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SOPAC

ECONOMIC IMPACT OF NATURAL DISASTERS ON DEVELOPMENT IN THE PACIFIC

Volume 1: Research Report

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Cover Photo:

Damage to a bridge in Port Vila, Vanuatu, after the earthquake in 2002 (source – South Pacific Applied Geoscience Commission).

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Acronyms

ADB	Asian Development Bank
AusAID	Australian Agency for International Development
CBA	Cost-Benefit Analysis
CBR	Cost-Benefit Ratio
CEA	Cost Effectiveness Analysis
CGE	Computable General Equilibrium (Model)
CHARM	Comprehensive Hazard and Risk Management
CRED	Center for Research on the Epidemiology of Disasters
DHA	Department of Humanitarian Affairs (United Nations)
DRM	Disaster Risk Management
EM-DAT	Emergency Disaster Database, Université Catholique de Louvain
FAO	Food and Agriculture Organisation
FEMA	Federal Emergency Management Agency
FFA	Forum Fisheries Agency
FSM	Fiji School of Medicine
FV	Future Value
GDP	Gross Domestic Product
GIS	Geographic Information Systems
HDR	Human Development Report (published by UNDP)
IDP	Internally Displaced Person
IDNDR	International Decade for Natural Disaster Reduction
IFAD	International Fund for Agriculture Development
IFRC	International Federation of the Red Cross and Red Crescent Societies
ITU	International Telecommunication Union
NDMO	National Disaster Management Office
NGO	Non-Governmental Organisation
NPB	Net Present Benefit
NPC	Net Present Cost
NPV	Net Present Value
NSO	National Statistics Office
PIC	Pacific Island Country
PIFS	Pacific Islands Forum Secretariat
PRA	Participatory Rural Appraisal
PRISM	Pacific Regional Information System
PV	Present Value
SOPAC	South Pacific Applied Geoscience Commission
SPC	Secretariat of the Pacific Community
SPDRP	South Pacific Disaster Reduction Programme
SPREP	South Pacific Regional Environment Programme
SPTO	South Pacific Tourism Organisation
UNDP	United Nations Development Programme
UNDRO	Office of the United Nations Disaster Relief Coordinator
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Education, Science and Cultural Organisation
UN-HABITAT	United Nations Human Settlements Programme
UNHCR	United Nations High Commission for Refugees
UNSD	United Nations Statistics Division
USAID/OFDA	Office of US Foreign Disaster Assistance
USP	University of the South Pacific
WB	World Bank
WFP	World Food Program
WHO	World Health Organisation
WTO	World Tourism Organisation

Glossary

Balance of payments	A record of all economic transactions between one country and the rest of the world, including exports and imports of goods and services, and financial transactions, such as loans.
CHARM	A comprehensive hazard and risk management tool and/or process within the context of an integrated national development planning network.
Cost-benefit ratio	Ratio of the present value of project benefits to the present value of project costs. A project is only a good investment if the cost-benefit ratio is greater than one.
Depreciation	A decrease in the value of a physical asset due to age, wear and tear.
Direct impacts	Effects on assets caused by a natural disaster that occur during or immediately after a natural hazard event.
Disaster risk management	The development and application of policies, strategies and practices to lessen the impacts of natural hazards through measures to avoid or limit their adverse effects (includes mitigation and preparedness activities).
Discount rate	The rate required to compensate for receipt of money in the future rather than in the present.
Externality	Spill-over effects arising from the production and/or consumption of goods and services for which no appropriate compensation is paid.
Geographic information system	A computer system capable of capturing, storing, analysing, and displaying geographically referenced information.
Gross domestic product	The total value of goods and services produced by a nation within that nation.
Gross investment	The amount of new physical assets purchased during a given time period, including purchases to replace depreciated assets.
Indirect impacts	Flows of effects that occur over time after a hazard event and are caused by the direct impacts of a disaster.
Inflation	The rate of increase of the general level of prices.
Intangible impacts	Disaster impacts that are difficult to assign a monetary value because there is no market for the good or service affected.
Macroeconomic impacts	Changes to the performance of macroeconomic variables caused by a natural disaster.
Mitigation	Action taken specifically to reduce future damages and losses from natural disasters.
Natural disaster	A severe disruption to a community's survival and livelihood systems, resulting from people's vulnerability to hazard impacts. A disaster involves loss of life and property on a scale that overwhelms the community's capacity to cope.
Natural hazard	Geophysical, atmospheric or hydrological event that has the potential to cause harm or loss.

Net present benefit	Present value of total project benefits
Net present cost	Present value of total project costs
Net present value	The sum of the present values of all benefits associated with a project, less the sum of the present values of all project costs. A project is only a good investment if the net present value is greater than zero.
Payback period	The length of time it takes for the sum of the project benefits to cover the sum of the project costs.
Present value	The value today of a benefit or cost that happens in the future, measured using the discount rate.
Preparedness	Activities and measures taken in advance to ensure effective response to the impacts of hazards, including the issuance of timely and effective early warnings, precautionary actions and arrangements of appropriate responses.
Real value	Measurement of economic value corrected for changes in price over time (inflation), thus expressing a value in terms of constant prices.
Reconstruction	Long-term activities required for rebuilding physical infrastructure and services after a disaster.
Risk	The likelihood of a specific hazard of specific magnitude occurring in a specific location and its probable consequences for people and property.
Vulnerability	The potential to suffer harm or loss, related to the capacity to cope with a hazard and recover from its impact.

Cyclone Ami you came so sudden
Ripping open my heart
Tearing my dreams, aspirations,
Hopes and ambitions apart

As if your devastation was not enough
You sent us the dessert the next day
Lost crops, lost loved ones, lost homes
And indeed lost job and pay.

No one else can imagine
The hardship and our pain
To educate our children
Now seems all in vain

I await answers and angels
As I sit and gaze the sky
You made my life such a struggle
In despair I question why.

Savita Devi Lal, Fiji
'Cyclone Ami: 13-14 January 2003'

EXECUTIVE SUMMARY

This report describes the findings of a research project examining 'The Economic Impact of Natural Disasters on Development in the Pacific', which was undertaken between October 2004 and April 2005. The research was commissioned and funded by the Australian Agency for International Development (AusAID). It was jointly conducted by the South Pacific Applied Geoscience Commission (SOPAC) and the University of the South Pacific (USP).

Phase One: Framework Development

The first phase of the project involved development of a framework to assist decision-making on the efficient and effective allocation of resources for Disaster Risk Management (DRM). The specific objectives of the first phase of the project were to 1) develop a framework for assessing the impact of future natural disasters in Pacific Island Countries, and 2) construct a model for assessing the relative effectiveness and cost-benefit ratio of various DRM measures. The research team conducted an extensive literature search of economic tools being used elsewhere around the world to assist DRM allocation decisions, and visited Fiji, Niue, Tuvalu and Vanuatu to determine what tools would be appropriate and useful for decision makers in Pacific Island Countries.

Two tools were developed. First, a set of guidelines was compiled for estimating the economic impact of natural disasters on development in the Pacific (see Tool 1). As most disaster impact assessments in the Pacific focus on direct damage to physical assets, the guidelines outline the wide range of other important indirect, intangible and macroeconomic effects of natural disasters. Guidance is provided on techniques for valuation of disaster impacts, and checklists are supplied of useful data and sources. Second, a toolkit was developed for assessing the costs and benefits of DRM measures in the Pacific (see Tool 2). The toolkit outlines the procedure for each step of standard cost-benefit analysis, including how to: identify alternative DRM measures; estimate the costs and benefits of DRM measures; discount the estimated costs and benefits; evaluate and rank DRM alternatives; conduct sensitivity analysis, and make policy recommendations on the basis of the analysis. Both the guidelines and the toolkit include worked examples from the Pacific region, in particular Fiji, Niue, Tuvalu and Vanuatu.

Phase Two: Analysis

In the second phase of the project, using the methodology developed in the guidelines and toolkit, the research team used data available in Fiji, Niue, Tuvalu and Vanuatu to assess the economic impact of a selection of natural hazards on particular sectors, and the impact and cost-effectiveness of a range of DRM measures. The specific objectives of the second phase of the research were to 1) assess the economic impact of natural disasters in the Pacific over the last 20 years, and 2) examine claims that greater emphasis on DRM can reduce the costs of disaster response and recovery. Research was conducted in the case study countries during visits to Fiji, Niue, Tuvalu and Vanuatu. The project team has faced difficulties in conducting comprehensive analysis due to the lack of relevant and easily available statistics in standard data collections. The four selected case studies examine the impact of:

- Cyclone Ami and related flooding on the agriculture and education sectors in Fiji;
- Cyclone Heta on the tourism and education sectors in Niue;
- Drought on the fisheries and health sectors in Tuvalu; and
- Cyclones and earthquakes on the agriculture and tourism sectors in Vanuatu.

Results

The experiences of the selected sectors in Fiji, Niue, Tuvalu and Vanuatu demonstrate that past natural hazards have resulted in significant short-term and long-term direct[1], indirect[2] and intangible[3] impacts. Examples of direct impacts include damage to buildings, infrastructure, crops and equipment. Examples of indirect impacts include losses of income and production, increased operating costs, costs of debris clearing, costs of repair of buildings

[1] Direct impacts are effects on assets caused by a natural disaster that occur during or immediately after a natural hazard event.
[2] Indirect impacts are flows of effects that occur over time after a hazard event and are caused by the direct impacts of a disaster.
[3] Intangible impacts are the effects of a disaster that are difficult to assign a monetary value, usually because there is no market for the good or service affected.

used as temporary shelters, and the costs of treating the population affected by resulting health problems. Examples of intangible impacts (both direct and indirect) include environmental damage, emotional and psychological trauma, lost learning opportunities, and positive impacts on community spirit. On the basis of the findings from the case studies, natural hazards have a considerable economic impact on development in the Pacific and often lead to deterioration in the quality of life of Pacific Island communities, justifying the term 'natural disasters'.

Due to the lack of easily available data, a complete cost-benefit analysis of a DRM measure could not be conducted for any of the case study countries. The limited analysis that was undertaken suggests that greater emphasis on hazard and risk management can reduce the negative impacts of disasters, and thereby reduce the costs of disaster response and recovery. However, our visits to Fiji, Niue, Tuvalu and Vanuatu suggest that decisions to allocate resources to DRM are frequently not based on careful consideration of the resulting costs and benefits. Funds are often not invested in DRM measures in order to cut costs in the short term, without a careful analysis of the present value of the stream of benefits in avoided disaster damages that will arise in the long term. If and when resources are allocated for DRM measures, the most cost-effective options are frequently not chosen.

Conclusions and Recommendations

Despite the serious negative impacts of natural disasters in the Pacific, there is no systematic collection of comprehensive data on these effects. Historical records of the impact of past natural disasters are scarce in Fiji, Niue, Tuvalu, and Vanuatu. After a large-scale natural disaster, Pacific Island Countries (PICs) typically respond by assessing immediate short-term impacts, focusing on deaths and injuries, and direct damage to assets and infrastructure. These immediate damage assessments are conducted to provide governments and aid donors with estimates of the amount of funds required to address immediate needs. Long-term indirect losses in the flows of goods and services, macroeconomic effects[4], and non-market impacts such as environmental damage and psychosocial effects are frequently omitted from disaster impact assessments in the Pacific.

The lack of data on disaster impacts is partly caused by: weak and under-resourced National Disaster Management Offices (NDMOs); little coordination between national planning offices, statistics offices and NDMOs; and, limited integration of Comprehensive Hazard and Risk Management (CHARM)[5] into national development planning. These problems lead to uncoordinated, inconsistent and unmethodical data collection. Assessments are done through different departments and record keeping is seldom centralised. The establishment of NDMOs and integration of the CHARM process are relatively recent developments, and there is still significant room for development and improvement.

There is awareness among disaster managers in the region of the need for more accurate, comprehensive, systematic and consistent information on disaster impacts, in order to increase support for DRM among policy makers, senior government officials and international donors. This would also help governments to develop appropriate national and sectoral policies, particularly for reconstruction, mitigation and preparedness.

One of the factors holding back the Pacific region has been the lack of standard tools available to assist Pacific Island Country decision makers. However, if the tools developed in this research project are to be utilised by decision makers in the future, they must be supported by: capacity building for disaster management institutions (particularly NDMOs); training in economic analysis; continued integration of the CHARM process; and, strengthened links between NDMOs, Ministries for Finance and Economic Planning, and Statistics Offices.

[4] Macroeconomic impacts reflect the manner in which the direct and indirect damage caused by natural disasters lead to changes in macroeconomic variables, such as gross domestic product (GDP), the balance of payments and public finances.
[5] In Fiji and Vanuatu, disaster risk management is being mainstreamed into national development planning processes through the Comprehensive Hazard and Risk Management (CHARM) process.

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OUTLINE

Sections 1 and 2 of this report briefly outline the tools developed in phase one of the project. Section 1.1 describes the current practice in Fiji, Niue, Tuvalu and Vanuatu for estimating the impacts of natural disasters. Section 1.2 outlines the tool that was developed to help decision makers to assess the economic impact of natural hazards on development. This tool is structured as a set of *Guidelines for Assessing the Economic Impact of Natural Disasters on Development in the Pacific*. The full version of these guidelines is provided in Tool 1. Section 2.1 discusses the current practice in Fiji, Niue, Tuvalu and Vanuatu for assessing the impact and cost-effectiveness of Disaster Risk Management (DRM) measures. Section 2.2 provides an overview of the tool that was developed to assist decision makers in the form of a *Toolkit for Assessing the Costs and Benefits of Disaster Risk Management Measures in the Pacific*. The full version of this toolkit is provided in Tool 2.

Sections 3, 4, 5 and 6 provide details on the analysis conducted in phase two of the research project for Fiji, Niue, Tuvalu and Vanuatu, respectively. Section 3.1 gives an overview of recent developments in the Fiji economy. Section 3.2 discusses previous assessments of the economic impact of Cyclone Ami and related flooding on the development of Fiji. Section 3.3 uses the methodology developed in the guidelines to assess the impact of Cyclone Ami and related flooding on the agriculture sector, while Section 3.4 assesses the impact on the education sector. Section 3.5 assesses the impact and cost-effectiveness of a community flooding mitigation project in Nabouciwa village in Tailevu, Fiji.

Section 4.1 outlines some aspects of the Niue economy. Section 4.2 describes the findings of previous assessments of the economic impact of Cyclone Heta in 2004 on the development of Niue. Section 4.3 uses the methodology developed in the guidelines to assess the impact of Cyclone Heta on the tourism sector, while Section 4.4 assesses the impact on the education sector. Section 4.5 examines the costs and benefits of relocating the Niue hospital to a safer location away from the vulnerable coastal zone in Alofi South, Niue.

Section 5.1 describes the Tuvalu economy. Section 5.2 discusses previous assessments of the economic impact of drought on the development of Tuvalu. Section 5.3 uses the methodology developed in the guidelines to assess the impact of droughts on the fisheries sector, while Section 5.4 focuses on the impact on the health sector. Section 5.5 assesses the costs and benefits of the Funafuti desalination plant for ensuring a safe and reliable water supply during droughts.

Section 6.1 gives an overview of the Vanuatu economy. Section 6.2 reviews previous assessments of the economic impact of cyclones and earthquakes on development in Vanuatu, looking in particular at the impact of Cyclone Uma in 1987, Cyclone Ivy in 2004 and the earthquake in 2002. Section 6.3 uses the methodology developed in the guidelines to assess the impact of Cyclone Ivy on the agriculture sector, while Section 6.4 assesses the impact on the tourism sector. Section 6.5 briefly outlines some of the DRM measures noted in Vanuatu.

Section 7 summarises the research team's recommendations. This is followed by the final conclusions in Section 8.

INTRODUCTION

Pacific Island Countries (PICs) are vulnerable to a range of natural hazards, such as cyclones, volcanic eruptions, earthquakes, floods, tsunamis, landslides and droughts. The small, highly dispersed land areas and populations, and changing nature of life in the Pacific, intensify this vulnerability. Official statistics suggest that natural hazards have a considerable economic impact on development in the Pacific, justifying the term 'natural disasters'. Official estimates of disaster impacts, however, do not give the whole story of how disasters affect people in the Pacific. The real total impact of natural disasters, including long-term impacts on the living conditions, livelihoods, economic performance and environmental assets of Pacific Island Countries, is likely to be much larger. In addition, due to the small populations, economies and land areas of many Pacific Island Countries, disaster-related damages that are small relative to the damages elsewhere in the world can have a large impact relative to the country's total GDP and population.

As there has been relatively little research on broader disaster impacts in the Pacific, the true costs continue to be underestimated, creating problems in alerting policy makers and international donors to the serious economic consequences of natural hazards and the imperative for integrating comprehensive Disaster Risk Management (DRM) into national development planning. Despite the serious negative impacts of natural disasters in the Pacific, there is no systematic collection of comprehensive data on these effects. The understanding and documentation of these effects are vital to the development of long-term policies for reconstruction, mitigation and preparedness. The lack of data also limits the scope for conducting cost-benefit analyses of DRM measures.

The purpose of this report is to describe the findings of a research project examining 'The Economic Impact of Natural Disasters on Development in the Pacific', which was undertaken between October 2004 and April 2005 by a team from the South Pacific Applied Geoscience Commission (SOPAC) and the University of the South Pacific (USP). The work was instigated and funded by the Australian Agency for International Development (AusAID), in order to achieve a greater focus on economic strategic planning and efforts to mitigate the economic impacts of natural disasters in Pacific Island Countries. The specific objectives of the project are to:

1. Assess the economic impact of natural disasters in the Pacific over the last 20 years;
2. Develop a framework for assessing the impact of future disasters in Pacific Island Countries;
3. Examine claims that greater emphasis on DRM can reduce the costs of disaster response and recovery; and
4. Construct a model for assessing the relative effectiveness and cost-benefit ratio of various DRM measures.

As discussed during meetings with representatives of AusAID in Suva and Canberra, the lack of readily available data in the existing standard data collections of NDMOs and other government departments placed constraints on the extent of analysis of the economic impacts of natural disasters, and the costs and benefits of DRM measures that could be conducted within the time and resources available for this research project. It is hoped that the development of the guidelines and toolkit is an important first step in improving the collection of the appropriate data needed to undertake meaningful economic analysis.

FRAMEWORK DEVELOPMENT

The first phase of this research project involved development of a framework to assist decision-making on the efficient and effective allocation of resources for Disaster Risk Management (DRM). The specific objectives of the first phase of the project were to 1) develop a framework for assessing the impact of future natural disasters in Pacific Island Countries; and 2) construct a model for assessing the relative effectiveness and cost-benefit ratio of various DRM measures. The research team conducted an extensive literature search of economic tools being used elsewhere around the world to assist DRM allocation decisions, and visited Fiji, Niue, Tuvalu and Vanuatu to determine what tools would be appropriate and useful for decision makers in Pacific Island Countries. Through the desk and field research, two tools were developed: a set of guidelines for estimating the economic impact of natural disasters on development in the Pacific (see Tool 1); and, a toolkit for assessing the costs and benefits of DRM measures in the Pacific (see Tool 2).

The major challenge of this research project was to create tools for economic impact assessment and cost-benefit analysis that are appropriate for use by decision makers in Pacific Island Countries. Fiji, Niue, Tuvalu and Vanuatu do not currently conduct systematic, comprehensive economic impact assessments or cost-benefit analyses of DRM measures. The guidelines and toolkit therefore include lists of data requirements so that, in the short term, Pacific Island Countries can begin to gather the data required and upgrade their practices. In the longer term, countries can make full use of the guidelines and toolkit.

The research team suggests that if the tools developed in this research project are to be adopted and used locally by decision makers in the future, they must be supported by capacity building for disaster management institutions (particularly NDMOs), training in economic analysis, continued integration of the CHARM process, and strengthened links between NDMOs, Ministries for Finance and Economic Planning and Statistics Offices.

1. Guidelines for Estimating the Economic Impact of Natural Disasters

1.1. Current Practice

Assessments of the impacts of natural disasters in Fiji, Niue, Tuvalu and Vanuatu are often limited in scope even for major natural disasters such as cyclones, volcanic eruptions and earthquakes. For small-scale disasters, assessments are rarely conducted. Most of the disaster impact assessments have focused on the direct and visible impacts of large- and medium-scale natural disasters, in order to provide governments with an estimate of the cost of relief efforts to address immediate needs. Assessments of disaster impacts typically only focus on quantifying immediate direct damages, such as deaths and injuries, and damage to buildings, subsistence and commercial crops, and economic and social infrastructure. The indirect effects of natural disasters are generally not assessed in Pacific Island Countries. Occasional reassessments are made of major natural disasters to estimate longer-term impacts, but this is rare. If they are included, it is uncommon for long-term indirect impacts to be measured in monetary terms. Macroeconomic effects on gross domestic product, the balance of payments, public finances and other macroeconomic indictors are largely ignored. Secondary effects on income distribution and poverty are seldom mentioned. Evaluations of intangible effects such as environmental, social and psychological impacts of natural disasters are also uncommon in the Pacific. The understanding and documentation of these indirect, macroeconomic and intangible effects are vital to the development of long-term policies.

Comprehensive historical records of damage from past natural disasters are not available in any of the countries visited. The assessments are done through different departments and record keeping has not been centralised. The establishment of National Disaster Management Offices (NDMOs) is only a recent development, starting from the 1990s onwards. Most NDMOs are poorly resourced in terms of both physical facilities and human resources. There seems to be little coordination between the national planning offices and NDMOs. The strengthening of NDMOs and their links to national planning and statistical offices would improve the ability of countries to adopt appropriate tools to collect data for assessing natural disaster impacts. This could facilitate the adoption of appropriate economic development policies, which will factor the impact of natural disasters into national planning and the development of appropriate DRM measures.

1.2. Outline of Guidelines

As our country visits showed that most assessments of the impacts of natural disasters focus on direct damage to physical assets, a priority for the guidelines was to outline the wide range of indirect, intangible and macroeconomic effects of natural disasters, both in the short and long term, that should be included in a disaster impact assessment. The guidelines are based on a simplified and adapted version of the Handbook for Estimating the Socio-economic and Environmental Effects of Disasters, which was developed by the Economic Commission for Latin America and the Caribbean (UNECLAC)[6]. Examples from the Pacific region, in particular from Fiji, Niue, Tuvalu and Vanuatu, are provided throughout the guidelines. Given the current basic standard of disaster impact assessments, it was considered appropriate not to go into too much detail on some of the more complicated aspects, such as valuation of intangible disaster impacts. A list of references is provided for those readers who wish to follow up on the more complex techniques.

In summary, the guidelines describe different types of common disaster impacts, including deaths and injuries, direct damage to physical assets, indirect losses, macroeconomic effects and intangible impacts. Guidance is provided on techniques for valuation of disaster impacts, including a brief explanation of methods for valuing intangible impacts, which are particularly difficult to value in monetary terms. A sectoral approach is taken, breaking up a disaster impact assessment into social, infrastructure and economic sectors. Checklists are provided on the type of data that may be useful for the assessment of each sector, including baseline information and data on disaster impacts, as well as lists of recommended sources. A similar overview is given of the procedure for estimating cross-sectoral disaster impacts, such as environmental, distributional, psychosocial and governance effects. Finally, the guidelines explain how to bring together sectoral and cross-sectoral assessments into an overall impact assessment, and use the information to plan reconstruction and mitigation activities.

2. A Toolkit for Assessing the Costs and Benefits of DRM Measures

2.1. Current Practice

Economic tools, such as cost-benefit analysis, are rarely used to assist resource allocation decisions for DRM in Fiji, Niue, Tuvalu and Vanuatu. Use of cost-benefit analysis is constrained by the difficulty in obtaining adequate data on the impact of natural disasters, the lack of economic assessment skills, and the paucity of physical and human resources needed to conduct in-depth economic analyses. These constraints prevent realistic assessments of the social and economic effects of disasters on development in Pacific Island Countries, thus making it difficult to conduct meaningful cost-benefit analyses of DRM measures. As a result, decisions to allocate resources to DRM are frequently not based on careful consideration of the resulting costs and benefits. Funds are often not invested in DRM measures in order to cut costs in the short term, without a careful analysis of the present value of the stream of benefits in avoided disaster damages that will arise in the long term. If and when resources are allocated for DRM measures, the most cost-effective options are frequently not chosen.

2.2. Outline of Toolkit

As expected, attempts to produce detailed cost-benefit analyses of DRM measures in the Pacific have been constrained by the limited data available. In light of this, the toolkit outlines the data required to conduct a cost-benefit analysis. This should increase awareness in Pacific Island Countries about the information that needs to be gathered in order to evaluate the cost-effectiveness of DRM measures.

In summary, the toolkit explains standard cost-benefit analysis methodology that can be used to assess the costs and benefits of DRM measures consistently across the Pacific region. A procedure for each step of cost-benefit analysis is outlined, including how to: identify alternative DRM measures; estimate the costs of DRM measures; estimate the benefits of DRM measures; discount the estimated costs and benefits; evaluate and rank DRM alternatives; conduct sensitivity analysis, and make policy recommendations on the basis of cost-benefit analysis. At the end of the toolkit a list of references is provided for additional information on more complicated aspects of cost-benefit analysis and alternative methods such as cost-effectiveness analysis.

[6] Economic Commission for Latin America and the Caribbean (ECLAC). 2003. Handbook for estimating the socio-economic and environmental effects of disasters, Vols. I – IV.

ANALYSIS

In the second phase of the project, using the frameworks developed in phase one, the research team used data available in Fiji, Niue, Tuvalu and Vanuatu to assess the economic impact of a selection of natural hazards in particular sectors, and the impact and cost-effectiveness of a range of DRM measures. The specific objectives of the second phase of the research were to 1) assess the economic impact of natural disasters in the Pacific over the last 20 years; and 2) examine claims that greater emphasis on DRM can reduce the costs of disaster response and recovery. Research was conducted in the case study countries during visits to Port Vila, Vanuatu in November 2004, Tuvalu in December 2004, Niue in February 2005, Nabouciwa village, Fiji in February 2005, and Labasa, Fiji in March 2005. The four selected case studies examine the impact of:

- Cyclone Ami and related flooding on the agriculture and education sectors in Fiji;
- Cyclone Heta on the tourism and education sectors in Niue;
- Drought on the fisheries and health sectors in Tuvalu; and
- Cyclones and earthquakes on the agriculture and tourism sectors in Vanuatu.

As discussed during meetings with representatives of AusAID in Suva and Canberra, the project team faced difficulties in conducting comprehensive analysis due to the lack of relevant and easily available statistics in standard data collections. The analysis that was possible given the limited data available is outlined in Sections 3, 4, 5 and 6 for Fiji, Niue, Tuvalu and Vanuatu, respectively. An inventory of documentary materials relating to disaster impacts in Fiji, Niue, Tuvalu and Vanuatu is listed in Appendix 2. A list of major natural disasters in the Pacific region and a brief summary of reported impacts over the last ten years are provided in Appendix 3. A list of cyclones and storms in the South West Pacific region over the last twenty years is provided in Appendix 4.

3. Fiji Islands

Research in Fiji involved meetings with stakeholders in Suva and Nadi on the island of Viti Levu, and in Labasa on the island of Vanua Levu to investigate the impacts of cyclones and related flooding events. The analysis focused in particular on the impacts of Cyclone Ami and severe flooding in 2003 on the agriculture and education sectors. A trip was also made to view a community flood mitigation project in Nabouciwa village in Nakelo, Tailevu, and to discuss how the project has reduced the negative impacts of flooding. Further details of these meetings are given in Appendix 1.

3.1. The Fiji Economy

Fiji is a small open economy, dependent on a few exports such as sugar, garments, gold, fish and light manufactures. It is also highly dependent on the tourism industry. In fact, the tourism industry provided the impetus for economic recovery after the coup of May 2000. As a result of active campaigning by the Fiji Visitors' Bureau, a quick recovery in tourist numbers was achieved after the 2000 coup in Fiji. Fiji's hopes for economic growth and development have centred on three sectors, namely sugar, garments and tourism. However, in recent years, with problems escalating in the sugar and garment sectors, tourism has been hailed as the cornerstone of growth and development.

Over the past 31 years Fiji's GDP growth rate has been low, averaging only 2.6 percent between 1970-2001 (Kumar and Prasad, 2002b). In the first five years of independence (1970-1975) the average GDP growth rate was 9.7 percent. Thereafter the growth rate has been below 2 percent. Slow economic growth has been one of the key reasons for the lack of jobs for the additional 13,000-15,000 people entering the labour market each year (Government of Fiji, 2002).

3.2. Literature Review – Economic Impact of Cyclone Ami and Related Flooding

Floods are regular occurrences in Fiji, happening almost annually. Most major floods are associated with episodes of severe weather phenomena, such as tropical depressions and cyclones that are characterised by high intensity rainfall. Many of the rivers and streams in Fiji are relatively small in size (<1000 km^2) and flow from steep mountainous terrain. High intensity rainfall together with the small size and steep nature of streams and rivers lead to swift rises and falls of water levels. The time period between heavy rainfall and flooding events can be as short as three hours. Flash floods are common, especially during the wet season from November to April. A list of floods in the Fiji Islands between 1990 and 2004 is provided in Appendix 5. A list of cyclones and storms in the Fiji Islands between 1972 and 2004 is provided in Appendix 6.

Data on floods and their impacts are scarce in Fiji. Estimates of the impacts of flooding are generally based on immediate direct damage to physical infrastructure. Progress has been made in assessing the impacts of natural disasters, but there is still room for further improvement in the scope and depth of disaster assessments in Fiji to include indirect and long-term impacts. Coordination between the NDMO and other relevant government departments that assess disaster impacts is still ad-hoc. There is, however, increasing realisation that better coordination and a centralised system of data collection on the impact of disasters is important.

The government assessment of Cyclone Ami was one of the most comprehensive assessments yet undertaken in Fiji. It appears from records that this was the first time that a wide-ranging national damage assessment report was coordinated and produced by the Fiji NDMO. The main aim of the assessment was to provide information for immediate relief purposes and provide a basis for rehabilitation and reconstruction programmes to restore basic infrastructure. The assessment of the impacts of Cyclone Ami and related flooding included an analysis of damage to the following sectors: housing, education, health, agriculture, business, tourism, sugar, infrastructure, telecommunications, and power supply. Different teams undertook the assessment of damages to each sector and the NDMO coordinated and compiled the final report. For all sectors the assessment tended to focus on direct impacts. Almost no estimation of long-term indirect impacts was undertaken.

According to the official government assessment, Cyclone Ami was a particularly destructive cyclone, which caused massive flooding, resulting in significant direct damage and fourteen deaths. The Fiji government's assessment of the impact of Cyclone Ami estimates that the total cost of damage amounts to FJ$104.4 million. 70 percent of this damage was to the public sector (FJ$73.8 million). The dollar values of damage are based on estimated replacement costs. The official damage assessment omits many of the impacts of Cyclone Ami and related flooding. The total costs of the disaster may therefore be significantly greater than the official damage estimate. The breakdown of the damage to each sector is shown in Table 1.

Table 1: Fiji NDMO's Assessment of Sectoral Impacts of Cyclone Ami and Related Flooding

Sectors	Sub-Sectors	Costs (FJ$)	Total Cost (FJS)
Social	Housing	$22,089,200	
	Health	$857,000	
	Agriculture	$1,020,671	
	Education	$4,770,635	$28,737,506
Economic	Taveuni Chamber of Commerce	$113,500	
	Labasa Chamber of Commerce	$12,110,000	
	Tourism	$144,000	
	Sugar Industry	$13,600,000	
	Agricultural Commercial Crops	$39,309,948	$65,277,448
Infrastructure	Roads and Bridges	$2,725,000	
	Regional Water Supply	$1,179,500	
	Rural Water Supply	$927,758	
	Sewerage	$522,223	$5,792,435
	Public Buildings	$437,954	
Utilities	Telecommunications	$1,185,400	
	Power Supply (FEA)	$3,395,000	$4,580,400
TOTAL			**$104,387,789**

Source: Fiji National Disaster Management Office, 2003

Computable General Equilibrium (CGE) models are now the best available tools for understanding the economy-wide impacts of natural disasters. The general equilibrium nature of the model ensures that all sectors are incorporated. This gives a more robust picture of disaster impacts than traditional input-output models. The Fiji CGE model was used to study the economy-wide impact of Cyclone Ami and produced estimates of the decline in different sectors of the Fijian economy (Narayan, 2003c). All the key variables were negatively affected (see Appendix 7). Both exports and imports declined, with exports declining more than imports reflecting a worsening balance of payments situation. Other key variables such as private consumption, income, investment and savings fell, leading to a reduction in real GDP. These macroeconomic impacts are likely to have led to declining levels of welfare for the people of Fiji.

According to Benson (1997), GDP data for the last 25 years suggest that economic growth rates in Fiji were affected in years where natural disasters occurred. Benson used an auto-regressive linear model using ordinary least squares multiple regression analysis for the period 1982-93 to determine the impact of natural disasters on economic growth. The results suggest that actual growth rates were lowered by natural disasters.

On the basis of this analysis it appears that natural disasters generally, and floods in particular, are major exogenous shocks to the Fiji economy and this has affected GDP growth rates. It may also be the case that natural disasters are more damaging when there are simultaneously other negative factors contributing to poor economic growth. In Fiji's case since 2000, the combination of seven natural disasters, six of which were cases of flooding, and political instability since 2000 appear to have had negative impacts on Fiji's economic growth.

3.3. Impact on Agriculture Sector

This section estimates the economic impact of Cyclone Ami and related flooding in 2003 on the agriculture sector in Fiji using the guidelines developed in phase one of this research project (see Tool 1). As recommended in the guidelines, the analysis is split into an assessment of the agriculture sector without the disaster, and a disaster impact assessment.

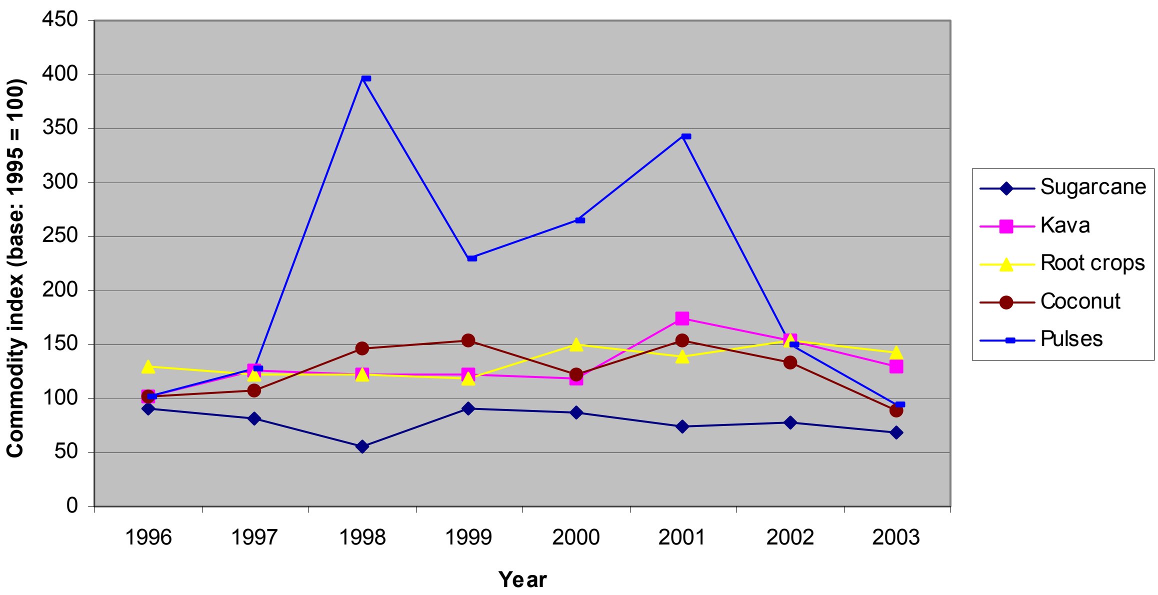
Limited data was available. Most of the baseline data used in this report was gathered from the Fiji Islands Bureau of Statistics and the Food and Agriculture Organisation (FAO). Data on direct impacts was gathered from the NDMO impact assessment and qualitative information on indirect and intangible impacts was gathered from interviews with stakeholders in Viti Levu and Vanua Levu, Fiji.

3.3.1. Agriculture Sector Without Cyclone Ami and Related Flooding

In 2002, the year before Cyclone Ami, there were 132,000 workers in the Fiji agricultural labour force, which constituted 40 percent of the total labour force. Agricultural GDP as a share of total GDP was 16.2 percent, a decline from 22 percent in 1990. The expiry of land leases and the decline of the sugar industry are obvious explanations for the wane of the agricultural sector. The agriculture trade balance, in terms of the value of agricultural exports less the value of agricultural imports, was US$44.5 million.

In 2002, sugar, the major agricultural export of Fiji, counted for 64 percent of total agricultural exports. In that year the FAO records that there were 21,246 growers of sugar cane. Before Cyclone Ami, Fiji Sugar Corporation forecast that the annual crop for 2003 would produce 930,600 tonnes of cane. After sugar, other important agricultural products in Fiji are coconuts, taro, cassava, rice and fruit. Annual indices of production of sugarcane, kava, root crops, coconuts and pulses for 1996-2003 are shown in Figure 1. All of these crops show a fall in production between 2002 and 2003, possibly caused by Cyclone Ami and severe flooding.

Figure 1: Annual Indices of Agricultural Crops in Fiji, 1996-2003



Source: Fiji Islands Bureau of Statistics

The situation in Fiji's agriculture sector in 2002 and its forecast development is summarised in Table 2.

Table 2: Summary Statistics – Fiji's Agriculture Sector Without Cyclone Ami

Information	Data Needed	Fiji's Agriculture Sector	Source
Infrastructure	Number of agricultural enterprises in affected area	Data not available	
Production	Type and quantity of production	See Figure 1. FSC forecast 2003 crop of 930,600 tonnes of sugarcane.	Fiji Islands Bureau of Statistics. Fiji Sugar Corporation
Importance	Contribution of agriculture sector to GDP and employment	40% of labour force involved in agriculture, Agricultural GDP as a share of total GDP 16% (2002)	FAO
Ownership	Public / private	Data not available	
Location	Rural / urban	Mostly rural areas	Ministry of Agriculture
Employment	Number employed	132,000 workers in agricultural labour force (2002)	FAO
Quality of infrastructure	Quality of agriculture infrastructure	Data not available	
Furniture and equipment	Furniture and agriculture equipment	Data not available	
Costs of replacement	Costs of replacement of infrastructure and stock	Data not available	
Cost of service supplied	Costs of any agriculture services supply	Data not available	

3.3.2. Impact of Cyclone Ami and Related Flooding on Agriculture Sector

The official damage assessment conducted by the Fiji government only included estimates of direct damage to the agriculture sector. Our analysis attempts to expand this estimate to include other important indirect and intangible impacts. The assessment is summarised in Table 3. It is still not a comprehensive assessment, due to the limited data and time available for the analysis.

Direct Impacts: 60-80 percent of subsistence crops were damaged at a cost of FJ$921,000. The value of this damage is based on market prices from weekly agricultural price surveys. Direct damage to commercial crops such as dalo, yaqona, and copra cost Fiji an estimated FJ$39.3 million. Cyclone Ami and the accompanying flooding in Vanua Levu caused extensive damage to sugarcane farms. The sugar industry suffered total direct damage estimated at FJ$13.6 million[7]. 150,000 tonnes of sugarcane were damaged at a cost of FJ$7.6 million. Direct damage to Fiji Sugar Corporation's infrastructure and equipment was valued at FJ$6 million.

Indirect Impacts: According to the Fiji Sugar Corporation, actual sugar production in Vanua Levu in 2003 was 30 percent lower than the forecast crop, a reduction of 292,230 tonnes of sugar cane. The price paid to growers in 2003 was FJ$38.80/tonne (Fiji Islands Bureau of Statistics). The value of lost production in 2003 is therefore approximately FJ$11.2 million. There appears to have been no impact on sugar production for 2004. The operating costs of the Fiji Sugar Corporation increased in 2004 due to the cost of employing 400 extra staff to help with the clear up and repair work. Using a conservative estimate of the daily wage of $8.50 for 400 workers for 260 days of the year, the estimated extra personnel costs amount to FJ$884,000. The sugar industry also suffered from increased transport costs due to the damage to the sugar-train rail system and damage to sugar cane transport roads, but no monetary estimates of these indirect costs could be obtained. The Fiji Sugar Corporation estimates the cost of debris clearing (excluding extra personnel costs) in the sugar sector was approximately FJ$114,600.

Intangible Impacts: Staff at the Fiji Sugar Corporation noted a positive impact on the community spirit of the work force as they laboured together in the clear-up and reconstruction process.

Table 3: Assessment of Impact of Cyclone Ami on Fiji's Agricultural Sector

Type of Impact	Impact	Estimated Value	Source
Direct Impacts	Damage to subsistence crops	FJ$921,000	NDMO
	Damage to commercial crops	FJ$39,300,000	NDMO
	Damage to sugar cane	FJ$7,600,000	NDMO
	Damage to sugar sector infrastructure and equipment	FJ$6,000,000	NDMO
	Damage to non-sugar agricultural infrastructure and equipment	Data not available	
	Damage to agricultural and farm land	Data not available	
Indirect Impacts	Loss of income from sugar production	FJ$11,200,000	FSC[8]
	Loss of income from non-sugar agricultural production	Data not available	
	Increased personnel costs in sugar industry	FJ$884,000	FSC
	Increased operating costs in agricultural sector (excluding personnel costs)	Data not available	
	Costs (excluding personnel costs) of debris removal in sugar sector	FJ$114,600	FSC
	Costs of debris removal in non-sugar agricultural sector	Data not available	
Intangible Impacts	Positive impact on community spirit	Not valued	FSC
Total Impact	Includes only impacts for which data was available and monetary value could be estimated	FJ$66,019,600	

3.4. Impact on Education Sector

This section estimates the economic impact of Cyclone Ami and related flooding in 2003 on the education sector in Fiji using the guidelines developed in phase one of this research project (see Tool 1). As recommended in the

[7] The estimates of damage to the sugar sector differed widely depending on who was making the estimate (e.g. Fiji Sugar Corporation and Cane Growers Council). The need to have a uniform assessment methodology to achieve comparable damage estimates was noted by stakeholders in the sugar industry.

[8] Fiji Sugar Corporation (FSC)

guidelines, the analysis is split into an assessment of the education sector without the disaster, and a disaster impact assessment.

Limited data was available. Most of the baseline data used in this report was gathered from the Fiji Islands Bureau of Statistics, the Ministry of Education and the United Nations Children's Fund (UNICEF). Data on direct impacts was gathered from the NDMO impact assessment. Qualitative information on indirect and intangible impacts was gathered from interviews with stakeholders in Viti Levu and Vanua Levu, Fiji.

3.4.1. Education Sector Without Cyclone Ami and Related Flooding

In 2003, there were 719 primary school, 157 secondary schools, and two universities in Fiji. In the same year, there were approximately 143,000 primary school students, 68,000 secondary school students and 22,800 tertiary students enrolled in Fiji's educational institutions. The education sector employed roughly 5,000 primary school teachers, and 4,000 secondary school teachers. Fiji has an excellent primary school enrolment rate over the period 1996-2003 of 100 percent, and total adult literacy of 93 percent. Summary statistics on the Fiji education sector are summarised in Table 4.

Table 4: Summary Statistics – Fiji's Education Sector Without Cyclone Ami

Information	Data Needed	Fiji's Education Sector	Source
Infrastructure	Number of educational buildings in affected area	719 primary schools, 157 secondary schools, 2 universities	Ministry of Education
Ownership	Public / private	Data not available	
Location	Rural / urban	Data not available	
Number of inhabitants	Number of students	142,781 primary students, 68,178 secondary students, 22,780 tertiary students	Ministry of Education
Employment	Number of teachers	5,107 primary teachers, 3,935 secondary teachers	Ministry of Education
Coverage	Coverage provided by education institutions	Net primary school enrolment of 100% (1996-2003)	UNICEF
Type of housing	Traditional / semi-modern / modern	Data not available	
Quality of buildings	Quality of education buildings	Data not available	
Furniture and equipment	Furniture and educational equipment	Data not available	
Costs of replacement	Costs of replacement of infrastructure and equipment	Data not available	
Cost of service supplied	School fees, government subsidies, average wages	Data not available	
General indicators		Net primary school enrolment of 100% (1996-2003), total adult literacy rate of 93%	UNICEF

3.4.2. Impact of Cyclone Ami and Related Flooding on Education Sector

The official damage assessment conducted by the Fiji government only included estimates of direct damage to primary and secondary schools in the education sector. Our analysis attempts to expand this estimate to include other important indirect and intangible impacts. The disaster impacts are summarised in Table 5. It is still not a comprehensive assessment, due to the limited data and time available for the analysis.

Direct Impacts: Cyclone Ami and the related flooding caused severe direct damage to school infrastructure, such as buildings, equipment and materials. The cost of this damage is estimated at FJ$4.8 million, valued at replacement and repair costs.

Indirect impacts: Five educational buildings were used as temporary shelters after Cyclone Ami and the related severe flooding: St. Bedes College, Koa Island Primary, Buca Government School, Rabi Islands School, and Druadrua Primary School. Data was not available on the costs of repairing the damage caused while the buildings were being used as evacuation centres. Many schools also lost income because families could not afford to pay student fees for some time (Acting Division Education Officer Northern, personal communication). As a result of the disaster, the school term had to be delayed by 1-2 weeks. Many students were taught in crowded classroom conditions as they were packed into the few educational buildings that were not damaged by the cyclone and floods.

Intangible impacts: The delays and poor school conditions are likely to have been a major factor causing the dramatic fall in exam results in the Northern Division of Fiji for the school term following Cyclone Ami.

Table 5: Assessment of Impact of Cyclone Ami and Related Flooding on Fiji's Education Sector

Type of Impact	Impact	Estimated Value	Source
Direct Impacts	Damage to buildings, equipment and materials	FJ$4,800,000	NDMO
	Damage to education sector government offices	Data not available	
Indirect Impacts	Cost of repair of educational buildings used as temporary shelters	Data not available	NDMO
	Loss of income in student fees	Data not available	Ministry of Education
	Costs of demolition and debris removal	Data not available	
	Additional education service operating costs	Data not available	
Intangible Impacts	Lost learning opportunities	Not valued	Ministry of Education
Total Impact	Includes only impacts for which data was available and monetary value could be estimated	FJ$4,800,000	

3.5. Cost-effectiveness of Community Flooding Mitigation Project

A community flooding mitigation project in Nabouciwa was visited to assess the impact and cost-effectiveness of the DRM measures involved in the project. A full cost-benefit analysis was not possible due to the limited data and time available for the analysis.

Nabouciwa is a village in Nakelo in Tailevu in the Fiji Islands, with a population of approximately 130 people, living in 27 housing units. The main source of income is gained from fishing for mud crabs and other seafood. Before any mitigation activities took place, Nabouciwa regularly experienced floods. In the rainy season, the village would sometimes flood every day, and would always flood at high tide. The flood level would occasionally be deep enough to reach thigh height.

The community of Nabouciwa was told to relocate by the Fiji government because of the severe flooding problem. The community was reluctant to relocate and so devised an alternative comprehensive flood mitigation and village-planning project. The project began in the mid-1970s and is still evolving. This integrated project has reduced the risk of flooding in the village through various risk reduction measures, including:

1) Dredging the river delta;
2) Using sludge from the dredging to raise the level of the village;
3) Raising houses on stilts using local materials;
4) Implementing a village drainage system; and
5) Mobilising the community.

A breakdown of the costs of these DRM measures could not be obtained within the data and time available for this research project[9]. A list was compiled during community discussions of some of the benefits that the village gained from the mitigation project and the resultant reduction in flooding, as detailed in Table 6.

Table 6: Impacts of Flooding on Nabouciwa With and Without DRM Measures

Type of Impact	Without DRM measure	With DRM measure
Physical	Possessions damaged Cost of using boat for transportation in the village during floods	Possessions not damaged Boat not needed within village
Human	Regular outbreaks of tuberculosis with approximately half the village typically affected. Regular occurrence of skin and intestinal diseases	No tuberculosis outbreaks Lower incidence of skin and intestinal diseases
Economic	Less time available for crabbing and fishing	More time available for crabbing and fishing
Social	People frequently leave village to move to urban areas Community not developing rapidly	More people choose to remain based in the village, and commute to urban areas if required Community development has accelerated
Environmental	Crop damage from flooding and seawater salinity	Subsistence crops can grow in village

The research team was only able to identify the impacts of the Nabouciwa flooding project within the time available and given the limited data that was easily accessible. There is, however, potential for a further study to follow up this interesting example of a DRM measure using the methodology in the toolkit developed for this research project. A further study would need to obtain data on the costs of the DRM measure, estimate the monetary value of the impacts of the DRM measure identified in this analysis, discount the costs and benefits, estimate cost-benefit analysis indicators and conduct a sensitivity analysis. Four other villages still experience flooding in the nearby area (Naivacau, Buretu, Mateinoco and Dakau). A participatory community research study of the impacts of flooding in these villages could help to determine the impacts of flooding in the hypothetical situation 'without' the DRM measure.

[9] Different elements of the project were funded by the Canada Fund (initial drainage), the Fiji Ministry of Agriculture (dredging), and the Australian High Commission (raising level of land).

4. Niue

Research in Niue involved meetings with stakeholders to investigate the impacts of cyclones, in particular the impact of Cyclone Heta in 2004. Meetings with those involved in the building of the new hospital were held to discuss how the relocation of the hospital is likely to reduce the negative impacts of future cyclones. Further details of these meetings are given in Appendix 1.

4.1. The Niue Economy

Niue is a small single coral island country of 259 km^2 situated in the South Pacific Ocean at longitude 19° South and latitude 169° West. Niue is the largest raised coral island in the world and is known for its undisturbed environment and dramatic coastal scenery. At the last population census count in 2001, Niue had a population of 1,788 people, originally of Polynesian descent. Since 1974 Niue has been self-governing in free association with New Zealand. Under the constitutional arrangement, New Zealand is responsible for defence and external affairs as well as providing economic and administrative assistance. The Niue Constitution allows the Niue population full residency in New Zealand. Niue's free association with New Zealand triggered substantial emigration and much of the decline in population. In contrast to its small land area, Niue has a vast Exclusive Economic Zone of 294,000 km^2.

Niue has no systematic national accounting system and does not routinely produce GDP figures. An estimate for GDP was made for 2002 at NZ$14.2 million, with GDP per capita estimated to be NZ$7,470. New Zealand provides about 50 percent of Niue's GDP through budget support programmes. The other major sources of revenue for Niue are from aid, remittances, telecommunications facilities, international business registrations and exports of taro, honey, fish, coconuts, handicrafts and vanilla. In 2002, exports (mostly to New Zealand) amounted to only about NZ$200,000, while imports were valued at NZ$4 million. In national development plans the Niue government has set goals to reduce dependency on aid, and promote tourism and exports of fish and vanilla. The main constraints on economic development in Niue include isolation, poor communication systems, limited natural resources and a shortage of skilled labour due to outward migration to New Zealand.

4.2. Literature Review – Economic Impact of Cyclone Heta

Niue has been affected by cyclones and droughts in the past but the impact of Cyclone Heta in January 2004 is considered to be the most destructive in Niue's recent history. Niue does not have any record of assessments of disasters prior to Cyclone Heta in 2004. The last assessment that officials recalled being done was in 1990 after Cyclone Ofa. Apparently these records were destroyed during Cyclone Heta.

The attempt by various departments to assess the damage after Cyclone Heta was impressive. Many of the techniques were innovative and significant effort was made to quantify the damage at the national and sectoral level. The assessment of damages from Cyclone Heta was based on the impact on three broad areas: civil society, the private sector and the public sector (see Table 7). The information gathering methodology adopted in the Heta assessment was a national survey format in which disaster-affected businesses and households were required to list the cost of direct damages suffered, supported by a validation assessment conducted by the Department of Economic Planning and the Department of Community Affairs. The method of valuation was based on replacement costs using current market values in the construction industry. No assessment of macroeconomic effects was made, but these would be difficult to calculate given the lack of base statistics on economic indicators in Niue.

Table 7: Niue Government's Categorisation of the Damage Caused by Cyclone Heta by Sector

Category	Composition
Civil Society	• Villages-housing and personal property
Private Sector	• All business enterprises • All tourism facilities
Public Sector	• Agriculture • Biodiversity and environment • Fisheries, including marine ecosystem and infrastructure • Forestry, including mahogany and indigenous forestry • National heritage, including museum, and marine and forestry conservation areas • National infrastructure, including utilities, fuel farm, hospital, educational facilities • Public services, including all government departments

Source: Premier's Department. April 2004. Cyclone Heta Recovery Plan.

The total damage inflicted by Cyclone Heta was estimated at NZ$37.7 million. The estimation of the impacts of Cyclone Heta was based on the immediate need to provide the New Zealand government and other aid donors with a recovery plan. In some cases, however, there was also an attempt to include indirect costs in terms of loss of future income, and intangible impacts, such as environmental damage. For example, the Department of Environment attempted to value the loss of biodiversity and certain species such as pigeons and flying foxes, without guidance on economic valuation techniques.

Within the category of 'civil society' the major concentration was on damage to housing. The assessment found that out of 1002 houses on the island (432 occupied[10]), about 90 percent were damaged during Cyclone Heta. Damage to housing and personal property is estimated to amount to NZ$4.1 million. Niue authorities recognized the social and psychological costs of the cyclone and related damage, but these impacts were not discussed in detail in the impact assessment.

The total damage to the private sector was estimated at NZ$4.5 million. The government allocated NZ$1 million to the private sector as part of its contribution to the recovery plan. The Niue economy is dominated by public sector activities. The government employs the majority of the population and provides most social services. All government assets and installations suffered extensive damage from Cyclone Heta, including buildings, plant and machinery, communication systems, utilities supply systems, office equipment, historical records, and government housing. Vital service buildings and facilities such as the hospital, Justice and Lands Department and the national museum and library were completely destroyed. Total official estimated damage and losses in the public sector amount to NZ$25.7 million (see Table 8). The value of the damage to the public sector was roughly double Niue's estimated GDP for 2002.

[10] Many houses are vacant, because families have left to live in New Zealand.

Table 8: Niue Government Assessment of Impact of Cyclone Heta on the Public Sector

Sector	Lost Amenities	Assessed Value (NZD)
Agriculture	Commercial and subsistence crops	$5,500,000
Health Services	Maternity ward, dental facilities, hospital, mortuary, aged care facilities	$4,000,000
Tourism	Sea tracks, eco-tourism sites, tourist accommodation and infrastructure	$3,120,000
Government Buildings	Civil service buildings	$2,324,000
Community Affairs	100% of Museum, 90% of archives, library services, cultural and historical records and artefacts	$2,525,000
Bulk Fuel	Fuel supply storage for whole island	$2,200,000
Telecom Niue	Communication services	$1,400,000
Niue Power Corporation	Electricity services	$890,000
Justice and Lands	Services for courts, registrar of births, deaths and marriages, land title register	$790,000
Niue Development Bank	Buildings in industrial park	$730,000
Fisheries	Fishing vessels launching site. Community sea tracks	$668,000
Broadcasting Corporation of Niue	Radio and television services	$542,000
Other Government Departments	Office and technical equipment (PWD, Premier's Department, Education, Treasury, Police, Meteorological Office), water supply repairs	$1,013,250
Total damage		**$25,702,250**

Source: Premier's Department. April 2004. Cyclone Heta Recovery Plan.

4.3. Impact on Tourism Sector

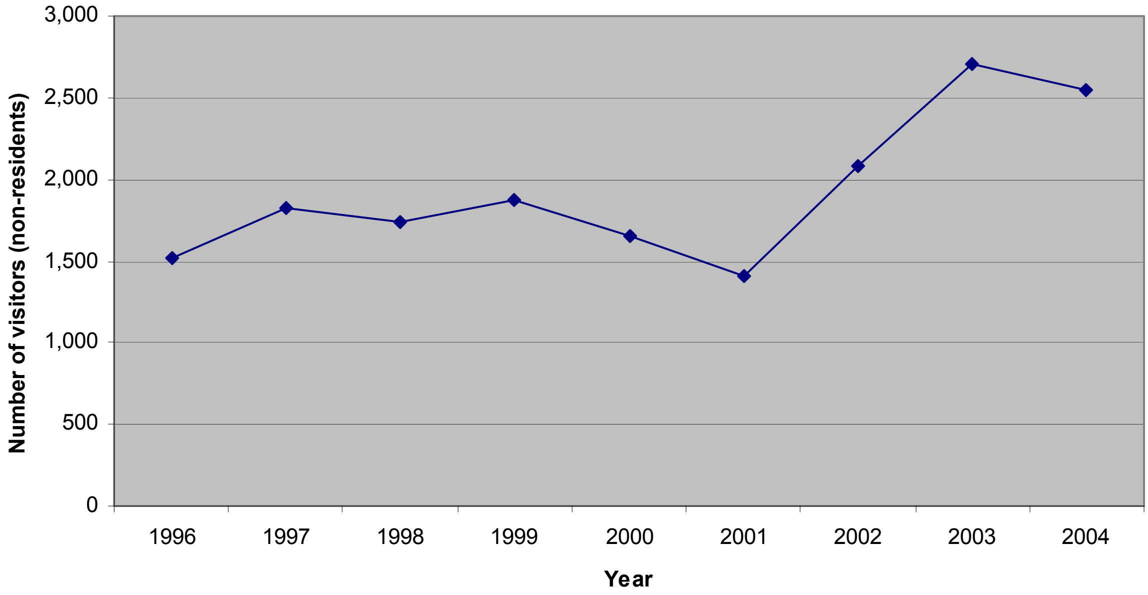
This section estimates the economic impact of Cyclone Heta in 2004 on the tourism sector in Niue using the guidelines developed in phase one of this research project (see Tool 1). As recommended in the guidelines, the analysis is split into an assessment of the tourism sector without the disaster, and a disaster impact assessment.

Limited data was available. Most of the baseline data used in this report was gathered from the Niue Department of Tourism. Data on direct impacts was gathered from the official government disaster impact assessment. Qualitative information on indirect and intangible impacts was gathered from interviews with the Department of Tourism and the Chamber of Commerce in Niue.

4.3.1. Tourism Sector Without Cyclone Heta

The tourism sector is small in Niue. However, the number of tourist visitors began to increase in 2001. Prior to Cyclone Heta, the Department of Tourism predicted that Niue's tourism sector would experience a significant increase in tourist visitors and tourism revenue in 2004. This prediction did not come true, as 2004, the year of Cyclone Heta, saw a decline in tourists (non-resident arrivals) from the previous year. There were 156 fewer tourists in 2004 than in 2003. The total number of tourist (non-resident) arrivals in Niue between 1996 and 2004 is shown in Figure 2.

Figure 2: Tourist (non-resident) Arrivals in Niue, 1996-2004



The Department of Tourism estimates that income from tourist expenditure in 2003 was approximately NZ$1.8 million. Before Cyclone Heta there were seven major hotels and motels accommodating tourists in Niue: Namakulu Motel, the Anaiki Motel, the Coral Gardens Motel, the Matavai Resort, Hotel Niue, Peleni's Inn, and Kololi's Guest House.

Table 9: Summary Statistics – Niue's Tourism Sector Without Cyclone Heta

Information	Data Needed	Niue's Tourism Sector	Source
Infrastructure	Number of tourism facilities in affected area	Seven major hotels and motels	Department of Tourism
Production	Level of tourism service provision	2,706 visitors in 2003, only 2,550 visitors in 2004 (see Figure 2)	Niue Statistics
Importance	Contribution of tourism sector to GDP and employment	Tourist expenditure in 2003 NZ$1.8 million	Department of Tourism
Ownership	Public / private	All tourism facilities privately owned, other than Hotel Niue which is owned by government	Department of Tourism
Location	Rural / urban	Three tourist facilities in main urban area of Alofi South.	Department of Tourism
Employment	Number employed	Data not available	
Quality of infrastructure	Quality of tourism infrastructure	Data not available	
Furniture and equipment	Furniture and agriculture equipment	Data not available	
Costs of replacement	Costs of replacement of infrastructure and stock	Data not available	
Cost of service supplied	Costs of tourism services	Data not available	

4.3.2. Impact of Cyclone Heta on Tourism Sector

The official damage assessment conducted by the Niue government only included estimates of direct damage to tourist accommodation and facilities, scenic sites and access routes. Our analysis attempts to expand this estimate to include other important indirect and intangible impacts. The disaster impact is summarised in Table 10. It is still not a comprehensive assessment, due to the limited data and time available for the analysis.

Direct Impacts: Tourist accommodation and infrastructure suffered severe damage, and in some cases total destruction as a result of Cyclone Heta. The cost of repairing damaged tourist accommodation and infrastructure was estimated at NZ$300,000. The cost of replacing tourist accommodation and infrastructure that was totally destroyed was estimated at a value of NZ$2,750,000. The value of damage to scenic sites and access roads was estimated at a value of NZ$289,740, based on the cost of clearing the access roads and rehabilitating scenic sites to a 'visitable' quality. The Niue government's Department of Tourism suffered minimal direct damage from Cyclone Heta.

Indirect Impacts: There was a reduction in the number of tourist visitors of 6 percent between 2003 and 2004. Assuming that income per visitor from tourist expenditure would be the same in 2004 as it was in 2003 (NZ$665 per visitor), the total estimated lost income for 2004 was approximately NZ$103,769. Data on the cost of demolition and debris removal and additional tourism operating costs were not available. It was estimated, however, that the cyclone necessitated a product development and certification programme for new dive sites, with an estimated cost of NZ$200,000.

Intangible Impacts: Cyclone Heta caused environmental damage to scenic sites such as caves, coral reefs, sea tracks and swimming spots, with roughly 70 percent of the scenic sites or access to scenic sites suffering serious damage. The value of rehabilitation of some scenic sites and clear-up of the access roads was included in the direct damage section, but this estimate omits some environmental impacts, such as damage to the forest in the Huvalu conservation area.

Table 10: Assessment of Impact of Cyclone Heta on Niue's Tourism Sector

Type of Impact	Impact	Estimated Value	Source
Direct Impacts	Damage to tourist accommodation and infrastructure (needs repairs)	NZ$300,000	Premier's Department
	Destruction of tourist accommodation and infrastructure (needs total replacement)	NZ$2,750,000	Premier's Department
	Damage to scenic sites and access roads	NZ$289,740	Premier's Department
	Damage to tourism government offices	No damage	Premier's Department
Indirect Impacts	Loss of income in tourist revenue	NZ$103,769	Department of Tourism
	Costs of demolition and debris removal	Data not available	
	Additional tourism operating costs	Data not available	
	Cost of development and certification programme for new dive sites	NZ$200,000	Premier's Department
Intangible Impacts	Damage to environment e.g. Huvalu forest conservation area	Not valued	
Total Impact	Includes only impacts for which data was available and monetary value could be estimated	NZ$3,643,509	

It is important to note that the loss of particular assets due to disasters may mask the fact that these assets were performing poorly prior to the disaster. For example, prior to Cyclone Heta the company that leased the government-owned Hotel Niue was struck off the New Zealand Companies Register as a result of bad debts, lack of reporting, mismanagement etc. Care must be taken not to overestimate the loss from such assets that are poor performing, even without the impact of a natural disaster.

4.4. Impact on Education Sector

This section estimates the economic impact of Heta in 2004 on the education sector in Niue using the guidelines developed in phase one of this research project (see Tool 1). As recommended in the guidelines, the analysis is split into an assessment of the education sector without the disaster, and a disaster impact assessment. The impact on the education sector of Cyclone Heta was not considered to be as serious as that affecting other social sectors, such as the health sector.

Limited data was available. Most of the baseline data used in this report were gathered from the Niue Government's Department of Education, Niue Statistics and the United Nations Children's Fund. Data on direct impacts were gathered from the official government disaster impact assessment and qualitative information on indirect and intangible impacts was gathered from interviews with stakeholders in Niue.

4.4.1. Education Sector Without Cyclone Heta

Education is compulsory in Niue between the ages of 4 and 16. There are three education institutions: Niue Primary School, Niue High School, and a branch of the University of the South Pacific. In 2002, there were 251 primary school students, 240 secondary school students, 17 primary school teachers and 29 secondary school teachers. The teacher-pupil ratio was 1:15 in primary schools and 1:8 in secondary schools. Between 1996 and 2003, Niue had a net primary enrolment rate of 97 percent. In 2000, the total adult literacy rate was 81 percent.

Table 11: Summary Statistics – Niue's Education Sector Without Cyclone Heta

Information	Data Needed	Niue's Education Sector	Source
Infrastructure	Number of educational buildings in affected area	One primary school, one secondary school and one USP post	Niue Statistics
Ownership	Public / private	Primary and secondary school funded and run by government	Department of Education
Location	Rural / urban	All three schools based around Alofi South (urban) area.	Department of Education
Number of inhabitants	Number of students	251 primary school students, 240 secondary school students	Department of Education
Employment	Number of teachers	17 primary school teachers, 29 secondary school teachers	Department of Education
Coverage	Coverage provided by education institutions	Net primary school enrolment of 97% (1996-2003)	UNICEF
Type of housing	Traditional / semi-modern / modern	Modern buildings	Department of Education
Quality of buildings	Quality of education buildings	High quality building materials and structures	Department of Education
Furniture and equipment	Furniture and educational equipment	Data not available	
Costs of replacement	Costs of replacement of infrastructure and equipment	Data not available	
Cost of service supplied	School fees, government subsidies, average wages	Data not available	
General indicators		Net primary school enrolment of 97% (1996-2003), total adult literacy rate of 81%	UNICEF

4.4.2. Impact of Cyclone Heta on Education Sector

The official damage assessment conducted by the Niue government focuses on the direct impacts of Cyclone Heta. Our analysis attempts to expand this estimate to include other important indirect and intangible impacts. The assessment is summarised in Table 12. It is still not a comprehensive assessment, due to the limited data and time available for the analysis.

Direct Impacts: Niue's education institutions suffered minor damage from Cyclone Heta due to their relatively sheltered locations away from the vulnerable coastal area. There was some damage to school buildings and facilities, which cost an estimated NZ$100,000 to repair. Damage to equipment and supplies were valued at replacement costs of NZ$200,000.

Indirect Impacts: There appear to have been few indirect impacts suffered by the education sector in Niue from Cyclone Heta. The education buildings were not used as temporary shelters and there was no loss of income in student fees.

Intangible Impacts: The primary and secondary schools were both forced to delay the school term due to Cyclone Heta, but extended the term to make up for this postponement. There appears to have been no significant alternation in student performance after Cyclone Heta. Officials from the education department and teachers, however, did point out that children were emotionally and psychologically affected by the experience of Cyclone Heta. Individual and group counselling exercises were organised by the schools.

Table 12: Assessment of Impact of Cyclone Heta on Niue's Education Sector

Type of Impact	Impact	Estimated Value	Source
Direct Impacts	Damage to school buildings and facilities	NZ$100,000	Department of Education
	Damage to equipment, supplies and teaching resources	NZ$200,000	Department of Education
	Damage to education sector government offices	No damage	Department of Education
Indirect Impacts	Cost of repair of educational buildings used as temporary shelters	Not applicable	Department of Education
	Loss of income in student fees	Not applicable	Department of Education
	Costs of demolition and debris removal	Data not available	
	Additional education service operating costs	Data not available	
Intangible Impacts	Psychological trauma suffered by children and teachers (counselling provided free of charge)	Not valued	Department of Education
Total Impact	Includes only impacts for which data was available and monetary value could be estimated	NZ$300,000	

4.5. Cost-effectiveness of Relocation of Hospital

After Cyclone Ofa hit Niue in 1990, repeated recommendations were made by various agencies (SOPAC, Niue Government etc.) that the Niue hospital should be relocated to a safer site away from the vulnerable coastal zone in Alofi South. In particular, Forbes (1996) made clear recommendations that a coastal hazard zone should be identified along the foreshore of Alofi Terrace, with setback requirements for new infrastructure projects. These recommendations were ignored to save money in the short-term, and instead the Niue hospital was renovated in its original location by the coast. Consequently the hospital was utterly demolished during Cyclone Heta in 2004, with total destruction of infrastructure, equipment and records, and high indirect costs of patient referrals to New Zealand. After the total destruction of the hospital in Cyclone Heta, the Niue hospital is now being rebuilt in a new location. The new hospital site is in Kaimiti, an area that is on the upper terrace and safe from any potential wave damage similar to that which devastated the hospital during Cyclone Heta.

The cost of the direct destruction caused by Cyclone Heta to the hospital building and equipment was estimated at NZ$4 million. In addition to this direct damage, there have been significant indirect costs involved in referring patients to New Zealand for treatment during the rebuilding period. The Niue Health Department reports that patients have been referred for 394 trips to New Zealand health-care facilities, with 96 family members also flying to New Zealand to accompany the patients. The average cost of a return trip to New Zealand was estimated at NZ$1,200, so the total cost of referrals was estimated at approximately NZ$588,000. The cost of building a temporary hospital extension was estimated at NZ$60,000. Data was not available on other indirect impacts, such as lost income from charged health services, and additional health service operating costs.

The estimated impacts of a major cyclone similar to Cyclone Heta, with and without relocation of the hospital to a safer location, are estimated in Table 13.

Table 13: Impacts of Cyclone Heta With and Without Hospital Relocation

Type of Impact	Without DRM measure	Approximate impact value	With DRM measure	Approximate impact value
Direct	Total destruction of hospital building and equipment from Cyclone Heta	NZ$4 million	Relocation of hospital inland could have saved two-thirds of damage[11]	NZ$1.3 million
Indirect	Cost of referral of patients for treatment in New Zealand	NZ$588,000	No referrals needed for treatment in New Zealand	NZ$0
	Cost of temporary hospital extension	NZ$60,000	No need for temporary hospital extension	NZ$0
Intangible	Psychological trauma of health personnel and patients	Not valued	Reduced psychological trauma of health personnel and patients	Not valued
TOTAL		NZ$4.648 million		NZ$1.3 million

The research team was only able to identify the likely impacts of Cyclone Heta with and without relocation of the hospital within the time available for this research project and the limited data that was easily accessible. There is, however, potential for a further study to follow up this interesting example of a DRM measure using the methodology in the toolkit. A further study would need to obtain more detailed data on the costs of relocating the hospital, including externality costs, estimate any other benefits of relocation, discount the costs and benefits, estimate cost-benefit analysis indicators and conduct a sensitivity analysis.

[11] Estimate of disaster management specialist working in Niue (Bonte, SOPAC).

5. Tuvalu

Research in Tuvalu involved meetings with stakeholders to investigate the impacts of droughts, particularly in the main atoll of Funafuti. Meetings were held with those involved with the desalination plant to collect information on the costs and benefits of this activity. Further details of these meetings are given in Appendix 1.

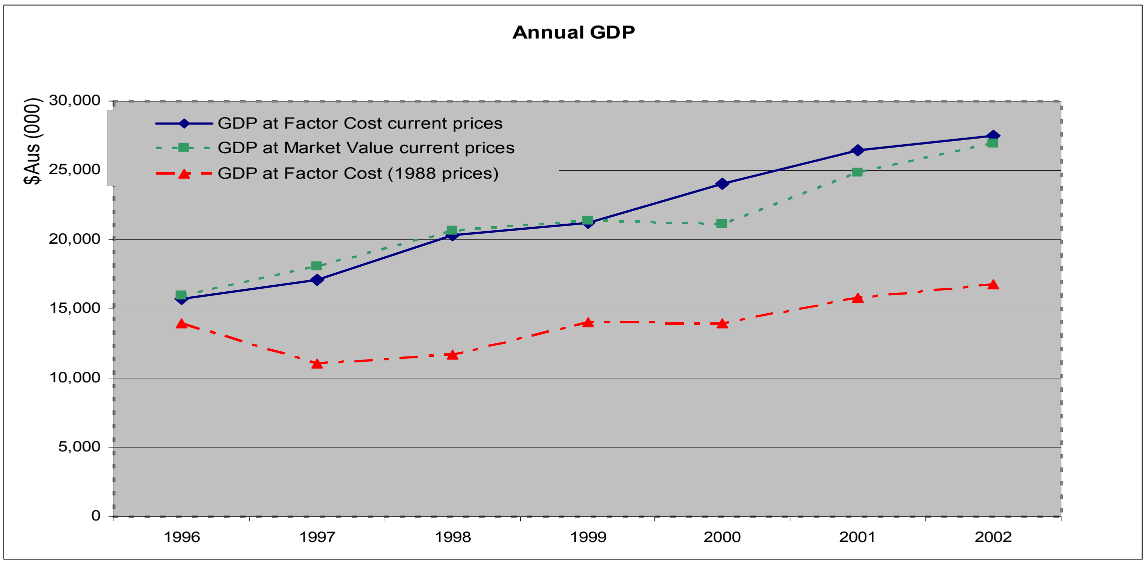
5.1. The Tuvalu Economy

Tuvalu is a small, low-lying and densely populated country made up of nine coral atolls with poor soil. The country has very few exports. Subsistence farming and fishing are the primary economic activities. On average, fewer than 1,000 tourists visit Tuvalu annually. Government revenues come largely from the sale of stamps and coins, trust income and worker remittances. The total population is approximately 10,000 people, and roughly half live on the main island of Funafuti.

A substantial amount of income is received annually from an international trust fund established in 1987 by Australia, New Zealand and the United Kingdom and also supported by Japan and South Korea. This fund has grown from AU$17 million initially to over AU$35 million in 1999. The US government is also a major revenue source for Tuvalu, which provides payments relating to a 1988 treaty on fisheries. In an effort to reduce its dependence on foreign aid, the government is pursuing public sector reforms, including privatisation of some government functions and personnel cuts of up to 7 percent. In 1998, Tuvalu began deriving revenue from use of its area code for "900" lines and in 2000, from the lease of its ".tv" Internet domain name. Royalties from these new technology sources could increase substantially over the next decade. With merchandise exports only a fraction of merchandise imports, continued reliance will be placed on fishing and telecommunications licence fees, remittances from overseas workers, official transfers, and investment income from overseas assets.

Tuvalu as a small economy has difficulty compiling even basic economic data. The only economic statistics available from the Ministry of Finance and Economic Planning were estimates of the balance of payments (1998-2003) and GDP (1996-1998). The National Accounts for Tuvalu were last compiled in 1999 for the years 1996 to 1998 funded by AusAID[12]. Following this the National Accounts were revised again in 2003 based on the worksheets and manuals archived in Statistics New Zealand. Based on the revised statistics, Tuvalu's GDP has been increasing over the last 7 years (see Figure 3). GDP at factor costs dipped in 1997, possibly affected by damages caused by Cyclones Gavin, Hina and Keli, which caused a loss of an estimated AU$1 million.

Figure 3: Annual GDP of Tuvalu, 1996-2002



Source: Tuvalu National Statistics Office

[12] Ministry of Finance and Development. September 1999. Tuvalu National Accounts Report. Ministry of Finance and Development, Tuvalu.

5.2. Literature Review – Economic Impact of Droughts

There are no streams or rivers in Tuvalu, and the groundwater source is unsuitable for human consumption due to saltwater intrusion and human pollution. Most water needs must be met using rainwater catchment systems and desalination plants. Although Tuvalu has an annual average rainfall of 3,500 mm irregular short periods of drought persist and have serious consequences. Just a short period of a few weeks without rain can lead to water shortages. A particularly severe drought in 1999 led to the purchase of a desalination plant from Japan. Increasing water storage capacity is a priority to alleviate water shortages from future El Niño and drought events.

There have been no official assessments made of the impacts of drought on Tuvalu, although there is widespread recognition of the damaging effects across many sectors. Very little data exists on the economic impact of natural disasters generally. To allow comprehensive economic analysis of the impacts of natural disasters in general, and drought in particular, better baseline data and data on economic impacts needs to be collected.

The assessment reports that do exist in Tuvalu focus on the impacts of cyclones, such as damage to subsistence food crops and housing during Cyclone Keli in 1998. A list of cyclones that have affected Tuvalu between 1972 and 2004 is provided in Appendix 8. While Tuvalu does not experience frequent cyclones, the low-lying (maximum height of 4.6 metres above sea-level) and narrow land area of its atolls makes the population particularly vulnerable to those cyclones that do hit the country. Storm surge and high waves have the potential to cause massive destruction to coastal areas and shoreline erosion. In the past, saltwater intrusion into vegetables gardens has caused extensive damage to the subsistence economy.

Two interesting analyses of cross-sectoral disaster impacts have been undertaken in Tuvalu. First, a consultant from New Zealand made an assessment of the social and psychological impacts of a man-made disaster, which consisted of a fire at Motufoua Secondary School in Vaitupu. Second, an assessment of the extent of coastal erosion caused by Cyclone Gavin was made, including estimates of the cost of rehabilitation. These two assessments demonstrate that innovative approaches are being undertaken in Pacific Island Countries to try to assess the environmental, social and psychological impacts of disasters, even though there is no systematic methodology employed for each disaster.

5.3. Impact on Fisheries Sector

This section estimates the economic impact of droughts on the fisheries sector in Tuvalu using the guidelines developed in phase one of this research project (see Tool 1). As recommended in the guidelines, the analysis is split into an assessment of the fisheries sector generally, and a drought impact assessment.

Limited data was available. Most of the baseline data used in this report was gathered from the Food and Agriculture Organisation and the Tuvalu Department of Fisheries. Data on the impacts of drought were gathered from interviews with the stakeholders in the fisheries sector.

5.3.1. Fisheries Sector Without Droughts

Tuvalu has a very small land area of only 26 km^2. Its most valued natural resources are contained in its Exclusive Economic Zone (EEZ), which covers almost 900,000 km^2 of the Pacific Ocean. The country has the highest EEZ per capita of any developing South Pacific Island Country.

Most of the fishing activity in Tuvalu is at the subsistence level. Subsistence fisheries contributed US$1.06 million to GDP in 1996 in real values, accounting for 9.6 percent of GDP. This value marginally increased to US$1.09 million in 2002 but accounted for only 6.4 percent of GDP. The FAO estimated that, in 1999, 94 people were employed in primary fisheries, 312 in secondary fisheries, and 1,118 people in subsistence fisheries. Census data suggest that 74 percent of households in Tuvalu participate in reef fishing and 63 percent in ocean fishing. The National Fishing Corporation of Tuvalu (NAFICOT) has carried out commercial fishing using two launches provided to Tuvalu in 1991 using Japanese grant-aid. The company sells its catch through a small fish retail outlet in Funafuti and participates in the operation of the outer island fishery centres.

Tuvalu generates substantial revenue from fishing licences, which averaged US$10 million per annum between 1999 and 2002. These revenues are highly volatile as they depend on external factors beyond Tuvalu's control. In 2003 for instance, revenues from fish licences declined very sharply to only US$1.5 million (Tuvalu National Budget, 2005). The volatility of fish licence revenues poses serious budget forecasting challenges to the Tuvalu Government. Tuvalu relies on the patrol boat vessel provided by the Australian Government under a defence cooperation agreement and the Forum Fisheries Agency (FFA) for the management and enforcement of fishing limits within its EEZ (Draft Tuvalu National Development Plan). Revenue from fish licences does not appear in Tuvalu's GDP statistics, but is captured in its Gross National Product as factor income from abroad.

Summary statistics on Tuvalu's fisheries sector are outlined in Table 14.

Table 14: Summary Statistics – Tuvalu's Fisheries Sector Without Droughts

Information	Data Needed	Tuvalu's Fisheries Sector	Source
Infrastructure	Number of fisheries enterprises in affected area	National Fisheries Corporation of Tuvalu, plus numerous subsistence fisheries	Department of Fisheries
Production	Type and quantity of production	Revenue from fishing licences was $10 million per annum between 1999 and 2002. Subsistence fisheries contributed $1.09 million (2002)	Department of Fisheries. FAO.
Importance	Contribution of fisheries sector to GDP and employment	In 2002 subsistence fisheries accounted for 6.4 percent of GDP	FAO
Ownership	Public / private	Mostly private enterprise	Department of Fisheries
Location	Rural / urban	Both urban and rural based fisheries	Department of Fisheries
Employment	Number employed	94 people employed in primary, 312 in secondary, and 1,118 in subsistence fisheries	FAO
Quality of infrastructure	Quality of fisheries infrastructure	Data not available	
Furniture and equipment	Furniture and agriculture equipment	Data not available	
Costs of replacement	Costs of replacement of infrastructure and stock	Data not available	
Cost of service supplied	Costs of any fisheries services supply	Data not available	

5.3.2. Impact of Drought on the Fisheries Sector

There is very little official data that can be used to estimate the impacts of drought on the fisheries sector in Tuvalu, forcing the analysis to rely on the observations of those working in the sector. The disaster impacts are summarised in Table 15. It is not a comprehensive assessment, due to the limited data and time available for the analysis.

Direct Impacts: Stakeholders in Tuvalu noted no direct impacts of droughts on the fisheries sector.

Indirect Impacts: The Manager of the National Fisheries Corporation of Tuvalu (NAFICOT) observed that drought creates problems getting enough ice for fish storage and fish processing, thereby disrupting production and reducing income between February and June each year. He also mentioned the adverse effects of the El Niño phenomenon on tuna catch rates, which led to a fall in the number of foreign fishing fleets and fishing agreements since 2002.

Intangible Impacts: Stakeholders in Tuvalu noted no intangible impacts of droughts on the fisheries sector.

Table 15: Assessment of Impact of Drought on Tuvalu's Fisheries Sector

Type of Impact	Impact	Estimated Value	Source
Direct Impacts	None mentioned		
Indirect Impacts	Loss of income from fish processing due to water shortages	Data not available	NAFICOT
	Loss of income from foreign fishing licences	Data not available	Department of Fisheries
Intangible Impacts	None mentioned		
Total Impact	Includes only impacts for which data was available and monetary value could be estimated	Not available	

5.4. Impact on Health Sector

This section estimates the economic impact of droughts on the health sector in Tuvalu using the guidelines developed in phase one of this research project (see Tool 1). As recommended in the guidelines, the analysis is split into an assessment of the health sector generally, and a drought impact assessment.

Limited data was available. Most of the baseline data used in this report was gathered from the Tuvalu Department of Health. Data on the impacts of drought were gathered from interviews with the stakeholders in the health sector.

5.4.1. Health Sector Without Droughts

There is one hospital in Tuvalu, which is run by the Tuvalu government and based in the main atoll of Funafuti. It is supported by health clinics in the outer islands. In 2002, the hospital treated approximately 8,000 outpatients and 600 inpatients. The hospital employs 45 staff members, including doctors, a dentist, nurses and assistants. In 2002, total health expenditure as a percentage of GDP was estimated at 5.4 percent.

UNICEF estimates that in 2002, 93 percent of Tuvalu's total population was using improved drinking water sources and 88 percent of the total population was using adequate sanitation facilities. Life expectancy at birth is 60 years for men and 61.4 years for women. The World Health Organisation estimates child mortality per 1,000 at 72 for males and 56 for females. The 2002 Tuvalu Health Department Annual Report points out that some diseases such as tuberculosis and HIV/AIDS are on the increase. There is also a rising trend in the incidence of non-communicable diseases such as diabetes, heart disease and hypertension.

Key statistics on Tuvalu's health sector are summarised in Table 16.

Table 16: Summary Statistics – Tuvalu's Health Sector Without Droughts

Information	Data Needed	Tuvalu's Health Sector	Source
Infrastructure	Number of health care facilities in affected area	One hospital	Department of Health
Ownership	Public / private	Hospital run by government	Department of Health
Location	Rural / urban	Hospital based in Funafuti	Department of Health
Number of inhabitants	Number of patients	7,928 outpatients and 613 inpatients (2002)	Department of Health
Employment	Number of staff	7 doctors, 14 nurses, 1 dentist, 1 laboratory technician, 2 pharmacists, 7 assistants, one radiographer, 12 hospital employees (2002)	Department of Health
Coverage	Coverage provided by health institutions	Data not available	
Type of housing	Traditional / semi-modern / modern	Data not available	
Quality of buildings	Quality of health care facilities	Data not available	
Furniture and equipment	Furniture, and medical and non-medical equipment	Data not available	
Costs of replacement	Costs of replacement of infrastructure and equipment	Data not available	
Cost of service supplied	Cost of medical services, hospital room charges, average wages	Data not available	
General indicators	Morbidity rate, disease incidence, under-nutrition rates, infant and maternal mortality rates	In 2002, infant mortality rate of 19.2. In 2003, under 5 mortality rate of 51. In 2002, under 5 mortality rate of 0 and maternal mortality rate of 0. High incidence of non-communicable diseases such as diabetes, heart disease and hypertension. 5% of infants with low birth weight (average 1998-2003)	UNICEF, WHO, Tuvalu Department of Health

5.4.2. Impact of Drought on Health Sector

There is very little official data that can be used to estimate the impacts of drought on the health sector in Tuvalu, forcing the analysis to rely on the observations of those working in the sector. The disaster impacts are summarised in Table 17. It is not a comprehensive assessment, due to the limited data and time available for the analysis.

Many officials working in Tuvalu's health sector suggested that acute respiratory infections (ARIs), viral illnesses, skin diseases, septic sores, cholera, diarrhoea and typhoid are all exacerbated by water shortages and sanitation problems during droughts in Tuvalu.

Table 17: Assessment of Impact of Drought on Tuvalu's Health Sector

Type of Impact	Impact	Estimated Value	Source
Direct Impacts	Damage to health care facilities, buildings and equipment	Not applicable	
	Costs of deaths and injuries	Not applicable	
Indirect Impacts	Cost of treating population affected by increased incidence of communicable diseases (resulting from environmental conditions during drought) e.g. ARIs, viral illnesses, skin disease, diarrhoea, septic sores	Data not available	Department of Health
	Cost of treating population affected by disease outbreaks caused by drought e.g. cholera outbreak (1991), typhoid outbreak (2003)	Data not available	Department of Health
Intangible Impacts	None mentioned		
Total Impact	Includes only impacts for which data was available and monetary value could be estimated	Not available	

5.5. Cost-effectiveness of the Funafuti Desalination Plant

There are no streams or rivers in Tuvalu, and the groundwater source is unsuitable for human consumption due to saltwater intrusion and human pollution. Although Tuvalu has an annual average rainfall of 3,500 mm, irregular short periods of drought persist and have serious consequences. Just a short period of a few weeks without rain can lead to water shortages.

DRM measures in Tuvalu that mitigate the impacts of drought include desalination plants, maintenance and improvement of rainwater catchment systems, basic health, nutrition and sanitary programmes, improved forecasting of droughts, and education and awareness programmes. The desalination plant was considered to be the DRM measure most appropriate for consideration using cost-benefit analysis.

A particularly severe drought in 1999 led to the purchase of a desalination plant from Japan. The desalination plant is the main source of water supply for Funafuti during droughts. The desalination plant involved initial investment costs of US$90,000 and incurs high operating costs of roughly AU$30,000 per month (Tuvalu PWD). These costs are borne by the Tuvalu Public Works Department, which heavily subsidises production. Maintenance of rainwater catchment systems is not subsidised, and hence there are few incentives for private individuals to invest in repairing their personal guttering and water storage facilities. There are also potential externality costs such as pollution from disposal of concentrated brine solution, transportation and electricity generation. Other health externality costs may occur in the form of health problems if filters are not replaced regularly and water quality is compromised.

Insufficient information was gathered to conduct a cost-benefit analysis of this DRM measure. This rough assessment suggests that the choice of a desalination plant to provide water during droughts may not be the most cost-effective option for Tuvalu. The breakdown of costs is given in Table 18 and has been used as an example in the cost-benefit analysis toolkit.

Table 18: Costs of Desalination Plant in Tuvalu

	Direct Costs		Externality costs	Further details
Item	**Fixed costs**	**Annual variable costs**		
Desalination plant	AU$140,000			Purchase, transport and set-up costs
Labour		AU$16,882		Fortnightly pay of the four watermen
Labour (overtime)		AU$32,191		
Electricity		AU$52,903		
Pump		AU$39,060		
Transport		AU$52,080		Usually seven water deliveries per day
Maintenance		AU$120,000		Maintenance of filters and other equipment
Other direct costs		AU$46, 968		
Brine pollution costs			Not valued	Pollution from disposal of concentrated brine solution
Energy and transportation pollution costs			Not valued	Pollution from transportation and electricity generation
Potential health costs			Not valued	Potential health risks if filters not replaced regularly and water quality compromised
Total	**AU$140,000**	**AU$313,116 p.a.**		

6. Vanuatu

Research in Vanuatu involved meetings with stakeholders in Efate to investigate the impacts of earthquakes and cyclones, in particular the effects of the 2002 earthquake and Cyclone Ivy in 2004. Further details of these meetings are given in Appendix 1.

6.1. The Vanuatu Economy

Vanuatu is a developing country with a population of just over 200,000 and a per capita GDP of US$1,276. The growth rate of GDP has not kept pace with the increase in population. Measures of poverty indicate that Vanuatu has been falling behind other Pacific Island Countries. In 1997 the Vanuatu government adopted a comprehensive reform programme, which aimed to improve governance, investment, economic growth, and social reforms and alleviate poverty in rural areas. Vanuatu's overall economic performance has been constrained by a number of factors, including poor economic management and governance, weak social service delivery, a rapidly growing population and regulatory barriers. The Vanuatu economy is heavily dependent on agriculture, tourism, fisheries and livestock and all these sectors are very sensitive to extreme weather conditions and natural disasters.

6.2. Literature Review - Economic Impact of Cyclone Ivy, Cyclone Uma and 2002 Earthquake

An additional constraint on development is the adverse impact of a wide range of natural disasters, which are common in Vanuatu. Vanuatu is located in a very weather-sensitive zone in the Pacific. The South Pacific convergence zone and the inter-tropical zones create hot and wet conditions. Vanuatu experiences on average 2.6 cyclones per year and can expect a cyclone-free year once every seven years. Vanuatu has about fifteen active volcanoes and regularly experiences earthquakes.

The impact of natural disasters in Vanuatu appears to have been underestimated in government assessments. There is awareness of the possible impacts among policy makers but the lack of resources and capacity prevents government from undertaking comprehensive assessments of natural disaster impacts. For those assessments that are conducted, different ministries provide reports of damages in their respective sectors and this information is collated and put together as national reports. These assessments are for the purpose of prioritising government and donor funding allocations for immediate relief needs. Since 2000, with the assistance of SOPAC, the Vanuatu government has established a NDMO. This office, though under-staffed and under-resourced, is making attempts to coordinate disaster impact assessment reports.

Vanuatu is prone to earthquakes. The largest earthquake recorded to date in Port Vila occurred at 17:22 hours GMT on 2 January, 2002. The shock measured M_s 7.3 (M_w 7.1) on the Richter Scale and the focus was located by the local network in Vanuatu at 17.763°S and 167.850°E, about 45 km west of Port Vila at a depth of 18 km below the sea floor. The earthquake was followed by a tsunami, which did not cause any major damage. Riskman (2003) provided actual and relative figures for losses of housing, public buildings and infrastructure associated with the Port Vila earthquake of January 2002, as detailed in Table 19. The 2003 report on "Catastrophe Insurance Pilot Project' provided a historical record of earthquake-related events in Vanuatu (see Appendix 9).[13]

[13] Shorten, G. et al. 2003. Catastrophe Insurance Pilot Project, Port Vila, Vanuatu: Developing Risk-Management Options for Disasters in the Pacific Region. Report prepared for World Bank Office, Sydney and AusAID Canberra.

Table 19: Estimates of Insured and Uninsured Damage from 2002 Port Vila Earthquake

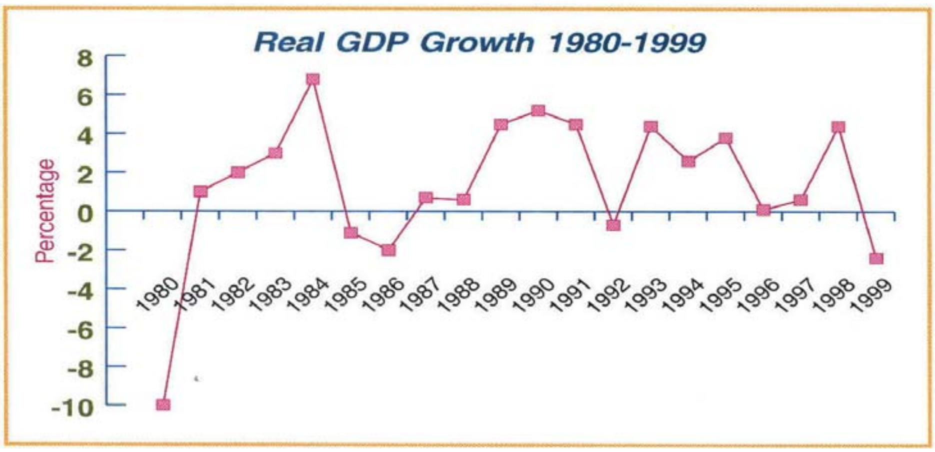
Estimated Damage	Cost (AU$)
Total insured commercial claims	$6,010,735
Total insured domestic claims	$2,355,798
Insured damage	$8,366,533
Total uninsured public buildings	$1,000,000
Total uninsured infrastructure	$1,000,000
Uninsured damage	$2,000,000
Total damage	$20,733,066

Source: Lindsay and Riskman, 2003

Disaster impact assessments in Vanuatu principally focus on the impacts of cyclones, and related flooding and landslides. The most comprehensive impact assessment in Vanuatu was conducted for Cyclone Ivy, which struck the country in February 2004. The total cost of Cyclone Ivy was estimated at VT 427.6 million. Cyclone Ivy affected 50,000 people, and caused one fatality. In the affected communities 90 percent of the water sources and water supply systems, 70 percent of roads, 60 percent of health infrastructure, 112 schools, and over 80 percent of food crops were damaged. The assessment focused on emergency needs, to guide immediate assistance from donor agencies, rather than a comprehensive assessment including indirect damages and macroeconomic impacts. Qualitative assessments of some of the indirect impacts are mentioned but no attempt is made to measure these effects in monetary terms.

The Catastrophe Insurance Pilot Project for Vanuatu included an assessment by local insurance and reinsurance experts of the losses to Vanuatu due to risks caused by natural disasters, such as temporary loss of tourism opportunities (Lindsay and Riskman, 2003)[14]. The estimates were based on the losses from Cyclone Uma in 1987 and the 2002 earthquake in Port Vila. According to this analysis, insured losses of the private sector due to Uma in 1987 amounted to AU$25 million. Damage to government infrastructure was estimated at AU$25 million. Cyclone Uma had a flow-on effect on other government sectors, and particularly affected government finances. The fiscal deficit increased from Vt 635 million (AU$8.5 M) in 1986 to Vt 797 million (AU$10.6 million) in 1987. In 2000 the Vanuatu Reserve Bank reported that the trade balance deficit widened to Vt 279 million (AU$3.7 million), due to the high number of imports to accommodate the reconstruction following Uma. Real economic growth in the 1987/88 period stagnated around 0.6-0.7 percent as shown in Figure 4, possibly as a result of Cyclone Uma.

Figure 4: Real GDP Growth in Vanuatu, 1980-1999



Source: Lindsay and Riskman, 2003

14 Lindsay, K. & Riskman. Preliminary Report and Vanuatu Government Risk Management System. Riskman International Pty Ltd, Port Vila, Vanuatu.

6.3. Impact of Cyclone Ivy on the Agriculture Sector

This section estimates the economic impact of Cyclone Ivy on the agriculture sector in Vanuatu using the guidelines developed in phase one of this research project (see Tool 1). As recommended in the guidelines, the analysis is split into an assessment of the agriculture sector without the disaster, and a disaster impact assessment.

Limited data was available. Most of the baseline data used in this report was gathered from the Vanuatu Department of Agriculture and the Food and Agriculture Organisation (FAO). Data on direct impacts was gathered from NDMO impact assessments and qualitative information on indirect and intangible impacts was gathered from interviews with stakeholders in Port Vila, Vanuatu.

6.3.1. Agriculture Sector Without Cyclone Ivy

Agriculture is the mainstay of Vanuatu's economy and engages about 80 percent of the population. Subsistence agriculture continues to be the major component of agricultural activities. Copra is the leading cash crop accounting for about one third of the country's exports, followed by timber, beef and cocoa. Exports of kava and forest products have continued to increase over the last five years. The Vanuatu government has made the agricultural sector a priority for economic and social development, with emphasis on improving the productivity of small-hold farmers in the production of traditional crops. The Vanuatu government aims to improve access to land, credit and other incentives.

The last agricultural census was conducted in Vanuatu in 1991. The limited data available on Vanuatu's agricultural sector is summarised in Table 20.

Table 20: Summary Statistics of Vanuatu's Agriculture Sector Without Cyclone Ivy

Information	Data Needed for Agriculture Sector	Data for Vanuatu's Agriculture Sector	Source
Infrastructure	Number of agricultural enterprises in affected area	Data not available	
Production	Type and quantity of production	Exports of cocoa, coffee, copra, timber, beef. Large subsistence sector.	Department of Agriculture
Importance	Contribution of agriculture sector to GDP and employment	Agriculture, fisheries and forestry accounted for 23% of GDP (1999). Large subsistence sector.	Asian Development Bank
Ownership	Public / private	Data not available	
Location	Rural / urban	Mostly rural	Department of Agriculture
Employment	Number employed	Data not available	
Quality of infrastructure	Quality of agriculture infrastructure	Data not available	
Furniture and equipment	Furniture and agriculture equipment	Data not available	
Costs of replacement	Costs of replacement of infrastructure and stock	Data not available	
Cost of service supplied	Costs of any agriculture services supply	Data not available	

6.3.2. Impact of Cyclone Ivy on the Agriculture Sector

Earthquakes, cyclones and floods cause extensive damage to agricultural infrastructure and crops. Natural disasters affect current and future production capacity. The data was generally insufficient to estimate the monetary value of direct and indirect impacts of Cyclone Ivy. Instead the general categories of impact noted by stakeholders in the agricultural sector are outlined in Table 21.

Table 21: Assessment of Impact of Cyclone Ivy on Vanuatu's Agriculture Sector

Type of Impact	Impact
Direct Impacts	Damage to subsistence crops Damage to commercial crops Damage to livestock Damage to agricultural infrastructure and equipment Damage to rural training centres Damage to agricultural and farm land
Indirect Impacts	Loss of income from agricultural production Increased operating costs in agricultural sector Costs of debris removal in agricultural sector

6.4. Impact of Cyclone Ivy on the Tourism Sector

The economic impact of Cyclone Ivy on the tourism sector in Vanuatu could not be systematically assessed due to the limited data available. Instead, this section simply provides baseline data on the tourism sector gathered from the Vanuatu Department of Tourism.

6.4.1. Tourism Sector Without Cyclone Ivy

Tourism has been identified by the Government of Vanuatu as an important sector and one that has potential to be a major foreign exchange earner, and generate employment and income for local communities. In 2000, tourism accounted for about 40 percent of GDP and generated about Vt 8.3billion in revenue. It is estimated that the government collected more than Vt 977 million in direct taxes from the tourism sector in 2000. Tourism generates about 75 percent of all foreign exchange earned by Vanuatu. An estimated 6,200 people are employed in the tourism industry, mostly in the capital Port Vila. In the December quarter of 2003, tourist arrivals totalled 14,326 showing an increase of 10.5 percent over the same quarter of 2002. Cruise ship arrivals increased by 13.2 percent compared with the December quarter of 2002. Australia continues to be the major source of tourists to the country, accounting for 59 percent of tourist visitors in 2003.

6.4.2. Impact of Cyclone Ivy on the Tourism Sector

The impacts of Cyclone Ivy on the tourism sector could not be systematically assessed due to the limited data available.

6.5. Cost-effectiveness of DRM Measures

The team struggled to find examples of DRM measures in Vanuatu that could be easily used as examples for the cost-benefit analysis toolkit. A Canadian International Development Assistance project for 'Capacity Building for the Development of Adaptation Measures in Pacific Island Countries' (CBDAMPIC) is relocating three pilot communities to adapt to climate change, including vulnerability to extreme weather events, such as cyclones. The research team was not able to collect the information needed for a cost-benefit analysis of these DRM projects.

RESULTS

7. Recommendations

Capacity Building

1. NDMOs require strengthened capacity generally, in terms of physical, financial and human resources.
2. More specifically, capacity building and training is needed in economic analysis appropriate to disaster impact assessments and cost-benefit analyses within NDMOs and other relevant government departments.

Integrated Comprehensive Hazard and Risk Management

3. NDMOs need to develop closer links with Ministries of Finance and Economic Planning, Statistics Offices, and other relevant government departments, in order to achieve comprehensive and coordinated disaster impact assessments.
4. The Comprehensive Hazard and Risk Management (CHARM) process needs to develop further, in particular to incorporate economic considerations with DRM into national development planning strategies.

Improved Data Collection

5. Pacific Island Countries need to expand the scope of the current practice of initial damage assessments, and start collecting data on long-term indirect impacts of natural disasters, and intangible effects, such as environmental and psychosocial consequences.
6. National focal points (NDMOs and national statistics offices may be the most appropriate) should gather and maintain historical records of past natural disaster impacts and relevant base line data.
7. Pacific Island Countries need to identify options for improving capacity in data collection appropriate to each individual country, such as tapping into sources of traditional knowledge on disaster impacts, establishing points of contact for community data collection and building up record holdings on DRM measures.
8. Additional in-depth case studies of post-disaster economic impact assessments and cost-benefit analyses of DRM Measures should be undertaken in the Pacific region to complement this study. Primary data collection from affected stakeholders and community-based participatory research will be necessary to conduct thorough analyses, which were not possible within the scope of this research project.
9. Where feasible, development and use of Computable General Equilibrium (CGE) models in bigger Pacific Island Countries such as Fiji, Vanuatu, Solomon Islands, Tonga and Samoa would help to study the economy-wide impacts of natural disasters.

Dissemination and Further Development of Guidelines and Toolkit

10. Dissemination of the Guidelines and Toolkit developed in this research project should take place, as planned, at the 12th Pacific Regional Disaster Management meeting in Papua New Guinea in June 2005.
11. The Guidelines and Toolkit should be amended with contributions from users as they gain experience from applying the methodology around the Pacific region.

8. Conclusions

The research team sees the principal value of this project in the development of the framework, which can be used to improve data on the impact of natural disasters, and assess the relative effectiveness of DRM measures, thereby making the allocation of resources for DRM more valuable and efficient. The guidelines for estimating the economic impact of natural disasters, and the accompanying toolkit for assessing the costs and benefits of DRM measures have been developed in conjunction with stakeholder meetings to ensure that the economic tools developed are appropriate to the needs of decision makers in Pacific Island Countries. Further development and amendment of the tools will be necessary, as users gain experience applying the methodology around the Pacific region and provide their own contributions and feedback. Members of the research team will begin the process of dissemination with a presentation of the research findings at the 12th Pacific Regional Disaster Management meeting in Papua New Guinea in June 2005.

The team faced difficulties in conducting analyses of the economic impacts of natural disasters on development in the Pacific and the cost-effectiveness of DRM measures due to the lack of comprehensive and readily available appropriate historical data. The limited analysis that could be undertaken with the incomplete data available suggests that natural disasters have had adverse economic impacts on development in the Pacific over the last twenty years. The case studies of Fiji, Niue, Tuvalu and Vanuatu have shown that natural disasters have caused extensive direct damage to physical assets, significant indirect effects on production and income, and serious intangible impacts, such as environmental damage and psychological trauma.

Due to the lack of easily available data, a complete cost-benefit analysis of a DRM measure could not be conducted for any of the case study countries. The limited analysis that was undertaken suggests that greater emphasis on hazard and risk management can reduce the costs of disaster response and recovery. However, decisions to allocate resources to DRM are frequently not based on careful consideration of the resulting costs and benefits. Funds are often not invested in DRM measures in order to cut costs in the short term, without a careful analysis of the present value of the stream of benefits in avoided disaster damages that will arise in the long term. If and when resources are allocated for DRM measures, the most cost-effective options are frequently not chosen.

Despite the serious negative impacts of natural disasters in the Pacific, there is no systematic collection of comprehensive data on these effects. Historical records of the impact of past natural disasters are scarce in Fiji, Niue, Tuvalu, and Vanuatu. After a large-scale natural disaster, PICs typically respond by assessing immediate short-term impacts, focusing on deaths and injuries, and direct damage to assets and infrastructure. These immediate damage assessments are conducted to provide governments and aid donors with estimates of the amount of funds required to address immediate needs. Long-term indirect losses in the flows of goods and services, macroeconomic effects, and non-market impacts such as environmental damage and psychosocial effects are frequently omitted from disaster impact assessments in the Pacific.

The lack of data on disaster impacts is partly caused by: weak and under-resourced National Disaster Management Offices (NDMOs); little coordination between national planning offices, statistics offices and NDMOs; and, limited integration of Comprehensive Hazard and Risk Management (CHARM)[15] into national development planning. These problems lead to uncoordinated and unmethodical data collection. Assessments are done through different departments and record keeping is seldom centralised. The establishment of NDMOs and integration of the CHARM process are relatively recent developments, and there is still significant room for development and improvement.

There is awareness among disaster managers in the region of the need for more accurate, comprehensive, systematic and consistent information on disaster impacts, in order to increase support for DRM among policy makers, senior government officials and international donors. This would also help governments to develop appropriate national and sectoral policies, particularly for reconstruction, mitigation and preparedness.

One of the factors holding back the Pacific region has been the lack of standard tools available to assist Pacific Island Country decision makers. However, if the tools developed in this research project are to be utilised by

[15] In Fiji and Vanuatu, DRM is being mainstreamed into national development planning processes through the Comprehensive Hazard and Risk Management (CHARM) process.

decision makers in the future, they must be supported by: capacity building for disaster management institutions (particularly NDMOs); training in economic analysis; continued integration of the CHARM process; and strengthened links between NDMOs, Ministries for Finance and Economic Planning and Statistics Offices. The creation of NDMOs in most Pacific Island Countries is a welcome development and has the potential of becoming an important institution in the assessment of the impacts of natural disasters on development. However, many NDMOs face serious constraints in terms of physical, financial and human resources. If NDMOs are to play a critical role in improving the data on economic impacts of natural disasters they will require strengthened capacity and high-level political support. The standard methodology developed in this research project will help to provide guidance on economic analysis, but some of the more complicated aspects of disaster impact assessments and cost-benefit analysis are beyond the current capacities and resources of Pacific Island Countries without a programme of capacity building and training.

The scope of post-disaster impact assessments needs to expand to include long-term indirect effects on development and intangible impacts, such as environmental and psychosocial consequences. There was awareness in the countries visited of the wide range of impacts of natural disasters, but few countries have included these effects in comprehensive assessments because of the lack of capacity in economic analysis. As the standard of data improves over time, a system of regional and national focal points should keep historical records of the impacts of past natural disasters and relevant base line data. NDMOs and national statistical offices may be the most appropriate places to store data nationally. Pacific Island Countries need to identify options for improving capacity in data collection appropriate to each individual country, such as tapping into sources of traditional knowledge on disaster impacts, establishing points of contact for community data collection and building up record holdings on DRM measures.

Given the limited analysis that was possible within this research project, additional in-depth case studies of post-disaster economic impacts and the costs and benefits of DRM measures should be undertaken in the Pacific region using the guidelines and toolkit developed here. The tools can then be amended with contributions from users as they gain experience from applying the methodology. The research team sees this project as the first step on a long journey needed to improve decision-making on the efficient and effective allocation of resources for DRM.

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APPENDIX 1

Details of Meetings during Country Visits to Fiji, Niue, Tuvalu and Vanuatu

Details of Meetings during Country Visits to Fiji, Niue, Tuvalu and Vanuatu

Fiji

Biman Prasad, Atu Kaloumaira and Emily McKenzie held meetings with the following people in Suva:

Name	Position	Department / Organisation
Mr. Tui Fagalele	Principal Research Officer	National Disaster Management Office
Mr. Sakiusa Tubuna	Acting Chief Economist	Department of Agriculture
Ms. Nilima Lal	Manager	Economic Statistics Division, Bureau of Statistics
Mr. Vula Vakacegu	Deputy Chief Executive Officer	Public Works Department
Dr. Lesi Korovavala	Acting Chief Executive Officer	Ministry of Home Affairs, Immigration and National Disaster Management
Mr. Joeli Rokovada	Director	National Disaster Management Office
Ms. Asenaca Bainivualiku	Research Officer	Department of Education
Ms. Manisha Prakash	Statistics Officer	Department of Education

Atu Kaloumaira and Emily McKenzie visited Labasa on the island of Vanua Levu during 15-16 March 2005. Meetings were held with the following people during the visit:

Name	Position	Department / Organisation
Mr. Pita Betevua	Acting Divisional Education Officer (Northern)	Department of Education
Mr. Ken McIntosh	Manager	Fiji Sugar Corporation
Ms. Sharma Nand	Labasa Town Clerk	Labasa Town Council
Mr. Tomasi Ledua	Water Supply Supervisor	Public Works Department
Mr. Hemant Charan	Hydrology Officer	Public Works Department
Mr. A.Q. Yucogo	Hydraulics Officer	Public Works Department
Mr. Rama Panikar	Water Supply Officer	Public Works Department
Dr. Ami Chandra	Director Health Services (Northern)	Department of Health
Mr. Kalisito Biaukula	Principal Agricultural Officer (Northern)	Department of Agriculture
Mr. Rajendra Raj	Senior Officer for Land Use (Northern)	Department of Agriculture

Emily McKenzie visited Nabouciwa village in Nakelo, Tailevu, on 7 February 2005 to view a comprehensive flood mitigation and village planning project. Meetings were held with the village community in Nabouciwa, Lagisoa Delana one of the community leaders who was involved with the flooding mitigation project, and Eliki Malodali a Provincial Government Officer in Nausori.

Niue

Biman Prasad, Atu Kaloumaira and Emily McKenzie visited Niue during 21-25 February 2005. Meetings were held with the following people during the visit (including meetings in Nadi, Fiji and Samoa during the travel to and from Niue):

Name	Position	Department / Organisation
Mr. Rajendra Prasad	Director	Fiji Meteorological Service
Mr. William Paterson	Lead Highway Engineer	World Bank
Ms. Sisilia Talagi	Secretary to Government	Prime Minister's Office
Mr. Deve Talagi	Director	Department of Works
Mr. Crossley Tatui	Head	Department of External Affairs
Ms. Ida Talagi-Hekesi	Director	Department of Tourism
Mr. Sionetasi Pulehetoa	Manager	Niue Meteorological Service
Mr. Brandon Pasisi	Director	Department of Agriculture, Forestry and Fisheries
Mr. Sauni Tongatule	Director	Department of Environment
Mr. Sunloy Liuvaie	Economist	Department of Economic Planning, Development and Statistics
Ms. Maria Tongatule	Acting Chief of Police	Police Department
Mr. Robert Tongiamana	Police Chief / National Disaster Management Officer	Police Department
Ms. Tiva Toeono	Director	Department of Education
Dr. Asu Pulu	Acting Director	Department of Health
Mr. Pita Vakaafi	Environmental Health Officer	Department of Health
Ms. Ketiligi Feveti	Principal Nurse Officer	Department of Health
Mr. Bob Talagi	Manager Health Services	Department of Health
Mr. David Poihega	Climate Change Project Coordinator	Department of Finance
Ms. Sonya Talagi	Member	Chamber of Commerce
Mr. Steve Jefferson	Member	Chamber of Commerce
Mr. Terry Coe	Member	Chamber of Commerce
Dr. Giovanni Deodato	WHO Representative	World Health Organization
Mr. Taito Nakalevu	Climate Change Adaptation Officer	South Pacific Regional Environment Programme

Tuvalu

Emily McKenzie visited Tuvalu 25 November – 7 December 2004. Meetings were held with the following people during the visit:

Name	Position	Department / Organisation
Mr. Sumeo Silu	Disaster Coordinator	National Disaster Management Office
Dr. Tekaai Nelesone	Director	Department of Health
Ms. Lillian Falealuga	Secretary General	Tuvalu Red Cross
Mr. Tomu Hauma	Training Officer	Tuvalu Association of NGOs (TANGO)
Mr. Itaia Lausaveve	Director	Department of Agriculture
Mr. Mataio Tekinene	Director	Department of Environment
Mr. Pusinelli Laafai	Acting Secretary	Department of Works and Energy
Ms. Valisi A. Tovia	Curriculum Officer (Acting Director)	Department of Education
Ms. Temukisa Hauma	Head Teacher	Nauti Primary School
Mr. Ampelosa Tehulu	Deputy Director	Public Works Department
Mr. Kelesoma Saloa	Coordinator	International Waters Programme
Mr. Panapasi Nelesone	Secretary to Government	Office of the Prime Minister
Mr. Niko Apinelu	Research Officer	Fisheries Department
Mr. Taukiei Kitara	Project Officer	TANGO
Ms. Hilia Vavae	Director	Meteorological Department
Ms. Hellani Tumua	Administrative Officer	AusAID
Mr. Malie Lototele	Director	Economic Research and Policy Division, Ministry of Finance and Economic Planning
Mr. Kilisimasi Setoga	Health Statistician	Department of Health
Mr. Tupulaga Poulasi	Fisheries Officer	Department of Fisheries
Mr. Satalaka Petaia	Manager	National Fisheries Corporation of Tuvalu
Mr. Tuilava S. Uofa	Fisheries Information Officer	Department of Fisheries
Mr. Levi Telii	Asset Manager (Acting Deputy Director)	Public Works Department

Vanuatu

Biman Prasad, Atu Kaloumaira and Emily McKenzie visited Vanuatu 4 – 11 November 2004. Meetings were held with the following people during the visit:

Name	Position	Department / Organisation
Mr. Steven Tahi	Director General	Ministry of Lands and Natural Resources
Mr. Sylvain Kalsakau		Reserve Bank of Vanuatu
Mr. Pedro Loughman	Acting Director	Agriculture Department
Mr. Job Esau	Director	National Disaster Management Office
Mr. Holi Simon	Secretary General	Vanuatu Red Cross
Mr. Chris Ioan		Department of Geology, Mines and Water Resources
Mr. Erickson Sammy	Hydrologist	Department of Geology, Mines and Water Resources
Mr. Tony Tevi	Water Resources Planner	Department of Geology, Mines and Water Resources
		Department of Finance and Economic Planning
Mr. Kalparam Gershom	Engineer	Department of Rural Water Supply
Mr. Alick Daniel		Department of Rural Water Supply
Mr. James Selwyn	Planning Officer	Department of Planning
Mr. Johnson	Director	Public Works Department
Mr. Willie Watson		Public Works Department
Mr. Dennis Alvos		Public Works Department
Mr. Kensy Josef		Public Works Department
Mr. Jimmy Mangawai		IFIRA Wharf & Stevedoring 1994 Ltd
Mr. James Selwyn		Physical Planning Office
Mr. Jerry Sampson		Physical Planning Office
Mr. Koran Wilfred		Ministry of Trade, Industries, Foreign Affairs and Tourism
Mr. Avio Niki Roberts	Senior Planner	Ministry of Trade, Industries, Foreign Affairs and Tourism
Mr. Anthony Brown		Law student – ex-director of National Disaster Management Office in the Cook Islands

APPENDIX 2

Inventory of Relevant Documents in Fiji, Niue, Tuvalu and Vanuatu

Inventory of Relevant Documentary Materials

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Appendix 3

Natural Disasters in the Pacific Island Region, 1994 – 2004

Natural Disasters in the Pacific Island Region, 1994 – 2004

Year	Location	Disaster Type	Population Affected	Lives lost	Estimated cost	Notes
1994	Papua New Guinea: Rabaul	Volcano	50,000	3		Buried much of Rabaul Town
	Fiji	Tropical Cyclone Thomas				Minor damage
	Niue	Drought	1,200		NZ$ 2 million	Major crop losses
1995	Fiji	Tropical Cyclone Gavin	3,500	25	US$ 18.3 million	
	Vanuatu	Volcanic eruption				Environmental damage
1996	Papua New Guinea: Manam I Madang	Volcano	3,000	17		
	Fiji	Tropical Cyclone June				Minor damage
	Papua New Guinea	Landslide		38		
	Palau	Bridge collapse			US$ 7.2 million	Affected transport between major islands
	Niue	Bushfires	100		NZ$ 50,000	Forestry damage
	Vanuatu	Tropical Cyclone Beti			Vt 3 million	Damaged shelters and food gardens
1997	Papua New Guinea: Milne Bay	Tropical Cyclone Justine	15,000	8		Housing and crop damage on atoll islands mainly
	Papua New Guinea: Nationwide	El Nino Drought	3,158,961	380	US$ 80 million +	
	Solomon Islands	El Nino Drought				
	Fiji	El Nino Drought	400,000		US$ 60 million	Agriculture in 75% of the country affected. Impact on food and water supplies, schools etc.
	Fiji	Tropical Cyclone Gavin	14,000	7	US$ 26 million	Building and crop damage
	Tonga	Tropical Cyclone Hina			T$ 18.2 million	Building and crop damage
	Tonga	Tropical Cyclone Ron	500		T$ 1.1 million	Housing and building damage on Niuafo'ou Island
	Guam	Typhoon				

Year	Location	Disaster Type	Population Affected	Lives lost	Estimated cost	Notes
	Federated States of Micronesia	Typhoon				
1998	Papua New Guinea: Ramu R, Madang	Floods	38,000	28		
	Papua New Guinea: Sepik R. East Sepik	Floods	23,000	0		
	Papua New Guinea: Aitape, Sandaun	Tsunami	12,427	2,227		
	Samoa	Tropical Cyclone Tui	1,143	1	SAT 2,506,602	6 houses damaged, power and communications disrupted, Food crops destroyed
	Samoa	Drought and bushfire			SAT 402,722	Forests and agricultural crops destroyed
	Tonga	Tropical Cyclone Cora	77,000		T$ 19.6 million	Housing and agricultural sector damage
	Niue	Tropical Cyclone Dovi	100		NZ$ 1 million	Structural damage to wharf only
	Vanuatu	Tropical Cyclone Katrina			Vt 800 million	Housing and schools, agriculture, water supply and health facilities
	Federated States of Micronesia	El Niño Drought	103,000			Water supplies and agriculture affected
	Marshall Islands	El Niño Drought				
	Tuvalu	Drought	10,000		AU$ 1.5 million	
1999	Papua New Guinea: Mid Fly, Western	Floods	10,000			
	Fiji	Tropical Cyclone Dani	2,000	12	US$ 2 million	Housing, business, agriculture damage – mainly by flooding
	Vanuatu	Tropical Cyclone Ela	28,600	5	Vt 700 million	Housing, agriculture, schools and health facilities damage
	Vanuatu	Earthquake & Tsunami	5,000	10		Housing and crop damage from earthquake, tsunami and landslides
2000	Papua New Guinea: Pangia, S Highlands	Thunderstorms	400+	1		Houses and gardens destroyed

Year	Location	Disaster Type	Population Affected	Lives lost	Estimated cost	Notes
	Papua New Guinea: Laloki, Central	Floods	1,000			Food gardens destroyed
	Papua New Guinea: Bougainville & Buka, N Solomons	Tsunami & Flood	1,600			Houses and food gardens destroyed
	Papua New Guinea: E New Britain	Earthquake	100,000		Kina 14 million	Infrastructure and property damage
	Papua New Guinea: W New Britain	Volcanic Ash Fall	3,750			House and crop destruction
	Papua New Guinea: S Highlands	Floods	16,000			Destruction of infrastructure
	Papua New Guinea: Bereina, Central	Floods	500+			
	Papua New Guinea: Morobe	Landslide	5	2		
	Papua New Guinea: Long I, Madang	Flood	1,900			
	Fiji	Coup and subsequent mutiny				
	Tonga	Tropical Cyclone Mona	65,000		T$ 4.2 million	Agriculture damage
	Vanuatu	Tropical Cyclone Iris				Housing and agriculture damage
	Fiji	Floods	5,000	4		Minor damage
2001	Papua New Guinea: Mumeng, Morobe	Floods	400			Infrastructure destroyed
	Papua New Guinea: Madang Town	Explosion (Contaminated kerosene)	60+	5		
	Vanuatu	Tropical Cyclone Paula		1		Housing and agriculture damage
	Fiji	Tropical Cyclone Paula Storm Surge	7,000	1		Housing damage

Year	Location	Disaster Type	Population Affected	Lives lost	Estimated cost	Notes
	Tonga	Tropical Cyclone Paula	20,000		T$ 700,000	Tourist resort damage
	Vanuatu	Volcanic eruption	1,700 +			Water supply contamination, respiratory problems, crop damage
	Samoa	Floods	5,000 directly, 28,000 indirectly		SAT 11 million	Houses and commercial buildings damaged. Lifelines (roads, bridges, water supply, hydro power stations) damaged and supplies interrupted.
	Palau	Tropical Cyclone Utor	11,000		US$ 4 million	Homes destroyed, communications, transportation and utilities systems disrupted
	Tonga	Tropical Cyclone Waka	68,000		T$ 104 million	470 houses destroyed. Food supplies, power system health and sanitation damage
	Tuvalu	Boarding school fire	36	18	AU$ 500,000	Affected almost every family in the country
	Guam	Earthquake				
2002	Papua New Guinea: Wewak, East Sepik	Earthquake	5,000	4		Building damage
	Papua New Guinea: Mt Pago, W New Britain	Volcano	13,000			Lifelines disrupted, major bridge destroyed by mudflow, homes affected by flooding. Major evacuations affected agriculture.
	Papua New Guinea: Ramu R, Madang	Floods				Houses affected
	Papua New Guinea: Wantuat, Morobe	Earthquake & Landslide	138	36		Village destroyed
	Papua New Guinea: Milne Bay	Mild El Nino drought	35,000			Reduced food security
	Vanuatu	Hailstorm	3,000		Vt 800 million	500 houses destroyed. Agricultural, infrastructure and water supply damage
	Federated States of Micronesia	Tropical Cyclone Mitag	8,000			Damage to housing and agriculture
	Guam	Tropical Cyclone Pongsona				
	Federated States of Micronesia	Tropical Cyclone Chata'an	1,000	47		Damage to housing and crops. Many landslides

Year	Location	Disaster Type	Population Affected	Lives lost	Estimated cost	Notes
	Guam	Tropical Cyclone Chata'an	1,600		US$ 60 million	Damage to housing, agriculture and utilities
	Vanuatu	Earthquake	1,100			Housing, schools and churches damaged
	Tuvalu	Tidal surge	50		AU$ 20,000	Flooded all low lying areas
2003	Papua New Guinea: Sepik R, E Sepik	Floods	4,365			
	Tuvalu	Tropical Cyclone Ami	27		AU$ 6,000	Coastal damage
	Solomon Islands: Rennell & Bellona	Tropical Cyclone Beni	2,010			Housing and agriculture damage
	Fiji	Tropical Cyclone Ami	60,000	15	FJ$104.4 million	Housing, infrastructure and agriculture damage
	New Caledonia	Tropical Cyclone Erica	1,000 +			Housing and agriculture damage
	Solomon Islands: Tikopia and Anuta	Tropical Cyclone Zoe	1,678			Housing, schools, clinics and agriculture damaged. Water supplies affected
	Tonga	Tropical Cyclone Eseta	15,000		T$ 1.9 million	Housing, harbour facilities and resort damage
	Papua New Guinea: S. Highlands	Landslide		13		Housing and crop damage
	Papua New Guinea: Bukawa, Morobe	Floods	1,197			
	Papua New Guinea: Madang Town	Internally displaced	13,000			
	Federated States of Micronesia	Tropical Cyclone Lupit	2,000			Damage to housing, water supplies and crops
	American Samoa	Floods and landslides				
2004	Papua New Guinea: Simbu	Landslides				Highlands Highway – the main transport link – disrupted. Cash crop movement stopped

Year	Location	Disaster Type	Population Affected	Lives lost	Estimated cost	Notes
	Papua New Guinea: Pamu R. Madang Markham R, Morobe	Floods				Major bridges destroyed or damaged. Cash economy disrupted.
	Tuvalu	Fire	16		AU$ 6,000	
	American Samoa	Tropical Cyclone Heta				
	Samoa	Tropical Cyclone Heta	Total		SAT 90 million (US$ 35 million)	50+ houses destroyed, Wind damage to houses, crops, utilities, and coastal ecosystems. Wave damage to roads, culverts and seawalls as well as depositing debris across roads and in coastal villages.
	Niue	Tropical Cyclone Heta	1,300	1	NZ$37.7 million	Whole country affected. Damage to housing, hospital, commercial buildings, crops, utilities, and transport systems.
	Wallis & Futuna	Tropical Cyclone Heta				Damage to power supplies and agriculture
	New Zealand	Floods			NZ$ 180 million	Housing, transport systems, utilities and agriculture affected
	Tonga	Tropical Cyclone Heta	1200		T$ 950,000	Housing and agriculture sector damage
	Fiji	Storms and Floods	36,500	23	FJ$ 3 million	
	Vanuatu	Tropical Cyclone Ivy	54,000	2	VT 427.6 million	Housing, agriculture, schools, health facilities and water supply system damage
	Federated States of Micronesia	Tropical Cyclone Sudal	12,000			Damage to housing, public and commercial buildings, crops, utilities

Appendix 4

Tropical Cyclones in the South West Pacific, 1980-2001

Tropical Cyclones in the South West Pacific, 1980-2001

Season	Dates	Name	Max. Intensity	Areas Affected
1979-1980	10-13 Dec	Ofa	Storm	Wallis, Niue
	2-5 Jan	Peni	Hurricane	Southwest Viti Levu, Fiji
	3-5 Feb	Rae	Storm	No land area
	12-15 Feb	Ruth	Gale	No land area
	22-28 Feb	Simon	Hurricane	Queensland
	23-25 Mar	Sina	Storm	Fiji
	26-29 Mar	Tia	Storm	Futuna
	1-6 April	Wally	Gale	Fiji
1980-1981	11-15 Jan	Arthur	Hurricane	Western Viti Levu
	31 Jan - 3 Feb	Betsy	Gale	Niue, Tonga
	8-14 Feb	Cliff	Hurricane	Vanuatu, New Caledonia
	21-23 Feb	Daman	Storm	Southern Cooks
	20-23 Mar	Fran	Storm	Southern Cooks
1981-1982	19-27 Dec	Gyan	Hurricane	West of Vanuatu
	25-31 Jan	Hettie	Hurricane	South West Viti Levu, Fiji
	28 Feb - 3 Mar	Isaac	Hurricane	Tonga
1982-1983	31 Oct – 7 Nov	Joti	Storm	Vanuatu
	9-14 Nov	Kina	Gale	No land areas
	10-16 Dec	Lisa	Storm	South-eastern Cook Islands
	23-29 Jan	Mark	Hurricane	Fiji
	26-28 Feb	Prema	Gale	Northern Cooks
	24 Feb – 2 Mar	Oscar	Hurricane	Fiji
	7-15 Mar	Rewa	Hurricane	Tahiti and Society Islands
	22-28 Mar	Nisha	Hurricane	Tahiti
	24-28 Mar	Sarah	Hurricane	Fiji
	29 Mar – 3 Apr	Tomasi	Hurricane	Niue
	8-14 Apr	Veena	Hurricane	Tahiti
1983-1984	28-31 Dec	Atu	Gale	Vanuatu
	14-22 Jan	Grace	Hurricane	No land areas
	2-6 Feb	Beti	Storm	New Caledonia, Loyalty Is.
	4-10 Feb	Harvey	Storm	New Caledonia
	16-20 Mar	Cyril	Gale	Fiji
1984-1985	26-28 Dec	Unnamed	Gale	Tuvalu
	11-14 Jan	Drena	Storm	Tonga
	14-21 Jan	Eric	Hurricane	Fiji
	14-19 Jan	Nigel	Hurricane	Vanuatu, Fiji
	26-30 Jan	Freda	Hurricane	Southern Cooks
	3-8 Mar	Gavin	Storm	Fiji
	10-18 Mar	Hina	Hurricane	Solomons, Fiji
1985-1986	5-14 Feb	Ima	Hurricane	Southern Cooks
	5-8 Feb	June	Hurricane	Tahiti
	8-12 Feb	Keli	Storm	Vanuatu, Fiji, Tonga
	3-9 Feb	Lusi	Gale	Vanuatu
	6-9 Mar	Alfred	Storm	Vanuatu, Loyalty Islands
	10-14 Apr	Martin	Storm	Fiji
	15-22 May	Namu	Hurricane	Solomons
1986-1987	21-25 Nov	Osea	Hurricane	Fiji
	14-18 Dec	Patsy	Storm	Vanuatu
	22 Dec – 1 Jan	Raja	Hurricane	Fiji, Futuna
	26 Dec – 5 Jan	Sally	Hurricane	Cook Islands

	15-21 Jan	Tusi	Hurricane	Samoa, Southern Cooks
	4-11 Feb	Uma	Hurricane	Vanuatu
	6-11 Feb	Veli	Gale	Vanuatu
	1-7 Mar	Wini	Hurricane	No land areas
	8-12 Mar	Yali	Hurricane	No land areas
	22-26 Apr	Zuman	Storm	Manua Group
1987-1988	7-14 Jan	Anne	Hurricane	Vanuatu, New Caledonia
	25 Feb – 4 Mar	Bola	Hurricane	Vanuatu, Fiji
	28 Feb – 3 Mar	Cilla	Hurricane	Rurutu, Tubai
	8-16 Apr	Dovi	Storm	Vanuatu
1988-1989	16-25 Dec	Eseta	Gale	Fiji
	31 Dec - 5 Jan	Delilah	Hurricane	New Caledonia, Vanuatu
	2-7 Jan	Fili	Storm	Niue
	6-9 Jan	Gina	Gale	Samoa
	8-19 Feb	Harry	Hurricane	New Caledonia
	23 Feb – 2 Mar	Ivy	Hurricane	Vanuatu, New Caledonia
	23-28 Feb	Judy	Hurricane	Southern Cooks
	29 Mar – 3 Apr	Kerry	Storm	Fiji, Tonga
	6-12 Apr	Lili	Hurricane	New Caledonia
	4-9 May	Meena	Gale	Queensland
	6-8 May	Ernie	Gale	No land areas
1989-1990	18-20 Dec	Felicity	Storm	Queensland Peninsula
	31 Jan – 3 Feb	Nancy	Hurricane	Australia
	30 Jan – 7 Feb	Ofa	Hurricane	Tuvalu, Wallis, Tokelau, Samoa, Tonga. Niue
	12-19 Feb	Peni	Hurricane	Cook Islands
	3-8 Mar	Hilda	Storm	No land areas
	16-25 Mar	Rae	Storm	Rotuma, Fiji
1990-1991	24-30 Nov	Sina	Hurricane	Fiji, Tonga
	7-13 May	Lisa	Storm	Marginally Vanuatu
1991-1992	14-21 Nov	Tia	Hurricane	Solomons, Vanuatu
	4-13 Dec	Val	Hurricane	Tokelau, Samoa
	5-13 Dec	Wasa	Hurricane	Northern Cooks, French Polynesia
	14-17 Dec	Arthur	Storm	French Polynesia
	5-13 Jan	Betsy	Hurricane	Vanuatu, New Caledonia
	5-9 Feb	Cliff	Storm	French Polynesia
	14-17 Feb	Daman	Hurricane	Vanuatu
	25 Feb – 5 Mar	Esau	Hurricane	Vanuatu, New Caledonia
	4-15 Mar	Fran	Hurricane	Wallis, Futuna, Fiji
	16-18 Mar	Gene	Storm	Vanuatu, New Caledonia, French Polynesia
	25-29 Mar	Hettie	Gale	Cook Islands
	28 Apr – 2 May	Innis	Storm	Southern Solomons, Vanuatu
1992-1993	6-13 Dec	Joni	Hurricane	Tuvalu, Fiji
	26 Dec – 5 Jan	Kina	Hurricane	Fiji, Tonga
	23 Dec – 5 Jan	Nina	Hurricane	Australia, Solmons, Tuvalu, Wallis, Tonga
	31 Jan – 5 Feb	Lin	Hurricane	Samoa
	4-14 Feb	Oliver	Hurricane	Coral Sea
	5-9 Feb	Mick	Gale	Tonga, Southern Fiji
	12-16 Feb	Nisha	Storm	Southern Cooks, French Polynesia
	15-18 Feb	Oli	Gale	Fiji

	24 Feb – 9 Mar	Polly	Hurricane	Western New Caledonia, Eastern Australia
	25 Mar –1 Apr	Prema	Hurricane	Vanuatu, New Caledonia
	11-21 Mar	Roger	Storm	Solomons, New Caledonia
1993-1994	28 Dec - 20 Jan	Rewa	Hurricane	Solomons, Vanuatu, New Caledonia
	20-30 Jan	Sarah	Hurricane	Vanuatu, New Caledonia
	23-28 Feb	Theodore	Hurricane	New Caledonia, Loyalty Is.
	20-28 Mar	Tomas	Hurricane	Tuvalu, Vanuatu, Fiji
	24-29 Mar	Usha	Storm	Solomons, New Caledonia
1994-1995	13-18 Nov	Vania	Storm	Vanuatu
	1-3 Jan	William	Storm	South Cook Islands
	3-8 Mar	Violet	Hurricane	No land areas
	17-21 Apr	Agnes	Hurricane	No land areas
1995-1996	16-18 Jan	Yasi	Gale	No land areas
	28-31 Jan	Celeste	Storm	No land areas
	16-18 Feb	Dennis	Gale	Queensland
	7-13 Mar	Ethel	Storm	Queensland
	9-10 Mar	Zaka	Gale	No land areas
	10-13 Mar	Atu	Gale	No land areas
	20-28 Mar	Beti	Hurricane	Vanuatu, New Caledonia
1996-1997	22-26 Nov	Cyrill	Gale	No land areas
	20-30 Dec	Fergus	Hurricane	Solomons, Vanuatu
	1-9 Jan	Drena	Hurricane	New Caledonia
	13-16 Jan	Evan	Hurricane	Samoa
	20 Jan –1 Feb	Freda	Storm	Fiji
	9-12 Feb	Gillian	Gale	Queensland
	16-22 Feb	Harold	Storm	No land areas
	23-24 Feb	Ita	Gale	Queensland
	2-12 Mar	Gavin	Hurricane	Tuvalu, Fiji
	4-22 Mar	Justin	Hurricane	Queensland
	12-17 Mar	Hina	Hurricane	Tonga, Fiji, Futuna
	17-19 Apr	Ian	Gale	Fiji
	3-5 May	June	Storm	Fiji
	10-15 Jun	Keli	Hurricane	Tuvalu, Wallis, Northern Tonga
1997-1998	6-12 Oct	Lusi	Storm	Fiji
	31 Oct – 5 Nov	Martin	Hurricane	Northern Cooks, French Polynesia
	18-21 Nov	Nute	Storm	Solomons
	24-28 Nov	Osea	Hurricane	Northern Cooks, French Polynesia
	6-11 Dec	Pam	Hurricane	Cook Islands
	1-8 Jan	Roon	Hurricane	Samoa, Wallis, Tonga
	3-8 Jan	Susan	Hurricane	Vanuatu, Fiji
	1 Jan - mid Feb	Katrina	Hurricane	Australia
	24-27 Jan	Tui	Gale	Samoa
	31 Jan – 2 Feb	Urusila	Storm	French Polynesia
	1-4 Feb	Veli	Storm	French Polynesia
	30 Jan – 5 Feb	Wes	Gale	Northern Cooks
	17-25 Mar	Yali	Hurricane	Vanuatu
	28 Mar – 5 Apr	Zuman	Hurricane	Vanuatu
	19-27 Apr	Alan	Gale	French Polynesia
	28 Apr –1 May	Bart	Gale	French Polynesia
1998-1999	24-27 Dec	Cora	Hurricane	Wallis, Futuna, Tonga
	15-23 Jan	Dani	Hurricane	Vanuatu

	20-23 Jan	Olinda	Storm	No land areas
	21-25 Jan	Pete	Storm	No land areas
	9-13 Feb	Ella	Gale	Solomons, New Caledonia
	17-21 Feb	Frank	Hurricane	New Caledonia
	26-27 Feb	Gita	Gale	No land areas
	11-19 Mar	Hali	Hurricane	Southern Cooks
1999-2000	7-10 Jan	Iris	Hurricane	Vanuatu
	23-28 Jan	Jo	Hurricane	No landa areas
	23-29 Feb	Kim	Hurricane	French Polynesia
	5-9 Mar	Leo	Storm	No land areas
	7-13 Mar	Mona	Hurricane	Tonga
	15-16 Apr	Neil	Gale	No land areas
2000-2001	20-22 Feb	Oma	Storm	Southern Cooks
	26 Feb – 4 Mar	Paula	Hurricane	Vanuatu, Fiji
	1-5 Mar	Rita	Storm	Tuamotu Archipelago
	5-11 Apr	Sose	Storm	Vanuatu

APPENDIX 5

Floods in the Fiji Islands, 1990-2004

Floods in the Fiji Islands, 1990-2004

Date of Flood Peak	Cyclone Intensity and Location	Flood Description and Areas Affected
1990, 16-30 March	Storm Rae (16-25). Most of the Fiji Group affected. Torrential rain fell over most parts of the country. Hurricane Sina (24-30) affected Southern Viti Levu and Lau.	• Shallow flooding in Vitogo Parade, Lautoka on the 16 (Blong, 1994). • Maximum flood level of 4.33m a.m.s.l in Nausori town on 22 March (PWD, 2000). • Ba River flood peak recorded as 2.42m below the 1931 peak Rarawai Mill probably flooded on the 23 March (Yeo, 1998). • Maximum flood level of 5.49m in Ba 5.93m in Nadi town and 3.03m in Sigatoka (all a.m.s.l and recorded on the 29 March). • Three lives lost due to drowning in flooded rivers, minor damage to crops and vegetation (FMS, 1996a). • Closure of roads and bridges all over the country (FMS, 1997a).
1990, 9 June	Low-pressure system developed and moved over Fiji (4-5th). On the 9th a second trough moved over the Group on the far south.	• Flood peak for the Ba River at Toge recorded at 2100hrs on the 9th. Highest discharge rate for the year at Toge (PWD, 2000).
1990 Nov 24-30	Hurricane *Sina*. Southern Fiji.	• Flood damages amounted to approximately (1998) FJ$33 million for the country (World Bank, 2000).
1991 Jan 10	Shallow low pressure passing southwards to the west of Viti Levu on the 9th.	• Ba River flood peak recorded as 4.22m below the 1931 peak [F] (Yeo, 1998). Rarawai Mill closed due to flooding and the Ba Bridge was closed to all traffic. • Flooding also noted on the King's Road at Tailevu • Roads closed in Labasa (FMS, 1991).
1991 Feb 21	Area of low pressure drifted over the group from the far west.	• Flood peak for the Ba River at Toge recorded at 1600hrs. Highest discharge rate for the year at Toge (PWD, 2000).
1992 Dec 10-11	*Joni*. (hurricane) Yasawas, Mamanucas, Southwestern Viti Levu and Kadavu.	• Ba River flood peak recorded as 3.61m below the 1931 peak [F] on the 10th (Yeo, 1998). Flood peak for the Ba River at Toge recorded at 0500hrs on the 11th. • Maximum flood level of 3.66m a.m.s.l in Nausori town [I] on the 11th (PWD, 2000). Flooding of rivers in Viti Levu, especially the Rewa Delta; • Significant loss of livestock due to flooding (FMS, 1997a). Flood damages amounted to approximately (1998) F$2 Million for the country (World Bank, 2000).
1993 Jan 3	*Kina*. (hurricane) Yasawas, Northern and Eastern Viti Levu, Southern Vanua Levu, Lomaiviti and Southern Lau.	• Ba River flood peak recorded as 0.21m below the 1931 peak [F] Rarawai Mill and entire Ba town on flat flooded. One drowning case was reported in the Ba area (Yeo, 1998). Maximum flood in Ba town was 6.68m a.m.s.l [E]. • Maximum flood level of 4.82m a.m.s.l recorded in Sigatoka town which is the highest on PWD records [H] • Maximum flood level of 6.00m a.m.s.l in Nausori

		town [I] (PWD, 2000) also highest according to PWD's records. • Prolonged heavy rain with a combination of factors including high tide and heavy seas blocked mouths of major rivers resulting in extensive flooding (FMS, 1996a). • Destruction of the Ba and Sigatoka Bridges; almost complete loss of crop in the Sigatoka, Navua and Nausori areas; major loss of livestock (FMS, 1997a). • The heaviest rainfall was centred over eastern Viti Levu. High runoff into the Wainimala river. The Vunidawa Bridge (Wainimala) was overtopped by some 16m. • The Kina flood in the Rewa watershed was large by world standards. Peak discharge at Nausori was estimated at 18,000m^3/s with just over 15,000m^3/s flowing under the Rewa Bridge, and the remainder as sheet flow over the flood plain. The Wainimala branch of Rewa system contributed over half of this with 9,000m^3/s at its peak. • The peak flow at Nausori may be a world record for a catchment of this size (2900km^2) (Raj, 1995). • Approximately $13.7 Million damage in Ba of that $4 Million in the Ba Commercial district and $9.7 Million at the Rarawai Mill (Yeo, 2000a). • Overall flood damage for the country amounted to approximately (1998) F$188 Million (World Bank, 2000).
1993 Feb 17	*Oli*. (gale) Yasawas, Mamanucas, Southern Viti Levu, Kadavu and Ono-I-Lau.	• Navatu flats in the Ba area flooded. (Yeo, 1998). • Some damages to bridges in the Ba and Sigatoka areas (FMS, 1997a).
1993 Feb 26-27	Active trough of low-pressure linked to Tropical Cyclone Polly.	• Ba River flood peak recorded as 1.97m below the 1931 peak [J] Rarawai Mill probably flooded, Shops near the Ba market flooded on the 26th (Yeo, 1998). Maximum flood in Ba town was 6.13m a.m.s.l [E] Maximum flood level of 7.06m a.m.s.l recorded in Nadi town, which is the second highest flood on record for Nadi town [G] on the 27th (PWD, 2000). • Three lives lost; Significant damage to crops, property and disruption to transportation.
1994 Jun 4-5	Weak trough of low-pressure on 2nd. An active trough followed with widespread rain on the 3rd and 4th.	• Ba River flood peak recorded as 5.03m below the 1931 peak [C] (Yeo, 1998).
1994 Nov 13-14	Tropical Cyclone *Vania* traversed to the west of Fiji.	• Severe flooding in Tailevu. The whole valley was flooded causing intensive damage to vegetable farms. • Over 100 hectares of crops and several horses and cattle worth over $250,000 perished during the flooding (FMS, 1995).

1995 Jan 28-30 1995 Mar 16-19	Presence of troughs caused moderate to heavy rainfall. Presence of troughs caused moderate to heavy rainfall.	• Floods in Naitasiri and Rakiraki. Hundreds of people stranded in Naitasiri after a river overflowed. Shops in Tailevu and parts of the Kings Road flooded (FMS, 1996b). • On the 30th the Ba River flood peak was recorded as 5.03m below the 1931 peak [C] (Yeo, 1998). Flood peak for the Ba River at Toge recorded at 1200hrs on the 30th (PWD, 2000). • Flooding in Labasa. • Floods in Nadi damaging over 250 tonnes of cane (FMS, 1996b).
1996 Feb 22	Shallow depression moved just Northwest of Yasawa-i-Rara on the 22nB.	• Flooding in low-lying areas around the country. Schools closed in Ra and parts of the Kings Road were inaccessible. • The Naqali Bridge collapsed. • A couple of bridges in the southwest tip of Vanua Levu were under water (FMS 1997b).
1997 Jan/Feb 19-2 1997 Feb 18-19 1997 Mar 8 1997 April 26	Tropical Cyclones *Evan* and *Freda* and several other low pressure systems dominate Fiji's weather. Tropical Depression *Gavin*. (hurricane) Yasawas, Mamanuca, Western Viti Levu. Trough of low-pressure near	• Flood peak for the Ba River at Toge recorded at 0800hrs on the 27th (PWD, 2000). On the 1st the Ba River flood peak was recorded as 3.57m below the 1931 peak [J] (Yeo, 1998). • Traffic disruption and schools closed in the Western Division. • Several low bridges and roads under water with an Irish crossing in Nadi washed away. • Crushing at the Labasa and Lautoka Mills temporarily suspended (FMS 1998). • Severe flooding in low-lying areas and Labasa (FMS 1998). • Ba River flood peak recorded as 0.51m below the 1931 peak [D, 1993] Rarawai Mill flooded and entire Ba town on flats flooded. Storm surge at Ba coast. One drowning recorded in the Ba area (Yeo, 1998). Approximately $6.0 Million damage in Ba, of that $2-3 Million in the Ba Commercial district and $3-4 Million at the Rarawai Mill (Yeo, 2000a). Maximum flood in Ba was 6.259m a.m.s.l [E] • Maximum flood level of 6.66m a.m.s.l recorded in Nadi town [G] • Maximum flood level of 3.44m a.m.s.l recorded in Sigatoka town [H] (PWD, 2000). • Overall flood damages for the country amounted to approximately (1998)F$35 Million (World Bank, 2000). • Severe flooding in Labasa (FMS, 1997a). • During the cyclone, the Wainimala and Wainibuka tributaries produced the most runoff in the Rewa system because of the high rainfalls in the highlands and on the northern coast. • Below the confluence of the tributaries the main Rewa River was able to contain the maximum 4.52m rise in water level (Terry & Raj, 1999). • Flash flooding and landslides in Eastern and

	Vanua Levu.	South-eastern parts of Viti Levu led to the temporary closure of parts of the Kings and Queens Road (FMS 1998).
1997 May 3-5	*June*. (storm) Significant rainfall over most parts of the Fiji Group.	• During the cyclone, rainfalls were record breaking at Matei airport, causing localised flooding on the northern coast and consequent damage to infrastructure and property. Local hydrologists reported that stream levels for the island were some of the highest in living memory (Terry & Raj, 1999). • Flood damages for the country amounted to approximately (1998) F$1 Million (World Bank, 2000)
1998 Jan 21	*Cora.* (hurricane) All parts of the Group received heavy rainfall.	• Flood peak for the Ba River at Toge recorded at 1700hrs (PWD, 2000).
1999 Jan 19	Frequent succession of westward moving troughs, traversing the country and bringing heavy rain in January. On this occasion one of the easterly waves merged with the SPCZ during its southward migration onto Fiji, with eddies embedded in it, enhancing associated deep convective activity that converged over Fiji.	• Code named 'Manumanu' or 'The Beast'. • Damage estimated in Ba town of approximately $15 Million, of that $7.5 Million was in the Ba Commercial district and $7-8 Million at the Mill (including $2 Million for rehabilitation bank protection works) (Yeo, 2000a). • Damage in Nadi town estimated at $12 Million to the business sector and $2 Million to private vehicles (Yeo, 2000a). • Government estimated agricultural, infrastructural and utilities losses at about $10 Million (Yeo, 2000a). • In another report Yeo (1999) reports losses of $25+ Million due to damages in the commercial and industrial sectors of Ba and Nadi towns. • In Ba, the 1999 event was the third large flood in a space of six years. • The three floods have left a direct damage bill of at least $27 Million. The maximum flood level in Ba town was 6.80m a.m.s.l [E] • Maximum flood level of 7.25m a.m.s.l recorded in Nadi town (highest on record) [G] • Maximum flood level of 3.40m a.ms.l recorded in Sigatoka town [H] (PWD, 2000). • Seven lives lost; $F8 Million allocated by the Government in relief funding. • Severe flooding in Labasa (FMS Reports).
1999 Jan 28-29	Westward moving troughs, traversing the country.	• Flash flood; Nadi worst hit; • Two children drown (FMS Reports).
1999 Feb 12	Westward moving troughs, traversing the country.	• Two brothers drown in a flooded drain in Lautoka (FMS, 2000a).
1999 Apr 19-22	Slow moving and deep low-pressure system in the Tasman Sea.	• Flooding in low-lying areas, people and livestock forced to move to higher ground in the South-eastern and Western parts of Viti Levu, this event coincided with 4m high sea swells and the local high tide (FMS, 2000a).
1999 Sept 22-23	SPCZ lingered to the north of Vanua Levu while a sub-tropical high-pressure system remained	• Flash flooding caused the closure of roads in the Central Division and parts of Nausori were under water (FMS, 2000a).

	south of the Group.	
1999 Dec 6-10	Trough of low pressure prominent in December	• Flooding caused damage to infrastructure in Vanua Levu. • Three people were reported missing in the Central Division, while another drowned while crossing a river in Rakiraki (FMS, 2000a).
2000 Jan 17-24	Two troughs drifted over Vanua Levu and Rotuma. Intensified into a Tropical Depression on 22nd.	• Two bridges washed away in the interior of Ba on the 17th and a bridge collapsed on the 24th (FMS, 2000b).
2000 Feb 16-18	A weak low-pressure system	• Reports of flash floods on the 16th with a man swept away in Lautoka on the 18th (FMS, 2000c)
2000 Mar 17	Trough of low pressure extended over the Group from the Northwest, from the 15th to 18th.	• A man drowned in a flash flood in Nadi. Flooding in other areas of the Western Division (FMS, 2000d)
2000 Apr 15-16	Series of low-pressure systems developed along a trough near Fiji between the 3rd and 16th. One of these formed into a Tropical Depression over the Northern Lau Group on the 13th then further developed into Tropical Cyclone *Neil* on the 16th Areas affected by the cyclone were mostly Kadavu and the Southern Lau Group.	• In the Macuata Province on the 15th, Major flood - Wainikoro, Bucaisau and Qawa Rivers. Labasa Mill flooded. Moderate flood - Wailevu. Minor flood - Labasa River. This flood event was clearly a rare event on the Lagalaga, Wainikoro, Bucaisau and Qawa Rivers. Records are insufficient to determine whether the flood was higher than the 1950 flood on the Wainikoro and Bucaisau Rivers. Though probably the highest in 50 years at the Labasa Mill, it was not a record there. The estimated financial losses associated with flooding of the Macuata Province in April 2000 approached ~F$2.85 million (Yeo, 2001) • Flooding in the Macuata Province and Northern Division caused damage to infrastructure and agriculture (FMS 2000e).
2000 May 2-3	A low-pressure system developed along a trough over the Lomaiviti Group.	• Reports of flooding in the northern and western areas of Viti Levu in the first week of the month resulting in damages to infrastructure (FMS, 2000f).
2000 May 24-25	Active trough of low pressure moved over the Group from the west.	• Flash flooding in Rakiraki with reports of water approximately 2m above the road level (FMS, 2000f).
2000 Jun 16-18	SPCZ north of the Fiji Group moved southwards and was over the Group on the 16th.	• Flash floods in Rakiraki led to a drowning incident (FMS 2000g).
2000 Dec 12	Tropical Depression passed over the Group from the Northwest.	• Flooding in the Western and Eastern Divisions. • Two people drown in Rakiraki (FMS 2000h).
2003	Tropical cyclone	• Flooding in the whole of Northern Division, 19 people died
2004	Heavy rainfall	• Flooding and landslide in the Western and Central Division • 10 people died

APPENDIX 6

Cyclones and Storms in the Fiji Islands, 1972-2004

Cyclones and Storms in the Fiji Islands, 1972-2004

Year	Type of Disaster	Description of Damage	No of deaths	Population Affected	Number of houses lost	Total Estimated Damage (FJ$ million)
1972	Hurricane	Severe damage to central Viti Levu, Rotuma and Eastern Kadavu	20	120,000	4,200	$28m
1973	3 Storms	Moderate damage to parts of Vanua Levu and outer islands	80	35,000	48	$5.8m
1975	2 Hurricanes	Mostly damages to outer islands	NA	20,000	38	$2.5m
1977	Hurricane	Kadavu and Lau group	NA	8,000	15	$0.87m
1978	2 Hurricanes and 1 Storm	Damage mostly confined to small islands	NA	3,000	13	$0.35m
1979	1 Hurricane	Kadavu and smaller islands	53	12,000	46	$3.8m
1980	3 Storms	Parts of Vanua Levu and Viti Levu	22	17,000	124	$6.9m
1981	Hurricane	Vanua Levu and Navua	5	27,000	76	$7.8m
1982	Hurricane	Damage to Viti Levu	3	15,000	38	$0.79m
1985	2 Hurricanes	Severe damage to areas in Viti Levu	26	156,000	6,000	$80m
1986	2 Hurricanes	Damage to both Northern and Western Viti Levu	1	8,600	NA	$28m
1990	2 Hurricanes	Damage to houses and crops in Viti Levu			600	$72m
1992	2 Hurricanes	Confined to Viti Levu				$1.6m
1993	Hurricane	Severe damage to infrastructure	23	28,000	5,540	$200m
1995	Hurricane	Widespread damage throughout Fiji	25	3,500		$36m
1997	Drought	Impact throughout Fiji		40,000		$120m
1999	Hurricane	Flooding	12	2,000		$4m
2000	Rain	Flooding	4			
2001	Hurricane	Storm surges	1			$1.6m
2003	Hurricane	Flooding - Northern Division	19		262	$44m
2004	Rain	Flash flood in Western and Central Viti Levu	10			$23m
Total			**304**	**495,100**	**17,000**	**$667m**

APPENDIX 7

CGE Model Assessment of Economy-wide Impact of Cyclone Ami in Fiji

CGE Model Assessment of Economy-wide Impact of Cyclone Ami in Fiji

Variables	Percentage Change
Private Savings	-1.7580
Private Consumption	-1.7682
Balance of payment surplus	$101.9 (thousands of dollars)
Total government consumption	-1.7906
Total government investment expenditure	-0.6021
Imports	-0.9422
Exports	-1.0434
Consumer price index	-0.9514
Investment price index	-0.5745
Private disposable income	-1.7581
VAT revenue	-1.6056
Income tax revenue	-2.8122
Company tax revenue	-0.8766
Production tax revenue	-2.3473
Excise tax revenue	-1.6689
Tariff revenue	-0.7123
Real GDP	-0.5470
Real GDP Deflator	-0.0370
Real Consumption	-0.8140
Real National Welfare	-0.7050
Labour Market	
Net after tax rural wage rate for unskilled labour	-1.6273
Net urban wage rate for unskilled labour	-0.9555
Wage rate for informal sector labour	-5.5727
Aggregate demand for informal unskilled labour	3.2637

Source: Narayan (2003)

APPENDIX 8

Cyclones in Tuvalu, 1972-2003

Cyclones Affecting Tuvalu, 1972-2003

Year	Date	Tropical Cyclone	Wind speed (knots)
1972	21 November	Bebe	70-100
1990	30 January	Ofa	64
1993	1 January	Nina	55
1997	5 March	Gavin	75
1997	12 March	Hina	50
1997	10 July	Keli	90
2003	12 January	Ami	55

Source: Office of the Prime Minister of Tuvalu

APPENDIX 9

Earthquakes in Vanuatu, 1880-1999

Earthquakes in Vanuatu

1880: The event of 1880 generated a seiche in the Port Vila Harbour that inundated extensive areas of the harbour islands and stranded large number of fish in the vegetated areas well above sea level.

1927: Eyewitness accounts from Port Vila suggest that the largest tsunami experienced there was as a result of the 24th January 1927 event of Ms 7.1 located on South Malekula. The tsunami entered the harbour and apparently caused seiching and flooding of the shoreline up to several metres above the normal tide levels. Its origin and magnitude are uncertain.

1950: An event with a magnitude near 7 occurred about 100 km southwest of Efate.

Between 1961 and 1978, a series of large earthquakes (Ms > 5.5) recorded in the vicinity of Efate ranged up to magnitude 6.0 with an isolated example of Ms 6.5.

1961: A small tsunami was recorded in Port Vila harbour after the 23rd July 1961 (Ms 6.0) event 100 km south of Port Vila.

1965: On 12th August 1965, an Ms 6.3 earthquake in the north of the group was felt with intensity MM7 in Efate.

1974: The 30th June 1974 a Ms 5.7 earthquake occurred about 25 km south of Port Vila, resulting in cracks in newly constructed multi-storey buildings and rock-falls from cliffs in the city.

The ORSTOM-Cornell network began operating in 1978. According to Prevot & Chatelain (1984), only four earthquakes of large magnitude had been recorded in the archipelago since the inception of the network. The largest one was the Mere Lava event near Santo in 1980.

1979: Three events occurred to the west of Efate. The first on the 17th August (Ms 6.1) occurred 35 km off Efate. It was followed nine days later by a second shock (Ms 6.0), some 20 km to the north of the first one.

1980: The largest, 12th May 1980 (Ms 6.1), was the Mere Lava event near Santo that caused relatively major damage but no casualties.

1981: The earthquake of 15th July 1981 (Ms 7.0) occurred approximately 85 km northwest of Efate and was reported to have caused damage in Port Vila. This earthquake is notable for having occurred in an area that had not experienced any large earthquakes in the preceding 75 years. According to Prevot & Chatelain each of the earthquakes was preceded by swarms around the zone where the aftershocks occurred, in areas of characteristically low seismicity, and even to the rear of the arc, east of Efate. The swarms occurred up to eight hours before the main shock, and the aftershock zone expanded quickly over the following days to cover areas 5 to 10 times greater than normal earthquakes of such magnitude. Thus, even though an earthquake of 7th July 1981 was centred some distance offshore of Efate, the region of aftershocks spread onto the island itself.

1999: The 26th November, Mw 7.5 earthquake occurred between the northern tip of Ambrym Island and the south of Pentecost. It was the largest known earthquake to be recorded in that area. Located at a depth of 18 km, it induced a maximum uplift of over 1.2m at the easternmost tip of the island near Pamal and Ulei. This earthquake caused felt intensities of MM6 to 7 on the Mercalli scale, and was the origin of a tsunami, which struck Baie Martelli in South Pentecost, which caused much damage, ten deaths, and several injuries in both Pentecost and Ambrym islands.

Source: Shorten et al., 2003.