WHO) and researchers as listed on Appendix 2. We also thank the Department of Climate Change and Energy Efficiency (DCCEE) and the Australian National University (ANU) and the National Centre of Epidemiology and Population Health (NCEPH) for their support and contributions.

EXECUTIVE SUMMARY

The United Nations Framework Convention on Climate Change (UNFCCC) recognises that developing countries are the most vulnerable to the adverse effects of climate change because they have fewer resources to adapt geophysically, socially, technologically and financially.⁽¹⁾ Small Island Developing States (SIDS) face multiple stresses that affect their exposures and sensitivity as well as their capacity to adapt. This overview examines the context of climate change, including existing major health challenges in the Pacific region, and its likely impacts on human health. We present an assessment of the existing health issues and future projections for Pacific Island Countries (PICs) and East Timor, countries vulnerable to climate change and likely to suffer significant negative human health impacts. Our analysis examines extreme weather events, coastal inundation, vector-borne disease, food-borne disease, water-borne disease and chronic health conditions. Drawing on existing knowledge, analysis, experience and expertise, we suggest recommendations for policy makers developing adaptive strategies.

KEY FINDINGS

- Climate change will have diverse impacts, predominantly detrimental, on human health in all regions of the world, via both direct and indirect pathways. These include heat-related impacts, dengue, diarrhoeal disease, physical injuries from storm surges, greater reliance on imported processed foods (obesity, etc.), and effects of social disruption after extreme events.
- In general, the health impacts of climate change will be additive to, or multiplicative of, existing health risks and burdens – beyond the possibility of facilitated entry and spread of some infectious diseases, climate change is not expected to cause ‘new’ types of health problems;
- Pacific Island Countries (PICs) currently face significant health challenges, specifically in terms of health service demands due to chronic (non-communicable) diseases and limited health service personnel and infrastructure, which influence their capacity to respond appropriately to additional stressors;
- PICs are at above-average, and some are at extreme, vulnerability to climate change and many of its impacts on human health, are due to their particular social, economic and development characteristics;
- The physical location (tropics), isolation, small size, geomorphology (topography) of PICs contributes to their heightened risk of harmful health effects of climate change.
- Limited research has been conducted on baseline climate-health relationships and on climate change risks to, and impacts on, human health in PICs;
- Significant gaps exist in community and institutional understanding of likely health impacts of climate change, especially at the local level, and the current knowledge remains fragmented;
- The lack of well-developed health-related surveillance systems and lack of expertise in data management are significant limitations on the capacity of PICs to monitor and cope with health impacts of climate change ;
- Limitations in health resources and public health infrastructure are likely to further restrict PICs capacity to cope with, and respond to climate change impacts on health;
- Existing public health infrastructure and capacity should be augmented. It will bring near-term benefits, reduce preventable ill-health, help limit inter-generational entrenched disadvantage, and assist PICs prepare for a climate change future;
- Cross-sectoral adaptation strategies are required, and these must include emergency responses, and disaster management in relation to human health;

Overview of Climate Change Impacts on Human Health in the Pacific Region

- Capacity building: Training in public health, epidemiology and biostatistics will improve PICs' capacity in monitoring health problems and data management;
- Community- and local-level engagement and input are essential in developing effective and equitable and cultural acceptable adaptive strategies;
- Improved interaction and communication between stakeholders including regional administrations, SPC, government and non-government aid organisations and health researchers engaged in the region are needed to optimise the use of resources, including information technology, laboratory materials and techniques, and available data.

Glossary of terms

APMEN: Asia Pacific Malaria Elimination Network

CO₂: Carbon dioxide

DCCEE: Department of Climate Change and Energy Efficiency

ECDPC: European Centre for Disease Prevention and Control

ENSO: El Nino-Southern Oscillation

IPCC: Intergovernmental Panel on Climate Change

GHG: Greenhouse gas

HABs: Harmful Algal Blooms

NCEPH: National Centre for Epidemiology and Population Health

PASAP: Pacific Adaptation Strategy Assistance Program

PCCSP: Pacific Climate Change Science Program

PICs: Pacific Island Countries

SIDS: Small Island Developing States

SPC: Secretariat of the Pacific Communities

UNEP: United Nations Environment Programme

UNISDR: United Nations International Strategy for Disaster Reduction

WHO: World Health Organisation

WMO: World Meteorological Organization

WPR: Western Pacific Region

Key definitions

Climate: This is typically described by the summary statistics of temperature, precipitation, soil moisture and sea surface temperature of a particular region, averaged over a set time-scale, usually 30 years.

Climate variability: This is the variation around the average climate, ranging from daily/weekly variability to seasonal and intra-decadal variations. Beyond that time scale, variation merges with 'change'.

Climate change: Earth's climate is always changing in response to natural forcing, operating at vastly different time-scales. The change can be global, regional, or sub-regional. Human actions are increasing the concentration of greenhouse gases in the lower atmosphere, and this has now begun to contribute a discernible additional element of climate change – an element that has become, apparently, the major source of global warming over the past half-century, and is anticipated to become even more dominant over coming decades.

Health determinants: Certain upstream, or distant factors have great potential to impact on public health even though these exposures are far apart in time or space from the witnessed ill-effects relates. Determinants of health include policies, for example those that drive current levels of population growth, consumption and waste issues, and the uses of technology.

Social determinants of health: The social determinants of health are the conditions in which people are born, grow, live, work and age, including the health system. These circumstances are shaped by the distribution of money, power, and resources at global, national and local levels, which are themselves influenced by policy choices. The social determinants of health are mostly responsible for health inequities - the unfair and avoidable differences in health status seen within and between countries.

Environmental determinant of health: These any external agent (biological, chemical, physical, social, or cultural) that can be causally linked to a change in health status. Used here, the term includes only those environmental influences that are involuntary. For example, breathing secondhand tobacco smoke would be an environmental hazard, whereas active tobacco smoking would be considered a behavioural determinant.

SCOPE OF SERVICES

In consultation with DCCEE, the NCEPH research team is required to

1. Produce a discussion paper reviewing how climate change will affect the human health challenges in the Pacific, including:
 - context of broader development challenges other than climate change that affect human health in the region;
 - overview of likely impacts of climate change, drawing on existing knowledge and expert judgement;
 - human health dimensions of likely climate change impacts;
 - an initial assessment of the relative significance of climate change on human health in relation to overall development challenges now and into the future; and
 - engage with key organisations with expertise on health in the region.
2. Participate in a workshop, to be convened by DCCEE, of regional experts and stakeholders in the region. Workshop participants to:
 - be provided with the above-mentioned discussion paper in advance of the workshop;
 - review and comment on the paper;
 - review existing health challenges in the region;
 - identify regional adaptive capacity and reach agreement on key areas of focus for further assessment; and
 - use workshop outcomes as a guide to production of the final report.
3. Produce a final report, drawing on the discussion paper and workshop, on outputs from the Pacific Climate Change Science Program (PCCSP) and where relevant, on interim outputs from other sections of the Pacific Adaptation Strategy Assistance Program (PASAP) regional overview, which:
 - analyses, and, to the extent possible, quantifies the human health dimensions of likely climate change impacts;
 - analyses constraints, opportunities and benefits of adaptation responses to the human health impacts of climate change, in the context of existing development challenges in the region; and
 - propose appropriate approaches for decision makers, in health policy and wider cross-sectoral policy to assist adaptation planning for human health impacts of climate change in the region.

We note the companion papers *“Water Security & Vulnerability to Climate Change and Other Impacts in Pacific Island Countries & East Timor”*, and *“Food Security in the Pacific and East Timor and its Vulnerability to Climate Change”* prepared as part of the PASAP Project. Water and food are inherently linked to human health. This paper extends this work by drawing the direct links to health threats arising from interruptions to food and water supplies.

KEY QUESTIONS

- What climate-sensitive diseases are likely to be of concern for PICs?
- What is known about the current distribution and burden of climate sensitive disease in PICs?
- What are the potential future health impacts for PICs?
- What is known about the current adaptive capacity?
- What are the key knowledge gaps?
- What are the key capacity gaps for PICs to respond to climate change?
- What recommendations can be made regarding appropriate approaches for health policy decision-makers that would best provide adaptation planning to minimise human health impacts of climate change in the region?

METHODS

The project was conducted in three phases from November 2010 to September 2011.

Phase 1: November 2010 – December 2010

In Phase 1, we undertook an initial assessment of climate change risks and likely impacts on human health in the Pacific to determine the scope of this report. Tasks completed in this phase included establishment of a reference group, identification of key stakeholders, making contacts between the NCEPH team and stakeholders, collection of existing accessible data, and planning for a key stakeholder workshop. Key stakeholders identified include, but are not limited to, SPC, WHO, Intergovernmental Panel on Climate Change (IPCC), PASAP researchers, PCCSP, local communities and regional government health departments and health service providers and researchers. One of the major contributions made in phase 1 was an extensive literature review to prepare a discussion paper for the next phases.

Phase 2: January 2011 – June 2011

In Phase 2, we held a workshop in Noumea jointly with DCCEE and SPC. Attendees included academic researchers in epidemiology; public health and emergency management from Australia and New Zealand; and key regional experts from the Pacific Region. A full list of participants and their areas of expertise can be found in Appendix 2. The workshop examined a number of initiatives underway to research, document, analyse and report on the likely impacts of climate on human health in the region. The workshop also discussed common challenges and lessons in understanding and addressing impacts on human health from climate change in the region. The workshop created engagement and ownership among stakeholders for the project. To continue developing the discussion paper initiated in phase 1, we further examined the health vulnerabilities of the PICs to analyse the focus areas identified at the workshop. We also synthesised findings to project future health risk and identify knowledge gaps.

Overview of Climate Change Impacts on Human Health in the Pacific Region

In Phase 3, we followed up the discussions from the workshop, and collated, analysed and summarised all the data and materials from the previous two stages. In doing so, we created a final report drawing on the findings from the discussion paper and workshop to make relevant recommendations for policy-makers. We also engaged in this final stage with contacts developed previously, and with PIC health Ministers and officials at the Health Ministers' Forum in Honiara.

Part 1: CONTEXT OF CLIMATE CHANGE IN THE PACIFIC REGION

1.1 Current Knowledge and Understanding

In 2001, the IPCC identified small island states as the nations most vulnerable to climate change.⁽²⁾ This hyper vulnerability makes the Pacific Island region a sensitive indicator of projected 21st-century climate change. Increasing awareness of the vulnerability of PICs to the impacts of climate change has prompted several previous examinations of the key issues. The United Nations Environment Programme (UNEP), WHO and the World Meteorological Organization (WMO) subsequently contracted Drs. Kristie Ebi, Nancy Lewis and Carlos Corvalan to examine the potential health effects of climate variability in Small Island States. Their report, released in 2005, made the following recommendations.⁽³⁾

- Enhance awareness potential impacts on human health of climate variability and change;
- Enhance development of adaptation strategies, policies and measures to reduce potential impacts;
- Address data needs, including the collection of more valid and comprehensive health, meteorological, environmental and socioeconomic data at the appropriate local, regional and temporal scales;
- Address high priority research questions, including expanding the knowledge of climate sensitive diseases of importance to small island states through national and regional research; conducting basic entomological research; improving understanding of the complex relationships between the risks posed by climate variability and change and by other factors that influence population health; developing and evaluating indicators of the potential health impacts of climate variability and change; and understanding the links between climate and other sectors, such as agriculture and water supply, and how these could impact on health;
- Increase capacity building by developing institutional arrangements for knowledge sharing at national, regional and international levels; improve education and training; encourage programmes of action and public/private partnerships; and transfer knowledge of adaptation options to countries with similar climate/health concerns;
- Develop and improve national and regional climate forecasts;
- Address resource needs by improving international, national and regional facilities and funding for capacity building, interdisciplinary research and regional/national assessments.

This project revisits health issues, briefly explores advances to date, and provides a snapshot of progress towards addressing climate change adaptation needs to protect population health in PICs. This report also notes the partner PASAP projects, specifically those reporting on food and water

security. Our review therefore is primarily limited to the health perspective of these climate related threats. These involve nutritional requirements and hygiene, and food and water borne disease.

1.2 Introduction

The world's climate has always varied naturally. Human actions are now imposing a relatively rapid change on the global climate.⁽⁴⁾ This is occurring primarily as a result of increases in greenhouse gas (GHG) emissions from power generation, agriculture, mining and transport, and from reductions in the extent and capacity of nature's carbon 'sinks' (especially via deforestation). Climate scientists agree that human-induced climate change accounts for most of the warming, since mid-twentieth century.⁽⁴⁾ There is also evidence that the rates of change (e.g. in emissions, sea-ice loss and sea-level rise) are accelerating, despite growing governmental and public awareness of this global environmental problem.

The global climate has warmed by 0.8°C since early in the twentieth century. As a result, 'increases in the frequency and intensity of various extreme events', such as tropical cyclones (including hurricanes and typhoons), floods, droughts and heavy precipitation events have occurred. Due the inertia in the system, the full influence from current CO₂ levels has yet to fully unfold, however this rise in extreme events across the globe provides indication of the trend. The "business as usual" (BAU) pathway of current emissions patterns produces a mid-range warming estimate of 4.5°C (range 3°C – 7°C) by 2100.⁽⁵⁾ Even if global CO₂ emissions stopped today, the oceans' thermal inertia will continue to drive the world's temperature higher by 0.3°C -0.8°C (by 2100), possibly higher, and sea-level rise continue to rise about 10cm/century from many centuries.⁽⁶⁾ Complete cessation of emissions is clearly impossible to achieve and so represents an extreme lower boundary to climate change over the next few centuries.

Even with relatively small temperature increases, changes in some types of extreme events will amplify as higher average temperature leads to a disproportionately large increase in the number of extreme climatic events.⁽⁷⁾ BAU option will create calamitous situations in many regions of the world,⁽⁸⁾ including Pacific Islands. While mitigation is an urgent necessity to prevent these worst case scenarios, adaptation is essential to minimise the adverse health outcomes from current and future warming.

The relationship between climate, and therefore climate change, and human health is complex and predominantly non-linear. Climate change, itself, has many dimensions and various environmental and social impacts that then, in turn, affect human health.

Health, too, is a complex concept. It was defined over half a century ago by the World health Organization as "*a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity.*"⁽⁹⁾ That definition resonates with the prevailing popular perception of 'health', which focuses on the individual level - which, for each of us, is important. However, importantly, 'health' is also a population-level concept that refers to rates and distributions of various states of health and disease within a population, how these change over time, and what

Overview of Climate Change Impacts on Human Health in the Pacific Region

those changes are due to. Climate change, in most respects, impinges on whole groups and communities, and it is therefore the population-level perspective on 'health' that is most relevant.

Good (or poor) human health has many determining factors, resulting from the interplay of many factors that are intrinsic and extrinsic to the human body. Intrinsic factors include a person's genes, which designate a predisposition to physiological resilience or susceptibility to certain diseases. Yet this underlying genetic endowment is modified by extrinsic factors deriving from environmental exposures, which include physical and social environments. Individual behaviours also influence health, and these factors act in concert, and patterns commonly occur. For example children born into disadvantaged families are often undernourished and under-educated, and, compared to wealthy children, the poor are more often exposed to an array of health risks, such as contaminated food and water, insecure housing, toxic chemicals, violence and emotional insecurity. Opportunities for good health therefore differ vastly between individuals and communities. Behaviour patterns are also influenced significantly by opportunities and local cultures.

Quantification of associations between an individual environmental factor and a specified health outcome (disease) is often difficult, as the estimation of risk due to that environmental exposure must take into account the influences of other coexistent risk factors. When done satisfactorily, such studies can estimate the increase in risk due to a 'unit' increase in environmental exposure and hence, within the population, the attributable fraction of the existing disease burden due to that environmental exposure. Methods for quantifying the burden of disease attributable to the joint impact of multiple health determinants, perhaps interacting with one another, require further development.

Climate change adds complexity to these research endeavours. Learning about the past influence of climatic variations or trends on health outcomes requires high-quality population-level health and meteorological data-sets, collected in standardised fashion over sufficient time. Such studies provide baseline information about climate-health relations, and help to identify the health outcomes that are most sensitive to climatic variation. Subsequent use of that baseline information to project the future health risks from climate change at a particular location in a specified time frame entails reliance on modelled scenarios of likely climate change, and the handling of multiple uncertainties (both about future climatic conditions and about concomitant changes in population circumstances and behaviours likely to influence levels of exposure and impact).

In most parts of the world much of the relevant 'baseline' data is often missing or lacking in detail. An increasing volume of ongoing empirical research is filling in these gaps. Meanwhile, this information deficit clearly applies in the PICs.

This report provides a high-level overview based on current understandings of relationships between environmental, social and cultural factors and health outcomes. We provide a summary of what is currently known, and the best available estimates of risk-relationships, focusing particularly on the health determinants that are likely to be affected by, or are part of, climate change in the Pacific Island Countries.

Box 1 (below) describes the GEF project approach taken by the Spickett Katcherian team.

Box 1: Climate Change, Vulnerability and Health in the Solomon Islands, Nauru and Vanuatu

WHO project conducted by Professor Jeffery Spickett (Curtin University) and Dianne Katscherian (Health Department Western Australia)

The WHO Project

- The aims of the project were to provide:
 - Training in methodologies to assess health vulnerability due to climate change
 - Technical guidance and support
 - Assist with the preparation of in country reports and Action Plans for adaptation
- Strong emphasis was placed on:
 - A learning by doing approach – technology transfer
 - The importance of inter-sectoral collaboration
 - Most activities that impact on health not actually addressed by the health sector

Logos: Curtin University of Technology, World Health Organisation Collaborating Centre for Environmental Health Impact Assessment, Government of Western Australia Department of Health

Health Impact Assessment (HIA) was used as the basis for evaluation of vulnerability to climate change, to identify Risk and Coping capacity

Consequence	Likelihood
Catastrophic	Almost Certain
Major	Likely
Moderate	Possible
Minor	Unlikely
Insignificant	Rare

Overview of Climate Change Impacts on Human Health in the Pacific Region

The critical importance of gaining detailed intelligence for planning purposes in relation to the anticipated climate change and its diverse consequences is gaining traction in the Pacific region. Considerable effort is therefore now underway to address this knowledge gap, and various specialised reports from different agencies and groups will become available in the near future.

The World Health Organization (WHO) is managing a series of projects funded through the Global Environmental Facility (GEF) of the World Bank. The focus of these projects is climate change adaptation, and capacity building. For that program of work, the Pacific is divided into its three main components – Micronesia, Melanesia, and Polynesia – and research teams from Japan and Korea (Yasushi Honda, Ho Kim and Masahiro Hashizume), Australia (Jeff Spickett & Dianne Katcherian) and New Zealand (Alistair Woodward, Teuila Percival and Graeme Lindesay) have been contracted to work with regional experts to develop mechanisms for assessing local vulnerabilities and identifying adaptation needs. Progress in that work has been delayed due to workforce limitations, particularly when appointed skilled people are diverted into addressing other emerging issues. Various other factors that also impede progress, and which occur often in small, developing, isolated countries, are discussed elsewhere in this report.

Identification of [impacts on sectors](#):

- Physical Environment -Issues including water quality, air quality and biodiversity.
- Social Environment -Social impacts, population displacement and mental health
- Service and Infrastructure Environment - Services, infrastructure and economics, including resource availability and access to a range of health, emergency and other services.
- Environmental Diseases - Production of food, vector-borne and food-borne disease and other environmental diseases

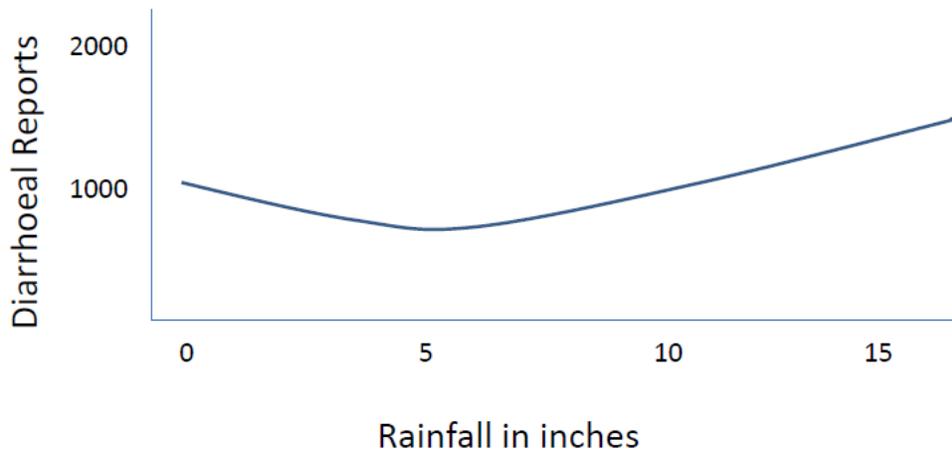
Most activities that impact on health are not actually addressed by the health sector

The World Health Organisation South Pacific Office, based in Fiji, is also conducting projects throughout the Pacific to identify and monitor health specific adaptation needs. Staff appointments include a Climate Change & Health Officer, Dr Lachlan McIvor. One of these projects will constitute his PhD thesis supervised by our team at ANU, and is in its initial establishment phase.

Another GEF/UNDP/WHO study covering 7 countries reported by Simon Hales (University of Otago) involves direct empirical studies of diarrhoea, vector-borne disease and ciguatera.^a This study used WHO global burden of disease estimates for 2000 and current updates, to provide projections for 2050s under extreme events, floods, heatwaves, diarrhoeal disease (2 pathways), malnutrition, VBD.

^a Ciguatera is a poisoning resulting from eating certain fish in particular environments in the Indian Ocean, Pacific Ocean, and The Caribbean. The poison occurs naturally in algae and plankton, the lower part of the marine food chain and bio accumulates up the food chain, reaching concentrations dangerous to human health in predatory fish over 6kg.

Figure 1: Relationship between Diarrhoeal Diseases and Annual Rainfall - Fiji.



Data Source: Simon Hales. Presentation to PASAP Project Workshop SPC Noumea 2011

Mclvor reports that, from June 2010 to September 2011, a team of environmental health and climate change experts from WHO SP worked closely with the Ministries of Health in Federated States of Micronesia (FSM), Republic of the Marshall Islands (RMI) and Republic of Palau on a three-phase climate change and health adaptation project (informally known as Micro-CCHAP, for Micronesian Climate Change and Health Adaptation Planning). This process involved both quantitative and qualitative research. This included statistical analyses of historical climate and health data to describe, as precisely as possible, the relationship between climate variability and climate-sensitive diseases in each country, and a survey of hundreds of households in Palau to better understand the community's perceptions and concerns with respect to climate change and health.

The Micro-CCHAP project also involved extensive, productive, consultations with climate and health stakeholders in each country. These included government departments, agencies, non-government organisations and individuals from the fields of health, environment, water, infrastructure, transport, energy, communications, agriculture, fisheries and disaster management.

The Secretariat of the Pacific Communities (SPC) reports that climate change is now viewed as a broad-based development issue, cutting across all sectors, and that a Climate Change Engagement Strategy is under development that adopts a 'Whole of organization' approach.

Key foci of SPC activities include:

- Food and water security;
- Extreme weather events/DRR: Managing risks to livelihoods and economic infrastructure;
- Health;
- Coastal zones;
- Building knowledge and understanding across all sectors.

Overview of Climate Change Impacts on Human Health in the Pacific Region

Several food security projects were due to report mid to late 2011.

- 1) PASAP Pacific Food Security Overview Report;
- 2) A climate change and food security gap analysis to identify future priority work areas;;
- 3) Pacific Fisheries Vulnerability Study Completion date is October 2011;
- 4) Additional work in modelling CC impacts on Tuna stocks;
- 5) Climate Ready Crop Collection, identified over 70 varieties of climate resilient crops (tolerant to drought, salinity, floods) already developed and field trials in selected countries have commenced;
- 6) Increasing resilience of farming systems through integrated farming system management approaches;
- 7) Water resources and sanitation capacity building, climate change vulnerability assessments & monitoring.

The SPC also coordinates Disaster Risk Management activities and provides technical expertise and support to the Pacific Public Health Surveillance Network (PPHSN). This health intelligence work covers : PacNet, LabNet, EpiNet, Inform'Action, website to provide WHO syndromic surveillance initiative for sexually transmitted diseases (including HIV), TB and others.

The SPC is overseeing a Ten-Year Pacific Statistics Strategy 2011 – 2020, adopting a regional approach to find nationally applicable solutions. Two key strategic priority areas for the period 2011 – 2014 are to a) Improve Vital Statistics/Civil Registration, and b) Improve Health Information Systems for their Pacific region member countries.

Among the international and regional efforts focusing on climate change assessment, monitoring and adaptation in the Pacific, only a very small proportion addresses human health. Consequently, despite a rapidly growth in overall knowledge, it remains true that health impacts arising from climate change at the local level remain largely under investigated. This deep, and fundamental, knowledge gap hampers adaptation initiatives, regional and local planning. Fortunately, as summarised in the following section, there is a more broadly-based general knowledge and understanding of how climate change dose and will affect human health, from research conducted around the world.

Summary of current knowledge

Climate change will pose diverse risks to human society and health, directly and indirectly, and via immediate and delayed processes. Many of the impacts on human society, of freshwater flows and quality, food yields, environmental constraints on infectious disease agents, natural buffers against extremes of weather, physical infrastructure, and social stability, will have adverse consequences for human health.^(10, 11) Therefore, food and water security, increased temperature and extreme weather events, and public health infrastructure have been widely emphasised in considering the likely impacts of climate change on human health.⁽¹²⁾ Principal problems are not expected to be a range of new health disorders, rather the impacts will result from exacerbation of existing health conditions, and the spread of existing health problems into new areas where communities are not accustomed

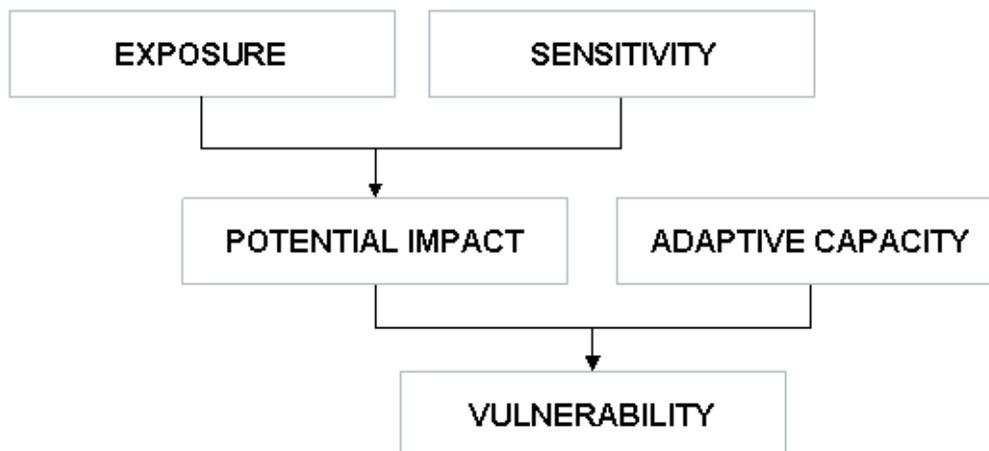
Overview of Climate Change Impacts on Human Health in the Pacific Region

to dealing with them. For example, increases in temperature and alterations in precipitation and humidity may result in expansion of sensitive zones where vectors capable of transmitting pathogens such as dengue and malaria occur.

According to available global statistics, least developed countries represent 11% of the population exposed to natural hazards but account for 53% of casualties. This contrasts with the situation for populations in the most developed countries who represent 15% of human exposure to hazards, but account only for 1.8% of all victims.⁽¹³⁾ Pre-existing health status and availability of protective infrastructure, options to minimize personal exposure risks, and organised recovery efforts influence the translation of exposure risks to ultimate outcomes.

Vulnerability to climate change is a function of the level of exposure, sensitivity to exposures, and adaptive capacity (Figure 2). Dangerous exposure to climate change can involve a shift to more extreme climatic conditions, or an increase in severe weather events, such as cyclones, floods, inundation by storm surges or extreme heat waves. For communities already facing harsh climates and who may be marginal in terms of food supply, infrastructure, health services and economy, possibly even with survival at risk, further minor climatic perturbations (e.g., increased severity of extreme events or more frequent droughts) can also present dangerous exposure. Sensitivity refers to the extent to which the community of interest (or the natural or social systems on which its health outcomes depend) are intrinsically (constitutionally) sensitive to changes in the weather or climate patterns – given their existing level of economic development and infrastructure. Empirically, sensitivity is evidenced by the exposure-response relationship for that system. The potential impact of climate change reflects the interplay between these two variables, and is modified by the adaptation measures and actions undertaken to reduce the burden of adverse health outcomes. Vulnerability is therefore defined as the degree to which individuals and systems are actually susceptible to and therefore liable to be affected by climate change, including the impacts of climate variability and extremes.

Figure 2: Climate change exposure, sensitivity, vulnerability pathway



Source: Schroeter d, et al., (2004)⁽¹⁴⁾

Overview of Climate Change Impacts on Human Health in the Pacific Region

What does this mean for the PICs?

PICs' vulnerability to climate change has a number of determinants,^(15, 16) and both their projected levels of exposure to aspects of climate change and their sensitivity to those exposures are high. The 22 PICs are classified as Small Island Developing States (SIDS), and like developing countries elsewhere, the PICs are poor, falling in the low and lower-middle income categories. They comprise a land area of only 553 959 km², with Papua New Guinea (PNG) accounting for 83 percent of the land area.⁽¹⁷⁾ The states that comprise the Pacific Island nations and territories are traditionally aggregated into three major groups - Polynesia, Micronesia and Melanesia - that reflect the geography, culture and ethnic backgrounds of the indigenous inhabitants of the islands.

The population is predominantly rural; however, urbanisation is rapid, resulting in more than 50 percent of the population residing in urban areas in a few countries.⁽¹⁸⁾ The total population of the region (10 million) is thinly dispersed across the largest body of water on the planet, and country geomorphology and socio-geopolitical features vary greatly. Several PICs have very small populations; current estimates for Niue range from 1,400⁽¹⁹⁾ to 1,000⁽¹⁸⁾, and after peaking at 250 in the 1930s the population in the Pitcairn Islands (not a member of the SPC) diminished to 63 people by 2009. In contrast, 6.7 million people live in Papua New Guinea (PNG).⁽²⁰⁾ Additionally, significant Pacific Island populations now live abroad, primarily in Australia, New Zealand and the United States. This diaspora helps the local economy through remittances home, but undermines the skilled workforce capability and capacity in critical areas such as health.⁽²¹⁾

Special characteristics of the PICS exacerbate their vulnerability to climate change. PICs are in cyclone prone areas, and subject to the vagaries of the El Nino / Southern Oscillation (ENSO) which bring quasi-cyclical droughts and floods. Some islands are elevated volcanic islands, yet many are low lying and subject to storm surge inundation and salination of arable land and water supplies. Many have limited available arable land, or space to relocate low lying populations. This generates susceptibility to natural disasters, and heightens vulnerability to increasing intensity or frequency of these weather events. Meanwhile, vulnerability to various infectious diseases is also high – including food-borne and water-borne infections and several mosquito-borne infections (esp. malaria in PNG, Solomon Islands and Vanuatu and dengue in PICs in general). Further, as temperatures rise and climate variability increases, vulnerability to extremes of heat will also increase (including for outdoors workers) – especially where rising incidence of underlying cardiovascular and metabolic disorders (e.g. diabetes type II) has heightened sensitivity.

Economic and development challenges also heighten sensitivity to some of the potential impacts of climate change. These include, but are not limited to, small populations and economies; isolation; limited human and ecological resources; and dependence on international trade and in some cases foreign aid.⁽²²⁾ Mounting an effective response to adapt to climate change will therefore require assistance from donor countries, and PICs welcome this.

Governments of PICs recognise that climate change poses a serious threat to most small island states and coastal populations. For many PICs sea level rise is arguably the most certain and potentially

Overview of Climate Change Impacts on Human Health in the Pacific Region

devastating climate change impact. Sea level rise could make several countries, particularly Atoll nations such as Tuvalu, Kiribati, Tokelau and the Keeling Islands, uninhabitable. Low-lying central areas are a feature of many islands, often locally excavated for production of taro. These lower-lying areas are already subject to inundation, which will increase as the sea rises, and threaten local food and water supplies.⁽²³⁾ Higher islands are anticipated to lose significant proportions of their land due to sea level rise, and Fiji and Samoa could also have problems since most settlements and infrastructure are in the coastal zone while the hilly, inland regions would experience severe ecological changes due to relocation of migrants from the coast. Their underlying health problems and limited local capacity to adapt have also worsened the situation and vulnerability.

Although the need for adaptation to climate change has been recognised via regional and international initiatives, practical adaptation measures have so far been limited.⁽²⁴⁾ In 2001, Barnett argued that uncertainties with regard to anticipated climate change impacts on PICs were hindering policy making.⁽²⁵⁾ A decade later, despite increasing evidence and (incipient) awareness of risks to human health, and a quickening pace of climate change itself, global policy action continues to fall well short of what is required. Few regionally contextualised studies or detailed analyses have been conducted in the Pacific region to confirm what real health risks of climate change exist for these communities. Addressing this lack of information is critical to the development of well-targeted adaptation strategies by PICs. Effective adaptation strategies are expected to produce better outcomes with respect to both the bio-geophysical conditions and socio-economic well-being of PICs' populations.⁽²⁶⁾

1.3 Existing Health Challenges

1.3.1 Health Status

A number of Pacific Island Countries rank poorly in terms of population health status. For example, many countries have a high incidence of infant and under-five mortality and a high prevalence of preventable diseases. At the country level, infant mortality rates in 2005 ranges from 15.7 per 1000 live births in Fiji to 55.2 per 1000 live births in Papua New Guinea (PNG). In the same year, under-five mortality rates ranged from 23.6 to 74.4 per 1000 live births in Fiji and in PNG, respectively. This compares poorly to Australia's rate of 6 per 1000.⁽²⁷⁾ (Table 1) Neonatal causes are the main contributor to deaths among children under five in most PICs; other notable causes include diarrhoeal diseases.

Considerable gains have been made in recent decades, although life expectancy remains variable throughout the region, (Table 1.) and in some countries is plateauing or even declining. Morbidity and mortality patterns are changing and the rising burden of non-communicable diseases (NCDs) is causing premature death in the Pacific. The existing health challenges in the Pacific region arise from a complex interplay between 'the prevalence of disease causing high rates of mortality and morbidity and the lack of skilled health personnel, infrastructure, financial resources and health systems that are responsive to the needs of society...'.⁽²⁸⁾ Both communicable and non-communicable diseases are on the rise in several Pacific countries and are significant contributors to morbidity and mortality.

Overview of Climate Change Impacts on Human Health in the Pacific Region

In his book *On Airs, Waters, Places*, (400 BCE) Hippocrates observed that disease can be traced to physical, social, and behavioural settings. The relationship between poverty, on either a national or personal scale, with health outcomes has therefore been long understood. The UN Secretary General Kofi Annan reaffirmed this in his 2001 address to the World Health Assembly: “The biggest enemy of health in the developing world is poverty”. The World Bank paper “Dying for change: Poor people’s experience of health and ill-health”⁽²⁹⁾ documents the findings from their survey of 60,000 of the world’s poor. The report notes

“Health emerged as a key issue in the interviews and discussions, often to the surprise of the World Bank researchers involved, since no probing questions on health or disease were included in the study’s research guides. We believe that this reflects the centrality of health to poor people’s lives.” (Source: Dying for Change. World Bank 2010)⁽²⁹⁾

This reflection indicates the lack of recognition of the significance of health to economics in the mindset of many outside the health and social science, whereas, in the lived experience of the poor, health is central to life and economic well-being, and represents a precondition for access to wealth and opportunity. Similarly, since the era of Hippocrates (and perhaps longer) it has been understood that many determinants of good health lie outside the formal health sector. It is difficult to achieve an optimal state of health and wellbeing amid squalor, food or water insecurity, lack of education, transport options, services, gender equity or civil governance.

Efforts to advance these in developing countries are therefore key to improving health outcomes, which in turn can improve productivity and economic security. Integration of portfolios policies and activities is essential – yet the ongoing jurisdictional disconnect has served as a barrier to the inclusion of health. *Health in all Policies* (HIAP) is an innovative policy strategy that responds to the critical role that health plays in the economies. This concept was first developed by the World Health Organization in the Ottawa Charter for Health Promotion in 1986. By incorporating a concern with health impacts into the policy development process of all sectors and agencies *Health in all Policies* allows government to address the key determinants of health in a more systematic manner, as well as taking into account the benefit of improved population health for the goals of other sectors. By injecting a health focus into decision making across other portfolios, better health outcomes can be achieved. Complex health challenges require an integrated policy response across portfolio boundaries. This approach helps close the health gap as all parts of government share goals and consider decision implications on the needs vulnerable populations.

In considering the Climate Change Impacts on Human Health in the Pacific Region, this report gives considerable weight to the HIAP framework. Recognising that the factors that determine health (health determinants) lie outside the health sector, the scan of this report encompasses many areas that are not often considered as strictly within health portfolio boundaries. Climate change will influence many of these, and we explore how this will in turn influence human health.

Overview of Climate Change Impacts on Human Health in the Pacific Region

Table 1: Key statistics- Health & health determinants

INDICATOR	Australia	Fiji	Kiribati	FSM	Nauru	New Cal	NZ	Palau	PNG	Samoa	Solomons	Tuvalu	Vanuatu
	VALUE	VALUE	VALUE	VALUE	VALUE	VALUE	VALUE	VALUE	VALUE	VALUE	VALUE	VALUE	VALUE
Estimated Population (’000s)	<u>22065.67</u> [*]	<u>854</u> [*]	<u>98.99</u> [*]	<u>107.97</u> [*]	<u>9.77</u> [*]	<u>245.5</u> [*]	<u>4318.06</u> [*]	<u>20.4</u> [*]	<u>6603.13</u> [*]	<u>183.2</u> [*]	<u>549.57</u> [*]	<u>11.09</u> [*]	<u>234.02</u>
Percentage of Population 5-14 years old	<u>12.62</u> [*]	<u>20.84</u> [*]	<u>23.18</u> [*]	<u>23.95</u> [*]	<u>23.05</u> [*]	<u>18.4</u> [*]	<u>13.56</u> [*]	<u>14.72</u> [*]	<u>24.38</u> [*]	<u>25.76</u> [*]	<u>25.06</u> [*]	<u>21.37</u> [*]	<u>24</u> [*]
Life expectancy at birth (years)	<u>81.4</u> [*]	<u>69.53</u>	<u>67</u> [*]	<u>68.5</u> [*]	<u>55.4</u>	<u>75.9</u>	<u>80.4</u> [*]	<u>69</u>	<u>60.7</u>	<u>73.2</u>	<u>65.8</u>	<u>63.6</u> [*]	<u>69</u> [*]
Under-five mortality rate (per 1000 livebirths)	<u>4.92</u>	<u>23.6</u>	<u>48</u> [*]	<u>39</u>	<u>37.9</u> [*]	<u>9.06</u>	<u>6.05</u>	<u>25.64</u>	<u>74.4</u> [*]	<u>13</u> [*]	<u>37.2</u>	<u>36</u> [*]	<u>31</u>
Total health expenditure as % of GDP	<u>8.8</u> [*]	<u>3.8</u> [*]	<u>15</u>	<u>13.6</u> [*]	<u>15.2</u> [*]	<u>9.66</u>	<u>8.96</u> [*]	<u>10.8</u> [*]	<u>3.2</u> [*]	<u>5.15</u> [*]	<u>5.26</u> [*]	<u>9</u> [*]	<u>4.06</u> [*]
General gov’t expenditure on health as % of total general gov’t expenditure	<u>17.6</u> [*]	<u>9.8</u> [*]	<u>8.2</u>	<u>18.8</u> [*]	<u>32.1</u> [*]	...	<u>17.97</u> [*]	<u>12.7</u> [*]	<u>7.3</u> [*]	<u>12.64</u> [*]	<u>16.04</u> [*]	<u>14.8</u> [*]	<u>11.37</u> [*]
Human development index	<u>0.97</u>	<u>0.74</u>	<u>0.52</u>	<u>0.57</u>	<u>0.66</u>	...	<u>0.95</u>	<u>0.86</u>	<u>0.54</u>	<u>0.77</u>	<u>0.61</u>	<u>0.58</u>	<u>0.69</u>
Per capita GDP (US\$) at current market prices	<u>39659.6</u> [*]	<u>3184.526</u> [*]	<u>1368.91</u> [*]	<u>2223</u> [*]	<u>2071</u> [*]	<u>38300.14</u> [*]	<u>30026.04</u> [*]	<u>8423</u> [*]	<u>969.23</u> [*]	<u>2881.808</u> [*]	<u>1014</u> [*]	<u>1139.32</u>	<u>2218</u>
Population below national poverty line	<u>12.2</u> [*]	<u>37.5</u> [*]
Adult literacy rate (%)	<u>86.6</u> [*]	<u>94.4</u> [*]	<u>91</u> [*]	<u>92.4</u> [*]	<u>95</u> [*]	<u>91</u> [*]	<u>89</u> [*]	<u>99.9</u> [*]	<u>57.8</u> [*]	<u>98.7</u> [*]	<u>76.6</u> [*]	<u>95</u> [*]	<u>78.1</u> [*]
Maternal mortality ratio (per 100 000 livebirths)	<u>8.4</u> [*]	<u>27.5</u>	<u>158</u>	<u>0</u>	<u>300</u>	<u>0</u>	<u>11.61</u>	<u>366.3</u> [*]	<u>733</u> [*]	<u>3</u> [*]	<u>103</u>	<u>0</u> [*]	<u>70.04</u>
Proportion of population with sustainable access to improved water source	<u>100</u>	<u>47</u>	<u>65</u>	<u>94</u>	<u>90</u>	<u>100</u>	<u>100</u> [*]	<u>89</u>	<u>40</u>	<u>88</u>	<u>84.2</u>	<u>97</u>	<u>83</u>
Proportion of population with access to improved sanitation	<u>100</u>	<u>71</u>	<u>33</u>	<u>25</u>	<u>50</u>	<u>90.3</u>	<u>100</u> [*]	<u>83</u>	<u>45</u>	<u>100</u>	<u>32</u>	<u>84</u>	<u>52</u>

1.3.2 Non-communicable diseases

The existing health challenges in the Pacific region arise from a complex interplay between ‘the prevalence of disease causing high rates of mortality and morbidity and the lack of skilled health personnel, infrastructure, financial resources and health systems that are responsive to the needs of society...’.⁽²⁸⁾ Both communicable and non-communicable diseases are on the rise in several Pacific countries and are significant contributors to morbidity and mortality.⁽³⁰⁾ Non-communicable diseases (NCDs), including cardiovascular disease, diabetes and cancer, are now causes of major disease burden in developing countries.⁽³¹⁾ Chronic non-communicable diseases now account for 75% of deaths in the PICs.⁽³¹⁾ Table 2 below provides the incidence rate (the number of new cases identified per unit population) for selected diseases for the PICs. The 9th Meeting of the Ministers of Health for the Pacific Island Countries (Honiara 2011) claimed the NCD epidemic has now reached a “crisis”, and highlighted the future loss of life, health costs and impact these are currently having, and will further make on capacity to respond to Millennium Development Goals, and responding to Climate change.

Many of the NCDs stem from the shift away from traditional diets and lifestyles. Weight gain results from adoption of western style diets that are high in carbohydrates, salt and fats, furthermore, these foods are purchased, rather than grown or caught, so the energy expenditure is less. The prevalence of overweight and obesity is commonly assessed by using body mass index (BMI), defined as the weight in kilograms divided by the square of the height in metres (kg/m^2). A BMI over 25 kg/m^2 is defined as overweight, and a BMI of over 30 kg/m^2 as obese. People with a BMI below 18.5 kg/m^2 tend to be underweight. There are national differences. Adult mean BMI levels of 22-23 kg/m^2 are found in Africa and Asia, while levels of 25-27 kg/m^2 are prevalent across North America, Europe, and in some Latin American, North African and Pacific Island countries.⁽³²⁾ Obesity and overweight pose a major risk for serious diet-related chronic diseases, including type 2 diabetes, cardiovascular disease, hypertension and stroke, and certain forms of cancer.

BMI increases amongst middle-aged elderly people, who are at the greatest risk of health complications. In countries undergoing nutrition transition, over nutrition often co-exists with under nutrition. The distribution of BMI is shifting upwards in many populations. And recent studies have shown that people who were undernourished in early life and then become obese in adulthood, tend to develop conditions such as high blood pressure, heart disease and diabetes at an earlier age and in more severe form than those who were never undernourished. The obesity epidemic is often faster in developing countries than in the developed world. This may help explain the rapid onset of NCDs in developing countries, where childhood under nutrition has been replaced by consumption of western style diets. Obesity rates that have risen three-fold or more since 1980 in some areas of the Pacific Island.⁽³²⁾

Overview of Climate Change Impacts on Human Health in the Pacific Region

Table 2: Crude Incidence Rates from Non-Communicable Diseases in Pacific Island Countries and Territories per 100,000 population aged 25+

PICT	Latest Year	Malignant Neoplasms			Circulatory diseases			Diabetes Mellitus		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
American Samoa	2002	..	..	221	..	..	..	8527	9935	9229
CNMI	2000	..	..	..	..	..	5377	..	..	5911
Cook Islands	2009	75	149	112	5367	4233	4798	..	..	833
Fiji	2005	58	122	90	..	..	753	42	53	47
French Polynesia	2007	379	334	357	..	..	..	..	..	..
FSM	2009	132	429	281	18958	21628	20303	21248	16822	19018
Guam	2000	..	..	521	..	..	2374	..	..	679
Kiribati	2009	..	..	..	2462	2817	2650	2675	3558	3240
Marshall Is	2009	229	321	274	..	..	..	..	..	1329
Nauru	2008	149	402	275	8112	7583	7849	448	653	550
New Caledonia	2006	564	441	502	..	..	15628	..	..	6223
Niue	2001	..	..	..	..	..	34646	..	..	31111
Palau	2008	170	316	236	..	..	32859	..	..	21623
PNG	2008	34	84	59	29	26	27	17	12	15
Samoa	2005/6*	108	79	94	361	416	388	..	..	9265
Solomon Islands	2005	..	..	..	..	..	..	..	..	..
Tokelau	2009	759	352	548	2277	0	1095	0	2463	1278
Tonga	2008	216	247	232	3300	2612	2948	3700	5600	4672
Tuvalu	2007	..	..	18	..	..	6347	..	..	5184
Vanuatu	2009#	76	121	98	442	407	425	119	127	123
Wallis & Futuna	2005	..	..	..	..	..	..	..	..	..

Source: SPC - NCD Statistics for the Pacific Islands Countries and Territories 2010 data

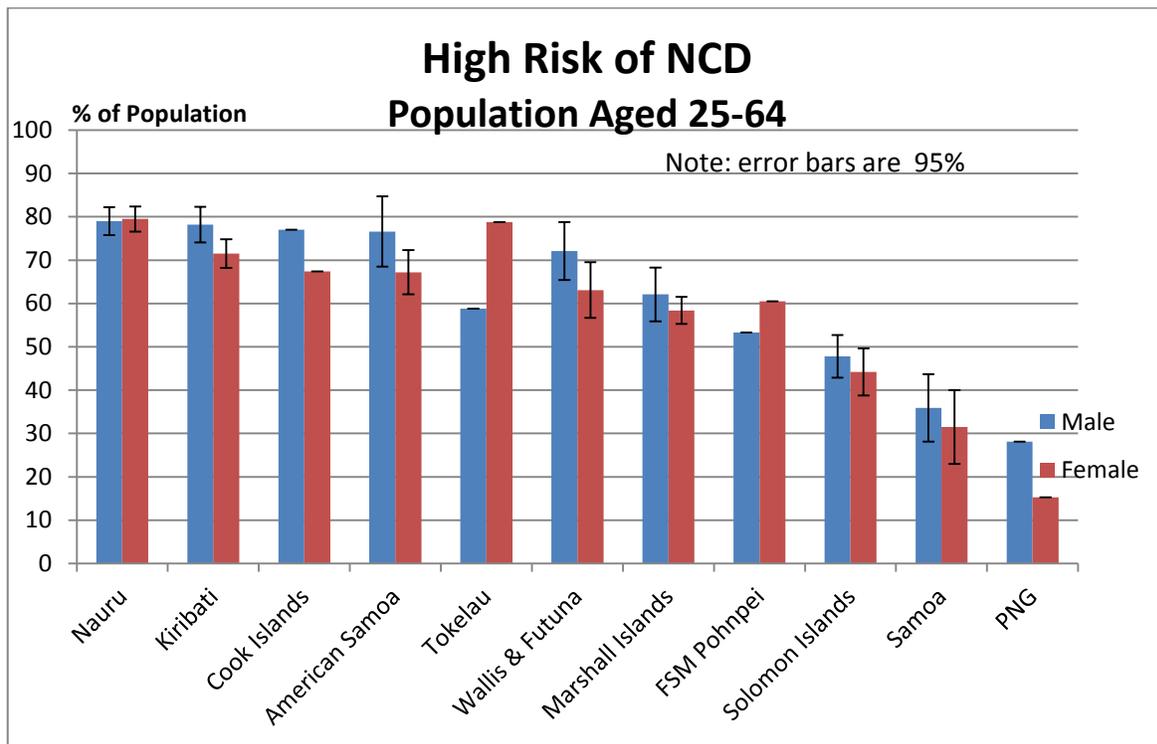
These NCDs have replaced infectious diseases as primary causes of death, and are considered to feature as a result of ‘western’ lifestyles of smoking tobacco, diets high in salts, carbohydrates and fat with inadequate daily exercise. Great variation can be seen, although data is unavailable for some countries (Solomon Islands), and for others with very small populations, it is not meaningful to provide figures per 100,000. Australia’s cancer incidence rates are not dissimilar; however the PIC circulatory and diabetes statistics are considerably more serious than in Australia. Cancer incidence rates in Australia continue to increase (484 cases per 100,000 people in 2006), although, due to advances in early diagnoses and treatment, death rates are decreasing, and by 2008, Australian cancer death rates were 232 and 144 per 100,000 for men and women respectively.⁽³³⁾ By the age of 85, 1 in 2 Australian men and 1 in 3 women will have been diagnosed with cancer at some stage of their life. The Australian standardised death rate for cardiovascular disease (CVD) was 183.4 per 100,000 population in 2009, (males 218.8 per 100,000, and 153.1 per 100,000 for females).⁽³⁴⁾ In Australia 4400 people per 100,000 have been diagnosed with Diabetes Mellitus (Men 4800, and Women 3400).⁽³⁵⁾ Australian diabetes death rates were 17.1 per 100,000 population in 2009, males

Overview of Climate Change Impacts on Human Health in the Pacific Region

20.6 per 100,000, and 14.2 per 100,000 for females). These diseases place considerable burden on health care systems and in countries unable to provide advanced care, the disease progresses to produce greater morbidity and eventual mortality.

Based on three out of five specific risk factors, the majority of the adult population in most Pacific Island countries have a high risk of developing NCDs. The high risk ranges from 80% of the Nauruan population to 55% of Pohnpeians. Proportionately fewer Melanesians have a high risk of developing NCDs, though nearly half of all Solomon Islanders have three out of five risk factors.⁽³⁶⁾

Figure 3. Proportion of population, aged 25-64, at high risk of Non-communicable Diseases, selected Pacific Island Countries

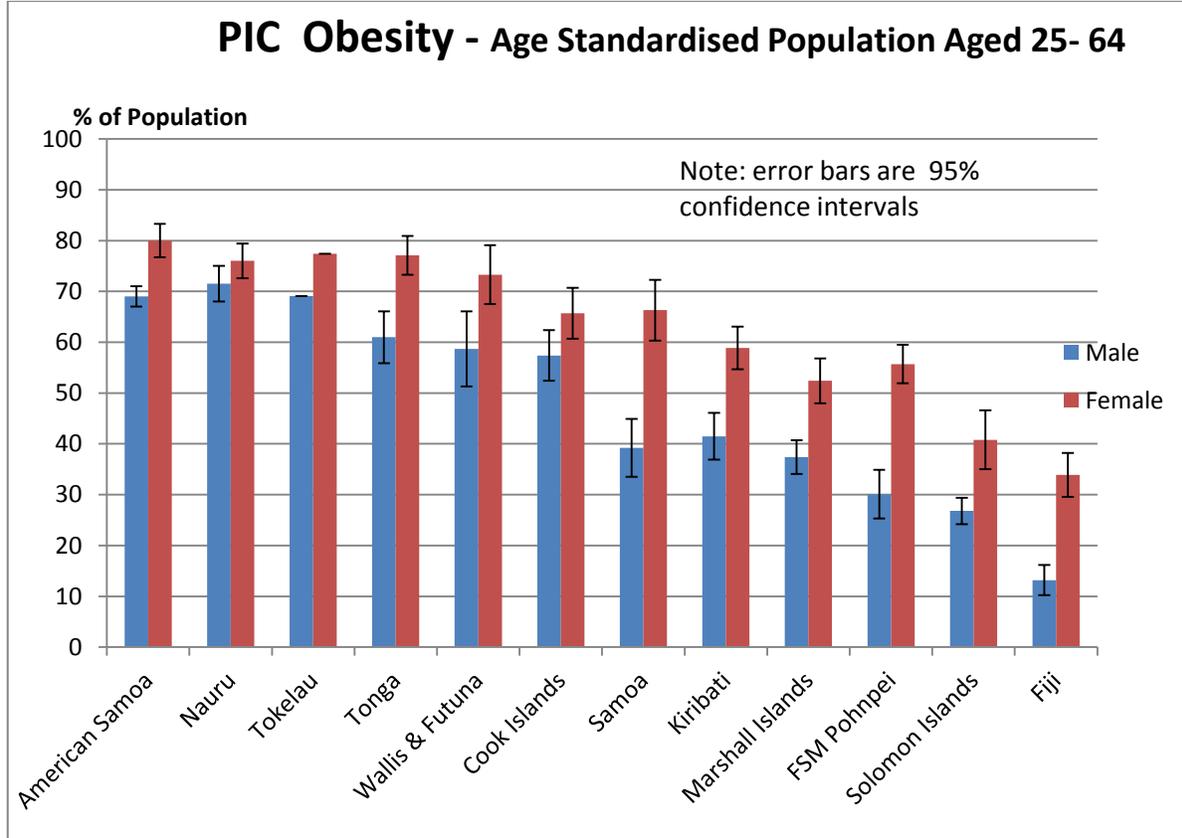


Source: SPC - NCD risk factor STEPS reports, 2005-2010.⁽³⁶⁾

The Pacific now has among the highest rates of obesity and type 2 diabetes, key risk factors for CVD. Diabetes was relatively unknown in the Pacific Islands while communities were still following traditional lifestyles. Due to the major changes to traditional lifestyles and dietary habits over the last few decades in the region, the prevalence of diabetes is now increasing at an alarming rate. Diabetes is a major risk factor for most non-communicable diseases and often results in limb amputations. Diabetes is mostly prevalent in American Samoa and Tokelau and significant proportions of the Micronesian population are also affected. The growing epidemic of diabetes and cardiovascular disease now presents a huge health and financial burden for Pacific Islands. In five Pacific Island Countries the estimated prevalence of diabetes ranges from 22.6 to 47.3%. This compares to 10% in Mexico, 3% in the UK and 5% in Australia.⁽³⁷⁾ Current loss of productivity and additional health care

costs are adversely affecting development of these vulnerable nations, and if left unchecked, the future impact will be substantial.

Figure 4. Population proportion classified as obese, selected Pacific Island Countries



Source: SPC - NCD Statistics for the Pacific Islands Countries and Territories 2010 data.

Pacific Islands Countries and territories (PICTs), the Secretariat of the Pacific Community (SPC) and the World Health Organization (WHO) have joined forces to combat NCDs in the region. Together they have developed the Pacific Framework for the Prevention and Control of NCDs which provides a combined 2-1-22 approach (2 organisations, 1 team, serving 22 countries).⁽³⁸⁾

1.3.3 Communicable Diseases

Communicable diseases also pose a significant public health problem for PICs.⁽³⁹⁾ Historically, the Pacific has been disproportionately affected by epidemics of communicable diseases, such as the 1918 influenza pandemic (Samoa experienced 20% mortality), other influenza epidemics (such as the 1940’s outbreak which killed 40% of the population of Jaluit in the Marshall Islands).⁽⁴⁰⁾ A measles epidemic in Fiji in 1875 nearly wiped out the indigenous population. Since that time, until the late 1990s, circulation of the measles virus and measles outbreaks were common occurrences in the Pacific, with an average of four outbreaks every year.⁽⁴¹⁾ In the late 1990s, the nations of the Pacific

Overview of Climate Change Impacts on Human Health in the Pacific Region

collectively decided to interrupt measles transmission within their region. In 2010-2011 there have been no reported deaths from measles in the PICs, although Fiji and PNG results are still pending.

Due their geographic isolation many PICs avoided previous contact with these diseases, meaning the communities had little resistance. Malnutrition and health resource challenges contributed to high morbidity and mortality rates. Communicable disease, particularly respiratory infections and gastroenteritis are prominent health concerns and are directly related to overcrowding, poor sanitation, contamination of drinking water and inadequate hygiene practices.⁽⁴²⁾ Mental health is an emerging public health issue in PICs, but is given low priority on the public health agenda.⁽⁴³⁾

Communicable diseases of concern in the region include, but are not limited to:^b

- Tuberculosis
 - The entire Western Pacific Region (WPR) (37 countries including China) has an estimated 2 million cases of tuberculosis (TB) and multi-drug-resistant tuberculosis (MDR-TB) annually, constituting one quarter of the tuberculosis burden world-wide.⁽⁴⁴⁾ Coordinated TB treatment programs in the Pacific Islands have delivered consistently high success rates, and the case detection rate is now close to the regional target, however the risk remains. There were 8% fewer PIC TB cases in 2008 than 2007, a notification rate of 48 per 100,000 of total population. Excluding Papua New Guinea , 1,459 TB cases were notified and a further 13,984 TB cases were notified in Papua New Guinea in 2008.⁽⁴⁵⁾ TB rates in Micronesian region poses a threat to TB control in the region.⁽⁴⁶⁾
- HIV/AIDS
 - HIV infection rates across the PICs are generally low, and are either unchanging or increasing very slowly.⁽⁴⁷⁾ Papua New Guinea is the exception, witnessing a huge growth in rate of infections from 17 reported new HIV infections in 1989, to greater than 1,000 in 1999.⁽⁴⁸⁾ Rates of sexually transmitted infections (STIs) are rising.
- Diarrhoeal Disease
 - Global estimates regarding burden of disease attributable to diarrhoea are thought to underestimate the significance of diarrhoeal disease among the PICs due to a lack of data.⁽⁴⁹⁾ The 2005 estimate of annual child deaths (under five years old) globally was 9.6 million of which 9% was accounted for by the WPR.⁽⁴⁹⁾
- Malaria
 - Malaria is endemic in Papua New Guinea, Solomon Islands and Vanuatu and despite near eradication of malaria from the Pacific in the 1970s, the vector-borne disease retreat then slowed.⁽⁵⁰⁾ Eight of 20 malaria-endemic countries in WHO's Western Pacific and Southeast Asia regions achieved declines in annual cases of more than

^b Disease ranked in the same order as the WHO's cause-specific mortality estimates 2008 in low- and middle-income countries of the WPC; http://www.who.int/healthinfo/global_burden_disease/estimates_regional/en/index.html

Overview of Climate Change Impacts on Human Health in the Pacific Region

50% from 2000 to 2008.⁽⁵¹⁾ Through Asia Pacific Malaria Elimination Network (APMEN),⁽⁵²⁾ the Solomon Islands and Vanuatu have set goals to eliminate malaria within the next 5–10 years.⁽⁵³⁾

- Dengue
 - Dengue is a significant public health issue for PICs, which suffered two significant epidemics in 1998 and 2001 affecting approximately 30,000 people each time.⁽⁵⁴⁾
- Influenza
 - Global pandemics such as Influenza A (H1N1) significantly stretch regional health systems, including the preparedness of each country to deal with the impacts of these major health threats, and their broader social and economic impacts. Pacific leaders have called for a more coordinated regional approach to address as a matter of priority to address the immediate impacts of emerging diseases.⁽⁵⁵⁾

1.3.4 Population and demographics

Many PICs have a significant ‘adolescent bulge’. Across the region the youth age group of 15–24 years accounts for nearly two million people, which is close to a fifth of the region’s total population. Over a quarter of the total population are in the wider youth age grouping of 15–30 years⁽⁵⁶⁾, and in 14 countries’, the proportion of population between 5 and 14 years is over 20%, and in half of these the figure is closer to 25%.⁽²⁷⁾ In the Solomon’s 39% of the population is less than 15 years of age, and 42% of Solomon Islanders are in the dependency age range (younger than 15, or older than 64).⁽⁵⁷⁾ Development is compromised when countries face such challenges expanding services to keep pace with this rapid population expansion. Schools and health services are under pressure. This sheer weight of numbers, and the particular challenges young people face in their transition to independence, creates pressures which demand responses from governments, regional agencies, donors and the wider community.⁽⁵⁶⁾

Almost half the world’s adolescents of the appropriate age do not attend secondary school.⁽⁵⁸⁾ And when they do attend, many of them – particularly those from the poorest and most marginalized households and communities – fail to complete their studies or else finish with insufficient skills, especially in those high-level competencies increasingly required by the modern globalized economy. This skills deficit is contributing to bleak youth employment trends. The global economic crisis has produced a large cohort of unemployed youth, which in 2009 stood at around 81 million worldwide.⁽⁵⁸⁾

Box: 2 The State of Pacific Youth 2011- UNICEF

Overall, the situation of young people in the Pacific in 2011 has changed little. If anything, the challenges have become more critical since 2005.

Poverty, education systems focused on white-collar employment skills, stagnating economies that do not provide enough employment opportunities, and rural/urban inequalities are still the most significant underlying causes of youth problems. Continuing high population growth; rapid urban expansion; political volatility; under-performing economies, now further weakened by the impact of the global economic crises; and the rising cost of food point to a future for many young Pacific Islanders that holds an increased risk of entrenchment of poverty and broadening disparities, which will cause widespread discontent. Without a major investment in young people, they may well flounder as a generation, undermining the capacity of Pacific Island countries and territories to escape aid dependence, develop economically and, in some cases, even survive as viable societies.⁽⁵⁶⁾

School education statistics vary across the PICs. Whereas Samoa and Kiribati, 60 percent of 20 years old women have completed secondary schooling, whereas the Solomon Islands (2007) the figure is less than five per cent, and gross enrolment for girls and boys is 16 and 22 percent respectively. In Vanuatu in 2009, the gross enrolment rate in upper secondary schools was 47 and 44 per cent for girls and boys respectively.⁽⁵⁶⁾ Lack of education constrains opportunities for the individual, and economic development for nations as skills shortages expand relative to the population.

Education also has a strong bearing on health. The single most significant factor in predicting child health is the education of the mother. Simply stated, the more education a mother has, the more likely her child will survive. African data shows that a 10 percent increase in female literacy rates results in a 10 percent reduction in child mortality. The impact is broader than for herself and her own child. The WHO stresses that “ girls ' education is key to everyone's health Improving education for girls significantly improves the health of the whole community.”⁽⁵⁹⁾ This is further discussed in Case Study 3.

1.3.5 Health Infrastructure

Health expenditure

Health expenditure allocation is only a minor portion of total government expenditure, however health expenditure as a percentage of total government spending has increased for most PICs. Between 1995 and 2006; health budgets doubled in Micronesia and Niue and increased by five-fold in Nauru. Only Papua New Guinea saw a decline in government spending on health over the decade.⁽²¹⁾ Eight Pacific Island Countries (Timor-Leste, Marshall Islands, Niue, Kiribati, FSM, Tuvalu, Nauru, Palau, are above the world average, including New Zealand and Australia,⁽⁶⁰⁾ and averaging at 13%, PICs have the highest health expenditures among developing countries.⁽⁶¹⁾ Health financing in the Solomon Islands has ranged between 12% and 16% of the government's recurrent budget over the past few years, of which 48% was funded by health sector donor partners, principally Australia.⁽⁵⁷⁾ Australia's health expenditure was 9.4% of GDP in 2009-2010.⁽⁶²⁾ Economies of scale are not available for these small nations, so government expenditure per GDP comparisons with large developed economies are limited in value. Funding strains on the health sector are further

Overview of Climate Change Impacts on Human Health in the Pacific Region

exacerbated by human resources limitations, with significant migration of skilled professional health care workers to Australia and New Zealand.⁽⁶³⁾

In addition to government provided health care, the capacity to supplement service provision with personal expenditure on health determines an individual's access to health care. Out of pocket expenses on health in Palau, Niue, Marshall Islands, Kiribati, Cook Islands are almost double that of Australia (33 percent), whereas Tuvaluans and PNG people spend just over half.⁽⁶⁰⁾ Over the period 1995-2006 the share of private spending declined in Fiji, Papua New Guinea, Samoa and the Solomon Islands, but rose substantially (from 8 percent to 45 percent) in Nauru. Logistic challenges exist for nations with small populations to build and maintain complex multifaceted health infrastructure, which places them at a distinct disadvantage. Interpretation of out-of-pocket expenditure data requires caution. Increased outlay can reflect a drop or inadequate service provision. Reductions in out of pocket expenditures can indicate a drop in health care costs, although this is unusual. It can also mean a decline in service availability, or a reduction in disposable income. When matched with increase on government spending, it can indicate greater accessibility to services.

Many health determinants lie outside the health sector, as these maintain good health and prevent ill-health. In the event of ill-health occurring, the health sector becomes necessary to restore optimal health. Health expenditure is positively linked to health outcomes. A 10% increase in per capita health expenditure results in an approximate 6.6% reduction in infant mortality rate, equating to an average reduction of 2.0 infant deaths per 1,000 live births for the Pacific Island countries.⁽⁶⁴⁾ This finding supports a strong focus on primary care services to ensure improved immunization coverage and lower infant mortality rates. Expenditure in public health can further optimise health outcomes.

Health Care Services

Health care services can broadly be divided into two categories. On the one hand, public or population health promotes health and prevents disease. As the name suggests, the focus is on populations, or subpopulations, and much of this activity occurs in the community as health promotion as well as through research, policymaking and advocacy. Acute or curative health services attempt to restore health and prevent further deterioration in unwell people. Services are usually provided in hospitals or clinics, following a biomedical model that focusses on providing personalised care to the individual patient. Public health serves the health outcomes of a group of individuals, including the distribution of such outcomes within the group, examines the reasons for health outcome differentials and systematic disparities between subgroups. Populations of concern are often geographic regions, such as nations or communities, but they can also be other groups, such as employees, ethnic groups, the young or old, disabled persons, or prisoners. Population health focusses attention on the vulnerable groups within those populations, and works to 'close the gap' in health inequalities.

These two health fields serve very differing purposes, and both are essential to good health. Hospitals services, employing specialist and highly technical services are expensive and consume a significant proportion of health budgets. By comparison population, health is relatively cheaper to

Overview of Climate Change Impacts on Human Health in the Pacific Region

provide, and provides significant cost savings in future health budgets. Despite this, public health attracts very small proportion of national health budgets. For example, Australia health expenditure on public hospital services in 2009–10 was 31.2%, medical services consumed 18.3%, and medications, 14.0%.⁽⁶²⁾ Australia spent a mere 5.5% on population health in 2008–09, per person expenditure of \$106 per annum.⁽⁶⁵⁾ The efficacy of public health activities is shown in Table 7 in section 2.4.1, where cost benefits from water interventions range from 4:1 to 12: 1 in benefit over costs in US\$. Populations confronting broad scale disadvantage in social and environmental determinants of health will inevitably have poorer health outcomes than developed nations. Redressing this health status gaps requires substantial investments in addressing those unhealthy determinants through social policies, and public health practice.

There is considerable variation in the provision of hospitals among the Pacific Islands. New Caledonia has a central hospital (the Centre Hospitalier Territorial de Nouvelle-Calédonie) distributed across four sites in Noumea: Gaston Bourret^c (260 beds, 15 day hospital places); Magenta^d (166 beds, 13 day care places and 17 haemodialysis stations); Follereau^e (26 beds. Leprosy centre); Col de La Pirogue^f (34 beds) Fiji has a private hospital in Suva.^g There are also two public hospitals in Fiji, one in Suva and one in Lautoka. In the Cook Islands there is an 80 bed hospital in Rarotonga and a 20 bed hospital and dental clinic in Aitutaki. In the Solomon Islands Gizo Hospital in the Western Province has 52 beds, and The National Referral Hospital in Honiara has a further 3-400 beds. There are also a number of smaller provincial hospitals with 20 to 160 beds in the Solomon Islands.

The College of Medicine and Health Science (Fiji School of Medicine and Fiji School of Nursing) at Fiji National University educate nurses and doctors to work in the Pacific. The University of Papua New Guinea Medical School^h trains doctors for Papua New Guinea.

Public health – disease preventions

The Secretariat of the Pacific Community (SPC), based in Noumea, provides technical and policy advice and assistance, training and research services to its Pacific Island members. The SPC aims to achieve three development outcomes – sustainable economic development, sustainable natural resource management and development, and sustainable human and social development. It was established in Australia in 1947 by the six governments that then administered territories in the Pacific: Australia, France, New Zealand, the Netherlands, the United Kingdom and the United States of America, to restore stability to a region that had experienced the turbulence of the Second World War. SPC now sources additional donor funding to help Pacific Island people position themselves

^c 7, avenue Paul Doumer, BP J5 - 98849 Nouméa Cedex, Nouvelle-Calédonie

^d 27, rue du 18 Juin, Magenta - BP J5 98849 Nouméa Cedex Nouvelle-Calédonie

^e 7, rue Follereau - Presqu'île de Ducos BP J5 - 98849 Nouméa Cedex Nouvelle-Calédonie

^f Rue Pas de Loup, Col de la Pirogue - Païta - BP J5 - 98849 Nouméa Cedex Nouvelle-Calédonie.
(http://www.cht.nc/public_4_cht.asp).

^g Suva Private Hospital 120 Amy St, Toorak, Suva, Fiji Islands
(http://travel.state.gov/travel/cis_pa_tw/cis/cis_1114.html#medical).

^h UPNG School of Medicine and Health Sciences, P.O. Box 5623, Boroko, NCD Phone: (675) 3112626 Fax: (675) 3250809

Overview of Climate Change Impacts on Human Health in the Pacific Region

effectively to respond to the challenges they face and make informed decisions about their future and the future they wish to leave for the generations that follow.

The Public Health Division (PHD) of the SPC assists regional health departments by providing technical expertise and support in public health surveillance, prevention of communicable and non-communicable diseases and promotion of adolescent reproductive health. The SPC PHD manages a Public Health Programme to tackle the many and varied health challenges across the Pacific region. By taking a whole-of-health approach its aims are to improve the health and well-being of Pacific Islanders.⁽⁶⁶⁾ Specific SPC programs include Communicable Diseases (HIV & Sexually transmitted diseases, Public Health Surveillance and Communicable Disease Control, and TB Control), Non-communicable diseases (Healthy Pacific Lifestyle, Adolescent Reproductive Health) in addition to specific regional initiatives (Pacific Public Health Surveillance Network). This PPHSN is a voluntary network of countries and organisations dedicated to the promotion of public health surveillance and appropriate response to the health challenges of 22 Pacific Island countries and territories, which prioritises communicable diseases, especially those prone to outbreaks. At this stage the target diseases include: dengue, measles, rubella, influenza, leptospirosis, typhoid fever, cholera, SARS and HIV/STIs. Examples of the work of PPHSN include producing clinical case management guidelines for influenza, Infection prevention and control guidelines, and Infection control posters.

Additional technical expertise is provided by SPC staff in the fields of epidemiology, surveillance, data management for reporting and analysis. SPC - PHD staff are currently based in five locations, with 78 per cent of positions project-funded and 94 per cent of the budget sourced from grants-based project funds. The reliance on project funding creates vulnerability for the division, as many 'mission-critical' positions do not have continuity of funding.⁽⁵⁵⁾

The SPC and the Pacific Plan, July 2010 – June 2011, provided a cross cutting examination of existing development challenges and mapped a way forward. The goals of the Pacific Plan are to enhance and stimulate economic growth, sustainable development, good governance and security for Pacific countries through regionalism.

Despite a generally close –knit community structures the *Asia Pacific Strategy for Emerging Diseases*⁽⁴⁰⁾ identified this interconnectedness is not a feature of government structures in many Pacific Island Countries. The Strategy notes there has been a relatively low level of integration of health and non-health sectors (e.g. Animal health, disasters preparedness, transport, information technology) of hospital –based and community health services. The strategy recommends improved communications between the sectors and increased representation of public health sectors in non-health sectors. Potential benefits from this include improved outcomes from community plans and routine operations of health and non-health systems, with specific improvements in health care surge capacity and surge effectiveness.

The SPC is developing a series of plans to address the most pressing issues of Climate Change, Food Security, the Millennium Development Goals, Poverty Alleviation and Gender Issues. Pacific leaders highlighted a series of overarching issues that continued to require extra effort to achieve results.

Overview of Climate Change Impacts on Human Health in the Pacific Region

These included a sustained increased coverage of safe drinking water and sanitation services; focussing education efforts on increasing literacy and numeracy rates; expanding the definition of disaster risk management beyond climate change to be 'people focused', covering responses to health disasters and population growth and movement; and addressing the lack of technical and managerial capacity.⁽⁵⁵⁾

Public health services through the Pacific are funding limited. Despite the proven cost effectiveness, and high level of need, health promotion activities in the Solomon Islands are absent in many rural areas. Positions are vacant as grants to provinces are not sufficient to finance public health activities.⁽⁵⁷⁾ Instead of focussing on awareness raising and information sharing, health promotion needs to be action oriented to effect behaviour change, and this incurs a higher operational costs.

Health Workforce

For many diseases and health-threatening conditions, proven public health and health promotion technologies are readily available, but cannot be implemented to their full potential due to a lack of adequately trained and equipped local health professionals.⁽⁶⁷⁾ There is need for qualified practitioners anchored in third world localities, but also for public health administrators, researchers and educators. This emphasis on indigenous expertise acknowledges the critical cultural dimension of effective public health practice. Among the most cost-effective approaches to disease prevention and health promotion, for example, are community-based approaches to health program planning, implementation, and evaluation. Public health workers who 'belong' to the communities in which they work enjoy advantages that are simply unrealistic for even the best trained and motivated visiting professionals.

In the Pacific region, doctors are generally employed in hospitals in urban areas, while nurses deliver the majority of health services in rural areas. For example, more than 50 per cent of all doctors in Papua New Guinea work for the National Department of Health (including urban clinics in the National Capital District), approximately 37 per cent work in hospitals and less than 10 per cent work in the provincial areas, while over half of all nurses work for provincial health services.⁽⁶⁸⁾

The World Health Organization estimates that there is a global shortage of almost 4.3 million doctors, midwives, nurses and support workers.⁽⁶⁹⁾ These shortages are most acute in developing countries, and are exacerbated by the migration of many health workers to developed countries. Since the 1960s, there has been significant international migration of skilled health workers (SHWs). In the past decade, migration has become more complex, more pan-regional and of growing concern to countries that lose workers from fragile under-resourced health systems. Countries most affected by emigration are relatively poorly performing economies, notably the small Pacific island states. Data on migration flows and workforce structures is largely absent and entirely absent for many countries. This is particularly the case for physiotherapists, pharmacists and radiologists, whose migration may be as critical as that of better documented nurses and doctors.⁽⁷⁰⁾ Detailed regional information on the distribution of disease burdens and mortality rates within PICs is lacking, hence it is impossible to determine where regional needs for medical care are greatest.

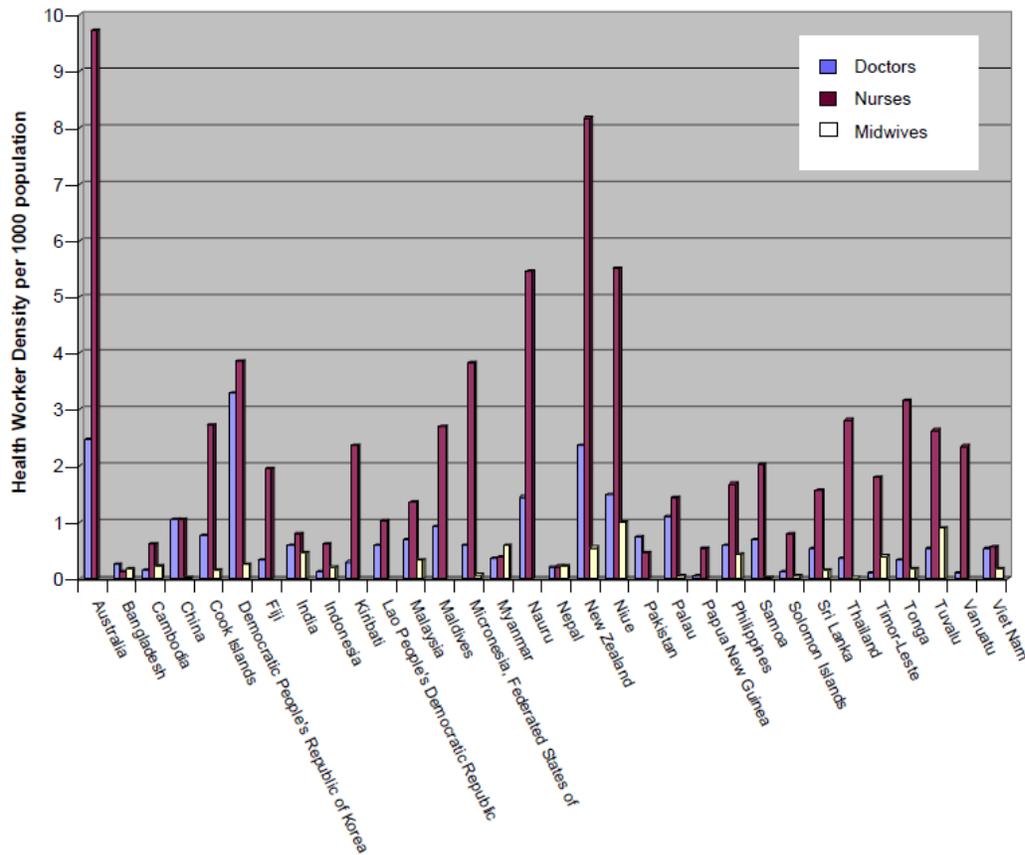
Overview of Climate Change Impacts on Human Health in the Pacific Region

The severe shortage of health workers in Pacific Island countries is a critical issue that must be addressed as an integral part of strengthening health systems.⁽⁶⁸⁾ Health workers are vital to health systems but their professional needs are often neglected. Factors that contribute to the shortage of skilled health workers include:

- a lack of effective planning;
- limited health budgets;
- migration of health workers, ;
- inadequate numbers of students entering and/or completing professional training;
- limited employment opportunities,;
- low salaries and poor working conditions, weak support and supervision; and
- limited opportunities for professional development.

The shortage of workers often results in inappropriate skill mixes in the health sector as well as gaps in the distribution of health workers. Staff shortages are especially acute in rural and remote areas where the provision of services is difficult because of limited health budgets and scattered populations living in isolated villages or islands.

Figure 5: Density of health workers in Pacific Island Countries



Data Source: WHO Global Atlas of the Health Workforce⁽⁶⁸⁾

Little is known of the structure of the international migration of skilled health professionals. Accelerated migration of doctors and nurses from the Pacific island states to the Pacific periphery is part of the globalization of health care. The findings from a recent survey of 251 doctors and nurses from Fiji, Samoa and Tonga identified Nurses’ and doctors’ propensities to migrate are influenced by both income and non-income factors, including superior working conditions, ownership of businesses and houses.⁽⁷¹⁾ The role of kinship ties, relative income differentials and working conditions is evident in other developing country contexts. Remittances and return migration, alongside business investment, bring some benefits to compensate for the skill drain. There is a need for national development policies to focus on encouraging return migration, alongside retention and recruitment, in order to stem the out migration.

Challenges of Distance

The Pacific Islands suffer from ‘the tyranny of distance’, being small scattered populations, with small markets, lack of infrastructure and human resources, and high costs of connectivity. The PICTs are dispersed over an area covering a substantial part of the earth’s surface, the ‘Blue Continent’. Populations range from less than one hundred people in Pitcairn Islands to approximately 6.8 million

Overview of Climate Change Impacts on Human Health in the Pacific Region

people in Papua New Guinea. Large distances, poor infrastructure and lack of economies of scale are common phenomena in the region, and these characteristics underpin the inequities and systematic disadvantage among the remote communities. The features that hinder connectivity are exactly those which intensify the necessity for dispersed population to access Information and Communication Technologies (ICT).

Information Systems and E-Health

The ICT Ministers recognised these challenges and in their 2009 Pacific ICT Ministerial Forum Communiqué called for *'increased coordination amongst all stakeholders in the Pacific at regional, sub-regional and national levels to consolidate efforts to improve connectivity'*. The 2011 Pacific Island Health Ministers Forum reaffirmed the high priority of ICT development to underpin health infrastructure. At present, applications such as e-government, e-commerce, e-health and e-education are either non-existent or in their infancy in most PICTs. When competing against access to food and water, ICT is not a household priority. Whilst provisioning access to ICT is not a specific "health action", the capacity for community connectivity is vital infrastructure to the delivery of health promoting programs, surveillance and monitoring. It is also vital for identifying, and transmitting warning alerts. ICT therefore becomes a vital part of health infrastructure, specifically for dispersed populations.

Information and communication technology (ICT) is an example of an infrastructure issue that is external – but essential to - health services, and which reflects another developmental challenge. E-health serves to partially off-set the rural disadvantage of distance and lack of specialist services. ICT is a critical element of communications systems, surveillance and laboratory services. Ongoing work in this area is vital to enable a well-functioning health system, and the necessary surveillance and monitoring activities, plus communications to coordinate responses during emergencies. Absent or slow speed internet communications hampers health surveillance and health service delivery. A recent review of the digital strategy provided the basis for the development of the new *Framework for Action on ICT for Development in the Pacific*. The primary objective is the implementation of national policies and plans to achieve the longer-term aspiration of *affordable ICT for all Pacific Islanders*. Teledensity (the number of landlines per 100 inhabitants) rates in the region is low, about 10 per cent. Landline connection rates are considerably in rural and isolated areas. Mobile telephony had increased rapidly, particularly in countries where the sector has been liberalised, yet few PICs have national ICT policies and legislation, and Internet access was expensive in much of the region. Capacity building in this sector remains critical for many PICTs. In developed countries, E-health (electronic health) is a rapidly growing area that is proving its investment value especially in isolated regions by linking health speciality expertise to regional practitioners.⁽⁷²⁾

Non-health - health infrastructure

As outlined above, health status is a function of a plethora of interacting determinants, social and environmental in origin, and embedded within political and infrastructure frameworks. The 40th Meeting of the Committee of Representatives of Governments and Administrations noted good progress made in the *Framework for Action on Food Security in the Pacific*. The link between food security is relatively clear, however links to other 'externalities' critical to provision of health

Overview of Climate Change Impacts on Human Health in the Pacific Region

services, and infrastructure necessary for opportunities for health are less obvious. Energy security cuts across many sectors and is an essential driver for economic development. Health service provision and accessibility can also be adversely affected by prohibitively high fuel prices. There are also wider implications such as a similar situation also applies for food production and accessibility. A *Framework for Action on Energy Security* had languished on the Forum leaders' agenda for six years. The recent economic crisis brought energy security into prominence, and highlighted the Pacific's heavy reliance on petroleum fuels and need to lessen dependence on fossil fuel. The need for sustainable energy supplies, and vulnerability to energy insecurity brought to prominence the need for assistance to move to clean, renewable, locally generated energy resources.

1.4 Projections

The following predictions derive from various sources, including the reports of the IPCC and papers in the international peer-reviewed literature, and recent CSIRO modelling.

- Increase in air temperature:
 - Globally, over the next two decades a warming of about 0.2°C per decade is expected. Beyond this period the projections depend on specific emission scenarios;⁽⁷³⁾
 - Projected air temperature (°C) increase for 2080-2099;⁽⁷⁴⁾
 - Southern Pacific: 1.8°C
 - Northern Pacific: 2.3°C
 - “most likely” (climate) future: warmer with little rainfall change;⁽⁷⁵⁾ and
 - “largest change” (climate) future: warmer and much wetter⁽⁷⁵⁾
- Increase in sea-surface temperature.⁽²⁴⁾ Many of the climate models indicate:⁽⁷⁵⁾
 - A maximum warming in the central equatorial Pacific
 - The least warming occurring in the south-eastern Pacific
- Changes in precipitation
 - Despite projections of likely change in rainfall events, there is ambiguity as to whether precipitation will increase or decrease;⁽²⁶⁾
 - It is estimated that there will be more rainfall during summer and more frequent heavier rainfall events;⁽²⁶⁾
 - Rainfall variability in the South Pacific will be strongly influenced by future changes in the El Nino-Southern Oscillation (ENSO), which are poorly understood;⁽⁷⁴⁾
 - Range of projected precipitation change (%) for 2080-2099;⁽²⁶⁾
 - Southern Pacific: -14.0 + 14.6

Overview of Climate Change Impacts on Human Health in the Pacific Region

- Northern Pacific: -2.7 + 25.8
- Sea level rise
 - Estimated global sea level rise according to various climate scenarios will be 0.19-0.58m by the end of the 21st century;⁽⁷⁶⁾ with predictions of 0.032, 0.056, 0.083 metres for the periods 2021-2040, 2046-2065 and 2081-2100, respectively⁽⁷⁵⁾
 - A number of locations worldwide are predicted to experience a more marked sea level rise including the southern Pacific at about 30°S,⁽⁷⁴⁾
- Ocean acidification
 - Increased concentration of carbon dioxide (CO₂) in the atmosphere has resulted in the oceans taking up a greater amount of CO₂ causing an increase in carbonic acid concentration and a decrease in bicarbonate ions, and hence a decrease in the pH of about 0.1 over the past several decades.⁽⁷⁷⁾ This represents around a 25% increase in the acidity of the oceans, and this trend is predicted to continue.
- Extreme events
 - Tropical cyclones
 - There is greater uncertainty in future projections regarding tropical cyclones. It is, however, anticipated that while climate change will probably result in fewer tropical cyclones, there will be an increased proportion of severe tropical cyclones with greater wind speeds and more intense precipitation;⁽⁷⁴⁾
 - The available model projections suggest that the Pacific Island and East Timor may experience a 10 to 50% decrease in cyclone numbers by the end of the 21st century, with the possibility that the proportion of cyclones with higher intensities will increase. However, some of the predictions show the opposite result.⁽⁷⁵⁾
 - Heat waves
 - More frequent heat waves of longer duration and greater intensity are projected globally;⁽⁷⁴⁾
- ENSO
 - ENSO, typified by irregular warming of the eastern equatorial Pacific ocean is the principal cause of year to year climate variability in the Pacific.⁽²⁶⁾ From current modelling, there is no projected change in ENSO amplitude or frequency for the 21st century;⁽⁷⁴⁾

James Hansen examined recent global extremes of temperatures, and analysed these against 'climate norms' (based on the climate record).⁽⁸⁾ Hansen observed that these events lie outside 3 standard deviations (3σ), making them statistically very unusual, and therefore ranked as anomalies. His next step was to compare these with his projections of 1988, to find an excellent match. He

Overview of Climate Change Impacts on Human Health in the Pacific Region

therefore concludes that Earth is on track for a trajectory whereby these 3σ events will become the new norm, and that 5σ events will become common.

Part 2: CLIMATE CHANGE IMPACTS ON HUMAN HEALTH

Climate change will have a range of impacts on human health, and it is expected that many of these will be negative and most likely significant. The full impact in terms of specific consequences, degree of effect and timing are difficult to predict with any certainty, as the epidemiological study of the health effects of climate change faces numerous challenges, especially at this relatively early stage of the investigation⁽⁷⁸⁾. Indeed, determining the 'baseline' causal relations between natural climate variation and health is often difficult, especially when causal processes are complex and involve a multitude of indirect pathways. One salient and very important example, of the indirect relationship between climatic conditions and human health occurs via nutrition and food supply. The association is self-evident, yet the relationship between seasons, food yields and health outcomes has not been quantified. Studies drawing the link to climate change, seasons, food supply and health impacts are currently underway. Oxfam highlighted food insecurity in their *Suffering the Science: Climate change, people, and poverty* report⁽⁷⁹⁾ in which they described the rise in hunger and death following rising food prices, brought about by widespread crop failures. In many countries, including the PICs, the lack of long-term good quality health data restricts the conduct of epidemiological research and hampers measurement of past trends. This data needed to conduct scientifically rigorous projections of likely future scenarios.

Further, achieving a high level of confidence in detecting and measuring health effects derived from climatic influences is particularly difficult, since health outcomes are influenced by factors other than climatic conditions. Prominent factors that contribute to health outcomes are called health determinants. Socio-economic factors, the influences of the relative efficacy of public health infrastructure on population health, plus other situation specific factors promote resilience and provide interim health supports. Absence of these serves as a barrier to good health. In the above example food systems, food self-sufficiency and access to other food sources and foreign aid influence hunger and nutritional status. These confounding factors generate 'background noise' in epidemiological studies and therefore make it difficult to discern overarching climate signals.

Human health, culture and societies have evolved in response to their local ecosystems and existing climates, and the inherent variability embedded within. The hallmark of success of human societies is their capacity to develop adaptive strategies to prepare for, and survive, the extreme weather events that inevitably occur within their local regions. Therefore, through generations of responding to events, and devising protective systems, successful societies are well adapted to their local climates and environments. The current and projected threats to human health arise predominantly from projected increase in extreme events, and gradual shifts in climatic patterns that strain (or exceed) adaptive capacity and cause major disruptions to existing food and water supplies, and also to the protective systems and infrastructure.

Climate change effects on health will include direct and indirect mechanisms, as depicted in Figure 6. The direct effects of heatwaves, storms, floods, inundation and droughts interrupt food and water supplies, damage infrastructure and cause direct injuries. Mental health problems arise from

Overview of Climate Change Impacts on Human Health in the Pacific Region

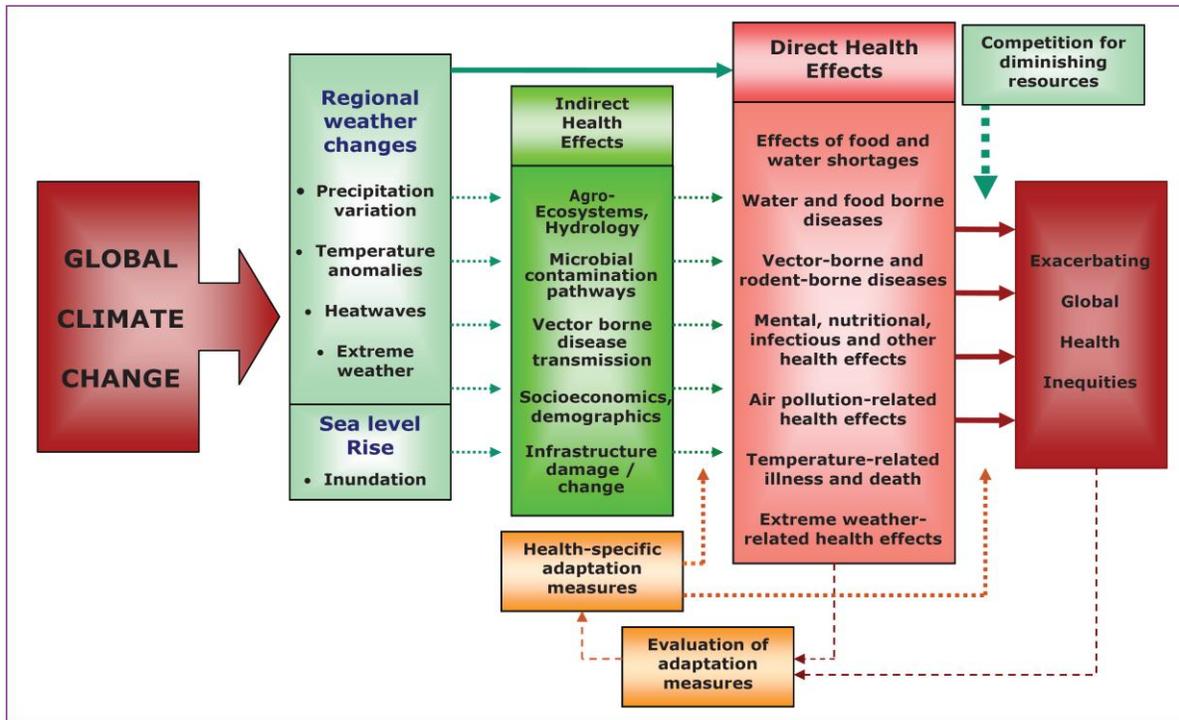
feelings of inadequacy, despair about the future, loss and grief. These have been called primary effects.⁽¹¹⁾

Indirect health effects arise from changes that occur as a result of impacts on other systems. Examples of secondary effects arise from interruptions in ecosystems such as vector ecology, plant and animal tolerance of new climate patterns, changes in agricultural productivity and other effects such as deteriorations in air quality. Altered vector ecology includes shortened breeding cycle of mosquitoes resulting in greater concentrations, and increased biting rates, and shortened pathogen incubation periods leading to greater risks of disease transmission⁽⁸⁰⁾. Many impacts will feed back on each other and affect societies' capacity to rebound after major perturbations and ability to protect the vulnerable whilst rebuilding and repairing. For example, floods can destroy crops and weaken populations through increased disease burden, which can reduce their work capacity and deepen their malnutrition as current and future seasons of food yields are diminished. This in turn leads to greater susceptibility to subsequent disease. Societies can suffer repeat extreme events prior to return to functional normality. This can a) set 'normality' to a new *lower* level, and b) increase vulnerability to further harm from subsequent events, thereby compounding the adverse effects and establish a downward spiral reversing previous progress towards reaching economic development goals.

Tertiary effects arise as these consequences accumulate and interact and have broader implications across the society and societies. Tertiary effects were demonstrated in Sudan,⁽⁸¹⁾ where environmental and climate impacts brought water scarcity, drought and a lack of land for farming and grazing contributed to human insecurity and conflicts. This risk is especially strong in contexts where people and communities already suffer deprivations and exclusions, and are highly dependent on the environment for a living.⁽⁸²⁾ losses exacerbate competition for diminishing resources, which can spark or escalate tensions resulting in conflict and increasing the risk of widening the equity and health gap. Progress towards meeting Millennium Development Goals can be significantly threatened as climate change impacts unfold, as conditions deteriorate and health suffers.⁽⁸³⁾ Pacific Islands are highly vulnerable.

The UN Security Council recognizes the potential for climate induced security threats. At the first meeting on the topic (April 2007, New York) the Papua New Guinea's representative, spoke on behalf of the Pacific Islands Forum, said that the Pacific island countries were likely to face massive dislocations of people, similar to population flows sparked by conflict. The impact on identity and social cohesion were likely to cause as much resentment, hatred and alienation as any refugee crisis.⁽⁸⁴⁾

Figure 6: Schematic summary of main pathways by which climate change affects population health



Source: Hanna, McMichael et al (2011)⁽⁸⁵⁾ Modified from McMichael AJ, Woodruff et al. (2006)⁽¹⁰⁾

2.1 Extreme weather events and disasters

When announcing its intention to broaden its disaster warning services, the World Meteorological Organization WMO stated that “about 90% of natural disasters in recent decades were caused by weather or climate-related hazards such as tropical cyclones, storm surges, floods and droughts. Economic losses from these hazards currently amount to about 100 billion US dollars per year and are rising, and can inhibit the pace of development by years if not decades.”⁽⁸⁶⁾

SIDS are particularly susceptible to extreme weather events.⁽⁸⁷⁾ Globally, the number of extreme weather related natural disasters is increasing,⁽⁸⁸⁾ with a greater than two-fold increase reported from 1980-1989 to 1999-2009.⁽⁸⁹⁾ People of the Asia-Pacific region, especially those living in coastal tropical regions,⁽⁹⁰⁾ are four times more likely to be affected by natural disasters than those living in Africa, and 25 times more likely than those living in Europe or North America.⁽⁸⁹⁾ Cyclones in the Pacific islands region accounted for 76 per cent of the reported disasters between 1950 and 2004, with the average costs relating to damage caused per cyclone standing at USD 75.7 million in 2004 value.⁽⁹¹⁾ Their losses are greater in terms of injuries and fatalities and direct economic losses relative to annual GDP. Estimations of post-disaster losses under-value the extent of impact as estimates tend to exclude indirect losses, including impacts of lost livelihoods and flow on impacts to families and throughout local communities and the intangible losses of human fatalities, injuries and residual disability, quality of life and cultural heritage, and impacts to ecosystem services. Disasters can therefore cause important adverse long-term effects by amplifying national and domestic poverty,

Overview of Climate Change Impacts on Human Health in the Pacific Region

which reduces direct and indirect tax revenue, dampens investment, and exerts residual harm by restricting economic recovery, and delaying progress towards reaching Millennium Development Goals. Recovery time is slow from severe setbacks, and if repeat events occur before full recovery is achieved, a downward trend can be established.

The Pacific Islands and East Timor are therefore among the countries most at risk from extreme weather events.⁽⁹²⁾ Studies predict that climate change will be a significant cause for increasing frequency, intensity and duration of extreme weather events in the future.⁽⁹³⁾ United Nations International Strategy for Disaster Reduction (UNISDR) also suggests climate change will increase extreme weather events.⁽⁸⁸⁾ Significant stakeholders, such as the insurance giant Munich Re, now suggest that extreme weather events can no longer be explained by natural climate oscillations alone, and the probability is that climate change is contributing to warming of the world's oceans and resultant extreme weather events.⁽⁹⁴⁾ Following the steady increase in extreme weather events across the globe, the IPCC has declared that

In the second half of 2010, agricultural prices surged following a series of crop failures in major crop-producing areas. The severe and prolonged La Niña weather phenomenon has resulted in massive flooding in many countries, and is considered the worst in 3 decades (the last time was in 1973–1976). Extreme weather disturbances are being touted as the main culprit causing supply shortfalls in a range of commodities such as corn, coffee, rice, wheat, and sugar.⁽⁹⁵⁾

While specific outcomes of climate change are uncertain, the IPCC report *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)* states that “it is virtually certain that the frequency, intensity, and variability of extreme and non-extreme climate events, in addition to the mean values of climate variables, will be altered”, and further, “that these alterations are very likely to change the nature and frequency of weather and climate extremes that can contribute to disasters, although this does not necessarily imply only intensification or increases in the number of such events.”

Extreme weather events have considerable impacts on human health and society.⁽⁹⁶⁾ They cause injuries and deaths as a direct impact. Indirect health effects occur through social and economic disruption, destruction of houses, medical facilities and essential infrastructure and service, or delayed treatment of chronic health problems. Accurately assessing the full effects of extreme weather related disasters is difficult as indirect and delayed effects are often poorly recorded.⁽⁹⁷⁾ The direct effects of weather related disasters are relatively minor compared to subsequent secondary effects.⁽⁹⁷⁾ Health impacts of natural disasters include: physical injury; malnutrition; increased risk of water-borne and infectious diseases and contamination of water supplies with dangerous chemicals and wastes; and increased respiratory and diarrhoeal illness.⁽⁹⁷⁾ Mental health problems can emerge immediately with fear, and grief resulting from loss, or long after the event.

When extreme events involve *extreme direct and indirect social and economic impacts* leading to a severe disruption of the normal, routine functioning of the affected society, they contribute to the occurrence of “disaster”.

Table 3: Major Extreme Weather Events between June and December 2010

Weather Event	(Most) Affected Area
Severe winter and/or snow fall	Europe (Western)
	United States
Heatwaves	Russian - European
Drought and wildfires	China, People’s Republic of (Shandong)
	Russian Federation (mainly west)
	United States (California, Texas, Alabama)
	Brazil
Cyclone, flooding,	Australia (Queensland)
	Pakistan
	China, People’s Republic of
	Malaysia, Myanmar, Philippines, Thailand
	United States (Arkansas)

Source: US National Climatic Data Center.⁽⁹⁸⁾

The 2001 IPCC report *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)* projects likelihood of future events.

- It is "very likely" (90-100% certainty) that the length, frequency and/or intensity of warm spells, including heat waves, will continue to increase over most land areas.
- Peak temperatures are "likely" (66-100% certainty) to increase - compared to the late 20th century - up to 3 degrees Celsius by 2050, and 5.0 degrees C by 2100.
- Heavy rain is likely to increase, especially in the tropics and at high latitudes.⁽⁹⁹⁾

2.1.1 Heat Waves

Annual and seasonal ocean surface and island air temperatures have increased by 0.6 to 1.0 °C since 1910 in the southern Pacific region, with significant increases in the annual number of hot days and warm nights, with significant decreases in the annual number of cool days and cold nights. The November 2011 IPCC *Managing the Risks of Extreme Events and Disasters* report suggests that global temperatures are "likely" (with 66-100% certainty) to increase compared to the late 20th century, by up to 3°C by 2050, and 5.0°C by 2100.⁽⁹⁹⁾ Whereas global warming of a few degrees has significant impact on weather systems, the few extra degrees of daily maximum temperature over the next few decades (to 2030) are not likely to adversely affect the health of most human populations. There will however, be significant health impact from the combined effects of the warm shift and associated greater temperature extremes. It is "virtually certain" (99-100% sure) these will deliver more record-hot days and more intense and frequent extreme heat waves over the 21st century on a global scale.

Overview of Climate Change Impacts on Human Health in the Pacific Region

Extreme heat events observed recently, are already responsible for the significant morbidity and mortality seen in Europe, Russia, the Middle East, South Asia, the United States and Australia.⁽¹⁰⁰⁾ This new category of extreme climate outliers lie more than three standard deviations (σ) outside the norm. These extremes were practically absent in the period of between 1951-1980, and when they did occur, they covered much less than 1% of Earth's surface, but now summertime extremely hot outliers typically cover about 10% of the land area.⁽⁸⁾

The evidence of heat wave impacting on human health has been well established. To date, studies investigating extreme heat exposure and human health have been conducted in Australia, Europe, Central Asia and North America.⁽¹⁰¹⁾ These studies have found convincing evidence that diverse human populations are vulnerable to heat exposure. This vulnerability is greater where acclimatisation is less and infrastructure is poorly designed for the heat. Future increases in the number and severity of heat waves will continue to cause increased heat related deaths,⁽⁹⁷⁾ particularly in those persons with pre-existing underlying cardiovascular and chronic respiratory impairment.⁽⁸⁸⁾

Major extreme heat events have thus far occurred primarily on continents rather than on small island nations due to the "heat sink" properties of surrounding water as island states, which offers a moderating protection from temperature extremes. Models cited in the 2007 IPCC AR4 Report projected the central Pacific Ocean is likely to experience the greatest warming, whereas the subtropics, and in particular the southeast Pacific Ocean, are expected to warm less.⁽⁴⁾ The more recent Pacific Climate Change Science Program reports suggest that average temperature rises in the PICS will range from 0.2°C by 2030 under low emission scenario to about 3.4°C under a high emission scenario by 2090.⁽¹⁰²⁾

Average temperature rises are not the primary health concern at this point in time. Evidence suggests that rather than average temperatures, or even absolute temperature values, the trigger points for populations to suffer heat illnesses relate more to variations from the local climate norms.⁽¹⁰³⁾ Across the globe, the frequency and intensity of heat extremes is already increasing. Heat extremes, by definition are a rare event. Rather than 1% of the globe experiencing heat events that are three standard deviations from the norm, these have been occurring over 10% of the world.⁽¹⁰⁴⁾ This trend suggests that PICs may also experience extremes, and their lack of familiarity with exposure to heat extremes may manifest as an increased vulnerability for PICs.⁽¹⁰⁵⁾ Prudence therefore dictates that nations prepare for heat extremes by developing extreme heat health plans.

Acclimatisation to heat occurs at many levels; physiological, behavioural and technological. Pacific island populations are acclimatised to their current warm and often humid climate. However for many, the technology option of artificial cooling is not available. There are upper limits to human physiological acclimatisation,⁽¹⁰⁶⁾ beyond which serious health consequences can occur. Humans must maintain their core temperatures within the very narrow range (36.0-37.8°C). Basal metabolic rate and movement via working muscles generate internal heat, which must be dissipated to the environment. The primary method of heat loss is via sweating, which relies on evaporation from the skin, and becomes ineffective when humidity rises.⁽¹⁰³⁾ If additional heat cannot be shed, core temperatures rise, and hyperthermia (above 37.8°C) occurs which poses serious risks to organ

Overview of Climate Change Impacts on Human Health in the Pacific Region

function. Hyperthermia is associated with feelings of discomfort. The body's natural (protective) tendency is to avoid additional heat generation, by resting. Enthusiasm to exercise diminishes. This health-sustaining measure, can negatively impact on productivity.

Periods of extreme heat also pose significant, though under-recognised, risks to workers – especially outdoor workers and those working in unventilated uncooled buildings.⁽¹⁰⁷⁾ The proportion of people working in agriculture and outdoor occupations, and in non-air-conditioned environments, is significantly greater in developing countries than higher income nations. The Wet Bulb Globe Temperature (WBGT) is an index developed to incorporate humidity and wind speed into temperature to provide an overall measure of *experienced* heat exposure. Occupational health and safety guidelines recommend that workers doing light work at 30.5°C WBGT should rest 25% of time, at 31.5°C rest should increase to 50%, and at 32°C, workers should rest for 75% of the time.⁽¹⁰⁸⁾ To avoid health harm high intensity work should be reduced at lower temperatures.

Maximum daily temperatures in PICs commonly reach 30-33°C, and this is often accompanied by a relative humidity in excess of 55%. The WBGT table (below) shows this will produce a WBGT reading that frequently falls within the range of 29.5 to 33.5°C, under which sustained physical exercise is regarded potentially damaging to human health, and on high humidity days, dangerous WBGT can be reached with ambient temperature as low as 26°C. Willingness to perform labour, to run, climb stairs, play sport, carry heavy parcels, walk, shop, cook or clean is severely compromised as temperature and humidity climb. Physical activity becomes increasingly unpleasant for the overweight as temperature and humidity rise.

A coloured flag system has been developed to guide the U.S. Military and employers on recommended work and rest periods calibrated for WBGT readings. The table below, published by the US EPA and Occupational Safety and Health Administration,⁽¹⁰⁹⁾ shows the increasing rest periods required per hour to avoid the onset of dangerous heat stress. Health risks are extreme beyond a WBGT of 32.2°C, and all work is recommended to cease.

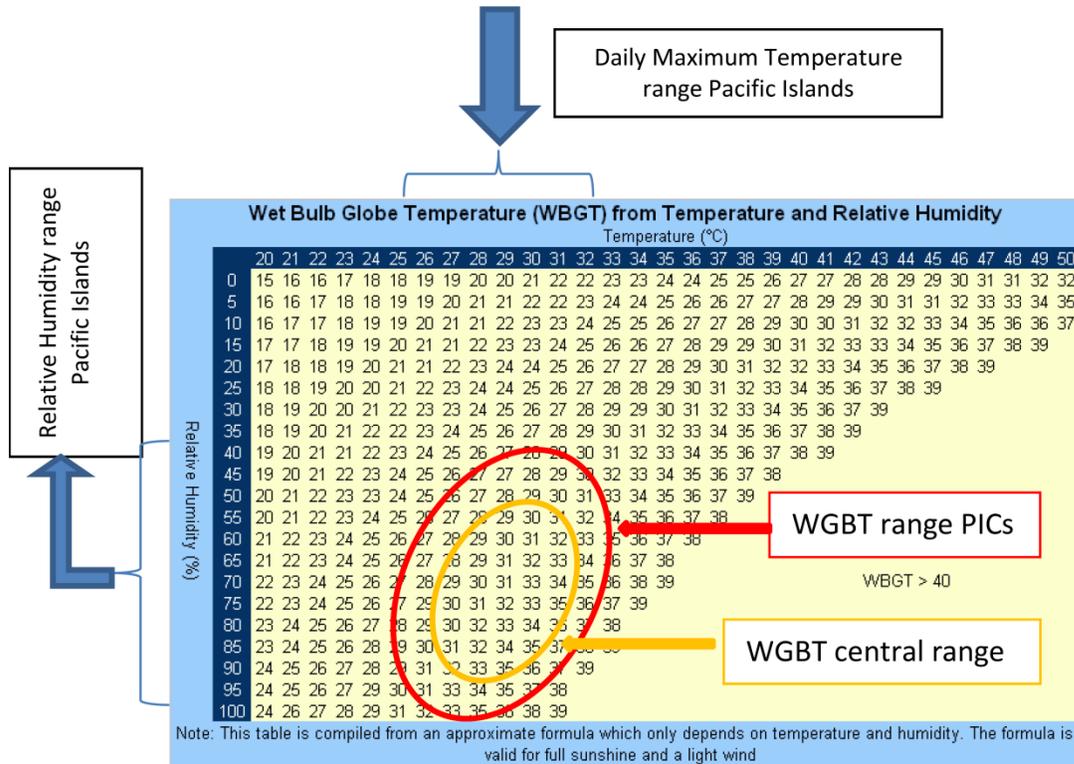
Category	WBGT °C	Flag colour	Work level - Work/rest in mins		
			Easy	Moderate	Hard
1	<=26.6	No flag	No limit	No limit	40/20
2	26.7-29.3	Green	No limit	50/10	30/30
3	29.4-31.0	Yellow	No limit	40/20	30/30
4	31.1-32.1	Red	No limit	30/30	20/40
5	=>32.2	Black	50/10	20/40	50/10

Modified from U.S. EPA/ OSHA⁽¹⁰⁹⁾

The following table lists WBGT in degrees Celsius, calculated from temperature (°C) and relative humidity (RH).⁽¹¹⁰⁾ Daily maximum temperatures and RH in PICs are indicated to reveal the thermal environment already existing is not conducive to exercise, where WBGT commonly approaches, or exceeds the recommended upper limits for ceasing physical activity. The red circle shows the WBGT range across the PICs, and the inner orange section is indicative of commonly occurring thermal environment faced by regional populations in the region.

Overview of Climate Change Impacts on Human Health in the Pacific Region

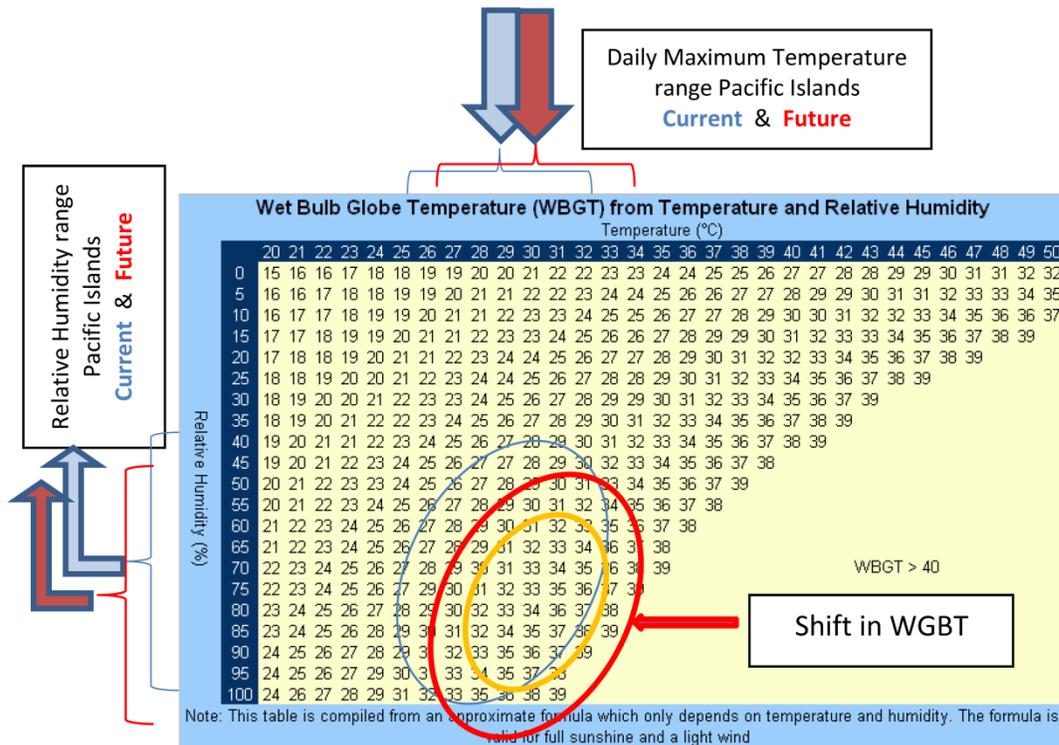
Table 4: Wet Bulb Globe Temperature calculations – PICs range and central range



The region has already warmed by up to 1°C, and PCCSP projections indicate further warming across the region ranging from 0.2 – 1.3°C by 2030. Warmer air holds more water, such that relative humidity increases approximately 7% per degree Celsius.⁽¹¹¹⁾ Relative humidity will therefore have risen in line with past warming, and can be expected to further increase. This will cause a shift in the WBGT, as indicated on the WBGT table below. As PICs are currently on the precipice – or beyond – of human tolerance for exercise, the additional shift to the right on the WBGT table suggests the central point will move from a current level of approximately 31°C WBGT to 33.5°C. Not shown here is the projected temperature rise for 2055 which may result in a WBGT that exceeds 35°C. This presents an extremely high risk of potential lethal heat stress in people attempting to perform relatively minor physical exercise.

Overview of Climate Change Impacts on Human Health in the Pacific Region

Table 5: Projected shift in Wet Bulb Globe Temperature for PICs by 2030.



Source: WBGT table data Bureau of Meteorology.⁽¹¹⁰⁾

Due to rising heat projected under the IPCC A2 scenario, population-based labour work capacity has been predicted to fall by 11% to 27% in Southeast Asia, Andean and Central America, and the Caribbean by the 2080s.⁽¹¹²⁾ This has far reaching implications for national economies, personal incomes,⁽¹⁰³⁾ and those, in turn, are likely to have indirect adverse impacts on population health in PICs.

Developing countries will bring elevated risks more broadly for other population groups. With less access to technology and mechanical domestic devices, routine activities of daily living (ADLs) such as house cleaning, clothes washing, gardening, shopping and caring for others are more labour intensive than in developed countries. Domestic productivity will fall, and although not formally measured in national accounts, the social impact can be significant.

Cognitive impairment, diabetes, cancer, and obesity also elevate susceptibility to heat stress.⁽¹¹³⁾ The high levels of obesity and diabetes in many PICs is therefore cause for concern. Certain prescribed medications such as anti-cholinergics, anti-parkinsonian agents, some antipsychotics and tranquilizers can interfere with the body's thermoregulatory system and fluid and electrolyte balance, and trigger symptoms of heat overload and heat stress.

2.1.2 Storms and cyclones

Annually, about 120 million people globally are exposed to tropical cyclone hazards, which killed 250,000 people from 1980 to 2000. Tropical cyclones affect all PICs, although their patterns and frequency differ. For example, in Vanuatu cyclones occur between November and April. In the 41-year period between 1969 and 2010, 94 tropical cyclones passed within 400 km of Port Vila, an average of two to three cyclones per season. The number of cyclones varies widely from year to year, with none in some seasons but up to six in others.⁽¹¹⁴⁾ Over the period 1969–2010, cyclones occurred in the Solomon's more frequently in El Niño years,⁽¹¹⁵⁾ whereas in PNG cyclones occurred more frequently in neutral phases of the El Niño-Southern Oscillation.⁽¹¹⁶⁾

Storms and cyclones in tropical regions lead to storm surges, inundation of coastal land, and soil erosion with significant damages to public health infrastructure.^(4, 117) High-density populations in low-lying areas such as those in the Pacific region are particularly vulnerable to tropical cyclones.⁽⁹⁷⁾ PICs are already victims to the assaults of cyclones which accounted for 76% of reported disasters between 1950 and 2004.⁽¹¹⁸⁾ Extreme winds, such as those produced by cyclones are particularly devastating for small islands.⁽⁸⁸⁾ The frequency of severe cyclones is likely to increase, with such cyclones generating greater wind speeds and more intense precipitation.⁽⁷⁴⁾ The mechanisms by which storms affect health, both directly and indirectly, are similar to those of floods.⁽⁸⁹⁾ Case Study 1 describes the effects on the health and wellbeing of community in Niue after super cyclone Heta.

Case Study 1 – Cyclone Heta Niue

On Monday 5 January 2004, 'super-cyclone' Heta struck the island of Niue, the world's smallest sovereign nation. Cyclone Heta, considered to be the most destructive in Niue's recorded history, also caused significant damage to Tokelau, Cook Islands, Tonga and Samoa and American Samoa. Niue comprises a large, single island of 259 sq. km and is home to a declining resident population of approximately 1,400.⁽¹⁹⁾ Most Niueans (estimated 30,000) live overseas, mainly in New Zealand. The centre of the category 5 (T 6.5) cyclone passed within 30 km of the capital Alofi, bringing winds in excess of 270 km. The combination of a high spring tide, directional travel, wind velocity, spiral direction, and a sloping seabed combined to maximum effect in producing a sea surge estimated at 50m.⁽¹¹⁹⁾ This battered the west coast and overtopped the cliffs and pushed 100m inland devastating all in its path. Among the small population, there were 2 deaths and many injuries.

All 12 villages were affected, with Alofi and the western villages of Makefu, Tuapa, Namukulu and Hikutavake receiving the full force. Alofi district sustained the most damage to both housing and property. All government housing and private homes at the Aliluki housing estate were totally destroyed together with the only hospital and health institution on Niue, Justice & Lands Department, Museum and Cultural Centre, the Niue Hotel, Industrial Centre, community halls, churches and supporting facilities for community and NGOs activities.

National infrastructure also suffered severe damage. The bulk fuel storage tanks were badly damaged: communications within and outside the island were not fully operational for months afterwards; health service provision struggled to meet demand as a result of the total destruction to

Overview of Climate Change Impacts on Human Health in the Pacific Region

the hospital; and damage to water and power utilities reduced capacity to supply essential services. In addition, there was extensive damage to family kitchens, garages, toilets, fruit-bearing trees, farming lands, and the surrounding eco-system, which provides stable food sources and food security to all village communities. The loss of assets on this scale in such a small community had a direct bearing on the ability of the community to restore their lives, one example of lost capacity is the destruction and damage to heavy machinery that constrained the and capacity of clean up teams to dispose of debris from destroyed buildings, damaged trees rocks washed up onto roads by the wave surges.⁽¹²⁰⁾ When ports and airfields are damaged, and restorative equipment is also damaged, the island becomes isolated. Delays in delivery of urgent supplies of water, food and health care needs or evacuations can yield potentially lethal consequences.

Economic costs of rebuilding the Maternity ward, dental facilities, hospital, mortuary, aged care facilities were valued in 2001 as \$4,000,000NZD. The hospital rebuild provides a salient lesson, as numerous recommendations after Cyclone Ofa hit Niue in 1990, stressed the need to relocate Niue hospital to a safer site away from the vulnerable coastal zone. Attempts to save money in the short-term, led to the flawed decision to renovate, and remain at the high risk site. The hospital was utterly demolished by Heta, with total destruction of infrastructure, equipment and records. Economically, it was also a costly decision, necessitating a rebuild with the addition of high indirect costs of patient referrals to New Zealand.⁽¹²¹⁾ In health terms, the decision deprived the community of a fully functioning health centre, and delayed health care.

Pacific Islanders are familiar with cyclones. In response to the Cyclone warning , hospital staff evacuated all inpatients who could be cared for at home. In the immediate aftermath of the Cyclone Heta the main health challenge was primarily caring for the injured and providing to the psychological and physical health needs of the people whose houses had been washed away. Nurses and health staff worked for 24 hours at a stretch tending health needs and overseeing the establishment of a temporary hospital in the youth centre near the airport. Health support did not arrive for two days, when two Medivac planes arrived from New Zealand, one to airlift the seriously injured infant to Auckland and the other delivered much needed supplies. An Australian Defence Medical team later arrived and set up a field hospital, allowing local Niuean nurses their first opportunity to attend to their own families' needs.⁽¹²²⁾

The National Assessment found that 90% of total housing on Niue (570 occupied and 432 unoccupied) mostly built in the 1960s to 1980s period sustained some form of damage resulting in the release of asbestos; 63 houses were either totally obliterated or were no longer structurally sound.⁽¹²⁰⁾ The economic damage was equivalent to 17 years of GDP, or 200 years of Niue's exports,⁽⁴⁶⁾ and total recovery costs were estimated at \$44million.⁽¹¹⁹⁾ Several studies analysed the short and long term effects on the Niuean economy, tourism and biodiversity; however no report on health impacts could be located. It is known that all health records were destroyed, and recording systems would also have required establishment. Direct health impacts were kept to a minimum, and long term consequences remain unknown.

Overview of Climate Change Impacts on Human Health in the Pacific Region

A primary aim of disaster recovery management (DRM) is to avoid negative health effects. Emergency donor aid—in the form of blankets, tents, water decontamination pills and food—usually reaches affected areas quickly, keeping fatality rates to a minimum, but obtaining financial support for longer-term reconstruction is a different matter.⁽¹²³⁾ Australia’s official development assistance to Niue is estimated at A\$4.6 million (DFAT). Of this, approximately A\$2 million is provided annually to support Niue's efforts to promote economic development and growth, improved education outcomes and increase Niue’s resilience to climate change adaptation.⁽¹⁹⁾

In light of the acute vulnerability to Cyclones, sea level rise and the more complex ramifications of climate change, the long term viability of atoll nations has been questioned. This is a hard reality to face. Abandonment of one’s home, country and culture is difficult. It is not surprising therefore that despite a steady population decline since 1960s, the remaining Niueans report they prefer not to relocate.

Introduction and launch of the Millennium Development Goal (MDGs) was delayed until early 2006 as all of Niue’s resources and commitments were focused at recovery from the Heta Cyclone tragedy. Niue reports high levels of commitment to reaching its MDGs and reports achieving Goals 1: Eradicate extreme poverty and hunger, 2: Achieve universal primary education, 3: Promote gender equality and empower women, 4: Reduce child mortality, 5: Improve maternal health, and Goal 6: Combat HIV/AIDS, NCDs and other diseases.⁽¹²⁴⁾

Due strong donor support and local commitment, Niue has recovered and performs well in the major health determinants. Life expectancy is 71.6 years, the adult literacy rate is 100%, and all people have access to improved water supplies and sanitation.⁽¹²⁵⁾ Compared to other PICs Niue’s gender discrimination is minimal. Women are free to participate in all sectors of the economy without prejudice. Internal documents suggest there is no disparity between males and females in primary, secondary and tertiary education in Niue. Health care is considered to be of high standards and is provided to all residents free of charge. This includes good maternal and child health care with good nutrition, child safety, and immunization coverage of 100% against vaccine preventable childhood diseases. Thus infant death is rare.⁽¹²⁴⁾

Progress towards achievement of the MDGs is crucial not only for social and economic development, but also for health. There is a two way link between MDGs and health. While not all MDGs appear explicitly pertinent to health, they all have major health implications via the social determinants of health; countries scoring highly on the MDGs have better health. Conversely, improving population health status is associated with increased likelihood for achievement of the MDGs.^(126, 127) Evidence of the influence on health status of MDGs 2 and 3 can be seen by the clear association between education of women and child mortality. For example, of the 8.2 million reduction in deaths in children younger than 5 years between 1970 and 2009, an estimated 4.2 million (51.2%) could be attributed to increased educational attainment in women of reproductive age.⁽¹²⁸⁾

Niue’s remarkable post disaster recovery demonstrates the potential for viability with the continued combination of local determination, early warning provision and international aid. However the

question remains, how resilient the country can remain *if and when* another super cyclone hits. A critical issue for Niue, and other small island states, is maintaining a population size and skill base sufficient for survival of their society, given the critical mass requirements to provide and maintain services.

2.1.3 Coastal Inundation

Through the 20th century, global sea level rise has contributed to increased coastal inundation, erosion and ecosystem losses. Considerable local and regional variation exists now and in the projections, but the impacts are virtually certain to be overwhelmingly negative.⁽¹²⁹⁾ From 1993 to 2009, the mean rate of SLR had risen to 3.3 ± 0.4 mm/year suggesting that SLR is accelerating.⁽¹³⁰⁾ There have been credible warnings of a possible sea-level rise in excess of 5 m this century in the event of significant ice sheet melting.⁽¹³¹⁾ Sea level rise with consequent coastal inundation is possibly one of the most devastating climate change impacts to be faced by many PICs, particularly low-lying island nations,⁽¹³²⁾⁻⁽¹³³⁾ and East Timor.⁽¹³⁴⁾

Analysis of the sea-level trends in the Pacific and Indian Ocean between 1993 and 2001 demonstrate the significant interannual variability throughout the Pacific is strongly influenced by La Nina effects. Large rates of sea-level rise were observed over the western Pacific and eastern Indian Ocean (approaching 30 mm yr⁻¹) and sea-level falls in the eastern Pacific and western Indian Ocean (rates approaching -10 mm yr⁻¹).⁽¹³⁵⁾ A warm pool of water exists in the South Pacific and Intertropical Convergence Zones, placing islands within those regions at particular risk of inundation. For example, satellite data indicate the sea level has risen near the Solomon Islands by about 8 mm per year since 1993. This was considerably larger than the global average of 2.8–3.6 mm per year.⁽¹¹⁵⁾

As sea levels continue to rise, PIC risks of coastal inundation will be greatly exacerbated by these natural climate features and their oceanographic influences. Due to the combined effects of a rise in sea level, warm seas associated with La Niña events, and a rise in storm surges, coast regions are likely to experience quickened shoreline erosion, groundwater salinization, and inundation of settlements.^{(132),(134, 136, 137)} Destruction of ecological and agricultural systems will interrupt water and food supplies,⁽⁸⁸⁾ and disrupt the coastal infrastructure, settlements and amenities. All these negative impacts are likely to affect the social and economic welfare of small island communities and the health and well-being of their population.⁽¹³⁶⁾ Inundation could also force the displacement of coastal populations. Forced migration resulting in loss of social connection, culture and economic security significantly affects mental and social health. The resulting stress, anxiety and depression are the outcome of hardship in temporary accommodation, grief, uncertainty, loss of self-determination, social isolation, strained relationships and many other factors.⁽¹³⁸⁾

There has been little research to date to characterise or quantify the health consequences of sea level rise in the Pacific or elsewhere. Given the relevance of sea level rise and likelihood of coastal inundation of PICs, there is an urgent need to better understand the health implications. A detailed strategy is therefore required to help prepare nations to respond to this significant threat. Available maps identifying inundation projections must be sourced, and analysed for health risks. This intelligence can then inform the development of range of strategies, devised in consultation with

local communities, national health agencies and other sectors, trials initiated and evaluated. This is a large body of work and should take a high priority.

2.1.4 Flooding

Cyclones bring high rainfall events to the Pacific Islands, so their risk of more frequent and more intense flooding events will be higher under climate change. Warm air masses and rainfall are linked. It was previously thought that atmospheric water holding capacity increases by 7% per degree warming per degree Celsius (°C), however recent rainfall observations are suggesting this grossly underestimates the relationship.⁽¹¹¹⁾ The rate of global average precipitation intensity increase has been 23% per degree, and most of this has occurred in low latitude regions, the tropics, whereas there has been a reduction in moderate and light rainfall events. This finding suggests that projections are underestimating future heavy rainfall and flooding events.

Last year, 2010 was the world's second warmest. Globally-averaged land precipitation in 2010 was the highest on record, 52 mm above the 1961–1990 average of 1,033 mm, and resulted in widespread flooding across Europe, many parts of Asia and Australia,⁽¹⁰⁰⁾ considered the worst in 3 decades. Extreme weather disturbances are being touted as the main culprit causing supply shortfalls in a range of commodities such as corn, coffee, rice, wheat, and sugar. In the second half of 2010, agricultural prices surged following a series of crop failures in major crop-producing areas.

The effects of flooding on health can be considered as either immediate (occurring during or straight after the flooding event) or delayed.⁽¹³⁹⁾ Immediate health effects include injuries, communicable diseases or exposure to toxic pollutants, whereas delayed effects include malnutrition and mental health disorders.⁽¹⁰¹⁾ Flooding increases the risk of infectious diseases through the contamination of freshwater resources with high pathogen concentrations.⁽⁸⁸⁾ Floods create conditions conducive to outbreaks of infectious diseases, as heavy rains leave pooled water which serve as insect breeding sites, and drive rodents from burrows.⁽⁸⁰⁾ The risk of outbreaks is greatly increased by complicating factors, such as changes in human behaviour (increased exposure to mosquitoes while sleeping outside, a temporary pause in disease control activities, overcrowding), or changes in the habitat which promote mosquito breeding (landslide, deforestation, river damming, and rerouting).⁽¹⁴⁰⁾ Population displacement greatly increases infectious disease risk post flooding. Malaria epidemics in the wake of flooding are a well-known phenomenon in malaria-endemic areas world-wide,⁽¹⁴⁰⁾ and cholera outbreaks can occur.

Post-flood health impacts include:

- deaths and direct injuries, including bites from animals;
- insect- and rodent-borne diseases including dengue, leptospirosis, malaria and yellow fever;
- waterborne diseases including schistosomiasis, cryptosporidium and cholera;
- food-borne diseases including diarrhoeal diseases, cholera, food poisoning, salmonellosis and typhoid, hepatitis A and E;
- respiratory diseases including asthma, bronchitis and respiratory allergies and infections;

Overview of Climate Change Impacts on Human Health in the Pacific Region

- heat-related illness including sunstroke, sunburn, heat stress, heat exhaustion and dehydration;
- chemical pollution;
- skin infections;
- malnutrition resulting from disturbances in food production or distribution
- displacement (environmental refugees);
- hypothermia, if homeless or residing in wet conditions; and
- anxiety and stress, suicide and schizophrenia.^(141, 142)

These are known health impacts, but comprehensive studies quantifying the full impacts on population health in the aftermath of floods are not available. Studies conducted in Europe and the USA suggest that 70% of those who had been flooded reported health problems, both physical and mental. Of those affected by floods, 64% said that their health had been adversely affected, most commonly with stress, anxiety and depression, but also with a range of conditions, including dermatitis, worsening asthma, arthritis and chest infections.⁽¹⁴³⁾ Although housing design may differ, these symptoms are also likely to apply to Pacific Island populations. These studies also indicate that children moving out of their home were more likely to suffer emotional health problems, and that ongoing domestic debt related problems were common.

Flooding significantly disrupts societal functioning by damaging essential infrastructure, supplies, and transport; destroying agriculture operations; and disturbing the delivery of health services.^{(101),(97), (88),(89)} Health consequences continue long after the floodwaters recede. Contamination has lingering effects, where floods flush toxic chemicals and heavy metals into soils, aquifers and waterways. Many pesticides and petrochemicals are persistent organic pollutants that can be carcinogens and suppress the immune system. Exposure to heavy metals — such as mercury and cadmium — can cause long-term cognitive and developmental delays.⁽¹⁴⁴⁾

Floods risk across the Pacific are variable. Fiji experiences regular flooding, however greater flood risks tend to occur along major river systems than in small island states, as demonstrated by the recent floods across Bangladesh, Thailand, and Cambodia. Despite this, localised flooding remains a risk in PICs, with the associated potential health consequences listed above. PICs may also experience secondary effects where widespread flooding results in large crop losses in trading nations and resultant food price rises that lead to food insecurity.

The National Centre for Epidemiology and Population Health (NCEPH) at ANU is currently examining one post-flood health effect. This study is focussing on the cyclone induced flooding of agricultural areas in the Philippines, subsequent food availability, food prices, nutritional status and maternal and child health outcomes among the most vulnerable population groups.

2.2 Vector-borne Infectious Disease

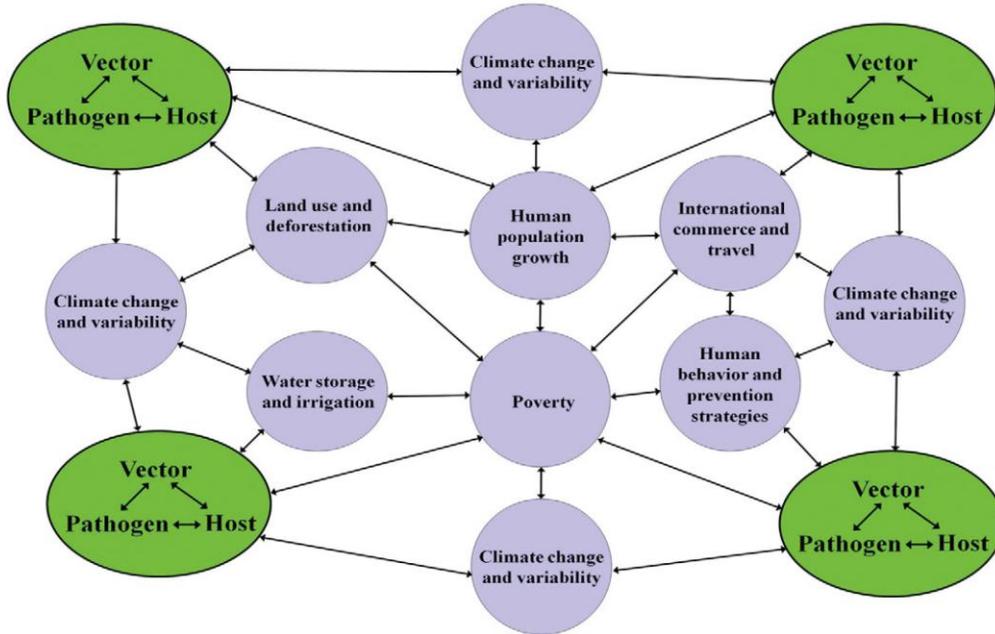
Vector-borne diseases are climate sensitive.⁽¹⁴⁵⁾ This has been demonstrated through historical and experimental evidence, as well as the association between disease dynamics and latitudinal, altitudinal, seasonal and inter-annual variations.⁽¹⁴⁶⁾ For example, in some countries, epidemics of vector-borne disease have been shown to directly correlate with the ENSO climate cycles.⁽¹⁴⁷⁾ All aspects of insect vector dynamics including ecology, population fluctuations, geographical distribution and disease transmission are inherently linked to climatic conditions.^(148, 149) Therefore, by changing the host/vector distribution range; population density and prevalence of pathogen infection,⁽¹⁵⁰⁾ climate change will likely affect vector-borne diseases, and further exacerbate its global burden.

Temperature, rainfall and humidity are of particular importance for vector-borne diseases.⁽¹⁴⁹⁾ Temperature affects both vector and pathogen.⁽¹⁵¹⁾ Temperature influences pathogen behaviour by modulating maturation and replication of the infectious organism within its vector.⁽¹⁴⁵⁾ An increase in temperature is associated with increased pathogen replication, decrease in the incubation period and enhanced transmission.⁽¹⁵²⁾ However, if mean temperature is close to the physiological tolerance of the pathogen, any further increase may prevent pathogen survival.⁽⁹⁷⁾ Vectors are also influenced by increase in temperature with warmer environments decreasing vector breeding time and increasing vector biting rates.⁽⁹⁷⁾ The relationship between rainfall and vector breeding has been well established.⁽⁹⁷⁾ Rainfall affects vector populations at different stages of their lifecycle.⁽¹⁵³⁾ Rain can create pooled water, favourable breeding sites for mosquito-vectors⁽¹⁵⁴⁾ or conversely, heavy rain periods might wash away eggs and larvae leading to decreased mosquito-vector population.⁽⁹⁰⁾ Droughts can limit the number of vector breeding sites by drying out small pools of water.⁽¹⁵³⁾ In wet regions, however, droughts may lead to stagnation of water in rivers leading to an increase in breeding sites.⁽⁹⁷⁾ Humidity also affects adult mosquito survival.^(148, 153)

Climate change impacts on vector-borne diseases are complex (Figure 7).⁽¹⁵⁵⁾ Climate change may affect humans' vulnerability, animal hosts, insect vectors and pathogens. The epidemiology of each vector-borne disease is a product of complex, commonly non-linear interactions between many disparate environmental factors.⁽¹⁵⁶⁾ Therefore, it is difficult to establish a direct correlation between climate change and vector-borne diseases or draw conclusive inferences.⁽¹⁵¹⁾

Overview of Climate Change Impacts on Human Health in the Pacific Region

Figure 7: The vector-borne disease episystem, illustrating interactions between selected environmental factors with effects on the vector—pathogen—host epidemiologic cycle⁽¹⁵⁵⁾



Source: Tabachnick Journal of Experimental Biology 2010; 213(6)

In the Pacific malaria and dengue are extremely important vector-borne diseases. Dengue is transmitted primarily by *Aedes aegypti* mosquitoes. Dengue is increased with increased temperature, and generally with increased rainfall, although increased water storage around dwellings may increase transmission during droughts.⁽¹⁵⁷⁻¹⁵⁹⁾

Table 6: Projections for temperature increase in degrees Centigrade, Pacific Island Countries, 2055 under medium and high emissions scenarios

Pacific Island country or island group	Medium emissions	High emissions
Northern Cook Islands	0.9–1.9	1.0–1.8
Southern Cook Islands	0.7–1.9	0.9–1.7
Timor-Leste	0.9–2.1	1.0–1.8
Eastern Federated States of Micronesia	0.9–2.1	1.0–1.8
Western Federated States of Micronesia	0.9–2.1	1.0–1.8
Fiji	0.9–1.9	1.1–1.7
Gilbert Islands (Kiribati)	0.9–2.3	1.0–2.2
Phoenix Islands (Kiribati)	1.0–2.2	1.1–2.1

Overview of Climate Change Impacts on Human Health in the Pacific Region

Line Islands (Kiribati)	1.0–2.2	1.0–2.0
Northern Marshall Islands	0.9–2.1	1.0–1.8
Southern Marshall Islands	0.9–2.1	1.0–1.8
Nauru	0.9–2.3	1.0–2.2
Niue	0.7–1.9	0.9–1.7
Palau	1.0–2.0	1.0–1.8
Papua New Guinea	1.0–2.0	1.1–1.9
Samoa	0.9–1.9	1.0–1.8
Solomon Islands	0.9–1.9	1.0–1.8
Tonga	0.7–1.9	1.0–1.8
Tuvalu	1.0–2.0	1.0–1.8
Vanuatu	0.8–2.0	1.1–1.7

(Data Source: <http://www.cawcr.gov.au/projects/PCCSP/publications.html>):

Rainfall projections in the Pacific Island Countries are less specific than the temperature projections given above (see <http://www.cawcr.gov.au/projects/PCCSP/publications.html>). This, along with the variable quality of data, differences in health systems and other factors determining dengue risk mean it is problematic to project the future for dengue in The Pacific. Projected temperature rises given above will increase risk, but other climatic, social and biological factors may increase or lessen this probable impact. Positive correlations between SOI and dengue have been identified in ten Pacific Island countries. In five of these (American Samoa, Nauru, Tokelau, Wallis and Western Samoa) there were positive correlations between SOI and local temperature and/or rainfall.⁽¹⁶⁰⁾ During La Niña, these five islands are likely to experience wetter and warmer than normal conditions. Local weather patterns may trigger an increase in transmission in larger, more populated islands where the disease is endemic, but infected people then carry the disease to smaller neighbouring islands. This implies that the effect of climate on vector-borne diseases is not necessarily confined to the region affected by altered climate, suggesting that forecasts also need to take account of regional social and environmental factors. Warming under climate change may result in greater distribution of Dengue – including to neighbouring regions where the climatic features are not regarded as fitting the Dengue profile.

Case Study 2 - Malaria in Papua New Guinea

Much controversy in the climate and health literature has centred on whether malaria has undergone, or will undergo, an increase in altitudinal range, particularly in the East African Highlands. There are as yet no clear cases of change in geographical in local malaria distributions

Overview of Climate Change Impacts on Human Health in the Pacific Region

attributable to climate change⁽¹⁶¹⁾– although evidence from western Kenyan studies is increasingly pointing to a climate-related increase in malaria incidence at higher altitude⁽¹⁶²⁾

In Papua New Guinea, at the end of the 2002 rainy season 11 villages at altitudes between 1,400 and 1,700 metres reported malaria epidemics⁽¹⁶³⁾ One thousand two hundred and sixteen people were surveyed in these villages, and nearly thirty percent of these were slide positive for malaria (i.e. malaria parasites were seen on blood films)⁽¹⁶³⁾ *Plasmodium falciparum* accounted for 59% and *P. vivax* for 34% of infections.⁽¹⁶³⁾ Temperature is the main climatic determinant for malaria endemicity in PNG. However, because of proximity to the equator there is little seasonal temperature variation, and altitude (space) rather than season (time) is therefore the major determinant for transmission.⁽¹⁶⁴⁾ Malaria is endemic in PNG, but above 1,300 metres transmission is unstable and transmission is limited to local epidemics; transmission does not occur above 1,800 metres.⁽¹⁶³⁾

In PNG malaria transmission ranges from areas where the vector is present without malaria to intense transmission comparable with the high endemic areas of sub-Saharan Africa (Muller et al., 2003). In many endemic areas malaria is the most common outpatient diagnosis (303 per 1,000 people at risk) and the second most common reason for admission (834 per 100,000 people).⁽¹⁶⁴⁾ In lowland areas malaria prevalence and morbidity are highest in children and pregnant women.⁽¹⁶⁴⁾ Mortality and severe malaria infections are less common than in areas of comparable endemicity in Africa, however

Plasmodium vivax and *falciparum* are the major human malaria parasites in PNG.⁽¹⁶⁴⁾ Before vector control programs the former was predominant. Spraying with dichlorodiphenyltrichloroethane (DDT) and dieldrin started in 1957 around Maprik, with extension of DDT spraying and mass drug administration (mainly chloroquine) to all endemic areas subsequently.⁽¹⁶⁴⁾ Following the cessation of spraying in the late 1970s there was a resurgence of *P. falciparum* malaria – while the cessation of spraying was probably an important cause for this increase, changes in patterns of use of antimalarial drugs and resistance patterns may also have contributed.⁽¹⁶⁴⁾

The principal malaria vectors in PNG are members of the *Anopheles punctulatus* group, now known to comprise 11 species.⁽¹⁶⁴⁾ *An. punctulatus*, *An. koliensis*, *An. farauti* s.s. (formerly *An. farauti* 1), and *An. farauti* 4-6 have been identified in PNG.⁽¹⁶⁵⁾ *An. farauti* s.s. has been collected > 100 km inland and at altitudes > 300 metres.⁽¹⁶⁵⁾ *An. farauti* 2 has been collected at up to 1,740 metres, and is associated with human habitation, laying eggs in human created water bodies such as wheel ruts and drains.⁽¹⁶⁵⁾ *An farauti* 3 is relatively uncommon in PNG, and *An. farauti* 4 generally occurs below 300 metres.⁽¹⁶⁵⁾ *An. farauti* 6 is commonly collected at altitude with the highest collection by Cooper et al. at 2,000 metres.⁽¹⁶⁵⁾ *Anopheles punctulatus* has been recorded to 1,760 metres in PNG.⁽¹⁶⁵⁾

Red blood cell traits provide varying degrees of protection against malaria in PNG,⁽¹⁶⁴⁾ South Asian ovalocytosis is an example. This red cell trait provides moderate protection against infection but complete protection against cerebral malaria, and, consistent with the foregoing, prevalence is found to increase with decreasing altitude in PNG.^{(164) (166)} Other traits that offer protection against malaria include glucose-6-phosphate dehydrogenase deficiency and α -thalassaemia.⁽¹⁶⁴⁾

As well as these characteristics of the human host other variables can influence malaria transmission at a small geographical scale. Significant differences in malaria transmission are found between villages only a few kilometres apart, and it is thought these differences are accounted for by heterogeneity in vector distribution, bed net and antimalarial drug usage, and possibly micronutrient deficiencies.⁽¹⁶⁴⁾ Resistance to chloroquine was first seen in PNG in 1976, and since that time resistance to other agents has appeared in both *Pl. vivax* and *falciparum*.⁽¹⁶⁴⁾

The village malaria epidemics described in the first paragraph of this case study exceeded the intensity of transmission and levels of morbidity that are usual on a seasonal basis in the PNG highlands.⁽¹⁶³⁾ It is likely that the increased involvement of *P. falciparum* is a major cause for increased morbidity.⁽¹⁶³⁾ Highland malaria epidemics are a serious and increasingly important public health problem in PNG.⁽¹⁶³⁾ Health system shortcomings and the cessation of vector control are the major causes for this. Longitudinal studies of malaria in the PNG highlands are currently infeasible.⁽¹⁶³⁾

The lack of such studies and the complex epidemiology and ecology described above mean that detecting changes in malaria epidemiology is difficult and renders consideration of any link between climate change and highland malaria in PNG speculative at present. Hopefully, the PNG Institute of Medical Research will be able to engage, in future, in systematic monitoring and study of this likely linkage.

2.3 Food Security and Food-borne disease

The term 'Food security' first originated in the mid-1970s. Initially understood simply as availability, health problems arising from foods high in fat, salt and sugar led to an expansion of the concept to incorporate the access to healthy nutritious food. Food Security was therefore redefined by the World Food Summit of 1996 as existing "*when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life*".⁽¹⁶⁷⁾ The concept of food security recognizes the importance of both physical and economic access to food that meets people's dietary needs as well as their food preferences.

Food is a fundamental necessity for life, and therefore food production underpins economic wellbeing. Food security is a complex sustainable development issue, linked to health through malnutrition, but also to sustainable economic development, ecological health, and trade, all of which indirectly link back to health. The potential for communities to meet their food needs for health and wellbeing can be interrupted by political and economic forces, as well as cultural and environmental influences. Food security is built on three pillars:

- Food availability: sufficient quantities of food are available on a consistent basis;
- Food access: there are sufficient resources to obtain appropriate foods for a nutritious diet;

Overview of Climate Change Impacts on Human Health in the Pacific Region

- Food use: appropriate use based on knowledge of basic nutrition and care, as well as adequate water and sanitation are available.

The PASAP Report “*Food Security in the Pacific and East Timor and its vulnerability to climate change*”, prepared by the SPC and CSIRO, identifies safety and nutrient values as additional vital considerations. Malnutrition arises when nutrient intake is low due to insufficient intake of proteins, and micronutrients, largely from diets low in essential amino acids (proteins) fruit and vegetables. This is a significant health threat for the very poor, and those facing food shortages for other reasons, such as political unrest, war, and environmental degradation.⁽¹⁶⁸⁾ However, malnutrition can even occur in the overweight. In many Pacific countries, health problems related to dietary excess, especially of fats, salts, carbohydrates and sugars are an ever increasing threat.

Malnutrition lowers immunity and increases susceptibility to opportunistic infections and other diseases. Malnourished mothers deliver children with suboptimal resilience which increases their likelihood of developmental and cognitive impairment, and higher rates of diseases in adult hood. Maternal and child under-nutrition is highly prevalent in low-income and middle-income countries. Globally, the resultant stunting, severe wasting, and intrauterine growth restriction together are responsible for 2.2 million deaths and 21% of disability-adjusted life-years (DALYs) for children younger than 5 years.⁽¹⁶⁹⁾ The impacts of food insecurity persist throughout the lifespan, and therefore have long term health effects on the health of populations. Unhealthy populations are less productive (domestically and commercially), it makes good economic sense therefore for nations to establish strategies to avoid under-nutrition amongst their most vulnerable population.

Diarrhoeal diseases reduce the body’s capacity to absorb nutrients from the little food that is consumed. Food contamination leading to foodborne diarrhoea therefore becomes a double health burden. Undernourished populations are weaker, which increases their susceptibility to disease and negatively affects their nation’s capacity to reach Millennium Development Goals. This further jeopardizes population health, and creates a vicious cycle of multi-generational disadvantage.

There is a great deal of debate around global food security, with some arguing that:

- There is enough food in the world to feed everyone adequately; the problem is distribution;
- Future food needs cannot be met by current levels of production;
- National food security is paramount – to provide resilience and a degree of self-determination;
- Globalization may lead to the persistence of food insecurity and poverty in vulnerable communities.

From a health perspective, the relationship between food security and climate change stems from the three pillars. Food availability is based in part by yields and quantity produced, and is also a function of equitable distribution of wealth, where nutritious food is in the market place and is affordable to all. The quantity of food production becomes threatened when fisheries are in decline,

Overview of Climate Change Impacts on Human Health in the Pacific Region

agricultural land is degraded, population needs outstrip food supply, questionable allocation of resources exists, such that food production systems are inefficient, especially relation to the land area, water, and energy input per calorie and nutrient return.

Beef production is often cited as a prime example of high environmental cost per nutritional unit benefit. Diet preferences shift towards greater proportions of meat consumption as populations gain wealth.⁽¹⁷⁰⁾ It is foreseeable that food shortages arising from the combination of climate related reductions in yield and greater demand through population increases, will generate food access inequities that will conflict and force a reversal of this trend. Until this trend is reversed, the 'more wealth = more meat' will manifest as a widening inequity gap in access to animal protein, and will render the disadvantaged in a weakened state, and, as outlined above, result in lowering of their general health, productivity and earning capacity. Nations need to consider equitable distribution of food, and perhaps more specifically, of the vital micronutrients required for healthy living. Climate change risks splitting communities and exacerbating existing disadvantage. Replacement of nutritious diets with low nutrient/high calorie substitutes is not the solution to better health.

Climate change is projected to impact on food production via alterations in the seasons. An extension of the dry season by 45 days or so would lead to a 30–50% reduction in maize, and a 10–35% reduction in sugar cane yields on some islands in the Pacific.⁽¹⁷¹⁾ Food prices rises have already commenced. Vulnerability assessments carried out in 2009 and late 2010 indicate that the more remote and import-dependent Pacific Island economies of Kiribati, FSM, RMI, Tuvalu, Tonga are particularly exposed to the economic costs of higher global fuel and food prices. Fiji, Solomon Islands, and Vanuatu are also vulnerable due to high inflation and structural issues such as the widely dispersed geographic structure of the population, the existing levels of gender inequality and rural/urban divide and the growing poverty in the urban centres.⁽¹⁷²⁾ Nutrition concern is increasing as family shift their food to cheaper and low quality food such as tin fish, noodles, and turkey tails.

Food security is integral to health and wellbeing, and economic development of nations. The PASAP Food Report identified that consumption patterns in the Pacific today do not appear to be satisfying nutritional needs or requirements. Climate change is likely to exacerbate many of these entrenched food security problems for PICs, with consequent reinforcement of the drivers of poor health outcomes and disadvantage.

2.3.1 Food-borne Disease

Extreme weather events, including temperature variation, flooding, and droughts, are believed to be the major climate change contributor to food-borne disease. They may lead to contamination of soil, agricultural lands, water and food and animal feed with pathogens, chemicals and other hazardous substances,⁽¹⁷³⁾ leading to food-borne disease outbreaks. A positive association between temperature and food-borne disease has been found in a number of geographical locations.⁽¹⁷⁴⁾ Increases in temperature and variation in precipitation influence the survival of pathogens and subsequently the diseases they produce.⁸³ Climate change is also a contributor to the emergence and expansion of animal infectious diseases, and the transmission of pathogens from animals to humans.⁽¹⁷³⁾ It may cause changes in the marine environment which favour the growth of Harmful Algal Blooms (HABs).⁽¹⁷³⁾ HABs produce toxins which are particularly harmful to human health and usually cause illness when an individual ingests seafood, usually shellfish, contaminated with these toxins.⁽¹⁷³⁾

Diarrhoeal disease has been demonstrated to have a strong association with climate change. Countries with inadequate sanitation infrastructure and a high incidence of infectious diseases, such as PICs, have been noted to experience high rates of diarrhoeal disease following flooding.⁽¹⁷³⁾ Two related studies exploring the relationship between climate variability and diarrhoeal disease in the Pacific region suggest that climate change will worsen diarrhoeal illness in many PICs.⁽¹⁷⁵⁾ The European Centre for Disease Prevention and Control (ECDPC) identified the following food-borne diseases as a priority for routine monitoring in a changing climate: *Salmonella*, *Campylobacter* and *Listeria* infections and cholera.⁽¹⁷⁶⁾

Case Study 3 - Food Security and Child Health

The minimum requirements for health, wellbeing and indeed, survival are air, water, food and shelter. It has been understood since the times of Hippocrates (and possibly beforehand) that when these are inadequate, or contaminated ill-health ensues. Yet provision of these fundamental health determinants lies outside the formal health sector, and so are commonly regarded as 'externalities' to health. Good health, manifested as health status, is therefore an *outcome* of a person's access to these basic human rights. We should also add here equity, peace and security. The role of the formal health sector, particularly hospitals and doctors, is not to deliver these basic health prerequisites, but rather, strive to reverse the disease or ill-health precipitated by deficits in those external factors.

Climate change will impact upon air quality, water quality and quantity and shelter. Food security will also be impacted. Food is central to good health and yet despite this criticality, and advances in food production and distribution systems, access to sufficient amounts of nutritious food is still not universally achieved. In 2009, there were over 1.2 billion people to be undernourished. The 2010 data suggests that 925 million people are undernourished, this represents 13.6 percent, or one in seven of the estimated world population of 6.8 billion.⁽¹⁷⁷⁾ Nearly the entire undernourished are in developing countries.

A reliable food supply is required for populations to flourish and grow, and agricultural yield is climate dependant. Approximately 11,000 years ago, in many parts of the world, villages and towns

almost simultaneously, emerged alongside developments in agriculture. This could only occur when advances in farming methods reached a stage that enabled food production surplus to one's domestic needs. That timing also coincides with a period of relative stability in the climate, where the average global temperature largely remained within a 0.6°C range of 14.6°C. This temperature and stability was not only unusual, but also proved ideally suited for agriculture, and allowed for the production of reliable yields.

Since that time, increasingly technical societies have shifted away from subsistence or self-catering lifestyle towards complex food systems, where access to sufficient nutritious food supplies becomes less dependent upon personal endeavour, and more dependent upon an array of socio-political and economic factors, that can be distorted and manipulated. In keeping with this urbanisation trend, shifts from domestic farm ownership to national or corporate enterprises, access to food becomes politicized, and is intertwined with trade and national powers.

Food insecurity – a climate change risk

Food security serves well as a case study to depict climate pressures ultimately affecting health outcomes, and the interlinking of both environmental forces and complex socio-economic and political filters. This case study outlines the complex systems network linking environment, to food, to health, and the long term ramifications of these influences. Starting from an examination of vulnerability, inability to withstand shocks (be they climate or economic in origin), food insecurity as food and fuel prices increase and yields fall, we then explore impacts on vulnerable subgroups, at the domestic level, and effects on nutrition, health (maternal and child) and ultimate capacity to contribute to society and societies' economic status. This sets up a feedback loops as a poverty trap.

Vulnerability to both climate change and food insecurity is strongly linked with poverty. The poverty and vulnerability experienced by PICs reflects the stresses placed by a wide range of factors on these societies. AusAID lists these factors as:

- Weak economies that are vulnerable to economic shocks and do not provide sufficient jobs;
- increasing urbanisation is loosening the ties within extended families and leading to the creation of squatter settlements with greater dependency in rural areas;
- a high susceptibility to natural disasters stretches the resilience of families, communities and states;
- inter-ethnic conflicts that are weakening the state.⁽¹²³⁾

The Commonwealth Vulnerability Index combines vulnerability to both economic and natural shocks and ranks Vanuatu, Tonga, Kiribati and Samoa among the five most vulnerable states worldwide.⁽¹⁷⁸⁾

The vulnerability of PICs to natural disasters is due to a number of factors. Many Pacific states lie along active fault lines and the resultant earthquakes and devastating tsunamis take a heavy toll on development progress. The tropical climate in many PICs makes them also vulnerable to landslides, epidemics and climate extremes.

Food insecurity through economic vulnerability

Vulnerabilities associated with macroeconomic shocks and natural disasters are not evenly distributed across the globe, nor are they evenly distributed within countries, throughout sub-populations. Their impacts fall disproportionately upon the poor on whom the effects may be cumulative and irreversible, and inequality (measured as Gini co-efficient) is worsening.⁽¹⁷⁹⁾

Developing countries, especially small countries with limited resources have little reserves to rechannel resources for rebuilding. They have little power in trade negotiations, so are at the mercy of their powerful trading partners, and are sometimes forced to compromise their nation's best interest. Indeed, they are heavily dependent upon these partners for aid, and must contend with the uncertainty that Aid may not always be available, or timely, or appropriate to needs. In the situation of increasing climate disasters and continuing Global Financial Crises – an increasingly likely scenario is one where foreign governments may be pressured by their home constituents to focus on internal reparation and rebuilding at the expense of international aid generosity or meeting their aid obligations.

In the Pacific today, the demand for food is increasingly being serviced by imports. Basic staples such as rice and wheat for flour have become key substitutes for traditional diets, and are now central to Pacific Islander's daily diet.⁽¹⁷⁷⁾ Deteriorating terms of trade, rising external debts and inflation stifle the capacity of Pacific Islanders to adequately meet their nutritional requirements from imported food alone. Ramifications of both the current Global Economic Crisis and the 2008 Global Food Crisis have therefore been felt keenly by the PICs, through declining tourism income and falling amounts of remittances (and falling values of those denominated in US dollars), depreciating values of internationally-held Trust fund portfolios.⁽¹²³⁾ Their economies are weakening, and living standards are falling.

Vulnerability assessments carried out in 2009 and late 2010 indicate that the more remote and import-dependent Pacific Island economies of Kiribati, Federated States of Micronesia, RMI, Tuvalu, and Tonga are particularly exposed to the economic burdens of higher global fuel and food prices. Fiji, Solomon Islands and Vanuatu are also vulnerable due to high inflation and structural issues and their geographically dispersed population.⁽¹⁸⁰⁾ The particular vulnerability of Tonga and Vanuatu lies in their high frequency of natural disasters and the resultant effects on agricultural production, and very limited social protection activities. Conversely, the economies of the Cook Islands, Niue and Samoa are among the better performing Pacific nations, with consistent economic growth, impressive social development and good progress towards achieving their MDGs, especially MDG 1 on eradicating extreme poverty and hunger.⁽¹⁸¹⁾

Since the rapid escalation in food prices during the 2008 Global Food Crisis, prices fell only briefly. The Food and Agriculture Organization (FAO) generates a global Food Price Index (FPI) to enable interannual comparisons. In June 2011, the FPI was 39 percent higher than in June 2010, and only marginally less than its all-time high of 238 points in February 2011, and cereal prices are 71% higher than June 2010.⁽¹⁸²⁾ The steady rise in food prices in the Pacific has caused widespread concern, for example in Kiribati (with a GDP per capita of US\$1,142 in 2009) prices for staples such as rice

Overview of Climate Change Impacts on Human Health in the Pacific Region

increased from AUD\$16 per 20 kg bag in 2006 to AUD\$21 in 2008.⁽¹⁸⁰⁾ Vanuatu populations have been exposed to price increases ranging from 40% to over 100% for staples such as taro, banana and yams.⁽¹⁸³⁾ According to the regional sentinel monitoring system, a majority of vulnerable families surveyed in six Pacific Island Countries reported increased economic stress in meeting food expenditure due to rising food prices, as the cost of some staple food items up by as much as 50-100% since 2009.⁽¹⁸⁴⁾ Households are forced to spend 39%–50% of their budgets on food.⁽¹⁸⁵⁾

Compounding the food stress imposed by import price rises are decreasing local food yields. Some agricultural crops in Vanuatu are already showing signs of stress under current climatic conditions. The food price increase takes the greatest toll on the poorest households due to their higher relative expenditure on food. Food stress is highest among the urban poor, whereas rural poor have a higher likelihood of supplementing their food supplies by resorting to subsistence farming.⁽¹⁸⁴⁾ Food poverty indicates the inability of households to feed themselves. Household surveys that have calculated the proportion of people falling below food poverty lines is high: 16.6% of the population in Palau, 11% in FSM, 10.6% in the Solomon Islands, 7.4% in Vanuatu and 4.9% in Kiribati.⁽¹²³⁾

There are significant differences across countries, with import dependency ranging from 36% in Kiribati to over 80% in Palau.⁽¹⁸⁶⁾ These figures represent import dependency at the national level but significant differences also exist within countries, especially between urban centres and rural areas. The share of total expenditure on food and transport in urban area ranges from 35% to 40% whereas the range is less in rural areas, from 20% to 25%.⁽¹⁸⁷⁾ Urban dwellers who rely mainly on purchased food-stuffs, are disproportionately more affected than rural households who live outside the cash economy,⁽¹⁸⁸⁾ and are therefore more at risk of under-nutrition and consequent ill-health. Having no significant food exports, the inhabitants of Polynesia and the atoll micro-states are similarly vulnerable due their dependence on imported food.

Within those vulnerable urban groups, those most likely to experience the greatest degrees of hardship and poverty will be: (i) the very young, (ii) the very old, (iii) people living with disabilities, (iv) those who have no source of regular income, or (v) those with no access to adequate land on which to grow food for consumption and/or sale.⁽¹⁸⁶⁾ Households headed by women and the elderly will be very vulnerable. It follows then that children living in female-headed households are likely to be especially disadvantaged.

Due to the strong emphasis on caring and redistribution that exists within the extended family system, poverty in the Pacific Island context thus does not necessarily mean outright hunger or destitution. However, the poor face a continuous struggle to meet essential daily/weekly living expenses, particularly those that require cash payments. Furthermore, the subsistence sector, which in the past has played an important role in sustaining livelihoods in the Pacific Island economies through difficult times, is having a diminishing role. The trend towards urbanisation is eroding the traditional support networks that for generations have helped safeguard food security in times of hardship.

High food prices accentuate the vulnerability of the rural and urban poor. Eroded purchasing power inevitably leads to difficult decisions and a deterioration in the amount and quality of food consumed. A sentinel monitoring system conducted in 2010⁽¹⁸⁰⁾ revealed a majority of vulnerable families, particularly those in urban areas were experiencing increased economic stress in meeting food expenditure due to rising food prices and the Global Economic Crisis. Food stress was reported by 63% families in Solomon Islands, 77% in Tuvalu, 54% in Kiribati⁽¹⁸⁰⁾, and stress forced changes to type and quantity of food consumed as well as cooking methods. Fresh or frozen meat and fish, now considered a luxury, have been predominantly replaced by cheaper alternatives such as tinned fish, noodles, and turkey tails. Where able, vulnerable families are relying on backyard gardens and consuming much less fresh meat. Rice, flour and milk were reportedly now considered expensive as women seek cheaper substitutes or cooked with them only rarely. Households commonly used food rationing to keep food costs down, and the poorest families reported living on tea and starchy basics. The report revealed that due their lower cultural status, children and women often are not prioritized at the meal table and may only consume one or two meals a day. Another practice commonly reported was for children to go without breakfast and eating meagre or no lunch at school.⁽¹⁸⁰⁾

As diets become more and more restricted they become increasingly deficient in micronutrients, with potentially pernicious long-term consequences for growing children and pregnant women. Malnutrition including micronutrient deficiencies is already common across the Pacific and changes in household food consumption patterns brought about by the economic crisis is likely to have increased these problems.⁽¹⁸⁶⁾ Despite a proportion of the population still relying on traditional subsistence agriculture, many Pacific Island countries and households already face food insecurities, and this will be exacerbated if impacts of the economic crisis, and high food prices do not abate. The World Bank predicts an increase in poverty as families face a triple squeeze from falling incomes and remittances, rising costs, and shrinking public expenditure, including aid.⁽¹⁸⁹⁾

Child health

There is considerable evidence demonstrating that food shortages in childhood can have important and sometimes permanent cognitive, motor, social-emotional, educational and economic repercussions across the life-course.⁽¹⁸⁶⁾ Food-insecure children have twice the odds of having only “fair or poor” health and their odds of being hospitalized since birth are almost a third larger than food-secure children, the greater the severity of food insecurity, the greater the risk.⁽¹⁹⁰⁾ A strong link has also been established between poor maternal nutritional status and low birth weight and increased infant and childhood morbidity and mortality.⁽¹⁹¹⁾ Poor mothers are more likely to die in childbirth,⁽¹⁹²⁾ the nutritional state of the mother and foetus is therefore critical, as the impacts linger for the life of the child, and diminishment in their health and earning capacity flows on to subsequent generations .

Prenatal environment triggers developmental changes in the endocrine, organ and physiological characteristics of the foetus that may persist after birth. The list of postnatal traits shown to be influenced by the prenatal environment has expanded to include such important functions as

Overview of Climate Change Impacts on Human Health in the Pacific Region

immunity, reproductive function, growth rates and muscle mass.⁽¹⁹³⁾ Furthermore the undernourished pregnant women experiences metabolism suppression of immune system synthesis, which contributes markedly to the high rates of perinatal and infant mortality seen in many poor countries.⁽¹⁹¹⁾ An undernourished mother suffering nutritional stress has intrauterine growth restriction, as a physiological coping mechanism, and delivers a low birth weight baby. The early and later life consequences for her child include type 2 diabetes mellitus, hypertension and hyperlipidaemias⁽¹⁹⁴⁾, all of which are prevalent and rising rapidly in the many Pacific communities.⁽¹⁹⁵⁾ Children that are compromised at birth have a higher susceptibility to disease such as diarrheal diseases, malaria and others.

The percentage of Pacific Island children born with a low birth weight (<2500g) varies from 3% in the Cook Islands, to 18% in Federated States of Micronesia. Another key indicator for childhood undernutrition is the proportion of children classified as underweight when under five years old. In the Pacific the figures range between 1.6% in Tuvalu and 16% in Vanuatu, and in Vanuatu, 20% of children under five are stunted.⁽¹⁸⁶⁾ Globally, it is estimated that stunting, severe wasting, and intrauterine growth restriction together are responsible for 2.2 million deaths and 21% of disability-adjusted life-years (DALYs) for children younger than 5 years.⁽¹⁹⁶⁾ Stunted children may never regain the height lost as a result of stunting, and most children will never gain the corresponding body weight. It also leads to premature death later in life because vital organs never fully develop during childhood.⁽¹⁹⁷⁾ Results indicate that children living in households belonging to the lowest wealth index quintiles are more likely to be underweight and children from households within the richest quintile are more likely to be overweight. Stunting remains throughout life, and stunted women have a 95% higher need for assisted deliveries when they reach childbirth, and if operative delivery services are not available, the life of the mother and child are at risk.⁽¹⁶⁹⁾

Deficiencies in micronutrients, such as calcium, iodine, the B vitamins (especially folic acid and vitamin B12), and vitamin D result in health problems for maternal and child health.⁽¹⁶⁹⁾ Zinc deficiency in children results in increased risk of diarrhoea, pneumonia, and malaria, whereas deficiencies in iodine result in goitres, congenital hypothyroidism, and developmental disability.⁽¹⁶⁹⁾ Vitamin A deficiency reduces immune system functioning, which places the child at greater risk of succumbing to infectious diseases.⁽¹⁸⁹⁾ Iron deficiency anaemia is another significant public health concern for the Pacific region. Figure are not available for all countries, however where data exists, 6 out of 10 children are anaemic, and for Vanuatu 34% of children aged 6-59 months are anaemic.⁽¹⁸⁶⁾ Many other health problems among Pacific Island Children result from under-nutrition, and every year around 18,000 children under five years of age die (13,000 in Papua New Guinea, 2,500 in Timor-Leste), four out of five of these children are under five years of age.⁽¹⁸⁶⁾ Maternal mortality is also high, which leaves her other children without a mother. Social services, such as disability services are under resourced, especially across the outer islands and remote areas. It is estimated that up to two-thirds of childhood disabilities are preventable, thus there is a lot of scope for improvements in prevention of disability, particularly in safe motherhood and deliveries, nutrition, water and sanitation.⁽¹⁹⁸⁾

Diarrhoeal disease is already the most common cause of illness and the second highest cause of death of all children under five years of age, causing as many as 1.6 million deaths (17%) per year.⁽¹⁹⁹⁾ It is estimated that 80% of the mortality from diarrhoea is attributable to unsafe water and lack of sanitation (with nearly 90% of the global burden of diarrhoeal disease caused by the lack of access to safe water and sanitation.⁽¹⁸⁶⁾

Climate and food and health

The relationship between rainfall and diarrhoea is well established, both in terms of incidence (higher number of cases related to reduced water availability) and the mortality rates of children under five.⁽¹⁴⁰⁾ Climate change is projected to bring greater variability in rainfall patterns.⁽²⁰⁰⁾ Both excessive rainfall and rainfall shortage can be problematic for human health. Heavy rainfall contaminates drinking water supplies, and water shortages leads to water conservation, reuse and sharing which risk multiple mechanisms for contamination. Lack of access to clean water exacerbates the burden of diarrhoeal disease and increases the risk of death and disability, especially in children who need more water per body mass compared to adults.

Water security, that is regular access to adequate quantities of clean water, requires water availability, (rainfall) and expensive infrastructure to purify and deliver to the end users. Developing countries face many challenges in delivering water security to their entire population. Children are especially vulnerable to infections that cause diarrhoea⁽²⁰¹⁾ because, in part, their immune system is less robust in fighting infections than that of older people, but also because their behaviour increases the likelihood of exposure to infectious agents from water and other people, especially family members and other children. Nutrient absorption from the diet is interrupted during bouts of diarrhoea, hence diarrhoeal diseases further compromise the nutritional status of the child, and increases susceptibility to other opportunistic parasitic infections. Malnutrition becomes a double burden as the reduced resistance to disease exacerbates the condition.⁽¹⁹⁹⁾ Climate change will directly affect the risk to children from diarrhoeal disease if the provision of adequate and safe food, water and sanitation are compromised through changing rainfall patterns.

The mortality and morbidity risk from environmental conditions is 44% higher in children under 14 years than in the rest of the population. By virtue of their early stage in development, children and especially very young children, are at greatest risk of injury, disability and death from the consequences of the changing climate system. Their dependence on others for sustenance, nurturing, protection from infection and physical harm, the susceptibility of children to threats is increasing.¹⁸ The overwhelming scientific evidence suggests that the three greatest killers of children— malnutrition, diarrhoeal disease and malaria—will be exacerbated by climate change.^{19,20} The risk of harm is greatest for children living in developing countries, because of the dual disadvantage, extreme climate effects and because poverty limits their ability to respond.

In situations of national poverty, funding cuts to schools lead to declines in education quality, and higher costs are transferred to parents. In extreme domestic poverty, one of the difficult decisions can be to withdraw children from school due to inability to afford the direct schooling costs, or to

Overview of Climate Change Impacts on Human Health in the Pacific Region

require children to supplement their family income. Often girls' education will be sacrificed, and if in later years she becomes a sole mother, her children are destined to remain in the poverty trap. Malnourished students perform poorly at school, and this also predisposes the child to a future with restricted economic opportunities. A poorly nourished generation deprives a Nation of its most valuable resource, human contribution to society and the economy.

Pacific Island Countries are vulnerable to natural disasters that can cause temporary food insecurity. Climate change will put pressure on food production systems and adaptation measures must be put in place to deal with these impacts. Traditional smallholder farming systems have proven to be robust and productive in the face of adversity. These systems need to be supported and strengthened to enable Pacific island countries to meet the challenges of increased food prices. Food and water security are health issues, and must be protected to secure human health. Nutrition is one of the most significant factors determining risks to the health of a child. Its importance extends beyond ensuring survival of an individual. Nutrition provides the source from which future social and economic opportunities flow for generations to come. Investing in children and women is necessary to protect population health now and into the future, by expanding and then maintaining essential health and social services for children and women (health, education, HIV prevention, and protection from abuse, violence and exploitation). Economic challenges are likely to persist. Climate change will exacerbate those challenges, and government health expenditures will likely decline in real per capita terms. Investments in fundamental public health cannot be compromised for a nation's future security depends upon a healthy population.

Government health expenditures will likely decline in real per capita terms. Even where health is prioritized within the overall budget, real health spending per capita may still fall. The demand on public services will increase at a time when funding for such services will diminish.

Basic strategies to enhance national food security include:

- supporting national agriculture;
- ensuring access to clean water – for urban and rural dwellers;
- provision of maternal and child health programs;
- provision of micronutrient supplements for children (vitamin A and zinc);
- micronutrient fortification (iron and salt iodization);
- expanded immunization coverage for children;
- deworming and other nutrition programs at school;
- lowering the price of schooling;
- increasing and improving girls' schooling;
- community-based nutrition promotion;
- providing support for women's reproductive role (and family planning);
- malaria prevention and treatment;
- conditional cash transfers;
- HIV combination prevention;
- total sanitation campaign; and

- microfinance to support the poor to become food secure.

The importance of food security in the Pacific has been identified as a key health issue. A multi-sectoral approach to improving food security throughout the Pacific was initiated via the “Food Secure Pacific” initiative in 2008. Supporting partners to WHO were the Food and Agriculture Organization of the United Nations (FAO), the Pacific Islands Forum Secretariat (PIFS), the SPC, Global Health Institute and the United Nations Children’s Fund (UNICEF).⁽¹⁷²⁾ The overall aim of this program was to ‘contribute to improved nutrition and health in a changing world and in a Pacific susceptible to climate change’. Because of the critical influence of nutritional status on health outcomes, and the potential for future food insecurity, the importance of this work cannot be overestimated, and the need is unlikely to abate as further climate effects emerge. A more probable likelihood is demand for increasing efforts. Sound investments in population health can be made by ensuring food security. It is unlikely that existing efforts are reaching their target. There is scope for further investment in this area, and more consumption targeted policy measures such as food and possibly cash assistance particularly targeting the urban poor, as well as production oriented policy intervention targeting rural poor.

Key adaptive strategies fall into distinct categories:

- Ensure access to the basic food necessities;
- Protect communities from food (and water) contamination;
- Educate communities and households about dietary requirements and food handling and storage;
- Provide adequate health care;
- Monitor health status;
- Evaluate programs and respond appropriately.

2.4 Water security, Water-borne Disease and Sanitation

The PASAP Water Security & Vulnerability report by Tony Falkland details climate change challenges for water supply among the PICs. Our focus therefore is health impacts.

Definitions

Water security is defined by the UNESCO Institute for Water Education as involving “the sustainable use and protection of water systems, the protection against water related hazards (floods and droughts), the sustainable development of water resources and the safeguarding of (access to) water functions and services for humans and the environment”.⁽²⁰²⁾

Water-borne disease is used in this paper to refer to infectious diseases that are contracted directly as a result of consuming water that is contaminated.

Drinking water is water used for domestic purposes, drinking, cooking and personal hygiene;

Overview of Climate Change Impacts on Human Health in the Pacific Region

Access to drinking water means that the source is less than 1 kilometre away from its place of use and that it is possible to reliably obtain at least 20 litres per member of a household per day;

Safe drinking water is water with microbial, chemical and physical characteristics that meet WHO guidelines or national standards on drinking water quality;

Access to safe drinking water is the proportion of people using improved drinking water sources: household connection; public standpipe; borehole; protected dug well; protected spring; rainwater

Basic sanitation is the lowest-cost technology ensuring hygienic excreta disposal and a clean and healthful living environment both at home and in the neighbourhood of users. Access to basic sanitation includes safety and privacy in the use of these services. Coverage is the proportion of people using improved sanitation facilities (public sewer connection; septic system connection; pour-flush latrine; simple pit latrine; or ventilated improved pit latrine).⁽²⁰³⁾

The term “improved” rather than “safe” drinking water sources is used as a proxy to measure progress towards achieving MDG Target 7c, “by 2015, to halve the proportion of people who are unable to reach or to afford safe drinking water”.⁽²⁰⁴⁾ “Improved” drinking water sources refer to piped water to standpipes or into houses, boreholes, protected springs or wells or rainwater catchments. Unimproved sources include unprotected wells and springs, water trucks, surface water including rivers, streams and lakes. “Safe” drinking water means water that is safe to drink and available in sufficient quantities for hygienic purposes. The significance of the distinction for health, is that water sources can be improved, yet still fall short of being safe, many “improved” wells are not safe to drink as their design cannot prevent influx of pathogens into the well.

2.4.1 An overview of water supply issues in the Pacific Island Nations

Access to quality water is arguably the most necessary requirement for human survival, as access to safe drinking water and basic sanitation is a key determinant of life expectancy.⁽²⁰⁴⁾ In the Pacific, the source of potable water depends on the geography and topography of each nation. Low-lying coral islands and limestone islands rarely have fresh surface water resources except where rainfall is abundant. In general, atoll nations draw water from shallow freshwater lenses or from groundwater. (Groundwater is water that is impregnated in rock or soil.) Freshwater lenses are close to the ground surface and only a few metres deep, thus easily contaminated by sewage and by flooding. They are by nature small, and can therefore adequately support a limited population only. Many small island lakes, lagoons and swamps, particularly those at or close to sea level, are brackish. Countries that rely on freshwater lenses and groundwater usually supplement with rainwater, collected in household tanks. Brackish water and seawater are used in some islands as a source of supplementary water for some non-potable uses. In contrast, countries that are volcanic in origin, and large enough, use surface water drawn from lakes and rivers, again supplemented with rainwater.

Only 50% of the total population across all the 15 countries had access to improved water supplies in 2010 which is significantly less than the world average of 86%.⁽²⁰⁴⁾ For individual countries, the access to improved water supplies varies from about 40% (in PNG) to 100% (in Nauru, Niue and Tonga). Over 60% of the Pacific island countries now provide improved water to 80% of their population, it is

Overview of Climate Change Impacts on Human Health in the Pacific Region

important to highlight the fact that only 13% of the population count on drinking water piped to internal household systems or household yards.⁽²⁰⁴⁾ This absence of piped water to the household hampers the ability of householders to utilize drinking-water in sufficient quantities as to meet the basic demand not only for drinking, cooking and hand washing, but also for bathing and laundry. In the absence of access to sufficient affordable qualities of clean water, hygiene and health is compromised.

The main vulnerable populations in terms of water security, access to clean water, from both climate and non-climate related factors are those living in:

- Crowded urban and peri-urban areas, due the lack of access to clean water supply, which necessitates their use of polluted sources for some water uses;
- Drought prone regions and those with limited storage capacity, especially those on remote islands, due the risk of local water resources depletion (including rainwater tanks) ;
- Very low level parts of islands, which are at risk of inundation, erosion and temporary salination of groundwater from waves caused by cyclones or tsunamis.

The PCCSP rainfall projections to 2030 suggest:

- Most, 12 of the 15 countries will show little change in mean rainfall for the “most likely” condition, and an actual decrease is projected for only three of these (Tonga, Vanuatu and East Timor).
- Significant increases in rainfall are projected for PNG, Nauru, Cook Islands, West FSM, the Kiribati, Palau.
- Drier conditions are projected for Fiji, East Timor, Niue, Vanuatu and Tonga.

2.4.2 An overview of water-borne disease and sanitation in the Pacific

Global analysis infers that access to basic sanitation, safe drinking water supply and good hygiene behaviours has the potential to prevent at least 9.1% of the disease burden (in disability-adjusted life years or DALYs – a weighted measure of deaths and disability). In developing regions, this translates to the possibility to prevent 6.3% of all childhood deaths. The health burden on children is disproportionately greater than adults, as unsafe drinking-water, inadequate sanitation or insufficient hygiene accounts for more than 20% of total deaths in children up to 14 years of age. Being underweight or undernourished causes about 35% of all deaths of children under the age of five years worldwide. An estimated 50% of this underweight or malnutrition is associated with repeated diarrhoea or intestinal worm infections as a result of unsafe water, inadequate sanitation or insufficient hygiene.⁽²⁰⁵⁾ Figures for children (under 5 years old) in the Pacific island countries are reportedly, about 10% of all deaths can be attributed to diarrhoeal diseases, and 90% of these are result from lack of sanitation, drinking-water and hygiene.⁽²⁰⁴⁾

Overview of Climate Change Impacts on Human Health in the Pacific Region

Since 1990, considerable progress has been made in the Pacific Island with respect to access to safe water and sanitation. Access to sanitation increased from 2.9 million to 4.0 million, a 41% increase. However this major achievement has been somewhat overshadowed by the substantial growth in population over the same period of time. The actual numbers of unserved increased over 30%, from almost 3 million in 1990 to 4.3 million in 2006.⁽²⁰⁴⁾ At 48% (in 2006) the sanitation coverage in the Pacific island countries falls well short of the world average of 62%. Communities in Kiribati, Federated States of Micronesia, Papua New Guinea and Solomon Islands are poorly served, with less than half of the population have access to improved sanitation. Rural communities are particularly poorly served. For example 90% of rural households in the Solomon Islands do not have access to improved sanitation facilities⁽⁵⁷⁾. Whereas Cook Islands, Niue and Samoa have achieved full coverage. Sewage systems in some countries are safe and functional, while in others suffer from leakage from broken pipes or lack a safe place for final disposal.

In addition to vector (mosquito) transmission, and via eating infected food, helminth infestation commonly results from contaminated water. Helminths (parasitic worms) are categorized into three groups: cestodes (tapeworms), nematodes (roundworms), and trematodes (flukes). Intestinal helminths (ascariasis, trichuriasis and hookworm infection) are plaguing the developing world due to inadequate drinking water, sanitation and hygiene. Infestation with parasitic worms is insidious, and many people are asymptomatic, and remain unaware of the infestation. With heavy infestation, symptomatology includes weakness, vomiting and stomach pains. Pathological effects can be cryptic and non-specific as health symptoms eventually emerge as a consequence of nutritional impairment. Indications can include problems such as vitamin deficiencies, stunting, anaemia, protein-energy malnutrition, and consequential reduction in cognitive ability and intellectual development.⁽²⁰⁶⁾ Also worth considering is the fact that the immune response triggered by helminth infection may drain the body's ability to fight other diseases, making affected individuals more prone to co-infection

In the last ten years, PICs have suffered outbreaks of leptospirosisⁱ, typhoid, and cholera. Diarrhoea is a symptom of infections caused by a host of bacterial, viral and parasitic organisms, most of which are spread by faeces-contaminated water. Infection is more common when there is a shortage of clean water for drinking, cooking and cleaning.⁽¹⁹⁹⁾ Rotavirus and Escherichia coli are the two most common causes of diarrhoea in developing countries. Diarrhoeal disease, with or without a pathology-confirmed diagnosis, is a significant cause of morbidity and mortality throughout the Pacific, especially in children. Although water can be sterilised by boiling, many poorer families are reluctant to do this because of the cost of fuel.

Contamination of water is often accidental, or it may be due to lack of awareness about how contamination occurs, for example burying deceased persons, or waste near freshwater lenses. Water quality can be protected through community-based education.

ⁱ [Leptospirosis is a zoonotic bacterial disease. Transmission occurs through contact of the skin and mucous membranes with water, damp soil or vegetation or mud contaminated with rodent urine.](#)

Overview of Climate Change Impacts on Human Health in the Pacific Region

Climate change will have considerable effects on water-borne disease by influencing water quantity and quality. The links between human health and water quantity and quality are complex.⁽²⁰⁷⁾ The consequences of climate change on health outcomes also vary significantly by the quality and maintenance of infrastructure, including the routine monitoring of water quality. This presents a challenge for resource limited less developed countries,⁽²⁰⁸⁾ including PICs. Effects of climate change on water-borne diseases can be considered broadly under the effects of heavy rainfall, flooding and increase in temperature.⁽¹³⁹⁾ In addition, climate influences the properties of water including salinity, temperature, ionic content and biota.⁽²⁰⁹⁾ Changes in climate will have an effect on these properties and thereby influence the survival and transmission of water-borne pathogens.⁽²⁰⁹⁾

Precipitation has a positive relationship with water-borne disease. Studies have shown a robust association between the incidence of water-borne disease and the occurrence of extreme levels of precipitation.⁽²¹⁰⁾ Intense rain increases the likelihood of contamination of drinking water with human and animal wastes.^{(101),(88)} Heavy rainfall events alter normal water flow patterns, and cause water to flow across fields rather than coursing through creeks as fertilizers and nutrients spread in this way, encourages growth of microorganism. Overloaded and storm-water drains sewers force pathogens from catchment areas into drinking water supplies.^{(207),(211)} Communities without reticulated water supplies are especially vulnerable to the effects of climate change-mediated increases in protozoan diseases.⁽²¹²⁾ Faecal contamination of water, through heavy rainfall or flooding, has serious health consequences including epidemics of diarrhoeal disease and increased risk for the development of cholera in endemic areas, typhoid fever, Salmonellosis, Shigellosis, hepatitis A and hepatitis E.⁽²¹³⁾ High rates of precipitation increase the concentration of both chemical and microbiological contaminants of surface water, which can overload water treatment processes,⁽¹³⁹⁾ and thus increase the risk of gastrointestinal disease.⁽²⁰⁷⁾

A study investigating the relationship between climate variation and diarrhoeal disease in PICs found a positive association between diarrhoea reports and extremes of rainfall events, and concluded that future changes in climate were likely to exacerbate diarrhoeal illness in PICs.⁽¹⁷⁵⁾ Conversely, low levels of rainfall or drought may cause water scarcity,⁽²¹⁴⁾ which will also contribute to an increase in diarrhoeal disease. Insufficient clean water resources will leave people no choice but to use contaminated water.^{(215),(214)}

Although most Island states tend to have fairly stable rainfall throughout the year, severe droughts do occur, and limited storage capacity reduces capacity to withstand breaks in rainfall patterns. Drought severity is often associated with the inability to store vast quantities of water on small islands. In October 2011 Tuvalu, and Tokelau both declared a state of emergency due to severe water shortages from low rainfall. Tuvalu, can poorly withstand even a short dry period of 2-3 weeks without rain. A severe drought in 1999 (i.e. period without rain longer than 2-3 weeks) forced the government to purchase a desalination plant from Japan (very expensive infrastructure) which now costs AU\$30,000 per month to run given its intensive use of costly diesel fuel. This is deemed to be quite unsustainable and the long-term costs could be prohibitive. During the 2011 drought, the desalination plants failed, and required assistance from New Zealand and Australia. Water insecurity

Overview of Climate Change Impacts on Human Health in the Pacific Region

questions the sustainability of a housing a resident population under increasingly variable rainfall conditions.

Rainfall in Fiji is seasonal and mainland PNG experiences distinct dry and wet seasons.⁽¹¹⁶⁾ Projected rainfall patterns for the region are mixed. Rainfall variability is likely to result in extreme rain events, and periods without rain. Both scenarios have deleterious health effects. Drought induced crop failures, stock losses bring food shortages and the associated economic consequences exacerbate the struggle to maintain nutrition levels among subsistence groups and farmers,⁽⁸³⁾ as discussed in section 2.3 Food Security.

Water chemistry alters in water shortages especially when water is stored and warm. Pathogen growth results in disease, and water restrictions limit washing, interrupting hygiene routines, which can also result in disease. Increased temperature will adversely affect human health by enhancing proliferation of a range of planktonic species,⁽¹³⁹⁾ causing water-borne disease directly or indirectly. For example, direct health consequences include clinical syndromes associated with consumption of water contaminated with toxins from blue-green algae. The toxins enhance survival of *Vibrio cholerae* in waters containing rich supplies of algae and plankton.⁽¹³⁹⁾

The Pacific Public Health Surveillance Network, Pacific Human Resources for Health Alliance, and Pacific Economic Cooperation Council provide information about recent outbreaks. Correlations between effects of climate change and frequency or distribution of outbreaks are not made in these documents. This would be a worthwhile area of study.

Many projects aimed at improving water infrastructure are small-scale, short term solutions, whose aim is to supply clean drinking-water according to the MDG 7.C target.⁽²¹⁶⁾ Other projects are broad in outlook, aiming to repair whole systems and increase capacity. The imperative will be on future projects to create water supply systems that are adapted to the additional stresses of climate change, and to create robust mechanisms for sharing expertise and best practice.

Appendix X gives a country-by-country breakdown of the source of water, focus areas for policy makers that have already been identified, the ways in which climate change is expected to affect water security and water-borne disease, and the projects and programs that have already been implemented. Appendix provides a regional summary of water projects being currently undertaken, and a list of websites is included for further reference. These tables are intended to allow for a rapid assessment of water related health challenges already present in PICs, and identify existing programs designed to address these issues. In most cases it is not known how climate change will alter health status, and many programs are not attempting to adapt to climate change.

These tables demonstrate that considerable efforts are being undertaken to improve water security, primarily to address basic living standards. In 2006 it was estimated that less than half of the Pacific Island population had access to sanitation, and only 13% of the population had access to drinking water delivered to the household via piped distribution system. The available water resources are currently often sub-optimally managed, delivering contaminated water and imposing significant

Overview of Climate Change Impacts on Human Health in the Pacific Region

health risks on communities. Even more concerning is that in some instances drinking water supplies have already run low, necessitating reliance on imported drinking water. Programs that prepare water infrastructure for climate change are urgently required, but have been slow in planning and execution.

The building of a robust water delivery infrastructure will help to ameliorate some of the existing shortfalls placing human health at risk. This is a prerequisite for preparing communities to adapt to additional stresses projected to occur with climate change. Access to a reliable source of clean water with accidental contamination eradicated or minimised, will reduce the incidence of water-borne disease, as well as improving living standards, thereby indirectly improving health outcomes. The predicted increase in rainfall variability will heavily reduce water access reliability, and sea level rise imposes a significant contamination risk to water lenses. Existing programs to improve current water systems usually aim to minimise system loss and prevent contamination, which again may ameliorate these problems. Capacity to manage ongoing repair work will be need post extreme weather events, such as tropical cyclones and flash floods, which inflict physical damage and destruction of infrastructure.

A survey of the existing programs and accompanying literature highlights that delivery of safe water supplies in the Pacific Islands is unsatisfactory for multiple reasons. These include lack of clarity of ownership of water resources, inappropriate government policies, insufficient cost recovery by water suppliers, non-financially viable operations and the lack of appropriate incentives for consumers to reduce demand to sustainable levels. Furthermore, there is limited community involvement in water service planning, management and delivery resulting in inadequate appreciation of responsible water management and use by these communities. These are general statements, and individual countries have unique challenges in providing safe water for their people.

Poor water quality, poor sanitation, and inappropriate health and hygiene practices through lack of awareness have resulted in communicable diseases being one of the most prominent public health problems in the Pacific Islands. Rates of gastroenteric infection related to water pollution remain high and should be prevented. With community education and reliable access to safe water, much of the existing burden can be removed. As sea levels rise, contamination of drinking water is possible, therefore an adaptive imperative is for water storage to be impervious to seawater contamination.

Monitoring of water quality and reporting of findings, with efficient data distribution and swift disease control, will limit outbreaks of water-borne disease across the region. Coordination of these processes also needs to be optimised, and linked with health sectors.

An overarching goal for water security and water-borne disease is to establish an appropriate policy framework that enables water delivery at fair cost to all households and businesses, and operating incentives oriented to improving customer service. These are changes that can bring immediate health benefits, and long term advantages in the health and economic wellbeing, and therefore help communities respond to other threats. Individual projects tend to be independent of each other and lack coordination. We expect that a combined effort, or at least tightly administrated, will enhance the capacity and durability of water delivery and quality monitoring. Bodies such as SOPAC (now the

Overview of Climate Change Impacts on Human Health in the Pacific Region

SPC Applied Geoscience and Technology Division) are working to collate projects and encourage collaboration, government level coordination may be required to eliminate wasteful overlap.

Community awareness is a fundamental necessity in curbing accidental water contamination and improving hygiene practices. Education should also have the aim of empowering those affected to improve their own water supply as and where possible, and to motivate resource owners to work together to create water solutions. These actions lie at the core of fundamental public health practice directed towards reaching the MDGs. Adequate rationale exists currently to provide all inhabitants on the PICs with access to safe water and sanitation, the added climate change challenge merely intensifies the urgency of need to optimise the health of local populations to facilitate their effective response to other climate health threats.

There remains a significant challenge in training of technical and scientifically qualified staff in order to fortify water quality improvement and monitoring, oversee water infrastructure projects and provide much needed community education and health promotion. Despite the numerous and complex challenges, there is cause for optimism, as groups and governments are increasingly motivated to work together to achieve the best possible outcomes in water supply and delivery.

Table 7: Benefit–cost ratio of investment in water and sanitation strategies

Intervention	Annual benefits in US\$ millions	Benefit–cost ratio by intervention
Halving the proportion of people without access to improved water sources by 2015	18 143	9
Halving the proportion of people without access to improved water sources and improved sanitation by 2015	84 400	8
Universal access to improved water and sanitation services by 2015	262 879	10
Universal access to improved water and improved sanitation and water disinfected at the point of use by 2015	344 106	12
Universal access to a regulated piped water supply and sewage connection by 2015	555 901	4

Data source: Hutton & Haller. World Health Organization. 2004⁽²¹⁷⁾

Table 7 above illustrate the wisdom in investing in public health actions, as reported in *Evaluation of the costs and benefits of water and sanitation improvements at the global level*, a report for the WHO.⁽²¹⁷⁾ In this example water and sanitation strategies are shown. The benefit–cost ratio figure is derived by dividing the total benefits by the total costs. Projects with a benefit–cost ratio greater than 1 have greater benefits than costs. The higher the ratio, the greater the benefits relative to the costs. The project reported there are many and diverse potential benefits associated with improved water and sanitation, ranging from the easily identifiable and quantifiable to the intangible and difficult to measure. Note, measurement problems limited analysis to a few tangible benefits, therefore figures provide an underestimate of the true relationship. Benefits include both (a)

reductions in costs and (b) additional benefits, including health benefits, resulting from the interventions, over and above those that occur under current conditions.

Substantial marginal health benefits can be gained by disinfecting water at the point of use, and the greatest proportion of time gain is from sanitation interventions – i.e. the closer proximity of toilets or less waiting time for public facilities. The cost-benefit ratio of water and sanitation interventions is high when all benefits are included, standing at around between US\$5 and US\$11 economic benefit per US\$1 invested for most developing world sub-regions and for most interventions. In some cases the ratio is significantly higher than this, and in some cases it is lower.

2.5 Chronic (non-communicable) Health Conditions

Climate change is likely to exacerbate existing chronic health conditions in PICs. A recent WHO publication, *Protecting Health from Climate Change: Global Research Priorities*, indicates that ‘most of the health impacts of climate change arise as a result of the extension or amplification of existing health hazards.’⁽²¹⁸⁾ A key feature of climate change is rising temperatures, and the excess mortality and illness observed during heat waves is a major health concern.⁽²¹⁹⁾ People with pre-existing chronic disease are at high risk, yet significant knowledge gaps pertaining to the relationship between chronic diseases and climate change exist in most countries,⁽²²⁰⁾ and this is particularly relevant for PICs. Throughout the region, chronic disease prevalence is increasing and they have become the leading causes of death in the majority of PICs.⁽³¹⁾ The increased chronic disease risks as a result of climate change,⁽²²¹⁾ therefore, will pose negative influences on the chronic health conditions in PICs. A clear need exists for further investigation in this area, to understand the specific relationships within the PICs, in order to target appropriate and culturally acceptable strategies to minimize the risk.

International research suggests that subpopulations, aged less than 1-year-old or older than 65 years and those with underlying health problems are known to be particularly vulnerable to climate change impacts.⁽²²²⁾ For example, extreme heat events have been found to be particularly harmful to individuals with psychiatric and behavioural disorders, neurological and cardiovascular disease, respiratory diseases, particularly asthma and chronic obstructive pulmonary disease, cancers and kidney disease or renal failure⁽²²³⁾

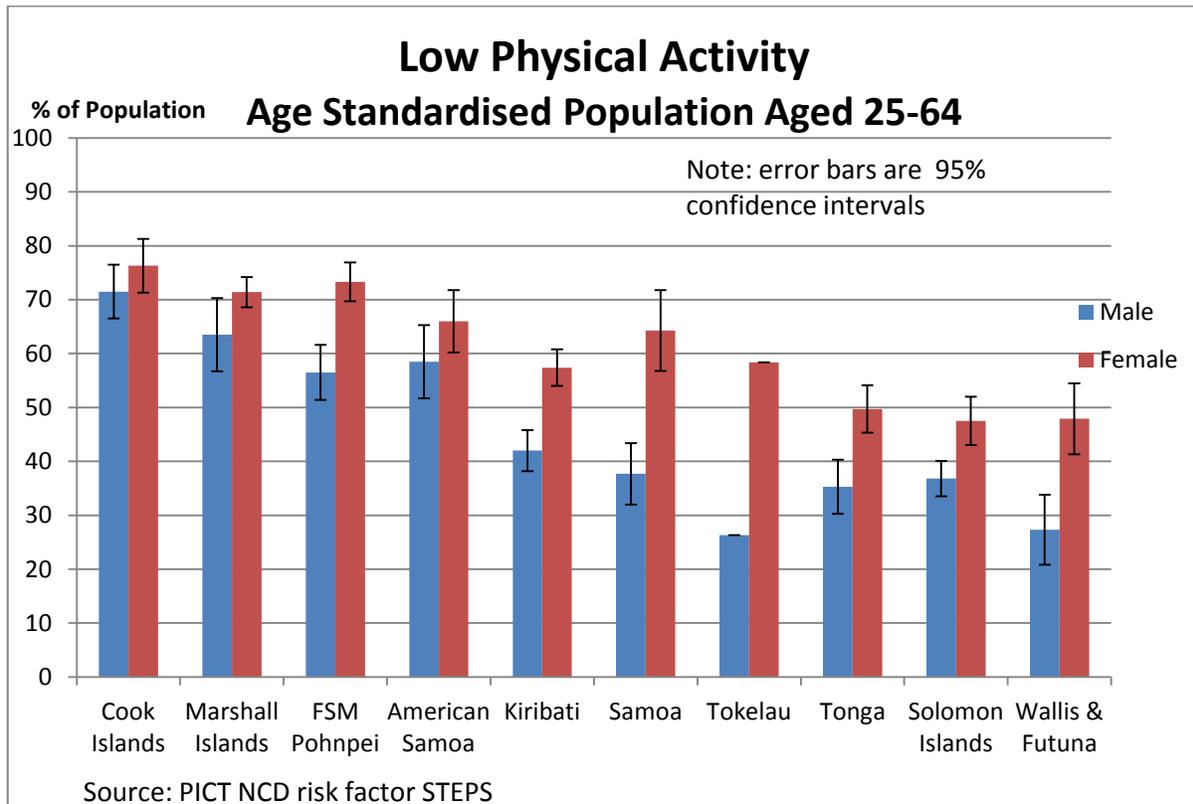
Although the majority of heatwave deaths occur in people with pre-existing cardiovascular or respiratory diseases,⁽¹⁰¹⁾ those with pre-existing psychiatric illnesses are also susceptible to the effects of high temperatures, with a tripled risk of death during an extreme heat event.⁽²²⁴⁾ A number of kidney diseases are also affected by high mean temperatures,⁽²²⁰⁾ for example, an increased occurrence of kidney stones has been observed among populations where heat waves increased hospitalisations for renal disease.⁽²²⁵⁾

As discussed in section 2.1.1, exercise for the unacclimatised will become even more problematical, and yet acclimatisation has upper limits, as muscular activity is perceived as more of a physical burden under additional heat and high tropical humidity levels. This generates a potential feedback loop amplifying risk for intractable obesity and poor health outcomes. A reluctance to engage in physical exercise can negatively impact on personal fitness levels, and lead to greater obesity and

Overview of Climate Change Impacts on Human Health in the Pacific Region

cardiac impairment. Cardiovascular disorders accentuate heat exposure risks as extreme heat places additional load on the heart, thereby precipitating cardiac insufficiency, a health emergency. Significant proportions of PIC populations are currently not receiving sufficient exercise to maintain cardio-respiratory fitness. To what extent existing hot humid environments have contributed to this has not been quantified, however it can be assumed that further warming and higher humidity levels will exacerbate the reluctance to exercise. Figure 8 illustrates the population percentages whose low level of physical activity is currently categorised as *high risk* among selected PICs.

Figure 8: Low Physical Activity by Pacific Island Country by gender (Percentages)



Source: SPC - NCD Statistics for the Pacific Islands Countries and Territories 2010 data. ⁽³⁶⁾

The level of non-communicable diseases (NCDs) has reached crisis levels in many PICs. Figure 3 in Part 1 showed the proportion of population considered at high risk of NCDs in selected PICs. Smoking is a major contributing factor to the development of cardiovascular disease. Current prevalence of smoking in certain PICs is extremely high. For example in PNG 76% of men and 80% of women smoke, and figures for Kiribati are 82% and 67% respectively, Nauru (61%, 47%), Niue (63%, 21%), Samoa (58%, 21%) Tuvalu (51%, 31%).⁽²²⁶⁾ The fraction of ischaemic heart disease attributable to smoking ranged from 13–33% in males and from 1–28% in females.

Obesity is also a major determinant of cardiovascular disease. As discussed previously (Section on NCDs in Part 1), obesity rates have risen three-fold or more since 1980 in some Pacific Islands. Although obesity rates are not available for children, the global pattern, replicated in developing

Overview of Climate Change Impacts on Human Health in the Pacific Region

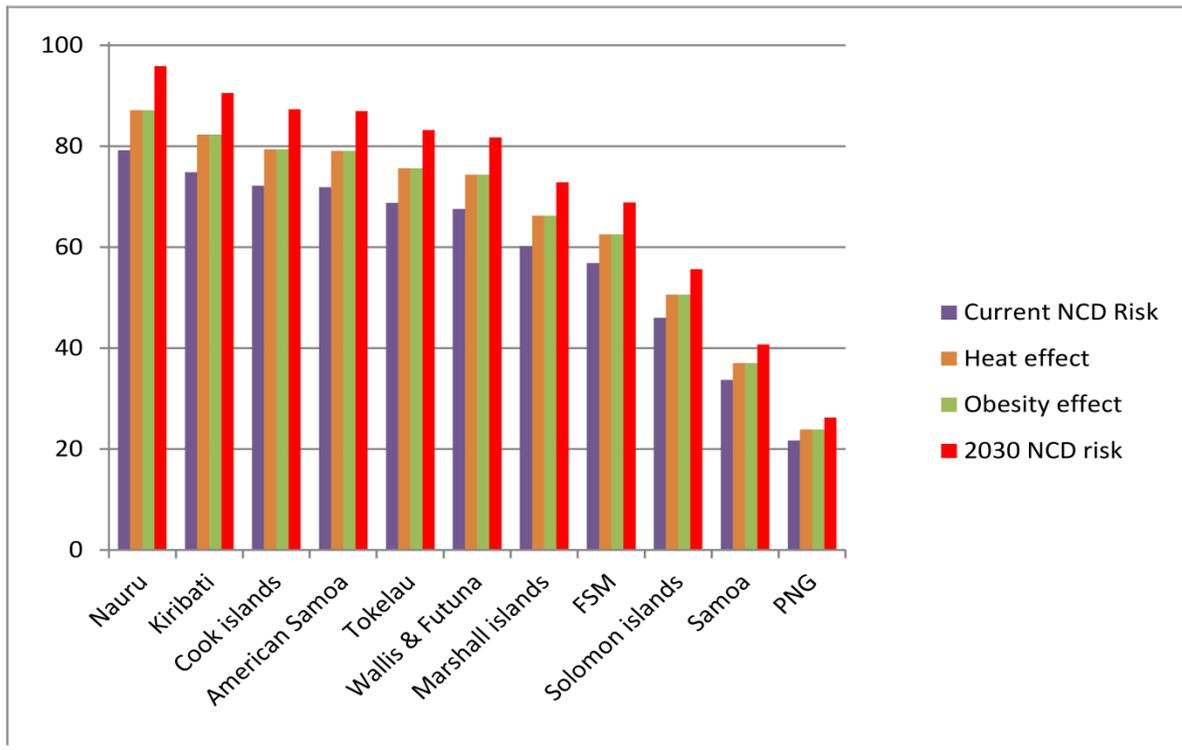
countries is for rapid rise in childhood obesity rates on countries with high adult rates. Also previously discussed (in section 2.1.1) global warming, more heat waves and the associated increasing humidity can be expected to further exacerbate the proportion of the PIC population who undertake low levels of exercise. The combined effects of high smoking rates, rising obesity and climate induced reductions in physical exercise indicates an escalation of NCD's. A conservative estimate could place the increase in NCD in PICs by 2030 at 10%.

Climate change will therefore further exacerbate NCD risks across all PICs, by the additional burden placed by the elevation in WBGT and additional cardiac loading this brings. Researchers are currently calculating the additional health burden caused by additional health, although the important influence of humidity remains unknown, but it is known that obese and cardio-compromised people are at significantly higher risk. Therefore, due the multiple determinants of NCDs, quantifying the additional health risk contributed by climate change remains difficult. Inclusion of all contributing factors (if the data were available) into a calculation would involve considerable margins of errors, such that a final figure would lack certainty, and be of little real value.

Figure 9 below superimposes an estimated proportional risk of 10% for continued rise in lifestyle generated NCD risk on current estimates published by the SPC.⁽³⁶⁾ A further 10% is then added for the additional health burden anticipated from shifting the WBGT into a realm of discomfort and cardiac stress to project a likely projection for NCD risk among selected PICs in 2030. The proportions applied in this example are estimates, and could be viewed as conservative. As these indicative figures suggest, the future could be dire for these populations, and the additional health costs would place considerable strain on health budgets. More accurate assessments require research. Of critical importance are identification, implementation followed by evaluation and refinement of programs designed to reduce this health burden given the likely exacerbation by rising heat and humidity.

Overview of Climate Change Impacts on Human Health in the Pacific Region

Figure 9: Estimated NCD risk in selected PICs by 2030 influenced by warming – percentage of adult population.



Part 3: IDENTIFIED CHALLENGES AND HEALTH INTERVENTIONS

The science underlying climate change has been in the public arena for over a hundred years, and increasingly over the past 30 years, effects on biota and sea levels have emerged. Provision of quantitative data linking effects of climate change to observable human health outcomes has faced numerous challenges in developed societies. Despite the greater impact on developing countries, measuring their specific health burdens has been particularly difficult. International attention is now directed at identifying and assigning priority to key health impacts and projected risks, however health intelligence remains scant. Several reports are due for release in the coming years. This section provides the key findings and recommendations of the Overview.

3.1 Challenges and Gaps

Pacific Island nations face similar challenges from climate change to those faced by other developing nations, yet these are exacerbated by the comparatively small size, remoteness, and the fact that many islands are part of large, dispersed archipelagos. Perhaps their most disadvantaging characteristic however is that the Pacific is one of the least developed regions in the world. Despite the significant resources invested in the region over the past 30 years, economic and social progress has been slow and uneven. These climate change threats facing Pacific islands Countries are of a magnitude that make adaptation a survival imperative. For this adaptation to be effective, it will entail adjustments and changes at every level – from community to national and international.

Communities must build their resilience, and will increasingly need support to achieve this. The process will include adopting appropriate technologies while making the most of traditional knowledge, and diversifying their livelihoods to cope with current and future climate stress. Local coping strategies and traditional knowledge need to be used in synergy with government and local interventions. The choice of adaptation interventions depends on national circumstances. To enable workable and effective adaptation measures, ministries and governments, as well as institutions and non-government organizations, must consider integrating climate change in their planning and budgeting in all levels of decision making.

Drawing on the discussion and analysis of the information collated in the first two stages, together with cross-sectoral expertise, we have examined and identified the following common challenges and gaps in PICs' health sectors:

- The manifestations of climate change on human health are likely to be complex, multifactorial, and difficult to isolate, for purposes of quantifying, analysing or devising adaptive strategies;
- Understanding the extent to which climate change will affect current disease patterns and human health in PICs is limited and the problem is under researched;
- Limited understanding of likely health risks at a local level;

Overview of Climate Change Impacts on Human Health in the Pacific Region

- Limited understanding of appropriate adaptive strategies that may minimise those risks;
- Limited public health infrastructure and capacity to meet existing health demands, for communicable and non-communicable disease; and disaster response;
- Lack of well-developed public health surveillance systems to monitor impacts and measure progress or program success. Only a few French Polynesian PICs are in the process of developing laboratory-based surveillance systems; the majority of PICs rely on syndromic surveillance;⁽²²⁷⁾
- Health data are poorly collected and under analysed. Paper-based records and disorganised data are common in PICs, which, in most cases, are not further analysed or examined;
- Stretched public health resources in personnel, capacity and techniques;
- Stretched health resources, and chronic shortages in skilled health workforce. The existing health problems in PICs place great demands on existing health services, and when the limited available health services response is inadequate to need, population health status is worsened;
- Shortage of technically and scientifically qualified staff in program and infrastructure monitoring, with significant challenges in meeting training needs;
- Barriers to efficacy due to small size, and isolation which limit options and limit economic independence
- Individual research and projects in the region tend to be independent to each other and there is a lack of coordination and communication;
- Resistance amongst existing health workforce in PICs, who see climate change as a competing agenda to other areas of population health.

3.2 Recommendation for health interventions

Given that population health determinants include Earth's biophysical systems and socio-political conditions, most climate change activities include a health focus, and can therefore in the broadest sense, be classified as health interventions. Accordingly, the climate change and health landscape in the Pacific Region is not a tabula rasa. Over recent years the climate change landscape has quickly populated. Many agencies are now involved: donor countries (primarily Australia, New Zealand and Japan, and China is now joining), Council of Regional Organisations of the Pacific (CROP) agencies, and UN agencies, NGOs and civil society organisations, including the Red Cross / Red Crescent societies at regional and national level, environmental and development NGOs, Pacific churches and youth groups. The Secretariat of the Pacific Regional Environment Programme (SPREP) Climate Change portal website lists many of these (http://www.sprep.org/climate_change/pccr.htm).

Despite these activities, progress in research or adaptation interventions which have a direct focus on population health has been limited. Little detail is available known about the climate related health effects likely to emerge for each country. Redressing this knowledge shortfall is an urgent

Overview of Climate Change Impacts on Human Health in the Pacific Region

priority. The WHO recently established a series of programs aimed at capacity building to enhance country capacity to assess their own health vulnerabilities and adaptive needs. These will deliver broad findings, Follow up studies will be required to furnish health departments with the level of details required for policy implementation. Their reports are yet to be published; however, early indications suggest that the process of capacity building remains incomplete, and further support is required.

It is important to note that although many climate change and health issues have regional application throughout the Pacific, there are significant country-specific issues that need to be incorporated in the design and rollout of programs aiming to boost climate change adaptation to protect population health.

The overarching recommendation of this report is for Donors' Agencies to work closely with country stakeholders to ensure that assistance meets the needs of the country and aligns well with other programs and development aims. Specifically, adaptation strategies should have identifiable benefits independent of the impact of climate change. Donors have occasionally succumbed to the failings exhibited in early attempts at tobacco control, where it was mistakenly believed that a single round of health hazards education would be sufficient to a) result in behaviour change (cessation of smoking), and that b) any change would be sustained over time. The health sphere in the PICs is plagued by overwhelming health needs and corresponding unmet service demands, and limited resources to respond.

An example of this can be seen by the recent establishment of pathology laboratories, without concomitant training on appropriate sample testing, or interpretation of results. Funding for transport of samples was also lacking. The resulting poor serviceability of laboratories meant that investments failed to achieve desired objectives. The upstream and downstream conditions must be considered, for these often determine program success or failure, and therefore the efficacy of investment. These pre- and post- conditions vary throughout the Pacific and within countries. Hence local input in planning and complex systems thinking are critical to effective planning of and assigning priority to strategies. Ongoing evaluation and support with flexibility to expand to accommodate upstream/downstream processes is also crucial to success.

Understanding of adaptive needs at the country level remains underdeveloped. Preliminary detailed investigations of vulnerability to climate change health impacts must be conducted at a national level before priorities can be determined. The following recommendations are therefore of a general nature.

We propose the following general recommendations to tackle the issues outlined above. Each recommendation has its own focus, but the challenges discussed cannot be considered separately in implementation.

3.2.1 Recommendation 1: Research

- Globally, there is minimal deep understanding of the likely health impacts of climate change. This is particularly true in PICs, The high vulnerability intensifies the need for better understanding of

Overview of Climate Change Impacts on Human Health in the Pacific Region

key threats. Targeted research is required to elucidate climate change risks to, and impacts on, human health in specific research domains. Areas requiring deeper investigation To avoid fragmentation, future research should be devised as part of an overarching program of work.

- **Suggested strategy.** Replicate the model adopted for the development of the *Framework for Action on Food Security*. Convene a broad based **Health and Climate Change Summit (CC&HHS)** to devise a roadmap for adapting to protect human health. Involve health and emergency sectors, transport and energy, food and water sectors. Allow for a process to draft a schema of key research needs, and establish teams and timelines. Such a strategy serves to avoid duplication, share knowledge, extend and expand on content, whilst a clarified process enables the clear identification of research gaps.
- Establish a **Climate Change and Human Health Taskforce for the PICs**. Roles include
 - Organising CC& HH summit
 - Establish a team /process for real time knowledge gathering as climate events unfold (tack health impacts post flood / storm/ disease outbreak price rises). Analyse findings, identify protective strategies for future events.
 - Coordinate CC activities and outreach
- Develop integrated modelling to examine both social and environmental health determinants of people in PICs; e.g. predictive models.
- Identify and map locations, hazards and communities especially at risk and vulnerable to sea level rise and associated health risks, taking a holistic, cross sectoral view
- Develop long-term adaptive strategies for sea level rise, based on an understanding of current coping strategies and of national development priorities
- Establish a strategy to identify key climate change and human health research questions for each country. Gather information via in-depth interviews during site visits with key regional experts (health staff, advisors, social, technical and clinical experts)
- Survey community leaders about
 - a) knowledge of Climate Change and health impacts,
 - b) observations of apparent change,
 - c) considered solutions,
 - d) knowledge and skills *needs* for adaptation,
 - e) knowledge and skills *expertise* for sharing
- Survey health workforce - as above
- Deliver and evaluate training programs

3.2.2 Recommendation 2: Expand Population Health Programs

- Strengthen existing public health resources and programs to cover the entire the region, including rural and remote areas, and build in climate change specific protective measures,

Overview of Climate Change Impacts on Human Health in the Pacific Region

- Improve population health workforce capacity
- Risk assessments – injuries, pollution, diarrhoeal diseases , infection, vectors, mental health , nutrition displaced populations
- Health protection programs (immunisations, deworming, education, family planning)
- Health promotion – for avoiding heat exposure, flood and storm injuries, vectors, food and water borne disease, malnourishment
- Provide community education and training for adaptation activities in the home/community
- Health and hygiene education
- Maternal and child health
- Water and sanitation protection
- Health care provision
- Develop health status monitoring
- Conduct inventories of existing data, identify current data gaps, and develop strategies to fill these gaps.
- Disease surveillance and control
- Protecting health infrastructure
- Enhance e- health and Information Communications Technology
- Develop and maintain firmer inter-sectoral linkages
- Enhance curative health sector capabilities
- Skilled health provider retention – workforce training, support and conditions

3.2.3 Recommendation 3: Emergency Response Programs

Incorporate health into emergency planning frameworks

- Risk assessments – injuries, pollution, diarrhoeal diseases , infection, vectors, mental health , nutrition displaced populations
- Flood risk amelioration
- Water and sanitation protection
- Warning systems and evacuation
- Emergency management – emergency supplies of basic needs: food, water, sanitation
- Health sector preparedness, mobile health teams
- Recovery activities

3.2.4 Recommendation 4: Data Management / Surveillance

- Develop and establish low-cost, more effective and more flexible surveillance systems, which are suitable to use in a resource-limited environment such as PICs; if possible, involving multi-sectoral sentinel sites;
- Clean and analyse existing data to examine disease trends, inform and evaluate health programs and interventions; improve process in future data collection, management and analysis;
- Enhance laboratory capacity and reporting procedures to support diagnosis and monitoring. Provide training, and training programs so these are ongoing, ensure specific pathway fully resourced;

Overview of Climate Change Impacts on Human Health in the Pacific Region

- Facilitate gathering and utilisation of existing data, including the rich sources of qualitative data. Inclusion of these can provide additional understanding which is especially valuable when designing programs to ensure cultural appropriateness, relevance and local acceptance.

3.2.5 Recommendation 5: Education

- Provide professional training in public health, environmental health risk assessments, epidemiology, biostatistics and data management, with appropriate IT support, to enhance local capacity in identifying, monitoring and analysing population health issues;
- Provide training in environmental and climatic impact assessments for human health in diverse and end user relevant formats (i.e. policy makers, health practitioners and workers, and others);
- Provide training and tools to educate community members on
 - public and environmental health;
 - domestic /community climate change adaptive responses;
- Develop flexible training program structures: community/sector/workforce-based as needed; delivered through effective advocacy and communications;
- Devise national education programs.

3.2.6 Recommendation 6: Governance

- Engage and interact with local stakeholder's through community-based management to create positive relationships, productive partnerships and program ownership; adopt flexible processes to incorporate local capacities, expertise and responses to new changes;
- Integrate health issues with other sectors, including emergency, disaster risk management and adaptation policy, to create a cross-sectoral collaboration within the region and among different stakeholders; maintain functioning of these links;
- Enhance communication and collaboration among researchers, international aids programs and local adaptive strategies to maximise use of data and program effectiveness;
- Input and cooperation at the international, national and local levels are required to develop effective adaptive strategies; governments, institutions and non-government organisations must aim to incorporate consideration of climate change into all future planning and budgeting.⁽¹³⁶⁾ Robust sustainable adaptation strategies suitable to a wide range of future scenarios are needed;
- Regional adaptation planning needs to be informed by human health concerns: this integration will not happen without effort from the health sector to collaborate with other key policy areas;
- Adopt a **Health In All Policies Framework**, to incorporate health considerations into all portfolios.

REFERENCES

1. UNFCCC. *Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries*. Bonn. 2007. Accessed: 6th May 2009. <http://unfccc.int/resource/docs/publications/impacts.pdf>.
2. IPCC. *Climate change 2001: Impacts, adaptation and vulnerability*. Cambridge. 2001. Accessed:
3. Ebi KL LN, Corvalan C. *Climate Variability and Change and Their Potential Health Effects in Small Island States: Information for Adaptation Planning in the Health Sector*. Geneva. 2005. Accessed: <http://www.who.int/globalchange/publications/climvariab.pdf>.
4. IPCC. *Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE. (Eds)*. Cambridge, UK. IPCC. 2007. Accessed: 26th April 2010. <http://www.ipcc.ch/ipccreports/ar4-wg2.htm>.
5. Australian Academy of Science. *The Science of Climate Change. August 2010 Questions and Answers*. 2010. Accessed: 15/6/2010. <http://www.science.org.au/reports/climatechange2010.pdf>.
6. Wigley TML. The Climate Change Commitment. *Science*. 2005; 307 (5716): 1766-1769.
7. Steffen W, The Climate Commission. *The Critical Decade*. Canberra. Commonwealth of Australia (Department of Climate Change and Energy Efficiency). 2011 May. Accessed: 02/6/2011. http://climatecommission.gov.au/wp-content/uploads/4108-CC-Science-WEB_3-June.pdf.
8. Hansen JE, Sato M, Reuedy R. *Climate Variability and Climate Change: The New Climate Dice*. New York. Columbia University. 2011. Accessed: 11th November 2011. http://www.columbia.edu/~jeh1/mailings/2011/20111110_NewClimateDice.pdf.
9. WHO, Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference. *Definition of health. 19 June - 22 July 1946; signed on 22 July 1946 by the representatives of 61 States and entered into force on 7 April 1948* New York. (Official Records of the World Health Organization, no. 2, p. 100). 1948. Accessed:
10. McMichael AJ, Woodruff RE, Hales S. Climate change and human health: present and future risks. *The Lancet*. 2006; 367 (9513): 859-869.
11. Butler CD, Harley D. Primary, secondary and tertiary effects of eco-climatic change: the medical response. *BMJ*. 2010; 86: 230-234.
12. Harley D, McMichael A. Global Climate Change and Infectious Diseases: paradigms, impacts and future challenges. *Infection and Chemotherapy*. 2008; 40 (Suppl. 2): S136-S143.
13. Peduzzi P, Dao H, Herold C, Mouton F. Assessing global exposure and vulnerability towards natural hazards: the Disaster Risk Index. *Nat Hazards Earth Syst Sci*. 2009; 9: 1149–1159.
14. Schroeter D and the ATEAM Consortium. *Global change vulnerability - assessing the European human-environment system*. Potsdam Institute for Climate Impact Research. 2004. Accessed: 7th March 2009. http://unfccc.int/files/meetings/workshops/other_meetings/application/pdf/schroeter.pdf.

Overview of Climate Change Impacts on Human Health in the Pacific Region

15. Pachauri RK, Reisinger A, Nottage R, Madan P, the Core Writing Team (including D. Karoly). *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the IPCC*. Geneva. 2007. Accessed:
16. UNFCCC. *Climate Change: Impacts, Vulnerability and Adaptation in Developing Countries*. 2007. Accessed:
17. FAO. *Climate Change and Food Security in Pacific Island Countries*. Rome, Italy. Food and Agriculture Organization for the South Pacific, SPREP, University of the South Pacific,. 2008. Accessed: 7th June 2011. http://www.fao.org/fileadmin/user_upload/foodclimate/forum/CCandFSinPIC.pdf.
18. Pacific Institute of Public Policy. *Urban hymns - Managing urban growth. Discussion paper: 18*. Port Vila, Vanuatu. 2011 July. Accessed: 7th June 2011. <http://pidp.eastwestcenter.org/pireport/2011/August/D18-PiPP.pdf>.
19. Department of Foreign Affairs and Trade. *Niue country brief* Canberra. Government of Australia. 2011. Accessed: 26th August 2011. http://www.dfat.gov.au/geo/niue/niue_brief.html.
20. World Health Organization Western Pacific Region. *Country health information profiles*. Manila. WHO-WPRO. 2011. Accessed: 23rd July 2011. <http://www.wpro.who.int/countries/list.htm>.
21. Russell L. *Poverty, climate change and health in pacific island countries. Issues to consider in discussion, debate and policy development*. University of Sydney / The Australian National University. 2011 April. Accessed: 28th October 2011. http://www.menzieshealthpolicy.edu.au/other_tops/pdfs_pubs/pacificislands2011.pdf.
22. Secretariat of the United Nations Framework Convention on Climate Change. *Vulnerability and Adaptation to Climate Change in Small Island Developing States*. Jamaica and Cook Islands. UNFCCC. 2007. Accessed: 13th January 2011. http://unfccc.int/files/adaptation/adverse_effects_and_response_measures_art_48/application/pdf/200702_sids_adaptation_bg.pdf.
23. Woodroffe CD. Reef-island topography and the vulnerability of atolls to sea-level rise. *Global and Planetary Change*. 2008; 62 (1-2): 77-96.
24. Barnett J, Campbell J. *Climate Change and Small Island States Power, Knowledge and the South Pacific*. London: Earthscan; 2010.
25. Barnett J. Adapting to Climate Change in Pacific Island Countries: The Problem of Uncertainty. *World Development*. 2001; 29 (6): 17.
26. Intergovernmental Panel on Climate Change. *Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability*. Cambridge, United Kingdom. 2007. Accessed: 4th January 2011. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg2_report_impacts_adaptation_and_vulnerability.htm.
27. WHO. *Western Pacific Country Health Information Profiles - 2010 revision*. . Manila. WHO. Regional Office of the Western Pacific. 2010 July. Accessed: 28th September 2011. <http://www.wpro.who.int/countries/list.htm>.
28. Bandara A. Emerging Health Issues in Asia and the Pacific: Implications for Public Health Policy. *Asia-Pacific Development Journal*. 2005; 12 (2): 26.

Overview of Climate Change Impacts on Human Health in the Pacific Region

29. World Bank. *Dying for change: Poor people's experience of health and ill-health* 2010 July. Accessed: 28th September 2011. <http://siteresources.worldbank.org/INTPAH/Resources/Publications/Dying-for-Change/dyifull2.pdf>.
30. Gani A. Some Aspects of Communicable and Non-communicable Diseases in Pacific Island Countries. *Social Indicators Research* 2009; 91 (2): 17.
31. World Health Organisation. *Noncommunicable disease and poverty: the need for pro-poor strategies in the Western Pacific Region: a review*. Manila. 2006. Accessed: 6th January 2011. http://www.wpro.who.int/NR/rdonlyres/1FC8050D-36F2-40D4-88A4-45E819EEF0FB/0/poverty_ncd.pdf.
32. WHO. *Global Strategy on Diet, Physical Activity and Health* Geneva. World Health Organization. 2011 July. Accessed: 28th August 2011. <http://www.who.int/dietphysicalactivity/publications/facts/obesity/en/>.
33. Australian Institute of Health and Welfare. *All cancers combined for Australia 1982-2007*. ACIM. Canberra. AIHW. 2010 July. Accessed: 22nd October 2011. <http://www.aihw.gov.au/WorkArea/DownloadAsset.aspx?id=6442475079>.
34. ABS. *Causes of Death, Australia, 2009 - 3303.0*. Canberra. Australian Bureau of Statistics. 2011 03/05/2011 Accessed: 22nd October 2011. <http://www.abs.gov.au/ausstats/abs@.nsf/Products/3303.0~2009~Chapter~Selected+Health+Conditions+and+Diseases?OpenDocument>.
35. Australian Institute of Health and Welfare. *Diabetes prevalence in Australia: detailed estimates for 2007-08. Diabetes series no. 17. Cat. no. CVD 56*. Canberra. AIHW. 2011 July. Accessed: 22nd October 2011. <http://aihw.gov.au/WorkArea/DownloadAsset.aspx?id=10737419307>.
36. Healthy Pacific Lifestyle Section. *NCD Statistics for the Pacific Islands Countries and Territories*. Noumea Public Health Division, Secretariat of the Pacific Community. 2011 February. Accessed: 18th October 2011. http://www.spc.int/hpl/index.php?option=com_docman&task=doc_download&gid=67.
37. SPC. *Diabetes is Everybody's Business (DEB). Diabetes prevention and management in Pacific Island countries and territories Introductory Training Programme: Facilitator's Manual*. Noumea. Secretariat of the Pacific Community. 2011 July. Accessed: 31 August 2011. http://www.spc.int/hpl/index.php?option=com_docman&task=doc_download&gid=72.
38. SPC. Global momentum grows on NCDs. *PIN - Pacific Islands NCDs - Promoting a healthier Pacific*. 2010; 70 (October): 3-5.
39. Gani A. Some Aspects of Communicable and Non-communicable Diseases in Pacific Island Countries. *Social Indicators Research*. 2009; 91 (2): 17.
40. WHO. *Asia Pacific Strategy for Emerging Diseases. Technical Papers*. World Health Organization, Western Pacific Regional Office,. 2010. Accessed: 24th June 2011. <http://www.wpro.who.int/internet/resources.ashx/CSR/APSED+Technical+Papers+-+03Sep10+Final.pdf>.
41. WHO. *Measles Bulletin. Issue 7*. Manila, Philippines: World Health Organization, Western Pacific Regional Office; 2005. Access via Thesis On-Line at <http://www.wpro.who.int/NR/rdonlyres/D96A8667-F9FC-4560-9D57-7B7E36AFB4FC/0/MeasBulletinIssue7.pdf>.

Overview of Climate Change Impacts on Human Health in the Pacific Region

42. Bandara A. Emerging Health Issues in Asia and the Pacific: Implications for Public Health Policy. *Asia-Pacific Development Journal*. 2005; 12 (2): 26.
43. World Health Organization Western Pacific Region. *Noncommunicable disease and poverty: the need for pro-poor strategies in the Western Pacific Region: a review*. Manila. 2006. Accessed: 23rd November 2010.
44. Maaren Pv, Tomas B, Glaziou P, Kasai T, Ahn D. Reaching the global tuberculosis control targets in the Western Pacific Region. *Bulletin of the World Health Organisation*. 2007; 85 (5): 4.
45. SPC. *Tuberculosis surveillance in the Pacific Island countries and territories: 2010* Noumea. Secretariat of the Pacific Community. 2010 October. Accessed: 14th October 2011. http://www.spc.int/tb/en/publications/doc_download/80-tuberculosis-surveillance-in-the-pacific-island-countries-and-territories-2010.
46. Rodgers J, Parr B, Taylor M, et al. *Climate change and health: a Pacific perspective. Commonwealth Health Ministers' Update 2009. Regional case study*. Noumea. 2009. Accessed: 27th June 2011. http://www.thecommonwealth.org/files/190386/FileName/SPCregionalpaper_2009.pdf.
47. Sladden T. Twenty years of HIV surveillance in the Pacific - what do the data tell us and what do we still need to know? *Pacific Health Dialog*. 2005; 12 (2): 5.
48. Caldwell JC, Isaac-Toua G. AIDS in Papua New Guinea: Situation in the Pacific. *Journal of Health, Population and Nutrition*. 2002; 20 (2): 8.
49. Water, sanitation and hygiene. World Health Organisation; 2005 2010. http://www.wpro.who.int/health_topics/water_sanitation_and_hygiene/general_info.htm.
50. Opeskin B. Malaria in Pacific populations: seen but not heard? *Journal of Population Research*. 2009; 26 (2): 25.
51. WHO. *World malaria report* Geneva. 2009 12 December Accessed: 15th February 2011. http://whqlibdoc.who.int/publications/2009/9789241563901_eng.pdf
52. Hsiang MS, Abeyasinghe R, Whittaker M, Feachem RGA. Malaria elimination in Asia-Pacific: an under-told story. *The Lancet*. 2010; 375 (9726): 1586-1587.
53. Mendis K, Rietveld A, Warsame M, et al. From malaria control to eradication: The WHO perspective. *Tropical Medicine & International Health*. 2009; 14 (7): 802-809.
54. The World Health Organization Regional Office for the Western Pacific (WPRO). *Dengue Epidemiology: Pacific island countries and areas*. Manila. World Health Organisation. 2005. Accessed: 11th December 2010. http://www.wpro.who.int/sites/mvp/epidemiology/dengue/pic_profile.htm.
55. Pacific Islands Forum Secretariat. *40th Forum Communiqué*. Cairns, Australia. Fortieth Pacific Islands Forum,. 2009 5 - 6 August. Accessed: http://www.pif2009.org.au/docs/40th_cairns_communique.pdf.
56. Curtain R, Vakaoti P. *The State of Pacific Youth Report 2011: Opportunities and Obstacles*. Suva, Fiji. UNICEF, SPC. 2011 July. Accessed: 28th August 2011. http://www.unicef.org/pacificislands/State_of_the_Pacific_Youth_Report_web.pdf.

Overview of Climate Change Impacts on Human Health in the Pacific Region

57. Maike P, SPC. *Framework of priorities for health: Solomon Islands country case study*. Noumea. Secretariat of the Pacific Community. 2010. Accessed: 31 August 2011. http://www.spc.int/hpl/index.php?option=com_docman&task=doc_download&gid=72.
58. UNICEF. *The State of the World's Children 2011: Adolescence – An Age of Opportunity*. Suva, Fiji. 2011. Accessed: 28th August 2011. http://www.unicef.org/pacificislands/SOWC_2011_Report.pdf.
59. WHO. *Local Action on Health Promoting Schools. The World Health Organization's Information Series on School Health*. Geneva. WHO, UNESCO. 2000. Accessed: 28th August 2011. http://www.who.int/school_youth_health/media/en/88.pdf.
60. UN Economic and Social Commission for Asia and the Pacific. *Statistical Yearbook for Asia and the Pacific*. 2010. Accessed: 1st November 2011. <http://www.unescap.org/stat/data/syb2009/10-Financial-human-resources-health.asp>.
61. Gani A. Health care financing and health outcomes in Pacific Island countries. *Health Policy and Planning*. 2009; 24 (1): 10.
62. AIHW. *Health expenditure Australia 2009-10 Health and welfare expenditure series no. 46. Cat. no. HWE 55*. Canberra. Australian Institute of Health and Welfare. 2011 April. Report No.: AIHW Cat. no. HSE 87. Accessed: 29th October 2011. <http://aihw.gov.au/publication-detail/?id=10737420435>.
63. Negin J. Australia and New Zealand's contribution to Pacific Island health worker brain drain. *Australian and New Zealand Journal of Public Health*. 2008; 32 (6): 5.
64. Gani A. Health Care Financing and Health Outcomes in Pacific Island Countries. *Health Policy and Planning*. 2009; 29: 72-81.
65. AIHW. *Public health expenditure in Australia 2007-08* Canberra. Australian Institute of Health and Welfare,. 2009 6 November. Report No.: AIHW cat. no. HWE 42. Accessed: 6th August 2010. <http://www.aihw.gov.au/publications/index.cfm/title/10952>.
66. Secretariat of the Pacific Community. *About the SPC Public Health Programme*. Secretariat of the Pacific Community. 2010. Accessed: 11th December 2010. <http://spc.int/en/publications/155-about-the-spc-public-health-programme.html>.
67. Mittelmark MB. The Role of Professional Education in Building Capacity for Health Promotion in the Global South: A Case Study from Norway. *Ethn Dis*. 2003; 13 (Suppl 2): 35-39.
68. Henderson L, Tulloch J. Incentives for retaining and motivating health workers in Pacific and Asian countries. *Human Resources for Health*. 2008; 6 (1): 18.
69. World Health Organization, Chen L, Evans DB, Evans T. *The World Health Report 2006: Working Together For Health*. Geneva. World Health Organization. 2006. Accessed: <http://www.who.int/whr/en/>.
70. Connell J. *Migration of health workers in the Asia-Pacific region*. Sydney. Human Resources for Health Knowledge Hub, University of New South Wales. 2010. Accessed: 16th October 2011. [http://www.med.unsw.edu.au/HRHweb.nsf/resources/3_Migration_Web_20100112.pdf/\\$file/3_Migration_Web_20100112.pdf](http://www.med.unsw.edu.au/HRHweb.nsf/resources/3_Migration_Web_20100112.pdf/$file/3_Migration_Web_20100112.pdf).
71. Brown RPC, Connell J. The migration of doctors and nurses from South Pacific Island Nations. *Social Science & Medicine*. 2004; 58 (11): 2193-2210.

Overview of Climate Change Impacts on Human Health in the Pacific Region

72. National Health and Hospitals Reform Commission. *A Healthier Future For All Australians – Final Report*. Canberra. Department of Health and Ageing. 2009 June. Report No.: P3 -5499. Accessed: <http://www.health.gov.au/internet/main/publishing.nsf/Content/nhhrc-report>.
73. Intergovernmental Panel on Climate Change. *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* Geneva, Switzerland. 2007. Accessed: Accessed 26th April 2010. http://www.ipcc.ch/publications_and_data/ar4/syr/en/mains1.html.
74. Intergovernmental Panel on Climate Change. *Climate Change 2007: Working Group I: The Physical Science Basis*. Cambridge, United Kingdom and New York, USA. Cambridge University Press. 2007. Accessed: Accessed 11th December 2010. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm.
75. PCCSP. PCCSP Interim Climate Projections. In: AusAID D, editor. Canberra; 2011. Accessed
76. Meehl GA, Washington WM, Collins WD, Arblaster JM, et al. e. How Much More Global Warming and Sea Level Rise? *Science*. 2005; 307 (5716): 4.
77. Intergovernmental Panel on Climate Change. *Carbon Dioxide Capture and Storage - Special Report*. Cambridge, United Kingdom. 2005. Accessed: 10th December 2010. http://www.ipcc.ch/pdf/special-reports/srccs/srccs_wholereport.pdf.
78. Vineis P. Climate change and the diversity of its health effects. *International Journal of Public Health*. 2010; 55 (2): 2.
79. Oxfam. *Suffering the Science. Climate change, people, and poverty*. Copenhagen. Oxfam International. 2009 July. Report No.: Oxfam Briefing Paper 130. Accessed: 19th March 2010. <http://www.oxfam.org/sites/www.oxfam.org/files/bp130-suffering-the-science.pdf>.
80. Bezirtzoglou C, Dekas K, Charvalos E. Climate changes, environment and infection: Facts, scenarios and growing awareness from the public health community within Europe. *Anaerobe*. 2011; Epub Jun 2.
81. UNEP. *Sudan: post-conflict environmental assessment*. Nairobi. United Nations Environment Programme. 2007. Accessed: http://postconflict.unep.ch/publications/UNEP_Sudan.pdf.
82. Bronkhorst S. *Climate Change and Conflict: Lessons for Conflict Resolution from the Southern Sahel of Sudan*. South Africa. African Centre for the Constructive Resolution of Disputes (ACCORD). 2011 03/05/2011 Accessed: 29th October 2011. http://www.accord.org.za/downloads/reports/Climate_Change_Southern_Sudan.pdf.
83. Fust W, Anan K, Desai N, et al. *The Anatomy of A Silent Crisis. Human Impact Report: Climate Change*. Geneva. Global Humanitarian Forum. 2009. Accessed: <http://assets.ghf-ge.org/downloads/humanimpactreport.pdf>.
84. United Nations Security Council *Security Council Holds First-Ever Debate on Impact Of Climate Change: On Peace, Security, Hearing Over 50 Speakers*. United Nations. 2007 17 April Accessed: <http://www.un.org/News/Press/docs/2007/sc9000.doc.htm>.

Overview of Climate Change Impacts on Human Health in the Pacific Region

85. Hanna EG, McMichael AJ, Butler CD. Climate Change and Global Public Health: impacts, research and actions. In: Parker R, Sommer M, editors. *The Routledge International Handbook on Global Public Health* Oxfordshire: Routledge. 2011.
86. WMO. Taskforce recommends new climate services framework to save lives, livelihoods and reduce disasters. Press Release No. 913. In. Geneva: World Meteorological Organization; 2010. Accessed 21st August 2011. http://www.wmo.int/pages/mediacentre/press_releases/pr_913_en.html.
87. Ebi KL, Lewis ND, Corvalan C. Climate Variability and Change and Their Potential Health Effects in Small Island States: Information for Adaptation Planning in the Health Sector. *Environmental Health Perspectives*. 2006; 114 (12): 7.
88. World Health Organisation. *Protecting Health from Climate Change - World Health Day 2008*. Geneva. 2008. Accessed: 18th June 2009. http://www.who.int/world-health-day/toolkit/report_web.pdf.
89. The Economic and Social Commission for Asia and the Pacific, United Nations International Strategy for Disaster Reduction. *Protecting Development Gains, Reducing Disaster Vulnerability and Building Resilience in Asia and the Pacific - The Asia Pacific Disaster Report 2010*. Bangkok, Thailand. 2010. Accessed: 17th November 2010. http://www.unisdr.org/preventionweb/files/16132_asiapacificdisasterreport20101.pdf.
90. Costello A, Abbas M, Allen A, et al. Managing the health effects of climate change. *The Lancet*. 2009; 373 (9676): 41.
91. Bettentcourt S, Croad R, Freeman P, et al. *Not If But When—Adapting to Natural Hazards in the Pacific Islands Region*. World Bank. 2006. Accessed: 10 May 2010. <http://siteresources.worldbank.org/INTPACIFICISLANDS/Resources/Natural-Hazards-report.pdf>.
92. Haque CE. Perspectives of Natural Disasters in East and South Asia, and the Pacific Island States: Socio-economic Correlates and Needs Assessment. *Natural Hazards*. 2003; 29 (3): 19.
93. Easterling DR, Meehl GA, Parmesan C, et al. Climate Extremes: Observations, Modeling, and Impacts. *Science*. 2000; 289 (5487): 7.
94. Munich Re. *Overall picture of natural catastrophes in 2010 – Very severe earthquakes and many severe weather events*. Press Release - 3 January 2011 Munich. 2011. Accessed: 26th February 2011. http://www.munichre.com/en/media_relations/press_releases/2011/2011_01_03_press_release.aspx.
95. Asian Development Bank. *Global Food Price Inflation and Developing Asia*. Manila. 2011 March. Accessed: 25th October 2011. <http://www.adb.org/documents/reports/global-food-price-inflation/food-price-inflation.pdf>.
96. Menne B, Kunzli N, Bertollini R. The health impacts of climate change and variability in developing countries. *International Journal of Global Environmental Issues*. 2002; 2 (3-4): 25.
97. McMichael AJ, Campbell-Lendrum DH, Corvalan CF, et al. *Climate change and human health risks and responses*. Geneva. World Health Organization, World Meteorology Organization, UNEP. 2003. Accessed: Accessed 11th December 2010. <http://apps.who.int/bookorders/anglais/detart1.jsp?sesslan=1&codlan=1&codcol=15&codcch=0551>.

Overview of Climate Change Impacts on Human Health in the Pacific Region

98. National Climatic Data Center (U.S.). *State of the Climate Global Hazards July 2010*. National Oceanic and Atmospheric Administration. 2010. Accessed: <http://www.ncdc.noaa.gov/sotc/?report=hazards&year=2010&month=7&submitted=Get+Report>.
99. IPCC. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)*. Cambridge, UK and New York, USA: IPCC; 2011.
100. WMO. Greenhouse Gases Reach Record Levels WMO Highlights Concerns about Global Warming and Methane. Press Release No. 903. In. Geneva: World Meteorological Organization; 2011. Accessed 26th February 2011. http://www.wmo.int/pages/mediacentre/press_releases/pr_903_en.html.
101. McMichael AJ, Woodruff RE, Hales S. Climate change and human health: present and future risks. *The Lancet*. 2006; 367 (9513): 11.
102. Pacific Climate Change Science Program. *Current and future climate of the Federated States of Micronesia*. Federated States of Micronesia National Weather Service Office, Australian Bureau of Meteorology, CSIRO. 2011 October. Accessed: 29th October 2011. http://www.cawcr.gov.au/projects/PCCSP/pdf/7_PCCSP_FSM_8pp.pdf.
103. Hanna EG, Kjellstrom T, Bennett C, Dear K. Climate change and rising heat: population health implications for working people in Australia. *Asia-Pacific Journal of Public Health*. 2011; 23 (2 Supp): 14S-26S.
104. Hansen JE, Reuedy R, Sato M, Lo K. Global Surface Temperature Change. *Reviews of Geophysics*. 2011; 48 (48, RG4004): 29.
105. Patz JA, Campbell-Lendrum D, Holloway T, Foley JA. Impact of regional climate change on human health. *Nature*. 2005; 438 (7066): 8.
106. Sherwood SC, Huber M. An adaptability limit to climate change due to heat stress. *PNAS*. 2010; in Press: 1-6.
107. Kjellstrom T, Holmer I, B L. Workplace heat stress, health and productivity—an increasing challenge for low and middle-income countries during climate change. *Global Health Action*. 2009; 2.
108. Occupational Health and Safety Council of Ontario. *Heat Stress Awareness Guide*. Ottawa. OHSCO. Accessed: 13th February 2011. <http://www.ohcow.on.ca/menuweb/heatstressguide.pdf>.
109. US EPA / OSHA. *Using the Heat Index: A Guide for Employers. About Work/Rest Schedules*. Washington. United States Environmental Protection Agency, Occupational Health & Safety Administration. 1998 June. Accessed: 17th August 2011. http://www.osha.gov/SLTC/heatillness/heat_index/pdfs/work_rest_schedules.pdf.
110. Bureau of Meteorology. *Thermal Comfort observations*. Melbourne. BOM. 2010 Updated 5-2-2010. Accessed: 22nd August 2011. http://www.bom.gov.au/info/thermal_stress/.
111. Liu SC, Fu C, Shiu C-J, Chen J-P, Wu F. Temperature dependence of global precipitation extremes. *Geophys. Res. Lett*. 2009; 36 (17): L17702.
112. Kjellstrom T, Kovats RS, Lloyd SJ, Holt T, Tol RSJ. The Direct Impact of Climate Change on Regional Labor Productivity. *Archives of Environmental & Occupational Health*. 2009; 64 (4): 217-27.

Overview of Climate Change Impacts on Human Health in the Pacific Region

113. Hanna EG. Health Hazards. In: Dryzek JS, Norgaard RB, Schlosberg D, editors. *The Oxford Handbook of Climate Change and Society*. Oxford: Oxford University Press. 2011. p. 217-231.
114. Pacific Climate Change Science Program. *Current and future climate of Vanuatu*. Vanuatu Meteorology and Geo-hazard Department, Australian Bureau of Meteorology, CSIRO. 2011 October. Accessed: 29th October 2011. http://www.cawcr.gov.au/projects/PCCSP/pdf/15_PCCSP_Vanuatu_8pp.pdf.
115. Pacific Climate Change Science Program. *Current and future climate of the Solomon Islands* Solomon Islands Meteorological Service, Australian Bureau of Meteorology, CSIRO. 2011 October. Accessed: 29th October 2011. http://www.cawcr.gov.au/projects/PCCSP/pdf/13_PCCSP_Solomon_Islands_8pp.pdf.
116. Pacific Climate Change Science Program. *Current and future climate of Papua New Guinea*. Papua New Guinea National Weather Service, Australian Bureau of Meteorology, CSIRO. 2011 October. Accessed: 29th October 2011. http://www.cawcr.gov.au/projects/PCCSP/pdf/14_PCCSP_PNG_8pp.pdf.
117. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Cambridge. 2007. Accessed: <http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter16.pdf>.
118. Mercer J. Disaster Risk Reduction or Climate Change Adaptation: Are we reinventing the wheel? *Journal of International Development*. 2010; 22 (2): 18.
119. Government of Niue. "Niue Foa - A New Niue" Cyclone Heta Recovery Plan. 2004. Accessed: 13th May 2011. <http://www.spc.int/prism/country/nu/stats/Images/Cylone%20Heta/Recovery%20Plan.pdf>.
120. Government of Niue. *National Impact Assessment of Cyclone Heta*. 2004. Accessed: 13th May 2011. [http://www.spc.int/prism/country/nu/stats/Images/Cylone%20Heta/Assessment%20Report\(Body\).pdf](http://www.spc.int/prism/country/nu/stats/Images/Cylone%20Heta/Assessment%20Report(Body).pdf).
121. McKenzie E, Prasad B, Kaloumaira A. *Economic Impact of Natural Disasters on Development in the Pacific. Volume 1: Research Report*. University of the South Pacific (USP) and the South Pacific Applied Geoscience Commission (SOPAC), AusAID. 2005 May. Accessed: 29th October 2011. http://www.ausaid.gov.au/publications/pdf/impact_pacific_report.pdf.
122. Hetu KFS, Rosemary Hibbert-Foy R. Coping with Cyclone Heta: nurses play a crucial role following natural disasters. *Kai Tiaki: Nursing New Zealand* 2004; Oct (Online http://findarticles.com/p/articles/mi_hb4839/is_9_10/ai_n29131170/).
123. Kidd S, Samson M, Ellis F, Freeland N, Wyler B. *Social Protection in the Pacific – A Review of its Adequacy and Role in Addressing Poverty*. Canberra. AusAID. 2010 February. Accessed: 27th August 2011. http://www.unicef.org/pacificislands/AusAID_SP_Study.pdf.
124. Government of Niue. *Niue's first Millenium Development Goals Report (MDGR)*. Statistics Unit of the Premiers Department, SPC Statistics Programme, UNDP office - Samoa. 2007. Accessed: 13th May 2011. <http://www.spc.int/prism/country/nu/stats/Images/Cylone%20Heta/Recovery%20Plan.pdf>.
125. WHO. *Western Pacific Country Health Information Profiles 2010 revision* World Health Organization, Western Pacific Regional Office. 2010. Accessed: 24th June 2011. <http://www.wpro.who.int/countries/list.htm>.

Overview of Climate Change Impacts on Human Health in the Pacific Region

126. Commission on Social Determinants of Health. *Closing the gap in a generation Health equity through action on the social determinants of health. Final Report of the Commission on Social Determinants of Health*. Geneva. World Health Organization. 2008. Accessed: 4th February 2010. http://whqlibdoc.who.int/publications/2008/9789241563703_eng.pdf.
127. Sacks J. The MDG decade: looking back and conditional optimism for 2015. *The Lancet*. 2010; 376 (9745): 950 - 951.
128. Gakidou E, Cowling K, Lozano R, Murray CJL. Increased educational attainment and its effect on child mortality in 175 countries between 1970 and 2009: a systematic analysis. *The Lancet*. 2010; 376 (9745): 959-974.
129. Nicholls RJ, Burkett V, Codignotto J, Hay J. *Coastal systems and low-lying areas*. Wollongong. University of Wollongong. 2007. Accessed: 6th September 2011. <http://ro.uow.edu.au/cgi/viewcontent.cgi?article=1192&context=scipapers>.
130. Nicholls RJ, Cazenave A. Sea-Level Rise and Its Impact on Coastal Zones. *Science*. 2010; 328 (5985): 1517-1520.
131. Hansen JE, Sato M. Paleoclimate Implications for Human-Made Climate Change. In: Berger A, Mesinger F, Šijački D, editors. *Climate Change at the Eve of the Second Decade of the Century: Inferences from Paleoclimate and Regional Aspects: Proceedings of Milutin Milankovitch 130th Anniversary Symposium*: Springer. 2011.
132. Woodroffe CD. Reef-island topography and the vulnerability of atolls to sea-level rise. *Global and Planetary Change*. 2008; 62 (1-2): 20.
133. Aung T, Singh A, Prasad U. A study of sea-level changes in the Kiribati area for the last 16 years. *Weather*. 2009; 64 (8): 4.
134. Woodward A, Hales S, Weinstein P. Climate change and human health in the Asia Pacific region: who will be most vulnerable? *Climate Research*. 1998; 11 (1): 8.
135. Church JA, White NJ, Hunter JR. Sea-level rise at tropical Pacific and Indian Ocean islands. *Global and Planetary Change*. 2006; 53 (3): 155-168.
136. United Nations Framework Convention on Climate Change. *Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries*. 2007. Accessed: December 23rd 2011. <http://unfccc.int/resource/docs/publications/impacts.pdf>.
137. Nunn PD. Responding to the challenges of climate change in the Pacific Islands: management and technological imperatives. *Climate Research*. 2009; 40 (2-3): 21.
138. Gray S. Long-term health effects of flooding. *Journal of Public Health*. 2008; 30 (4): 2.
139. Hunter PR. Climate change and waterborne and vector-borne disease. *Journal of Applied Microbiology*. 2003; 94 (s1): 10.
140. WHO. *Flooding and communicable diseases fact sheet*. Geneva. World Health Organization. 2011 August. Accessed: 24th July 2011. http://www.who.int/hac/techguidance/ems/flood_cds/en/.

Overview of Climate Change Impacts on Human Health in the Pacific Region

141. Ebi KL, Lewis ND, Corvalan C. *Climate Variability and Change and Their Potential Health Effects in Small Island States: Information for Adaptation Planning in the Health Sector*. Geneva. UNEP, WHO, WMO. 2005. Accessed: 12th Jan 2011. <http://www.who.int/globalchange/publications/climvariab.pdf>.
142. Few R, Ahern M, Matthies F, Kovats S. *Floods, health and climate change: a strategic review. Working Paper 63*. Norwich. Tyndall Centre for Climate Change Research 2004 November. Accessed: 22nd November 2011. <http://www.eird.org/isdr-biblio/PDF/Floods%20health%20and%20climate%20change.pdf>.
143. Gray S. Long-term health effects of flooding. *Journal of Public Health*. 2008; 30 (4): 353-354.
144. Epstein PR, Mills E, editors. *Climate Change Futures. Health, Ecological and Economic Dimensions*. Boston: The Center for Health and the Global Environment, Harvard Medical School, Swiss Re, UNEP; 2005.
145. McMichael AJ. Global Climate change: will it affect vector-borne diseases? *Internal Medicine Journal*. 2003; 33 (12): 2.
146. Lafferty KD. The ecology of climate change and infectious diseases. *Ecology*. 2009; 90 (4): 13.
147. Hales S, Weinstein P, Souares Y, Woodward A. El Nino and the Dynamics of Vectorborne Disease Transmission. *Environmental Health Perspectives*. 1999; 107 (2).
148. Kuhn K, Campbell-Lendrum D, Haines A, Cox J. *Using climate to predict infectious disease epidemics*. Geneva, Switzerland. 2005. Accessed:
149. Gubler DJ, Reiter P, Ebi KL, et al. Climate Variability and Change in the United States: Potential Impacts on Vector- and Rodent-Borne Diseases. *Environmental Health Perspectives*. 2001; 109 (Supplement 2): 12.
150. Mills JN, Gage KL, Khan AS. Potential Influence of Climate Change on Vector-Borne and Zoonotic Diseases: A Review and Proposed Research Plan. *Environmental Health Perspectives*. 2010; 118 (11): 8.
151. McMichael AJ, Campbell-Lendrum D, Kovats S, et al. Global Climate Change. In: Ezzati M, Lopez AD, Rodgers A, Murray CJL, editors. *Comparative Quantification of Health Risks: Global and Regional Burden of Disease Attributable to Selected Major Risk Factors*. Geneva, Switzerland: World Health Organisation. 2004. p. 108.
152. Patz JA, Strzepeck K, Lele S, et al. Predicting key malaria transmission factors, biting and entomological inoculation rates, using modelled soil moisture in Kenya. *Tropical Medicine and International Health*. 1998; 3 (10): 10.
153. Gage KL, Burkot TR, Eisen RJ, Hayes EB. Climate and Vectorborne Diseases. *American Journal of Preventative Medicine*. 2008; 35 (5): 15.
154. Githeko AK, Lindsay SW, Confalonieri UE, Patz JA. Climate change and vector-borne diseases: a regional analysis. *Bulletin of the World Health Organisation*. 2000; 78 (9): 12.
155. Tabachnick WJ. Challenges in predicting climate and environmental effects on vector-borne disease epistystems in a changing world. *The Journal of Experimental Biology*. 2010; 213 (6): 9.
156. Randolph SE. Perspectives on climate change impacts on infectious diseases. *Ecology*. 2009; 90 (4): 5.

Overview of Climate Change Impacts on Human Health in the Pacific Region

157. Koopman JS, Prevots DR, Mann MAV, Dantes HG, Aquino MLZ. Determinants and Predictors of Dengue Infection in Mexico. *Am. J. Epidemiol.* 1991; 133 (11): 1168-1178.
158. Halstead SB. Dengue Virus-Mosquito Interactions. *Annual Review of Entomology.* 2008; 53 (1): 273-291.
159. Ponte RJS, Freeman J, Oliveira-Lima JW, Hodgson JC, Spielman A. Vector densities that potentiate Dengue outbreaks in a Brazilian city. *American Journal of Tropical Medicine and Hygiene.* 2000; 62 (3): 378-383.
160. Hales S, Edwards SJ, Kovats RS. Impacts on health of climate extremes. In: McMichael AJ, Campbell-Lendrum DH, Corvalán CF, Ebi KL, Githeko AK, Scheraga JD, et al., editors. *Climate change and human health: Risks and responses.* Geneva: World Health Organization. 2003.
161. Harley D, Swaminathan A, McMichael AJ. Climate change and the geographical distribution of infectious diseases. In: Petersen E, Chen LH, Schlegelhauf P, editors. *Infectious Diseases: A Geographic Guide.* Chichester: John Wiley and Sons, Ltd. 2011. p. 414-423.
162. Omumbo JA, Lyon B, Waweru SM, Connor SJ, homson MC. Raised temperatures over the Kericho tea estates: revisiting the climate in the East African highlands malaria debate. *Malaria.* 2011; 10 (12).
163. Mueller I, Namuigi P, Kundi J, et al. Epidemic malaria in the highlands of Papua New Guinea. *American Journal of Tropical Medicine and Hygiene.* 2005; 72 (5): 554-560.
164. Müller I, Bockarie M, Alpers M, Smith T. The epidemiology of malaria in Papua New Guinea. *Trends in Parasitology.* 2003; 19 (6): 253-259.
165. Cooper RD, Waterson DGE, Frances SP, Beebe NW, Sweeney W. Speciation and Distribution of the Members of the *Anopheles punctulatus* (Diptera: Culicidae) Group in Papua New Guinea. *Journal of Medical Entomology.* 2002; 39 (1): 16-27.
166. Mgone CS, Koki G, Panu MM, et al. Occurrence of the erythrocyte band 3 (AE1) gene deletion in relation to malaria endemicity in Papua New Guinea. *Transactions of the Royal Society of Tropical Medicine and Hygiene.* 1996; 90 (3): 228-231.
167. FAO. *Rome Declaration on World Food Security and World Food Summit Plan of Action.* Rome, Italy. Food and Agriculture Organization of the United Nations. 1996 November. Accessed: 14th July 2011. <http://www.fao.org/docrep/003/w3613e/w3613e00.htm>.
168. FAO. *The State of Food Insecurity in the World: Addressing food insecurity in protracted crises.* Rome, Italy. Food and Agriculture Organization of the United Nations, World Food Programme. 2010. Accessed: 21st February 2011. <http://www.fao.org/publications/sofi/en/>.
169. Black RE, Allen LH, Bhutta ZA, et al. Maternal and child undernutrition: global and regional exposures and health consequences. *The Lancet.* 2008; 371 (9608): 243-260.
170. Nelson GC, Rosegrant MW, Koo J, et al. *Climate Change. Impact on Agriculture and Costs of Adaptation.* Washington, D.C. International Food Policy Research Institute (IFPRI). 2009 September. Accessed: <http://www.ifpri.org/sites/default/files/publications/pr21.pdf>.
171. Singh U. *Potential climate change impacts on the agricultural systems of the small island nations of the Pacific. Paper prepared for IFDC-IRRI.* Los Banos, Phillipine. 1994. Accessed: 12th June 2008.

Overview of Climate Change Impacts on Human Health in the Pacific Region

172. UNICEF. *Food & Nutrition Security in Pacific Island Nations and Territories*. Suva, Fiji. 2011. Accessed: 28th August 2011. http://www.unicef.org/pacificislands/Position_Paper_for_web.pdf.
173. Tirado MC, Clarke R, Jaykus LA, McQuatters-Gollop A, Frank JM. Climate change and food safety: A review. *Food Research International*. 2010; 43 (7): 21.
174. Lake IR, Gillespie IA, Bentham G, et al. A re-evaluation of the impact of temperature and climate change on foodborne illness. *Epidemiology and Infection*. 2009; 137 (11): 10.
175. Singh RBK, Hales S, de Wet N, et al. The Influence of Climate Variation and Change on Diarrhoeal Disease in the Pacific Islands. *Environmental Health Perspectives*. 2001; 109 (2): 5.
176. European Centre for Disease Prevention and Control. *Environmental change and infectious disease; ECDC Workshop Meeting Report: .* Stockholm. 2007 27 May 2008. Accessed: 3rd December 2011. http://www.ecdc.europa.eu/en/publications/Publications/0703_MER_Environmental_Change_and_Infectious_Disease.pdf.
177. World Hunger Education Service. *2012 World Hunger and Poverty Facts and Statistics*. 2012. Accessed: 28th January 2012. <http://www.worldhunger.org/articles/Learn/world%20hunger%20facts%202002.htm>.
178. Atkins J, Mazzi S, Easter C. *A Commonwealth Vulnerability Index for Developing Countries: the Position of Small States*. Commonwealth Secretariat Economic Paper 40. 2000. Accessed: 1st September 2011. <http://publications.thecommonwealth.org/a-commonwealth-vulnerability-index-for-developing-countries-89-p.aspx>.
179. Urbano M, Maclellan N, Tilman Ruff T, Blashki G. *Climate Change and Children in the Pacific Islands. Report submitted to UNICEF Pacific*. UNICEF, Nossal Institute for Global Health. 2010 April. Accessed: 27th August 2011. http://www.unicef.org/pacificislands/UNICEF_report_on_Children_and_Climate_Change_.pdf.
180. UNICEF. *Situation Monitoring: Food Price Increases in the Pacific Islands*. Suva, Fiji Islands. 2011 April. Accessed: 27th August 2011. http://www.unicef.org/pacificislands/FINAL_SITUATION_REPORTING2.pdf.
181. UNICEF. *Multi-country Programme Document 2008-2012. The Cook Islands, Niue, Samoa and Tokelau*. Suva, Fiji Islands. 2007. Accessed: 27th August 2011. http://www.undp.org/asia/country_programme/CP/MCP_SAMOA_2008-2012.pdf.
182. FAO. *FAO Food Price Index - 07/07/2011*. Rome. 2011. Accessed: August 30th 2011. <http://www.fao.org/worldfoodsituation/wfs-home/foodpricesindex/en/>.
183. UNICEF. *UNICEF ANNUAL REPORT for Pacific Island Multi-Country Programme*. Suva, Fiji Islands. 2011 April. Accessed: 27th August 2011. http://www.unicef.org/pacificislands/1850_16937.html.
184. Miskelly R, Cocco-Klein S, Abbott. D. *Situation Monitoring: Food Price Increases in the Pacific Islands*. Suva, Fiji Islands. United Nations Children's Fund (UNICEF), Pacific. 2011 April. Accessed: 27th August 2011. http://www.unicef.org/pacificislands/FINAL_SITUATION_REPORTING2.pdf.
185. Food Secure Pacific Working Group. *Pacific Food Summit - Meeting Report*. Port Vila, Vanuatu. WHO-WPRO / FAO / GHI / PIFS / SPC / UNICEF / 2010 21–23 April. Accessed: 6th February 2012. <http://www.wpro.who.int/internet/resources.ashx/NUT/Pacific+Food+Summit+Report.pdf>.

Overview of Climate Change Impacts on Human Health in the Pacific Region

186. Parks W, Abbott D. *Protecting Pacific Island Women and Children During Economic and Food Crises*. Suva UNICEF Pacific/UNDP Pacific 2009. Accessed: 27th August 2011. http://www.undppc.org.fj/resources/article/files/Pacific_GEC_children_and_women_final_edition_one.pdf.
187. Global Study on Child Poverty and Disparity. *Child Poverty and Disparity Study in Vanuatu*. Sydney. SPRC. 2009. Accessed: 27th August 2011.
188. McGregor A, Bourke R, Manley M, Tubuna S, Deo R. Pacific Island Food Security: Situation, Challenges and Opportunities *Pacific Economic Bulletin*. 2009; 24 (2): 24-42.
189. Rawe K, Jayasinghe D, Mason F, et al. *A Life Free From Hunger - Tackling Child Malnutrition*. London. The Save the Children Fund. 2012. Accessed: 16th February 2012. <http://www.savethechildren.org.uk/sites/default/files/docs/A%20Life%20Free%20From%20Hunger%20UK%20low%20res.pdf>.
190. Cook JT, Frank DA, Berkowitz C, et al. Food Insecurity Is Associated with Adverse Health Outcomes among Human Infants and Toddlers. *The Journal of Nutrition*. 2004; 134 (6): 1432-1438.
191. Amuna P, Zotor FB. Epidemiological and nutrition transition in developing countries: impact on human health and development. *Proceedings of the Nutrition Society*. 2008; 67: 82–90.
192. Inter-Agency and Expert Group on MDG Indicators. *The Millennium Development Goals Report*. New York. United Nations. 2008. Accessed: http://www.un.org/millenniumgoals/2008highlevel/pdf/newsroom/mdg%20reports/MDG_Report_2008_ENGLISH.pdf.
193. Prentice AM, Goldberg GR. Energy adaptations in human pregnancy: limits and long-term consequences. *Am J Clin Nutr*. 200; 71: 1226S–1232S.
194. Lucas A, Fewtrell MS, Cole TJ. Fetal origins of adult disease – the hypothesis revisited. *Br Med J*. 1999; 319: 245–249.
195. SPC. *Pacific NCD Forum Meeting Report*. Nadi, Fiji. Secretariat of the Pacific Community and World Health Organisation Office of the South Pacific. 2010 21-23 June. Accessed: 31 August 2011. http://www.spc.int/hpl/index.php?option=com_docman&task=doc_download&gid=47.
196. Black RE, Cousens S, Johnson HL, et al. Global, regional, and national causes of child mortality in 2008: a systematic analysis. *The Lancet*. 2010; 375 (9730): 1969-1987.
197. Finnigan G, Luetz JM. *Climate Change Threats to Health*. Melbourne. World Vision,. 2009. Accessed: 27th August 2011. <http://worldvision.com.au>.
198. Tavola H, Whippy N. *The Pacific Children with Disabilities* Suva. UNICEF. 2010 July. Accessed: 28th August 2011. http://www.unicef.org/pacificislands/Children_with_disabilities_final_report.pdf.
199. WHO. *Diarrhoeal disease - Fact sheet N°330*. Geneva. World Health Organization. 2009 August. Accessed: 24th July 2011. <http://www.who.int/mediacentre/factsheets/fs330/en/index.html>.
200. Australian Bureau of Meteorology and CSIRO. Chapter 6 Projections Based on Global Climate Models. In: *Climate Change in the Pacific: Scientific Assessment and New Research. Volume 1: Regional Overview*. Canberra: CSIRO. 2011.

Overview of Climate Change Impacts on Human Health in the Pacific Region

201. Parashar UD, Bresee JS, Glass RI. The global burden of diarrhoeal disease in children. *Bulletin of the World Health Organization* 2003; 81 (4): 236.
202. Schultz B, Uhlenbrook S. *Water security: what does it mean, what may it imply?* Delft, The Netherlands. UNESCO Institute for Water Education. 2007 June. Accessed: 24th August 2011. www.unesco-ihe.org/.../3.paper%20water%20Secur%20Box%20draft.pdf.
203. WHO. *Health through safe drinking water and basic sanitation* Geneva. 2009. Accessed: 13th May 2011. http://www.who.int/water_sanitation_health/mdg1/en/index.html.
204. WHO & SOPAC. *Sanitation, hygiene and drinking-water in the Pacific Island Countries – Converting Commitment into Action*. World Health Organization and Pacific Islands Applied Geoscience Commission. 2008. Accessed: 13th August 2011. http://www.wpro.who.int/NR/rdonlyres/719C55C7-3D25-48F4-B3A9-CFEBB998BA90/0/PacificReport_Final1copy6.pdf.
205. Prüss-Üstün A, Bos R, Gore F, Bartram J. *Safer water, better health: costs, benefits and sustainability of interventions to protect and promote health*. Geneva. World Health Organization. 2008. Accessed: 20th September 2011. <http://www.who.int/iris/handle/123456789/844>.
206. WHO Expert Committee. *Prevention and Control of Intestinal Parasitic Infections. Technical Report Series 749*. Geneva. World Health Organization. 1987. Accessed: 29th November 2011. http://whqlibdoc.who.int/trs/WHO_TRS_749.pdf.
207. Marcheggiani S, Puccinelli C, Ciadamidaro S, et al. Risks of water-borne disease outbreaks after extreme events. *Toxicological and Environmental Chemistry*. 2010; 92 (3): 7.
208. Kurane I. The Emerging and Forecasted Effect of Climate Change on Human Health. *Journal of Health Science*. 2009; 55 (6): 5.
209. Koelle K. The impact of climate on the disease dynamics of cholera. *Clinical Microbiology and Infection* 2009; 15 (Supplement s1): 3.
210. Hall G, Kirk M, Ashbolt R, Stafford R, Lalor K. Frequency of infectious gastrointestinal illness in Australia, 2002: regional, seasonal and demographic variation. *Epidemiology and Infection*. 2006; 134 (1): 111-118.
211. Kjellstrom T, Weaver HJ. Climate change and health: impacts, vulnerability, adaptation and mitigation. *NSW Public Health Bulletin*. 2009; 20 (1-2): 5.
212. Wilson N, Slaney D, Baker MG, Hales S, Britton E. Climate change and infectious diseases in New Zealand: a brief review and tentative research agenda. *Reviews on Environmental Health*. 2011; 26 (2): 93-99.
213. McMichael AJ, Woodruff RE. Climate change and infectious diseases. In: Mayer KH, Pizer HF, editors. *The Social Ecology of Infectious Diseases*. USA: Elsevier. 2008.
214. Lloyd SJ, Kovats RS, Armstrong BG. Global diarrhoea morbidity, weather and climate. *Climate Research*. 2007; 34 (2): 9.
215. Wiley LF, Gostin LO. The International Response to Climate Change: An Agenda for Global Health. *The Journal of the American Medical Association*. 2009; 302 (11): 3.

Overview of Climate Change Impacts on Human Health in the Pacific Region

216. WHO/Unicef Joint Monitoring Programme for Water Supply and Sanitation. *Meeting the MDG drinking water and sanitation target: the urban and rural challenge of the decade*. Geneva/New York. WHO/Unicef 2006. Accessed: 19-4-2010.
http://www.who.int/water_sanitation_health/monitoring/jmpfinal.pdf.
217. Hutton G, Haller L. *Evaluation of the costs and benefits of water and sanitation improvements at the global level*. Geneva. World Health Organization. 2004. Accessed: 22nd October 2011.
http://www.who.int/water_sanitation_health/wsh0404.pdf.
218. World Health Organisation. *Protecting Health from Climate Change: Global Research Priorities*. Geneva, Switzerland. 2009. Accessed:
219. O'Neill MS, Carter R, Kish JK, et al. Preventing heat-related morbidity and mortality: New approaches in a changing climate. *Maturitas*. 2009; 64 (2): 6.
220. Kjellstrom T, Butler AJ, Lucas RM, Bonita R. Public health impact of global heating due to climate change: potential effects on chronic non-communicable diseases. *International Journal of Public Health*. 2010; 55 (2): 7.
221. Friel S, Bowen K, McMichael AJ, et al. Climate change, non communicable diseases and development: The relationships and common policy opportunities. *Annual Review of Public Health* 2011; 32 (4.1-4.15): 133-47.
222. Balbus JM, Malina C. Identifying Vulnerable Subpopulations for Climate Change Health Effects in the United States. *Journal of Occupational and Environmental Medicine*. 2009; 55 (1): 5.
223. Khalaj B, Lloyd G, Sheppard V, Dear K. The health impacts of heat waves in five regions of New South Wales, Australia: a case-only analysis. *International Archives of Occupational and Environmental Health*. 2010; 83 (7): 10.
224. Bouchama A, Dehbi M, Mohamed G, et al. Prognostic Factors in Heat Wave-Related Deaths. *Archives of Internal Medicine*. 2007; 167 (20): 7.
225. Hansen AL, Bi P, Ryan P, et al. The effect of heat waves on hospital admissions for renal disease in a temperate city of Australia. *International Journal of Epidemiology*. 2008; 37 (6): 7.
226. Martiniuk ALC, Lee CMY, Lam TH, et al. The fraction of ischaemic heart disease and stroke attributable to smoking in the WHO Western Pacific and South-East Asian regions. *Tobacco Control*. 2006; 15 (3): 181-188.
227. Chiller T, Yan H, Tu'uau-Potoi N, et al. Foodborne disease surveillance in the Pacific: perspectives for the future. *Pac Health Dialog*. 2005; 12 (2): 127-33.

