ECONOMIC IMPACT OF NATURAL DISASTERS ON DEVELOPMENT IN THE PACIFIC

Volume 2: Economic Assessment Tools

May 2005

This research was commissioned and funded by the Australian Agency for International Development (AusAID). It was managed by USP Solutions and jointly conducted by the University of the South Pacific (USP) and the South Pacific Applied Geoscience Commission (SOPAC).

Volume 2 – Contents

Tool One:
Guidelines for Estimating the Economic Impact of Natural Disasters on Development in the Pacific

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Australian Government

AusAID

USP Solutions

The University of the South Pacific

SOPAC

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Cover photo:

Village damaged by a cyclone in Vanuatu (Source – South Pacific Applied Geoscience Commission).

Guidelines for Estimating the Economic Impact of Natural Disasters on Development in the Pacific

A practical guide for estimating the direct, indirect and macroeconomic impacts of natural disasters, both in the short and long term, on development in the Pacific.

April 2005

Contents

List of Tables

List of Boxes

List of Equations

List of Figures

It is widely recognized that existing data on the impact of disasters are weak, presenting an incomplete and, in parts, highly inaccurate account of their impact. Poor data are a problem in both the developed and the developing worlds.

Benson and Twigg
'Measuring Mitigation'
2004, p15

Foreword

Pacific Island Countries regularly suffer damages, losses and casualties caused by natural hazards, such as cyclones, floods, landslides, droughts, volcanic eruptions, earthquakes and tsunamis. The extent of the impact of these natural hazards on development in the Pacific, however, is not well known. Impact assessments of natural disasters are often incomplete and inaccurate. They are usually conducted immediately after a disaster, within a few weeks, to prioritise relief and rehabilitation needs. Assessments often focus on quantifying direct physical damage to infrastructure in the public sector, and estimating the number of deaths and injuries. Damage to the private sector is frequently ignored. There are rarely follow-up assessments to estimate indirect impacts that can only be ascertained months or years later, such as the effects of the disaster on production and income. Consideration of the macroeconomic, environmental, distributional and psychological impacts of natural disasters is rare.

The need for improved data on the impacts of natural disasters has been widely recognised by disaster risk management practitioners in the Pacific region[1] and elsewhere around the world[2]. Why is this an important area for Pacific Island Countries and international aid donors to address? The lack of comprehensive, systematic and consistent assessments of natural disaster impacts holds back Pacific Island Countries in several important ways: First, it makes it difficult to plan effective post-disaster rehabilitation and reconstruction strategies, and prioritise the needs of different sectors, geographical areas, and demographic groups. Second, it constrains the effective design and implementation of proactive Disaster Risk Management (DRM) measures. Without estimates of disaster impacts it is difficult or impossible to assess the relative merits of various DRM options. The *Toolkit for Assessing the Costs and Benefits of DRM Measures*, which accompanies these Guidelines, can be used to assess whether particular DRM measures are worthwhile investments and to choose the most effective option from a range of alternatives. Such DRM activities can lessen the impacts of future natural hazard events. Third, a consistent methodology for disaster impact assessments allows estimates to be compared across time and regions, which can help to determine whether long-term trends such as climate change are having any effect on the costs of disasters. Improving data on and assessments of disaster impacts should therefore be a high priority for the Pacific region.

Until now, one of the factors constraining the Pacific region from conducting comprehensive, systematic and consistent assessments of natural disaster impacts has been the lack of standard guidelines to assist Pacific Island Country decision makers. These guidelines have been developed to address this constraint by providing direction on disaster impact assessments. The approach is based on the standard internationally accepted methodology for estimating the socio-economic and environmental effects of disasters that was developed by the Economic Commission for Latin America and the Caribbean (ECLAC).

UNECLAC Handbook for Estimating the Socio-economic and Environmental Effects of Disasters

In 2003, the Economic Commission for Latin America and the Caribbean (UNECLAC) produced a 'Handbook for Estimating the Socio-economic and Environmental Effects of Natural Disasters', which is a revised and extended version of the original disaster impact assessment methodology that UNECLAC developed in 1991. The updated Handbook incorporates practical experiences acquired assessing numerous disasters in Latin America and the Caribbean in the 1990s. It has since become the standard internationally accepted methodology for assessing the impact of natural disasters in developing countries. Other areas of the world are adapting the UNECLAC disaster assessment methodology to the needs of their countries, including Asian countries such as Indonesia who have used the methodology to assess the impacts of the devastating tsunami that struck on December 26, 2004 (BAPPENAS, 2004).
The UNECLAC Handbook for Estimating the Socio-economic and Environmental Effects of Disasters can be downloaded from the Provention Consortium website at: http://www.proventionconsortium.org/toolkit.htm.

Box 1: UNECLAC Handbook for Estimating the Socio-economic and Environmental Effects of Disasters

[1] The Asian Development Bank's final report (1991, p11) on DRM in the Pacific recommends that 'more emphasis needs to be given to the study of the economic impact of disasters, evaluating their long-term as well as short-term effects'.
[2] The World Meteorological Organization (2003, Chapter 2, Item 12) recently called for the establishment of an international database that would track the social and economic impacts of tropical cyclones.

The UNECLAC methodology has been adapted within these guidelines for use by Pacific Island Countries, using a simplified approach appropriate to the resource, isolation and other constraints peculiar to Small Island Developing States, and illustrated with examples from Fiji, Niue, Tuvalu and Vanuatu.

The Australian Agency for International Development (AusAID) commissioned these guidelines in response to a call for more reliable data and systematic analyses of the short- and long-term impacts of disasters. It was prepared in collaboration between the South Pacific Applied Geoscience Commission (SOPAC) and the University of the South Pacific (USP).

Acknowledgements

These Guidelines were 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), and managed by USP Solutions.

Thank you to the many people who assisted the research for these guidelines in Fiji, Niue, Tuvalu and Vanuatu, including individuals from government departments, chambers of commerce, private companies, NGOs, and international and regional organisations, who provided valuable information and assistance. Particular thanks to the National Disaster Management Officers who supported and coordinated the research in the case study countries: *fakaue lahi* to Deve Talagi in Niue, *tankiu tumas* to Job Esau in Vanuatu, *fakafatai* to Sumeo Silu in Tuvalu, and *vinaka vaka levu* to Tui Fagalele in Fiji. Thanks also to Alan Mearns and Russell Howorth at SOPAC for their guidance and advice.

Acronyms

ADB	Asian Development Bank
AusAID	Australian Agency for International Development
CGE	Computable General Equilibrium (Model)
CHARM	Comprehensive Hazard and Risk Management
CRED	Center for Research on the Epidemiology of Disasters, Université Catholique de Louvain
DRM	Disaster Risk Management
EIA	Environmental Impact Assessment
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
GDP	Gross Domestic Product
GIS	Geographic Information Systems
HDR	Human Development Report (published by UNDP)
IDP	Internally Displaced Person
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
NSO	National Statistics Office
PIC	Pacific Island Country
PIFS	Pacific Islands Forum Secretariat
PRISM	Pacific Regional Information System
SOPAC	South Pacific Applied Geoscience Commission
SPC	Secretariat of the Pacific Community
SPREP	South Pacific Regional Environment Programme
SPTO	South Pacific Tourism Organisation
UNDP	United Nations Development Programme
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
UNICEF	United Nations Children's Fund
UNPHS	United Nations Public Health Service
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
WTTC	World Travel and Tourism Council

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.
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.
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.
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.
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.

Introduction

Natural hazard events occur frequently in the Pacific Islands region. The most common natural hazards in Pacific Island Countries (PICs) are cyclones, floods, droughts, earthquakes, volcanic eruptions, tsunamis and landslides. These events often cause harm, damage and loss, which can turn a natural hazard into a 'natural disaster' when they overwhelm the community's capacity to cope. Official estimates of disaster impacts, however, do not give the whole story of how disasters affect people in the Pacific. Natural disasters are likely to have major, long-term impacts on the living conditions, livelihoods, economic performance and environmental assets of affected Pacific Island Countries, which are not captured by current damage statistics. Current disaster assessments often omit indirect losses, and consideration of the macroeconomic, environmental, distributional and psychological impacts of natural disasters is rare.

Current Practice of Disaster Impact Assessments in the Pacific

Assessments of the impacts of natural disasters in the Pacific are often very narrow and limited in scope even for major natural disasters such as cyclones, volcanic eruptions and earthquakes. For small-scale disasters, assessments are made on an ad hoc basis. 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. Impacts on the private sector are frequently ignored. Assessments are usually conducted immediately following the disaster to prioritise relief and rehabilitation needs.

Evaluations of indirect costs, and environmental, social and psychological impacts of natural disasters are rare in the Pacific. Occasional reassessments are made of major natural disasters to estimate longer-term impacts, but this is not done on a systematic basis. Assessments of disaster impacts on social sectors, such as health and education, tend to focus on the immediate damage to infrastructure, without assessing the long-term impact on health and education indicators such as disease outbreaks and school attendance rates. Where indirect and long-term impacts of disasters are considered, they are usually quantified rather than valued in monetary terms. Valuation of direct damage is typically limited to estimating the monetary cost of rehabilitation of damaged buildings, subsistence and commercial crops, and economic and social infrastructure. Some assessments of declines in rural economies following a natural disaster have been conducted but on an ad hoc basis.

Damage assessments in the Pacific typically involve collaboration among a wide range of contributors. After a cyclone in Tuvalu a disaster assessment team visits the damaged site to make the assessment. The team comprises representatives from the Red Cross, Police, Public Works, and Agriculture Departments, and the National Disaster Management Office (NDMO). In Vanuatu different Departments (such as Health, Education, Public Works, Agriculture, Water Supply, and the Meteorological Office) do their own assessments and provide briefing reports to the NDMO who compiles an overall damage assessment.

Box 2: Current practice of disaster impact assessments in the Pacific

Impact assessment is the process of identifying the consequences of an action or event. The goal of a natural disaster impact assessment is to identify, and where possible measure in monetary terms, the impacts of a disaster on the society, economy and environment of the affected country or region. Ideally, the assessment should be as comprehensive as possible, attempting to estimate all of the effects of a disaster on every sector of society in both the short and long term. Not only immediate direct damage to infrastructure should be included, but also subsequent indirect impacts, which emerge after the disaster, such as reduced agricultural output or increased operating costs.

Conducting a disaster impact assessment can be a daunting undertaking. Which impacts and sectors should be included? What information needs to be collected? Where should the assessment begin? Where can the information be found? These guidelines steer the reader through the process, explaining the different categories of disaster impacts and sectors to be included, and providing checklists of data requirements, lists of recommended sources, and tables that can ease the process of data collection and analysis. A standard and comprehensive methodology is presented that can help to identify, quantify and value the economic, social and environmental impacts of natural disasters consistently across the Pacific. The guidelines are based on the sectoral methodology developed by UNECLAC (see Box 1), which can be used to estimate the impacts of all types of natural disaster. The tools are supplemented by worked examples from four Pacific Island Countries: Fiji, Niue, Tuvalu and Vanuatu.

The degree of detail that can be achieved in disaster impact assessments by using these guidelines will depend on the availability of information in the country affected. Initially, given the current low standard of data collection on disaster impacts in the Pacific, the level of detail may be limited. Over time, however, it is hoped that these guidelines will give PICs an idea of the baseline and impact data that needs to be collected to improve disaster impact assessments, and adoption will lead to a gradual improvement in the standard over time. The methodology can be used to help all individuals involved in assessments, whether they are government officials, volunteers, NGOs, communities or foreign technical assistants. These guidelines are not a finished product, but should be viewed as work in progress, which can be amended with contributions from users as they gain experience from applying the methodology to natural disasters around the region.

Outline

The following sections in these guidelines explain the methodology that can be used to assess disaster impacts comprehensively, systematically and consistently across the Pacific region. Section 1 gives a broad overview of the assessment procedure and the different steps involved. The following sections describe aspects of the procedure in more detail. Section 2 outlines the different types of impacts that disasters can have, including deaths and injuries, direct damage to physical assets, indirect losses in the flows of goods and services, intangible impacts, and repercussions for macroeconomic variables. Section 3 describes the procedure for sectoral assessments, estimating disaster impacts in social, infrastructure and economic sectors. Checklists of useful information and sources for each sector are provided. Section 4 provides a similar overview of the procedure for assessing cross-sectoral disaster impacts, in other words impacts in areas that affect many different sectors, such as environmental, distributional, psychosocial and governance effects. Finally, Section 5 explains how to bring together the sectoral and cross-sectoral assessments into an overall impact assessment, and how to use and analyse the data to plan reconstruction and DRM activities. For those still thirsty for more information and assistance, at the end of the guidelines there is a list of references that provide additional explanations of more complicated aspects of natural disaster impact assessments. In particular, more detailed information on the assessment methodology can be gathered from the UNECLAC Handbook for Estimating the Socio-economic and Environmental Effects of Disasters (UNECLAC, 2003).

1. Overview of Assessment Methodology

The goal of a natural disaster impact assessment is to identify, and where possible measure in monetary terms, all the impacts of a disaster on the society, economy and environment of the affected country or region. Disaster impacts include direct damage to physical assets, indirect losses in the production of goods and services, alterations to macroeconomic variables, and cross-sectoral effects, such as impacts on environmental and psychosocial conditions. Disasters can also have beneficial effects, such as increased flows of foreign aid or increased income in the construction industry.

There are four main steps to a disaster impact assessment, which are briefly outlined below. The process of collecting data for the assessment should not impose on the relief effort, which has priority in the immediate aftermath of a disaster. Further details on each step are given in subsequent sections.

STEP ONE: Gather background information on the natural hazard event

The first step is to gather information on the natural hazard event; including details on the type of hazard(s) that caused the disaster, and the timing and severity of the hazard event(s). An important initial activity is to determine the geographical area affected by the disaster. Maps, aerial photography, satellite imagery and geographic information systems can be valuable tools for identifying, analysing and demonstrating which areas have experienced different degrees of impact. Field surveys can provide more detailed estimates of damages in the worst affected areas. Depending on the location, hazard and type of impact being assessed, a combination of different survey methods may be appropriate, such as field surveys, household surveys, telephone surveys, in-depth interviews with stakeholders, community focus groups, or meetings with local government departments. The aim of consultation in a disaster impact assessment is to ensure that organisations, communities and individuals are aware of the assessment and support its objectives, and to obtain information on impacts from as wide a range of sources as possible.

STEP TWO: Sectoral assessments

It is often easiest to do an impact assessment on a sector-by-sector basis, so the next step is to determine the sectors that have been affected by the disaster. This methodology categorises sectoral impacts into:

- Social sectors, such as housing, education and health;
- Infrastructure sectors, such as energy, water supply and transportation; and
- Economic sectors, such as agriculture and tourism.

Information on disaster impacts in each sector should be gathered in as much detail as possible and using the same methodology to ensure consistency and non-duplication. Care should be taken not to 'double count' impacts by including them in two sectors. For example, damage to rural roads must be included either in the agricultural sector or in the transportation sector, but not in both sectors because this will give a falsely inflated view of the total damage.

The impacts caused by a natural disaster in each sector should be estimated by comparing the situation that develops after the disaster with the situation that would have occurred without the disaster i.e. the 'with disaster' and 'without disaster' situations. Note that impacts should be assessed in terms of comparisons of scenarios with and without the disaster, rather than a comparison of the situations before and after the disaster, to ensure that only impacts directly resulting from the disaster are included. Otherwise change that would have occurred anyway may be incorrectly attributed to a disaster. It will therefore be necessary to gather information on the situation in each sector before the disaster event, including forecasts of how the sector was likely to have developed if the disaster had not occurred. Information on the post-disaster situation is then collected so that the impact of the disaster can be accurately determined by comparing the 'with' and 'without' scenarios.

For each sector, a distinction should be made between damage to public and private sector assets. The impact on the private and public sectors can then be compared at the end of the assessment, which is useful for designing an appropriate post-disaster rehabilitation and reconstruction strategy. The different impact on the formal commercial and informal subsistence sectors may also be useful. The change in flows of funds and resources into and out of the country resulting from the disaster should also be identified, such as reduced exports, increased imports, external transfers, and national payments generated by increased debt. This information will be useful for estimating the macroeconomic impact of the disaster on the balance of payments and trade.

Wherever possible the population affected by the disaster should be identified in terms of demographic and socio-economic characteristics. This will help to identify the differential impact of the disaster on vulnerable groups, such as women, children and the elderly, or low-income households.

The procedure for sectoral assessments is outlined in more detail in Section 3.

STEP THREE: Cross-sectoral assessments

Disasters often have environmental, distributional, psychosocial and governance effects, which can have repercussions for many sectors of the economy and society. These cross-sectoral impacts also need to be assessed. The methodology is very similar to that for sectoral assessments. Particular care must be taken not to double count impacts included in other sectors. This is a common mistake with cross-sectoral effects such as environmental damage, which is often included under the tourism, health or agriculture sectors. Once again the 'with disaster' situation must be compared to the 'without disaster' situation, to get an accurate picture of disaster impacts.

Valuation of cross-sectoral impacts, such as environmental, in monetary terms is particularly challenging. Further details of methods that can be used to value environmental damage are given in Section 4.1.3.

STEP FOUR: Overall impact assessment

The final step in the assessment is to bring together all the information from the sectoral and cross-sectoral analyses into a summary assessment, which gives an overview of the disaster impacts. The overall assessment also breaks down impacts into important categories, to determine the worst affected sectors, geographical areas and population groups. The overall impact assessment can be extremely useful for clarifying priorities for reconstruction and for identifying possible DRM needs to reduce losses from future natural hazard events.

2. Types of Disaster Impact

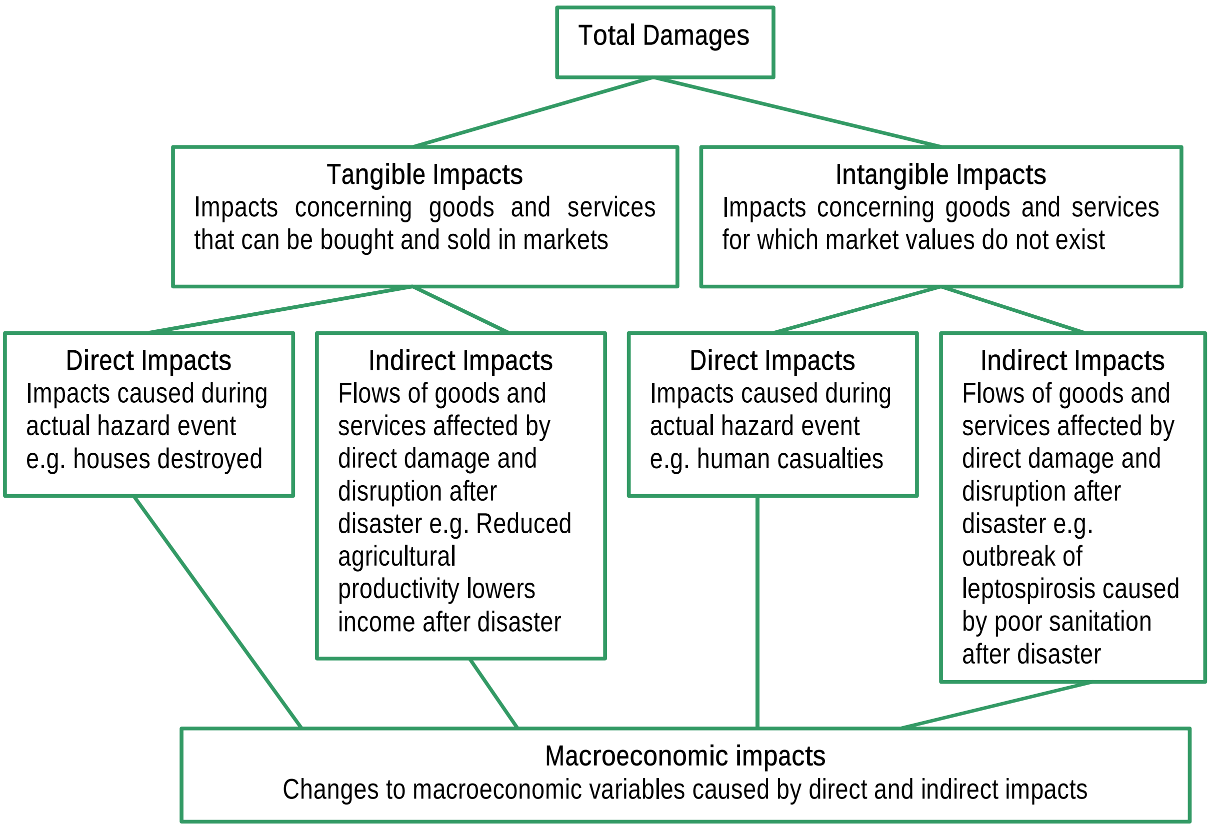
These guidelines obviously cannot outline all possible disaster impacts, as these will vary greatly between Pacific countries and different disasters. What these guidelines can do is simplify the process of identifying disaster impacts by placing them in logical categories. In basic terms, a natural disaster causes three main types of impact: 1) direct impacts caused by a natural hazard during the actual event, 2) indirect impacts in terms of flows of effects that occur over time after a hazard event, and 3) repercussions for macroeconomic variables. It is important to bear in mind that disasters may have positive as well as negative impacts in all of these categories. The assessment should aim to determine the net effect of natural disasters, including both negative and positive consequences.

Typically, disaster impact assessments in the Pacific have focused on estimating the number of deaths and injuries, and assessing the quantity and value of direct damage to physical assets in the public sector. Much recovery effort and political attention in the Pacific typically focuses on restoration of physical damage because it is visible, easily valued, and politically easy to manage. Indirect impacts are often omitted from post-disaster assessments because they are difficult to measure and value, and often only emerge months or years after the disaster. One of the aims of these guidelines is to encourage Pacific Island decision makers to include estimates of indirect disaster impacts, such as losses in production and income, in their assessments.

International experience has shown that natural disasters caused by natural hazards of geophysical origin (such as earthquakes, volcanic eruptions and tsunamis) tend to lead to a high proportion of direct damage to assets and a low proportion of indirect losses in economic flows. Natural disasters caused by hydrological phenomena (such as droughts and floods) tend to cause a low proportion of direct damage, but a high proportion of indirect losses.

Figure 1 shows the categories of direct, indirect, intangible and macroeconomic impacts of natural disasters.

Figure 1: Direct, indirect, intangible and macroeconomic impacts of natural disasters



The rest of this section explains the different categories of disaster impact in more detail, including some tips on methods for valuing impacts in monetary terms.

2.1. Direct impacts

Direct impacts are caused by a natural hazard during the actual event. Direct impacts will occur over different periods of time depending on the type and magnitude of the disaster. During slowly evolving or long-duration events, such as droughts, direct damages may occur over an extended period of months or even years. In contrast, the direct damage of a short-duration disaster, such as an earthquake, may occur only in a matter of minutes. Natural disasters can cause direct damages involving the complete or partial destruction of physical assets in both the public and private sectors. Examples of physical assets that may be damaged by natural disasters include infrastructure, buildings, installations, machinery, final goods, raw materials, equipment, transportation, farmland, harvested crops and irrigation works. Deaths and injuries are also a type of direct impact if they occur during the natural disaster event (see Section 2.1.2).

Direct Damage Caused by Cyclone Heta to Residential Buildings in Niue

Destruction of residential buildings was one of the devastating types of direct damage caused by Cyclone Heta in January 2004. Damage to residential properties is categorised as a direct impact because it occurred during the time that the cyclone was passing Niue, creating vast waves and strong winds that battered buildings along the coast. To assess direct damages to residential buildings, the assessment in Niue began by quantifying the number of damaged residential units that suffered different levels of destructions (e.g. 100% destroyed, 50% destroyed). The value of each residential building was estimated based on replacement costs, using up to date information from the construction industry. The total direct damage to residential buildings in Niue was estimated by summing the estimated values for all units at every level of destruction.

The damage to communities was most severe in the western coastal villages from Hikutavake to Avatele. The Alofi district sustained the most damage to housing and property. All government housing and private homes at the Aliluki housing estate were totally destroyed together with the hospital, Justice and Lands Department, Museum and Cultural Centre, Niue Hotel, and Industrial Centre.

The assessment found that 90% of all housing in Niue (570 occupied and 432 unoccupied) sustained some form of damage. Of the occupied houses, 30 were totally obliterated, and 20 were no longer structurally sound for human occupation. The value of this damage to housing and personal property was estimated at NZ$4.1 million.

Box 3: Direct damage caused by Cyclone Heta to residential buildings in Niue

The different assets and stocks that are directly affected by a disaster in both the private and public sector must be identified, quantified and valued through surveys and field assessments. The small, isolated and dispersed nature of many Pacific Island Countries can make this a difficult, expensive and time-consuming process. When comprehensive surveys are not possible within the time and resources available, direct damage may have to be estimated using averages based on as broad and representative a sample as possible. Each type of affected physical asset must be quantified according to the number of physical units that sustained a particular degree of damage i.e. 'completely destroyed', 'partially destroyed', 'minor damage' and 'unaffected'. For example, quantification of direct damage caused by a cyclone might include the number of pieces of machinery completely destroyed, the number of kilometres of road suffering minor damage and in need of repair, or the tons of harvested crops that can no longer be sold.

Estimating Impacts of Cyclone Heta on Niue's Private Sector

Although the economy of Niue is dominated by public sector activities, there is a small private sector with a diverse range of small businesses, including agricultural producers, local market produce vendors, traders, service providers, tourism operators, carvers and weavers. Niue's assessment of the impacts of Cyclone Heta, which struck Niue in January 2004, included estimates of the impact on the private sector. A survey form was distributed to all business entities in the Niue private sector to assess the impact of Cyclone Heta. The assessment of the private sector showed significant direct damage to buildings, inventory, equipment and tools, and significant indirect losses in terms of lost production and income, debris removal and relocation to temporary sites. Some businesses were totally obliterated and lost all their assets, while the majority suffered significant structural damage to their buildings, which ruined inventory and essential equipment and tools.

Box 4: Estimating impacts of Cyclone Heta on the private sector in Niue

2.1.1. Valuing direct physical damage

A monetary value needs to be placed on direct impacts once they have been identified and quantified. There are a number of alternative methods for valuing direct impacts, which vary in how accurately they represent the real value of the damage. In theory, shadow prices rather than market prices should be used to obtain a close approximation of the value of damage to society. A shadow price is a "price" used in economic analysis to represent a cost or benefit from a good when the market price is a poor indicator of economic value or there is no market at all for that good. Shadow prices correct for distortions such as subsidies and taxes, which affect market prices so that they do not reflect the true social value of a resource. Shadow prices take into account all externalities that affect the well-being of society and correct for distortions in markets, such as taxes and subsidies. Although the use of shadow prices is preferable in theory, the use of market prices is more practical given the amount of information that using shadow prices requires, the number of sectors usually affected by disasters and the short time typically available for damage assessments.

For the purpose of accurately reflecting the impact of a disaster, these guidelines recommend that the value of direct damage should be estimated on the basis of the market price of repairing or replacing the asset with the same characteristics as the original design. Total destruction should be estimated as the cost of replacing the original assets that were damaged at their original location and specifications. Partial damage should be estimated as the cost of repair to original specifications. Ideally, the estimated value of direct damage should reflect the value of the asset's remaining useful life because asset value depreciates over time. This can be achieved by applying depreciation coefficients to reflect the age of the equipment. However, this process may be considered prohibitively difficult given the time and resources available for the assessment.

Alternatively, the value of direct damage can be estimated using reconstruction costs in terms of modernisation in new locations or with improved specifications. For example, the value of a piece of equipment that has been destroyed in a cyclone may be estimated not in terms of the value of the original equipment, but in terms of the cost of replacing it with technologically superior equipment with DRM features making it more resistant to the impact of future cyclones. If this method of valuation is used it should be clearly noted, as it will often lead to an inflated estimate of the real value of the damage.

It may be desirable to use more than one alternative for valuation of disaster impacts to allow assessment results to be used in different ways. Using the replacement cost of the original equipment will give a more accurate picture of the real damage caused, whereas the replacement cost of technically more advanced equipment may provide a more accurate cost of the financial resources required for reconstruction with improved DRM. The two valuation methods give different information, which can be useful for different purposes. The most important aspect is to make very clear the assumptions used when valuing impacts, and the sources of information used to make those assumptions.

Using Alternative Methods to Value Housing Damage Caused by Cyclone Keli in Tuvalu

The assessment of damage caused by Cyclone Keli in 1997 to the island of Niulakita in Tuvalu gave two estimates of the value of direct damage to housing. One estimate was in terms of the value of the damage to the original structures; the second estimate valued the cost of reconstruction with improved cyclone resistant housing. The total cost of damage to housing estimated on the basis of the market price of repairing houses with the same characteristics as the original design was estimated at AU$12,000, while the cost of rebuilding the houses with an improved, cyclone-resistant Tongan design was estimated at 7 times that value: at AU$84,000.

Box 5: Using alternative methods to value housing damage caused by Cyclone Keli in Niulakita, Tuvalu

To estimate the value of disaster impacts, gather illustrative price lists for relevant goods and services, such as the cost of a square metre of construction for housing, or current prices of agricultural products. If, at the time of the assessment, there are no equivalent goods available on the market, you can approximate using the cost of the most similar goods available. Foreign currency values should be converted to the local currency using a single official exchange rate for the date of the disaster.

2.1.2. Intangible direct impacts

Some direct impacts, often called ‘intangible impacts’, are particularly challenging to value in monetary terms because their very nature is difficult to measure and quantify. Examples of intangible direct impacts include death and injury, environmental damage, damage to cultural artefacts, and losses of memorabilia, such as photographs, books, toys and personal original work.

Loss of Historical and Cultural Records caused by Cyclone Heta in Niue

In 2004 Cyclone Heta totally destroyed Niue’s Museum, Cultural Centre and Justice and Lands Department, which led to the loss of 90 percent of the Museum’s archives, and loss of historical records relating to courts, the prison, lands, births and genealogy. It is very difficult to value these records, archives and artefacts as they can not be traded on markets and there is no market price that can be used to approximate their worth. Interviews with people in Niue suggested, however, that these losses are of significant importance to the local population.

Box 6: Loss of historical and cultural records caused by Cyclone Heta in Niue

The value of intangible direct damage is difficult to assess, as it is not reflected in market prices. Frequently intangible losses are not included in estimates of natural disaster impacts because they are considered too difficult to estimate meaningfully. This does not mean, however, that intangible direct impacts are unimportant. Most research shows that people value intangible losses at least as much as their tangible dollar losses, and sometimes, intangible losses are considered more important. Therefore every effort should be made to at least identify, list and, where possible, quantify intangible impacts, so that they are less likely to be ignored in decision-making. Some methods do exist for valuing intangible impacts, which are briefly described in Box 7, while methods for valuing losses of human lives are explained in Box 8, and methods for valuing environmental damage are outlined in Box 15.

Valuing Intangible Disaster Impacts

Difficulties arise in placing monetary values on certain intangible natural disaster impacts, such as environmental damage. Direct market based prices cannot be used to assess the value of these impacts, because no markets exist for these goods and services. There are, however, a variety of non-market valuation methods that can be used to assess the value people attribute to intangible natural disaster impacts. Care is needed when using these methods to estimate the value of disaster impacts, as they can be complicated and time-consuming. If the methods are beyond the time and resource capacities available, simply list the important intangible impacts of a natural disaster in as much detail as possible. The two categories of non-market valuation methods are known as 'revealed preference methods' and 'stated preference methods':

1. Revealed preference methods

Revealed preferences occur when individuals make choices in markets that reveal their preferences for non-market goods and services.

a) Replacement cost method: The economic value of an intangible disaster impact can be approximated as the amount people have to pay to replace the good or service. For example, the value of coastal erosion caused by sea surge and high waves during a cyclone may be approximated as the cost of rehabilitation of the coastal area affected.

b) Production method: Some intangible disaster impacts affect goods and services that are purchased in markets. For example, a tsunami may affect coral reefs and thereby alter the number of fish caught, or a cyclone may destroy trees and forests, thereby affecting the amount of timber available. The prices of the marketable goods (in these examples, the goods are fish and timber) can be used to estimate the economic value of the intangible impacts of natural disasters (in this case damage to the reef and forest).

c) Substitute or proxy method: Natural disasters may have intangible impacts on non-marketed goods and services that have close substitutes that are sold in the marketplace. The economic value of these impacts can be estimated using the price of the substitutes as a surrogate market price. For example, the value of damage to a subsistence crop harvest can be determined using the market price for closely related commercial crops.

d) Change in earnings: If human health is affected by a natural disaster, the economic value of this impact can be estimated using the resulting losses in earnings together with the cost of medical expenses needed for treatment. This approach, however, does not capture the economic impact of chronic health problems that do not result in losses in earnings, which may be the case for post-disaster trauma.

e) Hedonic pricing: This method estimates the value of intangible impacts on the basis of the amount that people are willing to pay for marketed goods and services of varying quality. For example, the value of environmental degradation may be estimated on the basis of the difference in house prices in areas where a natural disaster caused environmental damage as compared to house prices in unaffected areas.

f) Travel cost method: When a natural disaster affects the recreational and aesthetic value of an area, the economic value of the impact can be estimated on the basis of the amount that people are willing to pay to visit the area.

2. Stated preference methods

Expressed preference methods use what people say about their preferences to derive their willingness to pay for a non-marketed good or service, and thereby determine the value of an intangible disaster impact that affects that good or service. Contingent valuation is one of the best-known stated preference methods. In a contingent valuation survey people are asked to state how much they would be willing to pay for a change in the quality of an intangible good (e.g. environmental quality). Respondents are given hypothetical scenarios and asked to indicate how much they would be willing to pay to either avoid the negative intangible impact or gain a positive intangible impact.

Box 7: Valuing intangible disaster impacts

Placing a monetary value on deaths and injuries is a particularly difficult task. Setting aside the suffering sustained by victims and their families, fatalities are a direct loss of productive human assets, and injuries entail the expense of health treatment. The value of injuries may be roughly approximated as the cost of treatment and, if the appropriate data is available, as the average loss of income of the injured person while recovering. Methods exist that can be used to estimate the monetary value of a human life (see Box 8), but these techniques are controversial. Including estimates of the monetary values of deaths in a disaster impact assessment may be deemed prohibitively difficult or ethically undesirable. In this case, a quantitative summary of the number of deaths and injuries should be included as a separate table in the overall disaster impact assessment, with as much detail as possible on the resulting costs and losses.

Valuing a Human Life

There are two main techniques that can be used to value a human life, known as the 'human capital' and 'willingness to pay' approaches. Both of these methods have disadvantages and controversial aspects.

Human capital approach
A possible approach to estimate the value of a lost human life involves calculating the average expected future income that the deceased would otherwise have generated assuming that he or she had fulfilled their normal life expectancy. This method is controversial, because it implies that the human life of a low-income earner is worth less than the life of a high-income earner, and similarly a life lost in a developing country is worth less than a life in a more developed nation. It also ignores the intrinsic value of a life.

Willingness to pay approach
An alternative method for estimating the value of a human life is to conduct 'willingness to pay' surveys which assess how much an individual is willing to pay to reduce the risk of death. The survey can ask respondents questions about their willingness-to-pay for risk reductions in hypothetical scenarios. Alternatively surveys can examine wage premia paid to workers in dangerous jobs and estimate how much extra risk they are exposed to. On the assumption that the wage premium is paid for the risk increment, the value of the worker's life can be calculated. Willingness to pay methods have an advantage over the human capital approach because the value is not exclusively related to losses in human production capacity. However, it does not eliminate the problem of assigning a different value to people in different income groups or in countries at different stages of development, as rich people are likely to be willing to pay more to reduce their risk.

Box 8: Valuing a human life

2.2. Indirect impacts

Indirect impacts are flows of effects that occur over time after a hazard event and are caused by the direct impacts of a disaster. Examples of indirect impacts might include a decline in agricultural harvests after flooding or prolonged droughts, or losses in industrial production due to damage to factories caused by a cyclone or earthquake. Disasters may also generate positive indirect effects that generate benefits to society. For example, large-scale disasters often generate a construction boom as aid funds flow into the country for rebuilding damaged properties, which can boost production and income in the construction sector and supporting industries. Positive indirect impacts must also be estimated and included in a disaster impact assessment.

Indirect impacts are dynamic flows that occur over time. It is therefore particularly important when estimating indirect impacts to compare the situation that develops after the disaster with the situation that would have occurred without the disaster. The indirect impact is calculated as the difference between the 'with disaster' situation and the 'without disaster' situation. As indirect impacts occur over time, they should be measured in present value terms (an explanation of how to calculate present values is provided in Section 2.2.8).

Surveying is often the most appropriate method for estimating indirect losses caused by a natural disaster. Many indirect losses can only be ascertained months or years after a natural disaster making it difficult or impossible to assess these losses in the immediate initial damage assessment. It is therefore important to do subsequent follow up assessments to evaluate indirect impacts. The appropriate time period for estimating indirect losses is the length of time required for the country or region to achieve a situation equal to the one prevailing before the disaster. For many disasters, a two-year time frame is appropriate, although it may be necessary to assess indirect impacts over a shorter or longer time period depending on the type and scale of disaster.

Input-Output and Computable General Equilibrium (CGE) Modelling

Two modelling techniques provide alternative means for estimating or forecasting indirect losses caused by natural disasters. These two techniques are known as input-output and computable general equilibrium (CGE) modelling. CGE modelling is currently beyond the capacities of most Pacific Island Countries, with the exception of Fiji (see Narayan, 2003).

Input-output models
Input-output modelling can be used to estimate indirect impacts of 'shocks' to the economy, a shock being an external impact that affects the level of economic activity, such as a natural disaster. Input-output models, however, implicitly make a number of restrictive assumptions, so their use is increasingly limited to the analysis of relatively small, marginal shocks.

Computable general equilibrium models
A superior method for estimating the indirect losses of larger natural hazards is Computable General Equilibrium (CGE) modelling. A CGE model is a system of equations that represents all of the agents (including households, businesses and government institutions) in an economy. The supply and demand of all goods, services and factors is explicitly modelled. The amount of direct damage from a natural disaster can be fed into the model, which will forecast the indirect effects that are likely to arise in different sectors.

Box 9: Input-output and CGE modelling

A non-exhaustive list of some indirect impacts often caused by natural disasters in Pacific Island Countries is given below:

2.2.1. Production and income

Production and income can be affected by the disruption of activities after a disaster. Disruption often occurs due to temporary interruptions in water and sanitation, electricity, communications and transport services. Particular care must be taken not to double count effects by including estimates of disaster impacts on both production and income, as they are essentially two sides of the same coin. If effects are calculated on the production side, they must not be included again on the income side.

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 of income from such assets that are already poor performing, even without the impact of a natural disaster.

Loss of Income and Production in Fisheries and Education Sectors Caused by Drought in Tuvalu

During droughts in Funafuti, the main atoll in Tuvalu, the fisheries industry faces problems getting enough ice for fish storage and processing due to water shortages, which disrupts production and reduces income. Similarly, during the cyclone season, fishing boats are frequently anchored for safety reasons, disrupting production and lowering income. Linkages between suppliers and customers can cause further losses. For example, the problems faced by the fish processing plant during droughts reduce the economic activities of fishermen who supply the factory but have no alternative markets.

A disaster may also affect the provision of services in social sectors, such as health and education. In Tuvalu, cyclones can delay the ship that transports students to the secondary school on Vaitupu, causing postponement of the start of the school year by several weeks or even months. During times of drought and water shortages, schools must also close for health and safety reasons. As a result of these natural hazard events the school is often not able to complete the full school term and syllabus, resulting in a higher incidence of exam failures.

Box 10: Loss of income and production in fisheries and education sectors caused by drought in Tuvalu

2.2.2. Operating costs

Operating costs may rise after a disaster due to the disruption caused by the destruction of physical infrastructure. Operating costs are the day-to-day costs involved in running a business or service provider. Disasters often cause disruption due to temporary interruptions in water and sanitation, electricity, communications and transport services.

Higher Operating Costs Caused by Natural Disasters in Niue, Vanuatu and Fiji

After Cyclone Heta, the Niue Government Health Department incurred higher operating costs to replace health records that were lost when the hospital and health administration buildings were destroyed. While the new hospital was being built, the temporary medical facility did not have the capacity to respond to acute illness or injury. Patients and their family attendants had to be referred to New Zealand for medical treatment, which led to significant indirect costs to the Niue health sector.

The Vanuatu earthquake in 2002 led to high wharf operating costs because a bridge was damaged and could not be used for transportation for some time. This entailed the need to use boat taxis and barges to bring supplies to the wharf.

In the town of Labasa, on the island of Vanua Levu in Fiji, the sugar industry was badly affected by Cyclone Ami and related flooding. Fiji Sugar Corporation was forced to employ 400 extra people for the year after the Cyclone to help in the clear up and repair work.

Box 11: Higher operating costs caused by natural disasters in Niue, Vanuatu and Fiji

2.2.3. Reduced investor confidence

An important indirect impact is reduced investor confidence in countries regularly caught in cycles of exposure to, and recovery from, natural disasters. Reduced investment may affect production and income, and have subsequent repercussions for macroeconomic variables. Effective disaster mitigation efforts can contribute to improving investor confidence in levels of community resilience and thereby reduce the indirect economic impact of disasters.

2.2.4. Costs of responding to new situations

There may be additional costs for dealing with new situations arising from a disaster, such as the costs of environmental clean-up campaigns needed to attract tourists back into the country, or the costs of responding to disease outbreaks. For example, Cyclone Ami and related flooding caused problems with sanitation that led to an outbreak of leptospirosis in the island of Vanua Levu in Fiji. The health sector incurred costs for dealing with this outbreak.

2.2.5. Demolition and debris removal

In order to repair or rebuild a property, it must often be partially demolished and the resulting debris removed. Demolition and debris clearing costs can be estimated based on the volume to be removed, the unit cost of removing the debris and the number of affected units.

2.2.6. Relocation costs

After major natural disasters people and essential services may need to be relocated. For example, if large buildings such as schools or churches are undamaged, those made homeless by the disaster may be temporarily relocated there. When existing facilities such as schools or churches are used, the cost of relocation can be estimated as the cost of repairing any resulting damage or as the cost of not carrying out the activities for which the buildings are normally intended. If temporary shelters are built, it will be necessary to estimate the cost of construction and related services.

2.2.7. Valuing indirect impacts

Indirect losses in income and production can be valued at producer or market prices. In the case of interrupted service production in social sectors, such as health and education, the most suitable approach is to value the services not generated as a result of the disaster, based on the prices or fares paid by the consumer. If there is no charge for the service, or the service is heavily subsidised, the value of the reduction in the level of services can be estimated on the basis of the costs of providing those services e.g. the cost of providing education or health care.

Some indirect effects are difficult to evaluate in monetary terms given the limited time available for assessment. It is, however, important to at least estimate the scale of these impacts, with as much discussion as possible. In light of the challenges of estimating indirect losses, the assessment should be undertaken in close consultation with relevant authorities and experts who can provide input on the time needed to re-establish services, lost production volumes, costs incurred in the provision of services, and reductions in income. If there are limited resources and time available, the assessment should focus on the most important indirect effects, without wasting time quantifying impacts that will not significantly alter total damage estimates. It is, however, extremely important to include estimates of indirect effects in a disaster impact assessment, because these losses will directly affect the future economic performance and living standards in the area.

2.2.8. Valuing indirect impacts in present value terms

The value of disaster impacts that occur at different points in time should ideally be 'discounted' to reflect the decreasing value of money over time. Why does money decrease in value over time? Most people prefer to receive money in the present rather than in the future. This decreasing 'time value of money' is not due to inflation - even if inflation were zero, people would virtually always prefer to receive money now than in a year's time. There are three main reasons for the decreasing value of money over time. First, most people have an expectation that their wealth will be greater in the future, so the relative value to them of a particular sum of money will be correspondingly less in the future. Second, money received now can earn a return so that in a year's time it will have increased in value. Third, the benefit of money received now is certain whereas, because there is no guarantee that you will be alive next year, the benefit of money received next year is uncertain. In the Pacific, many nations have a high time preference, meaning that money decreases in value very rapidly over time, because people need to meet immediate needs. Consequently, projects that do not generate benefits until a long way into the future may have little significance to Pacific communities.

Because of the decreasing value of money over time, the benefits and costs that are incurred by a DRM measure need to be valued in terms of when they occur, using a 'discount rate'. The discount rate is the rate required to compensate for the receipt of money in the future, rather than the present. Using the discount rate, disaster impacts that occur further in the future can be adjusted to be comparable with immediate disaster impacts. The discount rate that represents the time preference of a broad community or economy is called the 'social discount rate'. It is this rate that should be used to calculate the present value of disaster impacts. There is disagreement on which rate should be used for the social discount rate. Some studies in the USA recommend using a 3 percent social discount rate while the Federal Emergency Management Agency mandates that a discount rate of 7 percent be used for all cost benefit analyses of DRM projects. It is recommended that the chosen discount rate be based on the rate chosen for previous similar studies elsewhere or using a domestic benchmark, such as the real interest rate in the country concerned.

To account for the decreasing value of money over time, use the discount rate to calculate the 'present value' of indirect disaster impacts that occur over time. 'Present value' is the value today of an impact that occurs in the future. It is measured using the discount rate. In mathematical terms, the present value (PV) of a sum of money received or spent in some future period is calculated using Equation 1, where *r* is the discount rate, and *n* is the number of years in the future that the cost or benefit occurs:

$$\text{Present Value} = \text{Future Value} / (1 + r)^n$$

Equation 1: Calculation of present value

For example, the present value of $1000 received in five years time at a 4 percent discount rate is equal to $821.93, as shown below:

$$\begin{aligned}\text{Present Value} &= \text{Future Value} / (1 + r)^n \\ &= 1000 / (1 + 0.04)^5 \\ &= \$821.93\end{aligned}$$

The further in the future that an impact occurs, the smaller is its present value at the same discount rate. Also, the higher the discount rate, the smaller is the value of an impact at a particular future time.

2.2.9. Intangible indirect impacts

Some indirect impacts, often called 'intangible impacts', are particularly challenging to value in monetary terms because their very nature is difficult to measure and quantify. Intangible indirect impacts of natural disasters include negative psychological effects, such as fear, stress and depression, and health problems that arise after the disaster, such as leptospirosis outbreaks or respiratory illnesses. Intangible indirect impacts can also be positive, such as development of community solidarity and trust.

Health Problems Caused by Drought in Tuvalu and Flooding in Fiji

Experts working in the health sector in Tuvalu claim that a number of health problems are exacerbated by drought in the main atoll of Funafuti, particularly among children. The incidence of acute respiratory infections, viral illnesses, skin diseases, septic sores, and diarrhoea rises around times of drought. According to the Director of the Department of Health, drought was a contributing factor leading to an outbreak of cholera in 1991, and an outbreak of typhoid at Motufoua Secondary School on Vaitupu in 2003.

According to the Northern Health Services division in Fiji, Cyclone Ami and related severe flooding had indirect health impacts on the population of the island of Vanua Levu. They report that the cyclone and flooding contributed to: outbreaks of diarrhoea due to contaminated water supplies; a higher incidence of dengue fever due to mosquitoes breeding in stagnant water pools; an epidemic of leptospirosis, and a typhoid outbreak involving 12 people. The value of the leptospirosis outbreak was included in the official assessment of the cost of Cyclone Ami, based on the cost of treatment of those affected.

Box 12: Health problems caused by drought in Tuvalu and flooding in Fiji

The value of these intangible losses is difficult to assess, as it is not reflected in market prices. Frequently intangible losses are not included in estimates of natural disaster impacts because they are considered too difficult to estimate meaningfully. This does not mean, however, that intangible direct damage is unimportant. Most research shows that people value intangible losses as at least as great as their tangible dollar losses, and sometimes, intangible losses are considered more important. Therefore every effort should be made to identify, assess and include them. A comprehensive evaluation should at least identify and where possible quantify intangible impacts, so that they are less likely to be ignored in decision-making. Some methods do exist for valuing intangible impacts, which are briefly described in Box 7, while extra detail is given on methods for valuing deaths in Box 8, and methods for valuing environmental damage in Box 15.

2.3. Macroeconomic effects

Macroeconomic effects are any changes to the main economic variables that are caused by the direct and indirect impacts resulting from a natural disaster. Macroeconomic indicators illustrate changes to economic activity. The most important macroeconomic effects of a disaster are usually on Gross Domestic Product (GDP), gross investment, the balance of payments, and public finances. Depending on the type and scale of the disaster, an estimate of the effects on inflation and employment may also be relevant. Quantification of macroeconomic effects is usually done for the national economy as a whole, although in principle, if the information is available, it can be done for disasters affecting smaller areas, islands or regions.

Estimating macroeconomic effects is a complementary way to assess direct damages and indirect losses from a different perspective, so they should not be added to direct and indirect impact estimates because this will involve double counting.

Like indirect impacts, macroeconomic variables are dynamic flows that occur over time. It is therefore important to compare how the macroeconomic variable develops after the disaster with how that variable was expected to behave if the disaster had not occurred. Background information on how macroeconomic indicators were expected to evolve without the disaster can help to make these forecasts. These forecasts provide the baseline for ascertaining the degree to which the disaster disrupted macroeconomic aggregates from the levels that would have been achieved otherwise. Forecasts can be based on different likely scenarios and these estimates are compared. The time frame for estimating macroeconomic effects is a couple of years, or in the case of a major disaster, five years, after a natural disaster.

The macroeconomic assessment begins by collecting information on pre-disaster economic trends, and features of economic policy. Central banks, economic, tax, finance and planning ministries, statistics offices, universities, regional and international organisations may have the macroeconomic information needed. On the basis of information and interviews, a projection should be prepared of how economic growth (GDP growth) was expected to develop before the disaster occurred and how this would have been reflected in inflation, exports, imports, debt etc. Estimates of the impact of the disaster on GDP should be made in real / constant terms, rather than nominal or current GDP figures.

Some of the most important macroeconomic aggregates are described here:

2.3.1. Gross domestic product

Gross Domestic Product (GDP) and GDP growth can be lowered by a disaster because of reductions in the production and income of affected sectors. A disaster can also have positive effects on GDP if there is increased economic activity for reconstruction. It is necessary to estimate both the negative and positive impacts, and calculate the net effect on GDP. Such projections require forecasts of how sectors were expected to perform without the disaster. If sectoral GDP figures are available, it may also be useful to assess the impact of the disaster on the growth of different sectors. GDP should be measured in real terms at constant prices.

2.3.2. Gross investment

A disaster usually negatively affects gross investment by causing loss of stock, and the suspension or cancellation of development projects that were underway. A disaster can also increase gross investment as asset restoration and reconstruction begins. Again, it is necessary to estimate both the negative and positive impacts, and calculate the net effect on gross investment.

2.3.3. Balance of payments

A disaster may affect a number of variables that are part of the balance of payments. A disaster may cause a decline in exports of goods and services as a result of reduced capacity of export companies or tourist activity. Increased imports of fuel, food, building materials or equipment may be required for the recovery and reconstruction stage. There may also be inflows of foreign funds through relief donations, foreign debt relief and reinsurance payments. These effects will alter the balance of payments, and the size of this effect should be determined.

2.3.4. Public finances

The balance of public sector expenditure to revenues is likely to be altered by a disaster, usually expanding fiscal deficits. Public sector spending generally increases after a disaster as a result of expenditure for the emergency, relief, rehabilitation and reconstruction stages. Fiscal revenues typically fall after a disaster due to decreased tax collection, and an erosion of income and consumer spending. A proportion of the government budget may have to be redeployed to meet the cost of rehabilitation, forcing the government to cut the budgets for other development programmes, ending or suspending other important projects.

Pressure on Public Finances Caused by Cyclones and Flooding in Fiji

In 2003 Cyclone Ami and related flooding put pressure on Labasa's public finances, by reducing the amount of taxes collected and increasing expenditure on recovery and reconstruction. The Town Council was forced to increase town rates, introduce garbage fees and lay off workers in order to pay off debts resulting from Cyclone Ami.

In 1993 Cyclone Kina and related flooding forced the Fiji government to reallocate FJ$40 million for rehabilitation work, which represents 32 percent of the total 1993 capital budget. As a consequence of these budget cuts, capital works programmes earmarked for 1993 were deferred or suspended.

Box 13: Pressure on public finances caused by cyclones and flooding in Fiji

2.3.5. Inflation

Prices may rise after a natural disaster in response to shortages brought about by destruction of crops, manufactured goods and transportation routes. Prices will also increase if there are new demands for goods and services for reconstruction. Ideally the influence of these variables on general and relative prices should be estimated.

2.3.6. Employment

Disasters may cause a change to the employment structure, owing to the destruction of production capacity and social infrastructure, and new demands for personnel arising during the reconstruction and rehabilitation process. If possible, not only the change to employment, but also the resulting impact on income should be estimated.

3. Sectoral Assessments

It is often easiest to do an impact assessment on a sector-by-sector basis. This methodology categorises sectoral impacts into:

- Social sectors, such as housing, education and health;
- Infrastructure sectors, such as energy, water supply and transportation; and
- Economic sectors, such as agriculture and tourism.

Information on disaster impacts in each sector should be gathered in as much detail as possible and using the same methodology to ensure consistency and non-duplication. Care should be taken not to 'double count' impacts by including them in two sectors. For example, damage to rural roads must be included either in the agricultural sector or in the transportation sector, but not in both sectors because this will give a falsely inflated view of the total damage.

The impacts caused by a natural disaster in each sector should be estimated by comparing the situation that develops after the disaster with the situation that would have occurred without the disaster i.e. the 'with disaster' and 'without disaster' situations. Note that impacts should be assessed in terms of comparisons of scenarios with and without the disaster, rather than comparisons of scenarios before and after the disaster, to ensure that only impacts directly resulting from the disaster are included. Otherwise change that would have occurred anyway may be incorrectly attributed to a disaster. It will therefore be necessary to gather information on the situation in each sector before the disaster event, including forecasts of how the sector was likely to have developed if the disaster had not occurred. Information on the post-disaster situation is then collected so that the impact of the disaster can be accurately determined by comparing the 'with' and 'without' scenarios.

For each sector, a distinction should be made between damage to public and private sector assets. The impact on the private and public sectors can then be compared at the end of the assessment, which is useful for designing an appropriate post-disaster rehabilitation and reconstruction strategy. The different impact on the formal commercial and informal subsistence sectors may also be useful. The change in flows of funds and resources into and out of the country resulting from the disaster should also be identified, such as reduced exports, increased imports, external transfers, and national payments generated by increased debt. This information will be useful for estimating the macroeconomic impact of the disaster on the balance of payments and trade.

Wherever possible the population affected by the disaster should be identified in terms of demographic and socio-economic characteristics. This will help to identify the differential impact of the disaster on vulnerable groups, such as women, children and the elderly, or low-income households.

3.1. Social sectors

Natural disasters can have an impact on social sectors such as housing, education, and health. For each social sector, the assessment should include a description of the pre-disaster situation (including how the sector was expected to develop over time without the disaster) and the disaster impact assessment, including both direct and indirect impacts. Links between sectors should be taken into account, and care should be taken not to double count impacts by including them in two sectors.

3.1.1. Overview of housing, education and health sectors

These guidelines focus on three social sectors: housing, education and health. There are other social sectors, which may be considered important to include in the assessment, such as culture and religion. The basic principles will be the same for any social sector assessment, it will just require adapting the general recommendations in these guidelines to the particular sector under analysis.

The housing sector refers to all buildings that are used as residential homes. Natural disasters often lead to direct damage to structural and non-structural elements of houses, which can entail large costs. Natural disasters also have indirect impacts on the housing sector such as additional costs for temporary housing while damaged homes are being rebuilt. The impacts of disasters on the housing sector have macroeconomic ramifications, for example, the construction activity to rebuild homes after a disaster may boost GDP growth. Note that damage included in the housing sector does not include buildings used for other sectoral activities, such as schools (to be included under education), or factories (to be included under enterprises). It also does not include damage to the construction sector, as this will be included in the assessment of economic sectors. The typical categories of impacts of natural disasters on the housing sector are listed in more detail in Section 3.1.3.

The education sector refers to educational establishments such as primary and high schools, and universities. Natural disasters often lead to direct damage to infrastructure such as classrooms and workshops, their installations, such as sports areas and libraries, and equipment, such as textbooks. Indirect losses are often incurred after cyclones if schools are used as temporary shelters, which leads to damages that need to be repaired. It can become more expensive to operate schools if a new temporary location must be used. The educational establishment's private income may be reduced if families cannot afford to pay school fees. These direct and indirect impacts may affect macroeconomic indicators such as public finances, particularly if governments are funding the reconstruction of education infrastructure. The typical categories of impacts of natural disasters on the education sector are listed in more detail in Section 3.1.3.

The health sector refers to medical care of all types, including hospitals, health clinics, and homecare. Natural disasters can lead to direct damage to infrastructure, such as hospitals and administrative buildings, and medical supplies and equipment. The health sector also suffers the costs of treating the affected population, including both those who are hurt during the disaster event, and those who subsequently get sick from disaster-related illnesses. Other typical indirect impacts of natural disasters on the health sector include the costs of public health interventions that are needed to stop the spread of disease outbreaks caused by conditions after the disaster. The health sector may have lower income to deal with these increased costs, if private patients can no longer afford to pay for health services. These direct and indirect effects may affect macroeconomic indicators such as the balance of payments, particularly if expensive medical equipment must be imported from overseas. The typical categories of impacts of natural disasters on the health sector are listed in more detail in Section 3.1.3.

3.1.2. Assessment of sectors 'without' the disaster

The first step for assessing the impact of a natural disaster on social sectors is to gather information on how the sector was likely to have developed if the disaster had not happened. This involves collecting data on the status of the sector before the disaster occurred, and any forecasts of how the sector was predicted to develop. Table 1 gives an indication of the kind of information that should be collected to give a comprehensive overview of the housing, education and health sectors.

Table 1: Information needed for assessment of social sectors 'without' disaster

Information	Housing	Education	Health
Number of buildings	Number of dwellings in affected area, classified by type (houses, apartments etc.)	Number of educational buildings in affected area, classified by education type e.g. primary school, high school, university	Number of health care facilities in affected area, classified by type of facility e.g. hospital, health clinic
Ownership	Rented property / home ownership, public / private	Public / private	Public / private
Location	Location, rural / urban	Location, rural / urban	Location, rural / urban
Number of inhabitants	Number of residents	Number of teachers and students	Number of staff and patients
Coverage	Proportion of people with certain types of dwellings	Proportion of people served by education institutions	Proportion of people served by health institutions
Type of building	Traditional / semi-modern / modern	Traditional / semi-modern / modern	Traditional / semi-modern / modern
Quality of buildings	Quality of dwellings e.g. construction material, age, maintenance	Quality of educational buildings e.g. construction material, age, maintenance	Quality of health care facilities e.g. construction material, age, maintenance
Furniture & equipment	Inventory of domestic furniture and equipment	Inventory of furniture and educational equipment and materials	Inventory of furniture and medical and non-medical equipment
Costs of replacement	Costs of replacement of buildings, domestic furniture and equipment	Costs of replacement of buildings, furniture and educational equipment and materials	Costs of replacement of buildings, furniture and medical and non-medical equipment
Cost of service supplied	Rental rates, house prices	School fees, government subsidies, average wages	Cost of medical services, hospital room charges, average wages, subsidies
General indicators	Rate of homelessness, proportion of squatter settlements	Literacy rate, school enrolment rates, proportion of population achieving different levels of education	Morbidity rate, disease incidence, under-nutrition rates, infant and maternal mortality rates

3.1.3. Disaster impact assessment

Table 2 lists some of the most common types of direct, and indirect impacts caused by natural disasters in social sectors.

Table 2: Information needed for disaster impact assessment of social sectors

Impacts	Housing	Education	Health
Direct impacts	• Damage to housing • Damage to domestic furniture and equipment • Damage to public buildings and areas • Damage to household connections to public utilities	• Damage to educational buildings e.g. schools • Damage to education installations e.g. libraries, sports areas • Damage to education sector government offices • Damage to furniture • Damage to educational equipment and supplies • Number of teachers lost	• Damage to health care buildings e.g. hospitals, health centres • Damage to health sector government offices • Damage to other health buildings e.g. drug warehouses • Damage to furniture • Damage to medical and non-medical equipment and supplies • Costs of treating population affected during disaster (deaths, injuries) • Number of health employees lost
Indirect impacts	• Temporary housing costs during reconstruction period • Costs of demolition and debris removal	• Costs of repair of educational buildings used as temporary shelters • Costs of temporarily leasing premises to provide educational services during reconstruction period • Loss of income in student fees • Additional education service operating costs • Costs of demolition and debris removal	• Cost of relocating health services • Loss of income from charged health services • Additional health service operating costs • Costs of extra staff e.g. recruiting and training additional health staff • Costs of treating population affected by disaster after event (disease) • Costs of public health and epidemiological interventions e.g. vaccination campaigns, post-trauma counselling • Increased public and private costs and declining productivity due to poor physical and mental health, and under-nutrition • Costs of demolition and debris removal

You may wish to summarise the findings in a summary table, similar to Table 3.

Table 3: Summary matrix of disaster impacts in social sectors

	Disaster Impact			Property	
	Direct Impact	Indirect Impact	Total	Private	Public
Social Sectors Housing Education Health Other					
TOTAL					

3.1.4. Example – Impact of droughts on Tuvalu's health sector

This section estimates the economic impact of droughts on the health sector in Tuvalu using the methodology in these 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 stakeholders in the health sector.

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 used improved drinking water sources and 88 percent of the total population used 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 4.

Table 4: 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

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 5. 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 5: 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	

3.1.5. Sources of information

Information is needed to assess 1) how social sectors are likely to have developed 'without' the disaster, and 2) how those sectors are affected by the disaster. Although disasters can obstruct normal channels of information, a range of different sources may still be available and provide useful data, including local, national, regional and international sources. As much information should be collected as possible, which can later be compared. Where possible, assessments should only use documented facts, credible oral reports or their own observations. Advice from sectoral experts can help to validate the reliability of information. Table 6 gives a non-exhaustive list of some recommended sources for assessments of social sectors.

Table 6: Sources of information on social sectors

Source	Housing	Education	Health
Census and survey data	Population and housing censuses and surveys	Education censuses and surveys	Health censuses and surveys
National statistics	National statistics office, Pacific Regional Information System (PRISM)[3]	National statistics office, Pacific Regional Information System (PRISM)	National statistics office, Pacific Regional Information System (PRISM)
National ministries	Housing, urban development and planning ministries	Education ministry and planning ministries	Health, social security and planning ministries
Private sector	Construction firms, producers and sellers of building materials, real estate agents, insurance companies	Private schools and universities, insurance companies	Pharmaceutical companies, private hospitals, insurance companies
Community	Community surveys and discussions	Community surveys and discussions	Community surveys and discussions
Professional associations	Construction industry chambers of commerce, trade and industry associations	Teachers associations	Medical associations
NGOs	NGOs in housing and construction sector	NGOs in education sector	NGOs in health sector
Regional organisations	PIFS, SPC	SPC, USP	FSM, SPC
International organisations	ADB, UNDP, UNPHS, UNSD, WB	ADB, UNDP, UNESCO, WB	ADB, UNDP, UNICEF, WB, WHO
Relevant donors	Relevant donors	Relevant donors	Relevant donors
Press	Press reports	Press reports	Press reports

[3] Pacific Regional Information System available at http://www.spc.int/prism/

3.2. Infrastructure

Natural disasters can have an impact on infrastructure sectors such as energy, water supply, sanitation, transport and communication. For each infrastructure sector, the assessment should include a description of the pre-disaster situation (including how the sector was expected to develop over time without the disaster) and the disaster impact assessment, including both direct and indirect impacts. Links between sectors should be taken into account, and care should be taken not to double count impacts by including them in two sectors.

3.2.1. Overview of energy, water and sanitation, transport and communication sectors

These guidelines focus on the following infrastructure sectors: energy; water and sanitation; and, transport and communications. Like the social sectors, infrastructure sectors often sustain direct damage and indirect losses caused by natural disasters, and these impacts have macroeconomic effects. There are other infrastructure sectors, which may be considered important to include in the assessment, such as coastal protection infrastructure. It may also be considered important to include more detailed analysis of certain sub-sectors, such as the gas and electricity sub-sectors of the energy sector. The basic principles will be the same for any assessment, it will just require adapting the general recommendations in these guidelines to the particular sector or sub-sector under analysis.

The energy sector refers to the supply system for sources of energy, such as gas and electricity. Direct impacts include immediate damage to infrastructure, such as electricity generation plants and distribution systems. Indirect impacts include effects on the income of the energy sector. The net effect on income will depend on the size of the increase in demand for energy for reconstruction and the decrease in demand due to the destruction of infrastructure. The overall indirect impact on income may be positive or negative, depending on which effect is stronger. The impacts of disasters on the energy sector have macroeconomic ramifications, for example, investments for repair and reconstruction, and cancelled or postponed energy projects will affect gross investment. The typical categories of impacts of natural disasters on the energy sector are listed in more detail in Section 3.2.3.

The water and sanitation sector refers to water supply, and wastewater and solid waste disposal systems. Direct impacts may affect water and sanitation infrastructure, equipment, supplies, sources and sites. During the recovery phase, there may be indirect impacts from the disaster as the water and sanitation sector incurs greater operating and distribution costs and earns less income from water supply and waste disposal charges. These direct and indirect impacts have macroeconomic effects, for example, the additional costs of supplying water after a disaster may lead to a change in the price of water if the government cannot subsidise the extra expenses. The typical categories of impacts of natural disasters on the water and sanitation sector are listed in more detail in Section 3.2.3.

The transport sector refers to all types of private and public transport services, including land, air and sea transport. The communications sector focuses particularly on the telecommunications sector, including services such as telephone, fax, Internet and email. Road transport is often one of the sub-sectors hardest hit by natural disasters – major direct damage to roads, bridges and vehicles is common during cyclones, floods, tsunamis and earthquakes. Indirect losses often occur due to the increased costs of operating transport and communications services during the recovery phase. Income from service fees may be reduced by lower output or the reduced ability to pay of customers. The direct and indirect effects have repercussions for macroeconomic indicators. For example, public finances may be affected by the revenue shortfalls arising out of diminished billing for public sector transport and telecommunications services, decreases in the collection of service taxes and unforeseen expenditure on rehabilitation of the transport and communications sectors. The typical categories of impacts of natural disasters on the transport and communications sector are listed in more detail in Section 3.2.3.

3.2.2. Assessment of sectors 'without' the disaster

The first step for assessing the impact of a natural disaster on infrastructure sectors is to gather information on how the sector was likely to have developed if the disaster had not happened. This involves collecting data on the status of the sector before the disaster occurred, and any forecasts of how the sector was predicted to develop. Table 7 gives an indication of the kind of information that should be collected to give a comprehensive overview of the energy, water and sanitation, and transport and communications sectors.

Table 7: Information needed for assessment of infrastructure sectors 'without' disaster

Information	Energy	Water and sanitation	Transport and communications
Infrastructure	Number and location of energy and power facilities in affected area, classified by type e.g. electricity generation plant, transmission lines	Number and location of water supply and sanitation systems in affected area, classified by type e.g. collective water system / individual well, latrine / septic tank	Number and location of transport and communication facilities in affected area, classified by type e.g. road network, wharf, telecom centre
Ownership	Public / private	Public / private	Public / private
Location	Location, rural / urban	Location, rural / urban	Location, rural / urban
Production	Average power production levels	Average water production and sanitation treatment	Average usage of transport and communication services
Capacity	Maximum possible power production levels	Maximum level of water production and wastewater treatment	Maximum possible provision of transport and communication services
Coverage	Proportion of people with electricity / gas coverage	Proportion of people with water service and sanitation coverage	Proportion of people with access to transport and communications facilities
Quality of infrastructure	Quality of energy infrastructure e.g. construction material, age, maintenance	Quality of water and sanitation infrastructure e.g. construction material, age, maintenance	Quality of transport and telecommunications infrastructure e.g. construction material, age, maintenance
Furniture and equipment	Typical furniture and power equipment	Typical furniture and water and sanitation equipment	Typical furniture and transport and communication equipment
Costs of replacement	Costs of replacement of energy sector infrastructure	Costs of replacement of water and sanitation infrastructure	Costs of replacement of transport and communication infrastructure
Cost of service supplied	Electricity costs, subsidies, wage rates	Water supply rates, sewage disposal rates, subsidies	Transport and telecommunication costs, subsidies

3.2.3. Disaster impact assessment

Table 8 lists some of the most common types of direct, indirect, and cross-sectoral impacts caused by natural disasters in infrastructure sectors.

Table 8: Information needed for disaster impact assessment of infrastructure sectors

Impacts	Energy	Water & sanitation	Transport & communication
Direct impacts	• Damage to energy infrastructure e.g. electricity generation plants, distribution systems, fuel depots • Damage to equipment and supplies • Loss of stock	• Damage to water supply, waste-water disposal and solid waste disposal infrastructure • Damage to equipment and supplies • Loss of water sources • Impact on waste disposal dumps and access routes	• Damage to transport infrastructure e.g. roads, bridges, railroads, airports, wharfs • Damage to public and private vehicles e.g. cars, aircraft, boats • Damage to communication infrastructure e.g. transceiver facilities for cellular phones • Damage to equipment and supplies • Loss of stock
Indirect impacts	• Increase in energy operating costs • Change in income from energy sales (may increase if greater demand for energy for reconstruction, or decrease if lower demand due to infrastructure destruction) • Costs of demolition and debris removal	• Increase in water and sanitation operating costs • Loss of income from drinking water supply, wastewater disposal and solid waste disposal charges (due to reduction in production and treatment output or reduced ability to pay of users) • Costs of treatment of health issues related to poor quality drinking water and sanitation[4] • Costs of demolition and debris removal	• Increase in transport and communications operating costs • Loss of income from transport and telecommunications fees (due to reduction in production and treatment output or reduced ability to pay of users) • Loss of productivity caused by disruption of transport and communication services[5] • Costs of demolition and debris removal

[4] Be careful not to double count these costs by including them in both the assessment of the water and sanitation sector, and the assessment of the health sector.

[5] Be careful not to double count these costs by including them in both the assessment of the transport sector, and the particular economic sector affected.

You may wish to summarise the findings in a summary table similar to Table 9.

Table 9: Summary matrix of disaster impacts in infrastructure sectors

	Disaster Impact			Property	
	Direct Impact	Indirect Impact	Total	Private	Public
Social Sectors Energy Water and sanitation Transport and communication Other					
TOTAL					

3.2.4. Sources of information

Information is needed to assess 1) how infrastructure sectors are likely to have developed 'without' the disaster, and 2) how those sectors are affected by the disaster. Although disasters can obstruct normal channels of information, a range of different sources may still be available and provide useful data, including local, national, regional and international sources. As much information should be collected as possible, which can later be compared. Where possible, assessment should only use documented facts, credible oral reports or their own observations. Advise from sectoral experts can help to validate the reliability of information. Table 10 gives a non-exhaustive list of some recommended sources for assessments of the energy, water and sanitation, and transport and communication sectors.

Table 10: Sources of information on infrastructure sectors

Source	Energy	Water and sanitation	Transport and communications
Census and survey data	Censuses and surveys of energy sector	Censuses and surveys of water and sanitation sectors	Censuses and surveys of transport and communications sectors
National statistics	National statistics office, Pacific Regional Information System (PRISM)[6]	National statistics office, Pacific Regional Information System (PRISM)	National statistics office, Pacific Regional Information System (PRISM)
National ministries	Public works department	Public works department, health ministry	Public works department, transport ministry
Utilities	Energy and power utilities	Water and sanitation utilities	Transport and communications utilities
Management / regulatory boards	Energy and power regulatory boards	Water and sanitation regulatory boards	Transport and communications regulatory boards
Private sector	Private power companies, insurance companies	Private water and sanitation companies, insurance companies	Private transportation companies, insurance companies
Community	Community surveys and discussions	Community surveys and discussions	Community surveys and discussions
Professional associations	Engineering associations	Engineering associations	Engineering associations
NGOs	NGOs working in energy sector	NGOs involved in water systems and sanitation	NGOs working in transport and communications sectors
Regional organisations	SOPAC, SPC, SPREP	FSM, SOPAC, SPREP, SPC	SOPAC, SPC
International organisations	ADB, UNDP, UNEP, UNESCAP, WB	ADB, UNDP, UNEP, UNESCAP, WB	ADB, ITU, UNDP, UNESCAP, WB
Relevant donors	Relevant donors	Relevant donors	Relevant donors
Press	Press reports	Press reports	Press reports

[6] Pacific Regional Information System available at http://www.spc.int/prism/

3.3. Economic sectors

Natural disasters can have an impact on productive sectors such as agriculture, fisheries, enterprises and tourism. For each productive sector, the assessment should include a description of the pre-disaster situation (including how the sector was expected to develop over time without the disaster) and the disaster impact assessment, including direct impact and indirect impacts. Links between sectors should be taken into account, and care should be taken not to double count impacts by including them in two sectors.

3.3.1. Overview of the agriculture, enterprise and tourism sectors

These guidelines focus on three economic sectors: agriculture, enterprise and tourism. Like the social and infrastructure sectors, economic sectors often sustain direct damage and indirect losses caused by natural disasters, and these impacts have macroeconomic effects. It may be considered important to assess the impact of a disaster on other economic sectors, such as fisheries, or sub-sectors such as sugar or textiles. The basic principles will be the same for any assessment, it will just require adapting the general recommendations in these guidelines to the particular sector or sub-sector under analysis.

The agriculture sector refers to the commercial and subsistence production of all types of agricultural goods, including crops and livestock. Agriculture is important to many Pacific Island Countries, in terms of both commercial and subsistence agriculture. Many households rely on agriculture for their livelihoods. The agricultural sector is usually most affected by hydro-meteorological natural disasters, such as cyclones, floods and droughts. The impacts of disasters that are geological in nature, such as earthquakes and volcanic eruptions are often only indirect or marginal. Direct damage from hydro-meteorological disasters can be extensive and include damage to infrastructure such as irrigation systems, damage to machinery and equipment, loss of livestock, inputs and crops ready for harvest, and damage to agricultural land. Indirect effects can continue long after the natural hazard event if the disaster affects operating costs, output, income and agricultural productivity. The impacts of disasters on the agriculture sector may be positive. For example, in the long-term volcanic ash can actually enhance the yield of future crop harvests. These direct and indirect effects will alter macroeconomic variables. For example if agricultural damages are high and the sector is a large contributor to the national economy, it may significantly reduce GDP. There may also be cross-sectoral effects, including an impact on the natural environment if harmful pesticides are released. The typical categories of impacts of natural disasters on the agriculture sector are listed in more detail in Section 3.3.3.

For the purposes of these guidelines the ‘enterprise’ sector is broad, including small, medium and large-scale enterprises in manufacturing and services. Direct damages from natural disasters often affect infrastructure, machinery, equipment and stocks of processed goods and raw materials. Indirect effects often occur due to increased operating costs and reduced income. If industry is a significant national economic sector, this can have repercussions for macroeconomic indicators such as GDP and gross investment. The typical categories of impacts of natural disasters on the enterprise sector are listed in more detail in Section 3.3.3.

The tourism sector is important to many Pacific Island Countries and includes a variety of types and scale of tourism, such as cruises, backpackers, and large-scale resorts. Tourist infrastructure can suffer direct damages from natural disasters, but the tourist industry may also be affected by damage to cultural, historical and environmental attractions, such as beaches and heritage sites. After the disaster event, the tourism sector often continues to suffer indirect losses, due to lost income from cancellations, higher operating costs and the cost of promotional campaigns needed to attract tourists again. These direct and indirect impacts will have macroeconomic repercussions. For example, any drop in tourist activities due to a disaster will cause major reductions in foreign-currency revenue from the export of tourism services. The typical categories of impacts of natural disasters on the tourism sector are listed in more detail in Section 3.3.3.

3.3.2. Assessment of sectors 'without' the disaster

The first step for assessing the impact of a natural disaster on economic sectors is to gather information on how the sector was likely to have developed if the disaster had not happened. This involves collecting data on the status of the sector before the disaster occurred, and any forecasts of how the sector was predicted to develop. Table 11 gives an indication of the kind of information that should be collected to give a comprehensive overview of the agriculture, enterprise, and tourism sectors.

Table 11: Information needed for assessment of economic sectors 'without' disaster

Information	Agriculture	Enterprises	Tourism
Infrastructure	Number of agricultural enterprises in affected area, classified by type e.g. farm, subsistence gardens. Irrigation systems	Number of enterprises, businesses and industries in affected area, classified by type e.g. factory, micro-enterprise	Number of tourism facilities in affected area, classified by type e.g. hotel, backpackers, restaurant
Production	Type and average quantity of production e.g. crop type, livestock breed	Type and average quantity of industrial production	Average level of tourism service provision
Importance	Contribution of agriculture sector to GDP and employment	Contribution of enterprise sector to GDP and employment	Contribution of tourism sector to GDP and employment
Ownership	Public / private	Public / private	Public / private
Location	Location, rural / urban	Location, rural / urban	Location, rural / urban
Employment	Number employed in agriculture sector	Number employed in enterprises, businesses and industry	Number employed in tourism sector
Quality of infrastructure	Quality of agriculture infrastructure e.g. construction material, age of equipment, maintenance	Quality of enterprise infrastructure e.g. construction material, age of equipment, maintenance	Quality of tourism infrastructure e.g. construction material, age of equipment, maintenance
Typical furniture and equipment	Typical furniture and agricultural equipment	Typical furniture and business equipment	Typical furniture and tourism equipment
Costs of replacement	Costs of replacement of agricultural infrastructure and stock	Costs of replacement of enterprise infrastructure and stock	Costs of replacement of tourism infrastructure and stock
Cost of service supplied	Costs of any agriculture services supplied	Costs of services supplied by enterprises, businesses and industries	Costs of services supplied by tourism sector

3.3.3. Disaster impact assessment

Table 12 lists some of the most common types of direct and indirect impacts caused by natural disasters in economic sectors.

Table 12: Information needed for disaster impact assessment of economic sectors

Impacts	Agriculture	Enterprise	Tourism
Direct impacts	• Damage to agriculture infrastructure e.g. buildings, product storage installations, irrigation • Damage to machinery and equipment • Loss of stock (livestock, inputs, harvested products) • Loss of crops ready for harvest • Damage to agricultural and farm land	• Damage to industrial infrastructure e.g. buildings • Damage to machinery and equipment • Loss of stock (processed goods, raw materials) • Damage to public facilities for commerce and trade	• Damage to tourist infrastructure e.g. hotels, restaurants • Damage to machinery and equipment • Damage to cultural and historical attractions • Damage to natural resource and environmental attractions[7] e.g. coastal erosion
Indirect impacts	• Increase in agricultural operating costs • Changes in agricultural income due to reduced production and effect on agricultural productivity e.g. negative impact of flooding on productivity of future crop harvests, or positive impacts of volcanic ash enhance yield of future crops • Costs of demolition and debris removal	• Increase in industrial operating costs • Loss of industrial income (due to reduced production and loss of demand) • Costs of demolition and debris removal	• Increase in tourism operating costs • Loss of tourism income • Cost of promotional campaign needed to attract tourists • Cost of clean-up of environment necessary to attract tourists • Loss of income for related services e.g. restaurants, taxis • Costs of demolition and debris removal

You may wish to summarise the findings in a summary table, similar to Table 13.

[7] Care must be taken not to double count these impacts by also including them in the assessment of environmental impacts.

Table 13: Summary matrix of disaster impacts in economic sectors

	Total Impact			Property	
	Direct Impact	Indirect Impact	Total	Private	Public
Social Sectors Agriculture Enterprise Tourism Other					
TOTAL					

3.3.4. Example – Impact of Cyclone Ami and related flooding on Fiji's agriculture sector

This section estimates the economic impact of Cyclone Ami and related flooding in 2003 on the agriculture sector in Fiji using the methodology of these 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.

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 waning 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. Sugar, the major agricultural export of Fiji, counted for 64 percent of total agricultural exports. Total sugar production was produced by 21,246 growers. 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.

The situation in Fiji's agriculture sector in 2002 and its forecast development is summarised in Table 14.

Table 14: 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	

Some of the impacts of Cyclone Ami and related flooding are summarised in Table 15.

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. 150,000 tonnes of sugar cane 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 15: Assessment of impact of Cyclone Ami on Fiji's agriculture 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	

3.3.5. Sources of information

Information is needed to assess 1) how economic sectors are likely to have developed 'without' the disaster, and 2) how those sectors are affected by the disaster. Although disasters can obstruct normal channels of information, a range of different sources may still be available and provide useful data, including local, national, regional and international sources. As much information should be collected as possible, which can later be compared. Advice from sectoral experts can help to validate the reliability of information. Table 16 gives a non-exhaustive list of some recommended sources for assessments of the agriculture, enterprise and tourism sectors.

[8] Fiji Sugar Corporation (FSC)

Table 16: Sources of information on economic sectors

Source	Agriculture	Enterprises	Tourism
Census and survey data	Agriculture censuses and surveys	Enterprise censuses and surveys	Tourism censuses and surveys
National statistics	National statistics office, Pacific Regional Information System (PRISM)[9]	National statistics office, Pacific Regional Information System (PRISM)	National statistics office, Pacific Regional Information System (PRISM)
National ministries	Public works department	Trade and industry ministries, central banks.	Tourism ministries
Private sector	Agricultural producers agricultural sales, processing companies	Small, medium and large-sized enterprises	Tourism operators
Field assessments	Field assessments of affected agricultural areas	Field assessments of affected industries	Field assessments of affected tourist establishments
Banks	Central bank, development bank	Central bank, development bank	Central bank, development bank
Unions	Agricultural workers' union	Industrial or manufacturing workers' union	Tourism workers' union
Community	Community surveys and discussions	Community surveys and discussions	Community surveys and discussions
Trade associations	Agricultural trade associations	Industry associations, chambers of commerce	Hotel and tourism associations
NGOs	NGOs working in agriculture sector	NGOs involved with enterprises	NGOs working in tourism sector
Regional organisations	FFA, PIFS, SPC, SPREP, USP	PIFS, SPC, USP	PIFS, SPTO, USP
International Organisations	ADB, FAO, IFAD, WB, WFP	ADB, UNDP, UNESCAP, WB	ADB, UNESCAP, UNDP, WB, WTO, WTTC
Press	Press reports	Press reports	Press reports
Relevant donors	Relevant donors	Relevant donors	Relevant donors

[9] Pacific Regional Information System available at http://www.spc.int/prism/

4. Cross-Sectoral Impacts

Disasters often have environmental, distributional, psychosocial and governance effects, which can have repercussions for many sectors of the economy and society. These cross-sectoral impacts also need to be assessed. The methodology is very similar to that for sectoral assessments. Particular care must be taken not to double count damages included in other sectors, as this is a common mistake with cross-sectoral effects. For example, environmental damage is often included under the tourism, health or agriculture sectors. Once again the 'with disaster' situation must be compared to the 'without disaster' situation, to get an accurate picture of disaster impacts. Valuation of cross-sectoral impacts, such as environmental damage, in monetary terms is particularly challenging. Further details of methods that can be used are given in Section 4.1.3.

4.1. Overview of environmental impacts

The quality of life and well being of communities, particularly in Pacific Island Countries, depends on the state of the environment. From an economic perspective, natural resources are considered assets from which goods and services are derived that help increase people's well being. Ecosystems provide a range of goods (such as food, water, medicines and energy) and services (such as the dilution and transformation of waste, the regulation of the water cycle, carbon sequestration, the maintenance of biodiversity, and recreation). These environmental goods and services sustain and satisfy human life.

Natural hazard events are part of nature, and ecosystems have evolved with them. Natural hazards can play an important role in the maintenance of biodiversity and ecosystem functions in the long term. For example, many ecosystems have adapted to occasional wildfire caused by droughts, and river habitats and ecosystems are often dependent on annual floods. When these events occur in remote areas without human habitation, they are usually not considered disasters. Where natural and human systems interact, however, extreme natural phenomena can cause environmental change that reduces community well being. For example, a cyclone can cover a beach with debris and prevent its recreational use, flooding can lead to contamination of water, or a drought might affect the survival of an endangered species. Such environmental change can be permanent or temporary. A volcanic eruption with lava flows can result in irreversible changes in the landscape. Changes in the atmosphere caused by the same eruption, however, such as pollution by the gases released, are temporary. Changes in people's well being might arise from the temporary or permanent inability to use environmental goods or services, or the increased costs of use of environmental goods or services. For example, the destruction of sea tracks leading to beaches and swimming areas caused by Cyclone Heta in Niue has made swimming recreation more costly, even though some of the beaches did not undergo major environmental change.

In the past in Pacific Island Countries, disaster impact assessments have rarely included estimates of the effects of disasters on the environment. Environmental damage is a type of 'intangible impact', which is particularly challenging to value in monetary terms because the value of environmental goods and services is not reflected in market prices (see Sections 2.1.2 and 2.2.9 for details on intangible impacts). Several factors may constrain countries from conducting thorough environmental impact assessments, such as the difficulty in valuing environmental damage, and a lack of time, baseline information and human resources and skills. A comprehensive evaluation should at least identify and, where possible, quantify environmental impacts, particularly if environmental damage is considered to be severe, so that they are less likely to be ignored in decision making.

Estimating Coastal Erosion Caused by Cyclones Gavin and Hina in Tuvalu

In 1997, the wave, storm surge and strong winds caused by Cyclones Gavin and Hina in Tuvalu led to coastal erosion in all of the country's nine atolls. In a country like Tuvalu with a limited land area of only 26 km^2 (consisting of nine coral atolls none of which is over 4.6 metres above sea level), the erosion caused by cyclones can have serious repercussions. An assessment of the extent and value of this coastal erosion was included in the overall disaster impact assessment. The government assessed the extent of erosion damage in square metres in all nine atolls in Tuvalu, and assigned a value to the damage based on the cost of rehabilitation of the coastal areas to their former state.

Currently there is no systematic input of environmental impacts of natural disasters into disaster impact assessments. Tuvalu has experienced other environmental impacts from cyclones that were not assigned monetary values, such as intrusion of saltwater into compost pits, contamination of freshwater wells, and shifting of layers of sand onshore.

Box 14: Estimating coastal erosion caused by Cyclones Gavin and Hina in Tuvalu

Estimates of the impact of natural disasters on the environment can be made through a number of indirect procedures. Each category of environmental impact must be analysed individually in order to choose the most appropriate method for estimating value. It is important to be aware that some environmental impacts may already have been included under different social or economic sectors, so take care not to count the damages twice in the final overall assessment.

4.1.1. Assessment of environment 'without' the disaster

First, it is necessary to describe the state of the environment before the disaster, and how the environment was likely to develop without the disaster, to ensure that only effects genuinely caused by the disaster are attributed to it. All available baseline information on the environmental conditions, including land and marine resources and ecosystems, in the area affected by the disaster should be collected. This baseline information can also be useful for analysing possible links between the scale of the damage caused by the disaster and the state of the environment prior to the event. Useful baseline information includes environmental profiles, maps of wildlife and plant life areas, maps of land use areas, geological and geo-morphological maps and reports, geographic information systems, aerial and satellite photographs, and relief maps.

4.1.2. Environmental disaster impact assessment

The next step is to identify, and where possible quantify, the impacts of the natural disaster on the environment. Natural disasters can cause temporary or permanent loss of economic opportunities from damaged ecosystems, such as reefs and forests, and loss of environmental services, such as water purification, floodwater retention, coastal protection, biodiversity protection, carbon sequestration, soil retention, and recreation potential.

In many cases, it may not be possible to conduct a quantitative assessment due to the restrictions on time, resources and accurate quantitative information. In these cases, it is best to describe the impacts qualitatively (in terms of the type of natural resource affected, and severity and extent of impact) and wherever possible try to quantify the effects. Satellite images and geographic maps can be useful for this. Examples of direct damage caused by natural disasters in Pacific Island Countries include soil erosion and beach damage caused by cyclones, the reduction in the volume of fishery catches caused by El Niño / El Nina phenomena, the reduced flow of water caused by drought, and the number of individual members of a species killed by a cyclone. Just like with other types of disaster damages, environmental impacts can be classified as direct and indirect. Direct environmental damage derives from changes in the quantity and quality of environmental assets caused during the actual disaster event, such as loss of soil or vegetation, and reduced quality and quantity of water. Indirect damage consists of modifications to the flows of environmental goods and services arising from damage caused by the disaster. Indirect damages can continue until the natural and man-made environments are restored to their previous conditions.

The table below identifies some of the types of environmental damage caused by Cyclone Heta in Niue, and the associated environmental goods and services that were affected as a result.

Table 17: Types of environmental goods and services affected by Cyclone Heta in Niue

Environmental change	Environmental goods and services affected
Deaths of flying fox and coconut crab, and destruction of their habitat	• Food source • Wildlife habitat • Recreation (tourism)
Changes in the quality of seawater: turbidity, fuel contamination from damaged fuel tanks	• Navigation • Fishing • Recreation (tourism)
Changes in shoreline erosion, loss of beaches, and beaches littered with debris	• Land (property) • Recreation (tourism)
Damage to coral reefs	• Coastal protection • Recreation (tourism) • Fishing • Unique ecosystem (existence value)
Changes in sanitation conditions caused by flooding and overflowing septic tanks	• Health conditions • Recreation (tourism)

4.1.3. Valuation of environmental impacts

Economists categorise the values of environmental goods and services into use and non-use values. Direct-use values derive from the consumption of natural resources such as firewood, and the non-consumptive use of natural resources, for example through tourism activities. Indirect-use values derive from the benefits that indirectly result from the primary ecological functions of natural resources. For example, the indirect use value of a wetland can derive from its contribution to the filtration of water used downstream. Non-use values arise from the psychological benefits derived from, among other things, the mere knowledge that the resource exists (existence value) or the wish to preserve natural resources for future generations to enjoy (inheritance value).

The presence of non-use values and the lack of markets for many environmental goods and services pose theoretical and practical obstacles to valuing environmental damage. Because many environmental resources are not traded in markets, they do not have a clearly defined price. Only a few environmental goods or assets can be measured directly in terms of their market value. Consequently, indirect procedures are commonly used to estimate them. Some of these procedures are outlined in Box 15. Further details on these methods can be found in the UNECLAC Handbook for Estimating the Socio-economic and Environmental Effects of Disasters (Volume 4), with detailed instructions on how to assess damage to the air, water resources, land, seabed, and biodiversity.

It is up to the assessor to decide whether to conduct an economic evaluation of environmental losses and benefits or whether just to conduct a quantitative assessment in non-monetary units.

Valuing Environmental Damage

Market values – total destruction
If there is a market for the environmental good or service, an estimate of the economic value of direct damage can be estimated as the market price. For example, if agricultural land is completely destroyed and restoration is not deemed appropriate (whether for technical or economic reasons), the direct damage will be the value of the land. Ideally, distortions to market prices through taxes and subsidies should be accounted for using shadow prices.

Restoration cost method
When direct environmental damage is deemed to be recoverable, it can be approximated as the cost of rehabilitation or restoration. For example, the value of hillside erosion can be approximated as the cost of stabilising the slopes through soil conservation works. Similarly, the value of contamination of rural drinking water resources may be estimated as the cost of restoring the water to drinkable quality.

Change in productivity method
When damage to environmental assets can be recovered naturally over a given period, the value of the damage can be estimated indirectly by measuring the value of the environmental services the assets will not provide over the period required for recovery. For example, the direct damage to soils caused by mudslides can be estimated as the agricultural or forestry production that cannot occur for the period the land takes to recover.

Contingent valuation
An indirect estimate of the value of environmental damage can be made by consulting users about the value that they ascribe to environmental goods and services. This procedure can be used for both use and non-use values. The cost involved and time needed for this method, however, is often not available after a disaster.

Box 15: Valuing environmental damage

4.2. Other cross-sectoral impacts

Other cross-sectoral issues may need consideration, some of which are outlined below. Just as with the sectoral assessments, cross-sectoral impacts are estimated by comparing the 'without disaster' situation to the 'with disaster' situation.

4.2.1. Impacts on vulnerable groups

Disasters often have a differential impact on certain groups in society, such as women, children, the elderly, ethnic minorities and the sick or injured. A discussion of the differential impacts and resulting needs of vulnerable social groups should occur throughout all the sectoral assessments. Men and women may be vulnerable to different disaster impacts. For example, women may not only sustain direct damages and production losses, but also lose income through an increased amount of unpaid reproductive work, such as caring for children when schools are closed. It is important to keep a clear gender focus in a disaster impact assessment. Disasters may also have a differential impact on other population groups, such as the elderly, children, and low-income households. If data is available an assessment of the disaster's impact on income distribution and poverty should also be included. This will help to design a post-disaster reconstruction programme that helps all social groups to recover. Even if a local economy booms following a disaster, some sections of the affected community may be substantially worse off and this must be reflected in the assessment to give an accurate and balanced view on the effects.

4.2.2. Psychosocial impacts

Major natural disasters may lead to a loss of social capital and community cohesion if people lose friends and family members. Natural disasters may affect migration patterns, and put pressure on urban centres and squatter settlements. Other psychosocial impacts frequently caused by disasters include trauma and stress, which can affect emotional, spiritual, cultural, psychological and social well-being. There are many effects of post-disaster trauma. In its most acute form, individuals are incapacitated and need medical treatment. Some may require counselling and public support. Trained mental health professionals may be needed to assist the most traumatised victims, through schools, community organisation and existing village structures. An estimate of the number of people affected by psychosocial impacts and the cost of treatment should be included in the disaster impact assessment.

The Tuvalu Dormitory Fire

On the night of 9 March 2000 a fire broke out in one of the girls' dormitories at Motufoua Secondary School on the island of Vaitupu in Tuvalu. The dormitory was locked for security reasons and a key was not easily available to allow the girls to escape. Trapped in the dormitory, 18 of the girls and the matron who was trying to free them were killed. Another 18 girls managed to escape, with three suffering burns. The girls were aged between 14 and 17. It is widely believed that a girl who was studying by candlelight under her blanket caused the fire by setting her bed alight.

Motufoua Secondary School is the only government secondary school in Tuvalu. The island of Vaitupu where the school is based has a population of 1,300 and the total population of Tuvalu is only 11,305 (2003 census). The victims came from seven different atolls. Most of the extended families in Tuvalu lost at least one member and almost everyone in the country had relatives attending the school. Because of the small size of Tuvalu's population, the fire killed a significant proportion of the teenaged girls in the country. In scale the loss is equivalent to the death of more than 200,000 girls in a single disaster in Japan, or 25,000 girls in Australia.

The fire had traumatic psychological impacts on the people of Tuvalu. The fire affected the primary victims that escaped the dormitory, their families, people at the school who doused out the fire and handled the bodies of those killed, school staff and students, and the wider community in Tuvalu. In response to the psychosocial impacts of the disaster, a group of doctors and nurses from different medical specialties created a body called the *Motufoua Psycho-Social Mission.* The Mission employed a trauma consultant from New Zealand to assess the situation at Motufoua, provide training to local medical staff in disaster stress and its treatment, and produce management guidelines for the affected communities and victims. Symptoms were observed of reactive depression, flashbacks, avoidance behaviour and hyper-arousal physical responses. Family and church networks also provided a support system for those suffering from psychological trauma.

The Motufoua fire is a clear example of the psychological impacts that can affect individuals and communities after both man-made and natural disasters in the Pacific, which should be included in an assessment of disaster impacts.

Source: Taylor, 2000.

Box 16: The Tuvalu dormitory fire

The loss sustained during a disaster can also lead to a greater sense of community if an atmosphere of mutual purpose, self-help and solidarity is created. For example, the experience of the Fiji Sugar Corporation in Labasa suggests that the process of repairing and rehabilitating the sugar industry and infrastructure had a positive impact on the team and community spirit of the workforce who took great pride in accomplishing a thorough clear-up.

4.2.3. Impacts on governance and financial sectors

The governance sector may experience damage from a natural disaster, which needs to be included in the overall assessment. The governance sector includes public administration, justice, and parliament and police infrastructure. Damage to governance, law and order and public administration may have numerous repercussions for social, infrastructure and economic sectors. Care must be taken not to double count governance damages included in other sectors.

Damage to the financial sector includes banking and non-banking finance. Damage to banking has cross-sectoral implications through loans, micro-credit, payment systems, etc. The banking sectors include commercial, rural, central and development banks, which may suffer infrastructure damage and losses of loans and deposits. The financial sector also includes non-bank financial institutions such as insurance and private pension companies. Damage to financial institutions may have numerous repercussions for social, infrastructure and economic sectors. Care must be taken not to double count damages included in other sectors.

4.3. Sources of information

Information is needed to assess 1) how the state of the environment and other cross-sectoral areas are likely to have developed 'without' the disaster, and 2) how the environment and other cross-sectoral areas are affected by the disaster. Although disasters can obstruct normal channels of information, a range of different sources may still be available and provide useful data, including local, national, regional and international sources. As much information should be collected as possible, which can later be compared. Where possible, assessment should only use documented facts, credible oral reports or their own observations. Advice from sectoral experts can help to validate the reliability of information. Table 18 gives a non-exhaustive list of some recommended sources for cross-sectoral assessments.

Table 18: Sources of information on cross-sectoral impacts

Source	Environment	Vulnerable groups	Psychosocial	Governance/finance
Census and survey data	Environmental censuses and surveys	Household censuses and surveys	Health / social censuses and surveys	Government / banking censuses and surveys
National statistics	National statistics office, Pacific Regional Information System (PRISM)	National statistics office, Pacific Regional Information System (PRISM)	National statistics office, Pacific Regional Information System (PRISM)	National statistics office, Pacific Regional Information System (PRISM)
National ministries	Ministry of Environment / Natural Resources / Fisheries / Forests / Lands	Ministry for Youth / Women, Department of Social Welfare / Poverty Alleviation	Ministry of Health, Ministry of Education	Justice and police departments, public administration
Private sector	Private environment consultancies	Businesses	Not Applicable	Commercial banks
Field assessments	Field assessments of affected environments	Field assessments of affected households	Field assessment of affected households	Field assessments of affected government buildings and banks
Banks	Development bank funding environment projects or research	Development bank	Not Applicable	Central, development and commercial banks
Community	Community surveys and discussions	Community surveys and discussions	Community surveys and discussions	Community surveys and discussions
Trade associations	Chamber of commerce	Chamber of commerce	Chamber of commerce	Banking associations
NGOs	NGOs working in environmental sector	NGOs working with communities, especially women and children.	NGOs working with communities in psychosocial areas	NGOs working in justice, human rights, governance etc.
Regional organisations	FFA, PIFS, SOPAC, SPC, SPREP, SPTO, USP	PIFS, SPC, USP	FSM, PIFS, SPC, USP	PIFS, SPC, USP
International Organisations	ADB, FAO, UNEP, WB	ADB, UNDP, UNESCAP, WB	ADB, UNDP, WB	ADB, UNDP, WB
Press	Press reports	Press reports	Press reports	Press reports
Relevant donors	Relevant donors	Relevant donors	Relevant donors	Relevant donors

5. Overall Impact Assessment

5.1. Analysis of direct and indirect impacts

The overall impact assessment brings together all of the sectoral and cross-sectoral assessments to estimate the total amount of direct and indirect impacts. It should include a breakdown identifying the most affected sectors, geographic areas, and population groups, which require priority attention for reconstruction.

5.1.1. Total impact summary

Direct and indirect impacts can be added together to obtain an estimate of the total impact. Make clear in the assessment report that the estimate of total impacts includes assets (direct impacts) and economic flows (indirect impacts). Special care must be taken to avoid double counting damage recorded in one sector, by including the damage in another sector. Remember to subtract any benefits from the disaster as positive impacts from estimates of damages and losses. Table 19 can be used to compile and summarise the direct and indirect impacts for each sector. The summary assessment of impacts should be continuously updated and refined as more and better quality information becomes available on the quantity and value of damages and losses.

Table 19: Summary matrix of total disaster impact

	Disaster Impact			Property	
	Direct Impact	Indirect Impact	Total	Private	Public
Social Sectors Housing Education Health Other TOTAL					
Infrastructure Energy Water & sanitation Transport & communications Other TOTAL					
Productive Sectors Agriculture Tourism Trade & enterprises Other TOTAL					
Cross Sectoral Environment Vulnerable groups Psychosocial Governance & finance Other TOTAL					
TOTAL DAMAGE					

The disaster impacts in the summary table can provide a good basis to start making informed decisions on both reconstruction strategies and DRM measures to reduce the impacts of future natural disasters. Remember, however, that the total damage estimated using the value of the assets in their original state is not equal to the cost of reconstruction. Reconstruction will involve replacing old assets with new, more expensive ones, and there may be additional costs if reconstruction involves DRM activities.

To determine the impact that a disaster will have on the affected country, the total amount of damages should be compared to regional or national GDP. This comparison will provide an indication of how severely the economy will be affected, how quickly the economy can be expected to recover, and whether the affected country has sufficient capacity to face reconstruction by itself or requires foreign cooperation. In Pacific Island Countries, the monetary value of disaster impacts may be small in absolute terms, but constitute a high proportion of GDP, thereby significantly affecting the country and its ability to recover. The magnitude of the disaster can be determined by comparing the disaster impacts to macroeconomic variables, such as:

- Total amount of disaster impacts as a percentage of GDP[10];
- Total amount of direct damage and indirect losses as a function of the population affected;
- Total amount of direct impacts as a percentage of GDP; and
- Total amount of indirect impacts as a percentage of GDP.

Heavy Impact of Disasters on Small Island Developing States Relative to Population and GDP

Many Pacific Island Countries have small populations but rapid population growth, low levels of GDP per capita, slow GDP growth, and limited land areas. For example Tuvalu has a population of only 11,305 people, GDP per capita of US$1,157, a land area of only 26 km^2 at a maximum height of 4.6 metres above sea level, very few natural resources, and limited transport and communication links with the rest of the world.

Box 17: Heavy impact of disasters on SIDS relative to population and GDP

At the end of the assessment it may be useful to convert the final damage figures to US, Australian or New Zealand dollars for the purpose of comparison and better understanding by the international community.

5.1.2. Breakdown by sector, geographical area and population group

The total impact summary should be complemented with a break down identifying the most affected sectors, geographic areas, and population groups, which require priority attention for reconstruction. Tables, graphs, maps and pie charts can help to illustrate reconstruction priorities.

It is useful to compare the total direct and indirect impacts. The total direct damage indicates the efforts needed to replace lost assets, whereas indirect losses reflect changes in economic flows and therefore in future economic performance. A comparison of the percentage of total damage attributable to direct damage, and the percentage attributable to indirect losses can help to clarify how the economy is most affected by the disaster. The summary table can also be used to determine which sectors were most affected overall. This can help to prioritise the sectors that need greatest support for reconstruction. It can also be useful to assess the proportion of total damage attributable to cross-sectoral impacts, such as environmental damage. A breakdown of the total damage by public and private sector will help to define the relative efforts required from the state and from private individuals and enterprises. If private sector damage is considerable, the government may wish to consider establishing financial schemes or credit for the private sector affected by the disaster, especially in the case of vulnerable population groups, or strategic sectors of the national economy.

The geographical distribution of disaster impacts can be estimated using maps to identify the most highly affected regions. Geographical damage information can be combined with data on the location of different socio-economic groups to help define a geographical distribution of resources for reconstruction. Try also to identify the

[10] International experience indicates that when the impact/GDP ratio exceeds 8%, the magnitude is considered moderate, and that when it exceeds 40%, the affected economy is likely to face significant difficulties in recovering.

most highly affected demographic and socio-economic groups, such as low-income households, women, children and the elderly. This can help to prioritise the most pressing needs for reconstruction.

5.2. Macroeconomic impacts

The summary of direct and indirect disaster impacts should be supplemented with an estimation of the quantifiable macroeconomic effects. If possible within the time and resource constraints the assessment should include an estimation of the effects of the disaster on the main macroeconomic variables, such as GDP, investment, employment, balance of payments, public finances and inflation. Remember that disasters may have positive impacts on macroeconomic indicators, such as economic growth in the long term. The macroeconomic assessment provides a complementary summary of the disaster impact. The macroeconomic effects cannot be added to direct and indirect damages because this would involve double counting.

Further details on the methodology used for estimating macroeconomic effects can be found in the UNECLAC Handbook for Estimating the Socio-economic and Environmental Effects of Disasters, Volume 4.

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Tool Two:
A Toolkit for Assessing the Costs and Benefits of Disaster Risk Management Measures in the Pacific

This research was commissioned and funded by the Australian Agency for International Development (AusAID) as part of a research project on: 'The Economic Impact of Natural Disasters on Development in the Pacific'. It was managed by USP Solutions and jointly conducted by the University of the South Pacific (USP) and the South Pacific Applied Geoscience Commission (SOPAC).

Australian Government

AusAID

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Cover photo:

Waves crashing in Port Vila harbour during a cyclone in Vanuatu (source – South Pacific Applied Geoscience Commission).

A Toolkit for Assessing the Costs and Benefits of Disaster Risk Management Measures in the Pacific

A practical tool for assessing the impact and cost-effectiveness of disaster risk management measures consistently across the Pacific.

April 2005

Contents

List of Tables

List of Boxes

List of Figures

List of Equations

As the human and financial costs of disasters rise, there are increasing demands for evidence that mitigation 'pays'. Until this proof exists, however, many aid agencies remain reluctant to pursue risk reduction as a key objective, or even to protect their own projects against potential hazards.

Underlying the generation of such evidence, it is necessary to have appropriate tools to analyse and measure the costs of mitigation and the nature of the resulting flow of benefits. These costs and benefits can take many forms, including social, environmental and humanitarian as well as financial ones.

Benson and Twigg
'Measuring Mitigation'
2004, p5

Foreword

Pacific Island Countries regularly suffer damages, losses and casualties caused by natural hazards, such as cyclones, floods, landslides, droughts, volcanic eruptions, earthquakes and tsunamis. The significant impacts of natural hazards place many Pacific Island Countries among the world's most vulnerable nations. To reduce the long-term impacts of disasters, Pacific Island Countries can invest resources in Disaster Risk Management (DRM) activities, which avoid or limit the adverse effects of natural hazards. Despite this, disaster relief continues to absorb far greater financial resources than proactive DRM measures, and reconstruction programmes are often designed without a DRM strategy. Lack of information on the relative effectiveness of alternative DRM projects is one factor holding back decisions to invest. Pacific Island Country leaders and international aid donors seek evidence of the value of DRM before adopting projects that make heavy demands on limited resources.

Economic techniques exist that can be used to estimate and compare the costs and benefits of DRM measures in Pacific Island Countries. These tools allow decision makers to assess whether particular DRM measures are worthwhile investments and to choose the most effective option from a range of alternatives. Use of such tools can help to make the limited funds and resources available for DRM activities achieve the greatest possible reduction in future damages, losses and casualties for each dollar spent on DRM. Objective evidence on whether investments in DRM measures make sound economic sense can help to convince Pacific Island governments and communities, and international aid donors to allocate funds for DRM projects. Investing resources for DRM wisely is in everyone's best interests.

There are a number of constraints preventing Pacific Island Countries from using economic tools to guide DRM resource allocation decisions. First, there is little accurate data on the impacts of past natural disasters, which makes it difficult to estimate the benefits of DRM projects. The guidelines accompanying this toolkit aim to improve the quantity and quality of estimates of the impacts of natural disasters in Pacific Island Countries, which should help to address this constraint (see accompanying *Guidelines for Estimating the Economic Impact of Natural Disasters on Development in the Pacific*). Second, there currently does not exist any formal guidance on how to conduct economic analysis to evaluate DRM measures in Pacific Island Countries. This toolkit is a first step towards producing such guidance. It is hoped that use of economic tools will help to allocate resources to DRM efficiently and effectively. AusAID commissioned this toolkit in response to a call for more rigorous cost-benefit analysis of the range of alternative measures for disaster reduction. It was prepared in collaboration between the South Pacific Applied Geoscience Commission (SOPAC) and the University of the South Pacific (USP).

Background – Shifts in Thinking on Natural Disasters

'Historically, the response to disasters has focused on relief, with governments, donors and NGOs providing post-disaster resources and aid. Whilst this work is essential to respond to people in need, the focus of disaster response has been shifting to encompass the wider issue of disaster preparedness, engaging NGOs and other stakeholders in preparing for the impacts of hazards, through measures such as early warning systems, evacuation planning and the protection of safe drinking water supplies. The most recent thinking has taken further steps towards a risk reduction approach, in which community risk is assessed and community-level initiatives attempt to reduce the negative impacts of a hazard, through reducing vulnerabilities and building on capacities. It is also increasingly recognised that local-level efforts alone will not break the cycle of vulnerability. The root causes of vulnerability, which may include cultural contexts, ineffective governance and international influences such as the globalisation of trade, all need to be incorporated into risk reduction if vulnerability is to be effectively reduced. Furthermore, there is a growing awareness that disaster risk reduction work needs to be integrated into development activities in order to ensure that the benefits of development are not lost and risk is not inadvertently created.

Despite these shifts in thinking, the incorporation of DRM into humanitarian and development work has been relatively slow, with the priority remaining on relief responses. A lack of evidence of the effectiveness of DRM, combined with the historic separation of humanitarian relief and development activities, has contributed to this.'

Source: Venton and Venton, 2004, p1

Box 1: Shifts in thinking on natural disasters

Acknowledgements

This toolkit was jointly 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), and managed by USP Solutions.

Thank you to the many people who assisted the research for this toolkit in Fiji, Niue, Tuvalu and Vanuatu, including individuals from government departments, chambers of commerce, private companies, non-governmental organisations, and international and regional organisations, who provided valuable information and assistance. Particular thanks to the National Disaster Management Officers who supported and coordinated the research in the countries: *fakaue lahi* to Deve Talagi in Niue, *tankiu tumas* to Job Esau in Vanuatu, *fakafatai* to Sumeo Silu in Tuvalu, and *vinaka vaka levu* to Tui Fagalele in Fiji. Thanks also to Alan Mearns and Russell Howorth at SOPAC for their guidance and advice.

Acronyms

ACP	African, Caribbean and Pacific
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
CHARM	Comprehensive Hazard and Risk Management
CRED	Center for Research on the Epidemiology of Disasters, Université Catholique de Louvain
DHA	Department of Humanitarian Affairs (United Nations)
DRM	Disaster Risk Management
EIA	Environmental Impact Assessment
EM-DAT	Emergency Disaster Database, Université Catholique de Louvain
FEMA	Federal Emergency Management Agency
FV	Future Value
GDP	Gross Domestic Product
IDNDR	International Decade for Natural Disaster Reduction
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
PRA	Participatory Rural Appraisal
PV	Present Value
SOPAC	South Pacific Applied Geoscience Commission
SPDRP	South Pacific Disaster Reduction Programme
SPPO	South Pacific Programme Office
UNDP	United Nations Development Programme
UNDRO	Office of the United Nations Disaster Relief Coordinator
USP	University of the South Pacific

Glossary

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.
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.
Indirect impacts	Flows of effects that occur over time after a hazard event and are caused by the direct impacts of a disaster.
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.
Nominal value	Measurement of economic value not corrected for changes in price over time (inflation), thus expressing a value in terms of current prices.
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.

Introduction

Natural hazard events occur frequently in the Pacific Islands region. The most common natural hazards in Pacific Island Countries (PICs) are cyclones, floods, droughts, earthquakes, volcanic eruptions, tsunamis and landslides. These events often cause harm, damage and loss, which can turn a natural hazard into a 'natural disaster'. 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 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 damages elsewhere in the world can have a large impact relative to the country's total GDP and population.

To reduce the long-term impacts of disasters, Pacific Island Countries can invest resources in Disaster Risk Management (DRM) activities, which avoid or limit the adverse effects of natural hazards. Although options for reducing disaster damage and losses exist, disaster relief continues to absorb far greater financial resources than proactive DRM measures. Reconstruction programmes are often designed without a DRM strategy. Lack of information on the relative effectiveness of alternative DRM projects is one factor holding back decisions to invest in DRM. Pacific Island Country leaders and international aid donors seek evidence of the value of DRM before adopting projects that make heavy demands on limited resources.

Current Practice of DRM in the Pacific

There was little coordination of hazard reduction activity in the Pacific region before the International Decade for Natural Disaster Reduction (IDNDR) in 1990-2000. Hazards, and the potential impact of those hazards, were rarely considered in national development plans. Disaster management projects funded by donors predominantly addressed preparedness measures. Formal disaster prevention and mitigation were rarely addressed directly, although many development activities had significant hazard reduction and disaster prevention and mitigation impacts. During the IDNDR, however, there was increasing interest in disaster reduction programmes and projects, particularly those relating to risk assessment and mapping, hazard reduction, and community development. DRM programmes and projects are increasingly common in the Pacific Islands region.

In 1995, the Pacific Island Forum Leaders transferred the mandate for coordination of regional DRM activities to the South Pacific Applied Geoscience Commission (SOPAC). SOPAC's Community Risk Programme, a comprehensive programme aimed at reduction of community vulnerability through improved hazard assessment and risk management, currently undertakes the role of regional coordination.

Continuous development since the late 1980s led to the adoption of broadly similar disaster management structures in many of the island countries in the Pacific. Almost all Pacific Island Countries have a system headed by a national disaster council or committee, supported by a National Disaster Management Office (NDMO) that acts as a source of day-to-day coordination and support. Similar committees operate at sub-national levels of government, while village or community committees are mechanisms through which the population can connect with and influence the system. The NDMO's daily activities make a significant contribution to disaster reduction and preparedness. It is generally responsible for coordinating disaster response and preparedness planning, training activities, public awareness and education campaigns, and providing a wide range of advisory functions, particularly to sub-national committees and local government.

Source: SOPAC, 2004, pp37-38

Box 2: Current practice of Disaster Risk Management in the Pacific

This toolkit presents a simple, standardised economic tool, known as cost-benefit analysis, which can be used by Pacific Island decision makers to evaluate investments in DRM measures.

Introduction to Cost-Benefit Analysis

Economic theory assumes that individuals and society have a common goal of maximising 'well being', within the constraints of limited resources and competing needs and desires. If a reallocation of resources increases the total well being of society, it is deemed by economists to be desirable. This is true even if some individuals are made worse off, because in principle the losers could receive compensation from those made better off.

Cost-benefit analysis is a systematic procedure for evaluating decisions that have an impact on society using the assumptions and principles of economics. As suggested by its name, cost-benefit analysis involves comparing the flows of costs and benefits of a project or investment decision. Investments are considered from the perspective of the whole of society, counting all factors that affect societal well being, including environmental, social and economic impacts. Its scope is broader than that of financial analysis, which only considers the financial expenses and revenues of economic agents directly concerned with a project.

Cost-benefit analysis evaluates projects on the basis of the two following principles:

1) If a project produces benefits greater than costs, it is a good use of resources.
2) Among competing projects, the best option will be the one that has the greatest benefits relative to costs.

Using Cost-Benefit Analysis to Assess Disaster Risk Management

A variety of sectors apply cost-benefit analysis to value investments. The cost-benefit analysis procedure outlined in this toolkit can be used in its basic form for a range of different natural hazards and different types of DRM measures. In the area of DRM cost-benefit analysis can be used to:

1) Determine whether the cost of investing in a DRM measure today will result in sufficient benefits, in terms of reducing natural disaster damages in the future, to justify spending money on the project.
2) Choose, from a range of alternatives, the DRM measure with the greatest 'net benefits' in terms of avoided future disaster-induced damages less the project costs.

For example, imagine a DRM project that reinforces residential buildings against earthquake damage. The project will make many people better off by reducing the damages, losses and casualties from future earthquakes. The measure will impose costs on others, however, because it will use up valuable physical and human resources that would otherwise have gone to different projects benefiting others in society. Despite the fact that some people are made worse off by the project, however, as long as the benefits are greater than the costs and under the assumptions of economics, the investment in the project is worthwhile.

Now imagine some alternative ways of spending the money are considered to reduce disaster damage. An alternative project will reinforce a market place against earthquake damage. The costs for this project are lower and the avoided damages will be greater than the DRM project that reinforces residential buildings. The market place project is therefore the best option out of the two alternatives.

Cost-Effectiveness Analysis: An Alternative Method for Assessing DRM Measures

Cost-effectiveness analysis is an alternative method to cost-benefit analysis for evaluating DRM measures. It can be used when the alternative DRM measures being considered all achieve identical benefits in terms of reducing disaster related damages and losses. Cost-effectiveness analysis assesses the least-cost alternative for achieving the identical level of benefits. Cost-effectiveness analysis is difficult to use for assessing DRM projects, because it is rare to find alternatives that achieve exactly the same reduction in disaster damages.

Box 3: Cost-effectiveness analysis

There is very little use of economic tools such as cost-benefit analysis to evaluate the effectiveness of DRM measures in the Pacific because of the many difficulties involved in conducting such analyses. Which impacts should be included? What information needs to be collected and where can it be found? Where should the assessment begin and what steps should be followed? This toolkit steers the reader through the process, explaining the different steps involved in cost-benefit analysis, and providing checklists of data requirements, and tables that can ease the process of data collection and analysis. A standard and comprehensive methodology is presented that can help to identify, quantify and value the costs and benefits of DRM measures consistently across the Pacific. The tools are supplemented by worked examples from four Pacific Island Countries: Fiji, Niue, Tuvalu and Vanuatu.

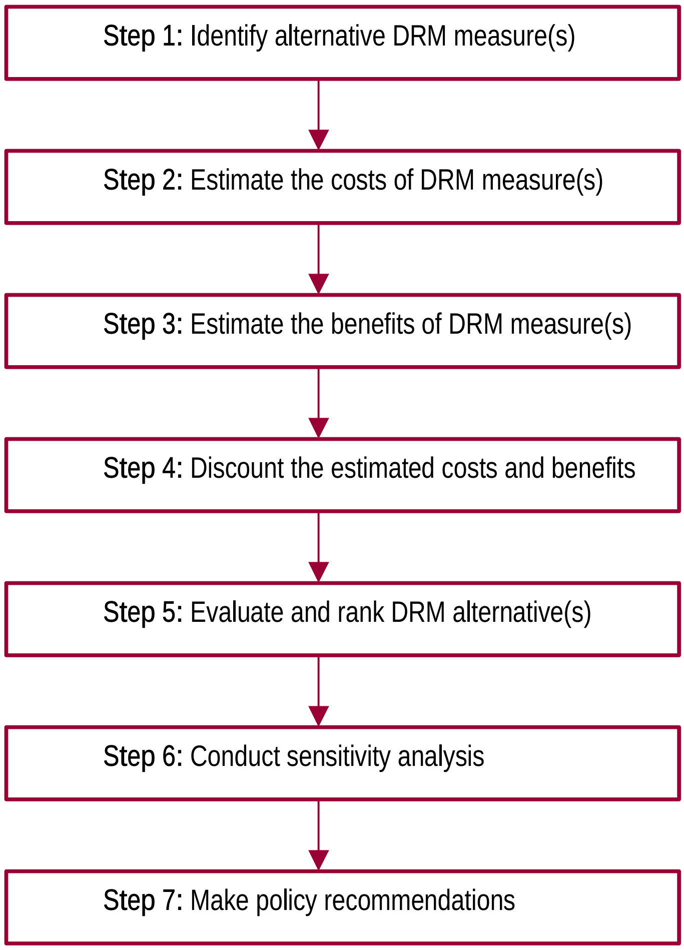
The degree of detail that can be achieved in cost-benefit analyses by using this toolkit will depend on the availability of information on disaster impacts and suitable DRM projects in Pacific Island Countries. Initially, given the current low standard of data collection on disaster impacts in the Pacific, the level of detail may be limited. Over time, however, it is hoped that this toolkit and the accompanying *Guidelines for Estimating the Economic Impact of Natural Disasters on Development in the Pacific* will give Pacific Island Countries an idea of the baseline and impact data that needs to be collected to improve disaster impact assessments and allow cost-benefit analyses of DRM measures. This will lead to a gradual improvement in the standard over time. The toolkit can be used to help all individuals involved in DRM, whether they are government officials, volunteers, NGOs, communities or foreign technical assistants. This toolkit is not a finished product, but should be viewed as work in progress, which can be amended with contributions from users as they gain experience from applying the methodology to DRM projects around the region.

Outline

The rest of this toolkit explains the methodology that can be used to assess the costs and benefits of DRM measures comprehensively, systematically and consistently across the Pacific region. The procedure involved in each step is outlined in each section of this toolkit. Section 1 outlines methods for identifying alternative DRM measures, with examples of past and current DRM projects in the Pacific. Section 2 describes how to estimate the costs of DRM measures. Section 3 gives an overview of how to estimate the benefits of DRM measures. Section 4 explains how to discount the estimated costs and benefits to calculate their 'present value'. Section 5 shows how to calculate various economic indicators, which can demonstrate the overall value of a DRM measure and help to rank DRM alternatives. Section 6 explains sensitivity analysis, a process that can be used to test the repercussions of any uncertain assumptions. Step 7 discusses how to make policy recommendations on the basis of the findings from a cost-benefit analysis. For those still thirsty for more information, at the end of the toolkit there is a list of references that provide additional information on more complicated aspects of cost-benefit analysis and alternative methods such as cost-effectiveness analysis.

The different steps in cost-benefit analysis are shown in Figure 1.

Figure 1: Steps in cost-benefit analysis of DRM measures



1. Step One: Identify alternative Disaster Risk Management measure(s)

The first step in cost-benefit analysis is to determine a range of alternative DRM measures that could reduce potential disaster-related losses, damages and casualties. This section explains some categories of alternative DRM measures, provides examples of DRM measures in the Pacific, and outlines some tools that can be used to identify appropriate DRM measures.

1.1. Categories of alternative DRM measures

Alternative DRM measures include all forms of activities that lessen the impacts of natural hazards, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) the adverse effects of hazards. Structural DRM measures are engineered changes to physical structures that can lessen the impacts of natural disasters. An example of a structural DRM measure in the Pacific is retrofitting houses to make them more resistant to cyclone damage. Non-structural DRM measures use non-engineered solutions to reduce the impacts of natural disasters. Examples of non-structural DRM measures in the Pacific include disaster legislation, building codes, disaster management plans, training, education and awareness programmes, and forecasting and warning systems.

Prevention activities totally eliminate the effects of future natural disasters. Mitigation activities are actions taken to reduce or minimise the impacts of future natural disasters, but do not completely remove their effects. Preparedness activities and measures are 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.

1.2. Examples of DRM measures in the Pacific

A number of regional DRM programmes and national DRM country projects address natural disaster risks in the Pacific. A few examples of these programmes and projects are outlined below.

1.2.1. Regional programmes

- *South Pacific Disaster Reduction Programme (SPDRP):* A four-year programme in the late 1990s designed to help Pacific Island Countries improve their disaster management systems and to develop cooperation for disaster management within the region.
- *Comprehensive Hazard and Risk Management (CHARM):* A tool for a whole-of-country and all-hazards approach to hazard and risk management for Pacific Island Countries.
- *Pacific Cities database*: A geographic information system database designed to aid understanding of the hazards facing Pacific Island communities.
- SOPAC/EU Project for 'Reducing the Vulnerability of Pacific ACP States': A project concentrating on three key focal areas for reducing vulnerability in Pacific ACP countries – hazard mitigation and risk assessment, aggregates for construction, and water resources supply and sanitation.

1.2.2. Country projects

Some past development projects designed to reduce specific risks and vulnerabilities in Pacific Island Countries include:

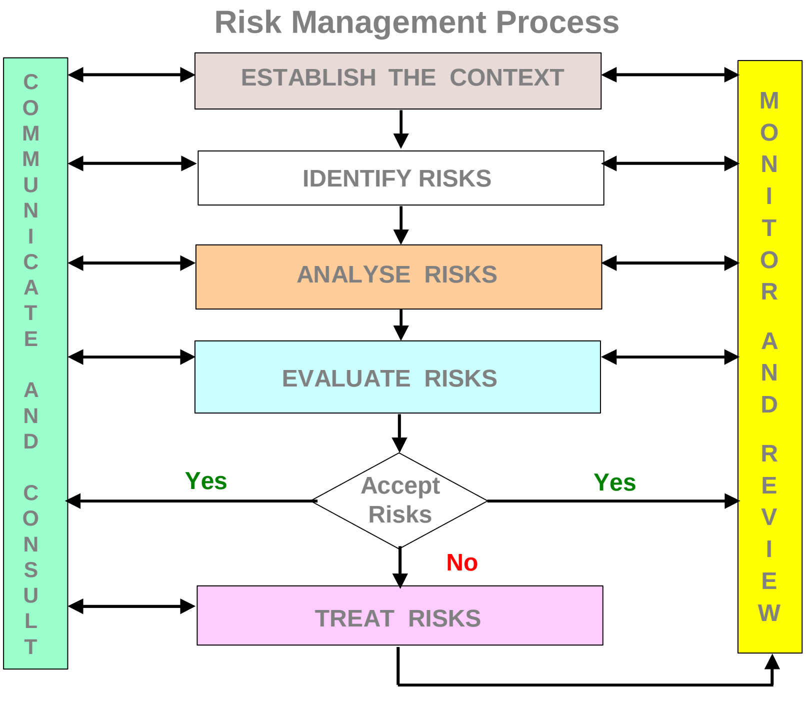
- Enhanced national meteorological services.
- Rehabilitation of coastal plains in Fiji to protect agriculture, particularly the sugar cane fields, against sea-level rise.
- Flood protection and reduction measures including dredging of rivers, building and maintenance of drainage channels, land-use controls, bunds and levee banks.
- Catchment management and soil conservation in Samoa to reduce topsoil loss and environmental damage.
- Improved road systems with better protection from sea, flood and landslide damage.
- Development of engineered building standards.
- Housing rehabilitation and reinforcement programmes in Tonga and Fiji to reduce the risk of damage from tropical cyclones.
- Research into hazard-resistant crops that were then made available to farmers in the relevant countries.
- Agricultural protection measures, including crop rotation, seed and cutting banks, and basic soil sterilisation.

1.3. The CHARM process

One tool that can be used to identify alternative options for reducing the economic impact of future natural hazards is the Comprehensive Hazard and Risk Management (CHARM) process. CHARM is an approach for managing unacceptable risks associated with major hazards using a whole of country perspective. CHARM is based on disaster management initiatives already developed in Australia from the Australia/New Zealand Risk Management Standard of 1999, and adapted for use by Pacific Island Countries. Guidelines for Pacific Island Countries on the use of CHARM are available from the South Pacific Applied Geoscience Commission (SOPAC)[1].

CHARM provides a means of identifying and ranking unacceptable risks from natural hazards and identifying alternative measures for dealing with those risks. The Pacific CHARM model can be used to develop a national matrix identifying unacceptable risks, existing government activities that address those risks, and options for addressing those risks that are currently untreated. Figure 2 shows the CHARM process.

Figure 2: The CHARM process



The main steps in the CHARM process are described in more detail below.

1.3.1. Establish the context

- Sensitise senior political and policy officials
- Identify strategic and organisational issues that will apply to the CHARM process
- Determine the CHARM management mechanisms and operational process
- Identify national development priorities
- Review existing policy related to development project appraisal processes
- Implement training to mainstream DRM into this process
- Develop the initial risk evaluation criteria

1.3.2. Identify risks

- Identify and assess primary and secondary hazards
- Identify vulnerable sectors and determine geographic scope of potential impact

[1] SOPAC. 2002. Regional Comprehensive Hazard and Risk Management Guidelines. South Pacific Applied Geoscience Commission.

- Identify potential disaster impacts using data collected from past disaster impact assessments
- Identify risks associated with primary and secondary hazards

1.3.3. Analyse risks

- Determine and assign levels of risk using indicators such as:
  - ⇒ How often are the hazards likely to occur?
  - ⇒ What are the potential consequences that may arise when the hazard impacts?
- Assign levels of risk

1.3.4. Evaluate risks

- Determine acceptable and unacceptable risks
- Rank risks in order of priority for treatment

1.3.5. Treat risks

- Evaluate and select appropriate treatments for dealing with unacceptable risks, which can be done using cost-benefit analysis
- Identify core business responsibilities and assess existing projects of agencies
- Develop an implementation process for the identified programme gaps
- Link with regional partners and programmes
- Close the new programming gaps through new project proposals
- Implement the new development programme

Data collected using the accompanying *Guidelines for Estimating the Economic Impact of Natural Disasters on Development in the Pacific* can be useful for identifying risks, vulnerable sectors and potential disaster impacts. This cost-benefit analysis toolkit can be used for evaluating and selecting appropriate treatments for dealing with unacceptable risks.

Alternative DRM Activities to Reduce Tuvalu's Vulnerability to Droughts

In 2000 a stakeholder assessment of vulnerability to natural disasters and existing National Disaster Management Programmes in Tuvalu identified four possible new DRM activities, including both structural and non-structural measures, for reducing Tuvalu's vulnerability to droughts, as outlined below:

- Construct three new government water cisterns on Funafuti (structural)
- Repair community cisterns (structural)
- Incorporate water supply by-laws including the requirement to have a rainwater catchment system (non-structural)
- Assessments of underground water piping systems (non-structural)

Box 4: Alternative DRM measures to reduce Tuvalu's vulnerability to droughts

1.4. Community vulnerability analysis

If the community is the primary stakeholder for identifying appropriate DRM measures, there are some useful methods that can be used to work with communities using participatory research techniques, such as participatory rural appraisal (PRA)[2]. A method of identifying alternative DRM measures in Pacific Island communities is outlined in the 'Guidelines for Community Vulnerability Analysis: An Approach for Pacific Island Countries'[3] published by the South Pacific Disaster Reduction Programme (SPDRP) and available from the South Pacific Applied Geoscience Commission (SOPAC). This document provides guidelines for community vulnerability analysis and for action planning to reduce natural disaster impacts in Pacific communities. Guidance is provided on ways of working with the community to analyse its disaster vulnerability, identify priorities and plan actions to reduce community risk.

[2] Participatory Rural Appraisal is distinguished by the use of local graphic representations created by the community that legitimise local knowledge and promote empowerment.

[3] SPDRP. 1998. Guidelines for Community Vulnerability Analysis: An Approach for Pacific Island Countries. South Pacific Disaster Reduction Programme.

2. Step Two: Estimate the costs of Disaster Risk Management measure(s)

The next step in cost-benefit analysis is to determine the cost of implementing each of the DRM measures under consideration. Some options will be more expensive to implement, using up more physical and human resources that could be invested in other valuable projects. The costs of each alternative must be determined so that they can be compared to the resulting benefits, which will allow calculation of the value per dollar spent on DRM.

Cost-benefit analysis considers all the costs to everyone that is affected by the DRM measure, not just the costs to the government or the individuals directly involved in the project. Both the direct costs and externality costs to others in society must be included in the estimate of total costs. Direct costs are the costs incurred by those direct involved in the DRM project. Externality costs are spillover effects affecting others in society who are not directly involved in implementing the DRM project.

Estimates of the direct and externality costs of DRM measures may be obtained from a number of different sources, such as local NGOs, businesses, communities and government officials. If you are evaluating a DRM measure that has already been implemented, a good place to start collecting cost data is the organisation, community or individuals directly involved with the project. If the DRM measure has not yet been implemented, it will be necessary to obtain best estimates of likely costs. Often a good way to start is to identify similar DRM measures that have been implemented elsewhere, and collect information on the type and extent of the costs involved in those projects, adapting them to estimate the likely costs of the proposed DRM measure in the local context.

Direct and externality costs are described in more detail below:

2.1. Direct costs

Direct costs are the costs to those directly involved in the DRM project under consideration. Direct costs include both fixed and variable costs. Fixed costs are initial one-off investment costs, which occur at the outset of the project and do not increase over time as the project continues. Examples of fixed costs are expenditure on materials, equipment and construction. Variable costs occur on a regular basis, and increase as the project continues over time. Variable costs include expenditure on repair and maintenance of equipment or infrastructure, wages and personnel support costs.

In economic analysis, the correct measure of the cost of a project is the economic value or 'opportunity cost' of all the inputs. The opportunity cost of an input is its value in the next best alternative activity. If markets are competitive, market prices can be used to approximate opportunity costs. Where markets are not competitive, however, prices may not reflect their true value, so they should be adjusted to correct for market distortions, by using adjusted prices known as 'shadow prices'. A shadow price is a "price" used in economic analysis to represent a cost or benefit from a good when the market price is a poor indicator of economic value or there is no market at all for that good. Shadow prices correct for distortions such as subsidies and taxes, which affect market prices so that they do not reflect the true social value of a resource.

2.2. Externality costs

In addition to the direct costs of DRM measures, there may be economic, environmental or social externality costs, which also need to be accounted for. Externality costs are spillover effects affecting others in society who are not directly involved in implementing the DRM project. For example, a hazard-zoning project, which restricts access to economic and environmental resources, may impose a cost on those individuals who use the resources for their well being and livelihood, and can no longer access them. DRM measures can also have psychological costs, for example a project that relocates a community away from a flood plain may cause psychological and emotional distress by moving the community away from their homeland. Such negative impacts should, where possible, be included in the estimated total cost of each DRM measure.

Externality costs are much more difficult to measure, but it is important to identify any negative externality impacts of DRM measures in as much detail as possible. The economic, environmental and social costs of DRM measures can be identified using interviews or participatory research techniques with communities, local NGOs and government officials. It can be difficult to quantify externalities in terms of a monetary value, especially if they involve intangible impacts (see Box 8 on how to value intangible disaster impacts). If it is not possible to quantify costs in monetary terms, identify them and describe the extent of the cost in as much detail as possible.

Table 1 can be used to help analysts to collect information on the costs of DRM measures.

Table 1: Matrix for collecting information on costs of DRM measure

	Direct Costs		Externality costs	Further details
Item	Fixed costs	Annual variable costs		

Costs of a Desalination Plant in Tuvalu to Provide Water During Drought

There are no streams or rivers in Tuvalu, so most of the population has traditionally relied on rainwater catchment for their water supply. During a drought in 1999 the Tuvalu Government purchased a desalination plant to provide a supply of drinkable water in Funafuti. The costs of the desalination plant are shown in the table below. The Tuvalu Public Works Department collected much of the cost data shown in the matrix. There were high fixed costs involved in purchasing, transporting and establishing the desalination plant in Funafuti. There are also regular variable costs involved in operating the desalination plant such as labour costs, fuel costs, and transportation costs for transferring the water to households. Maintenance costs are particularly high. 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.

An alternative DRM measure for providing water during drought is to improve rainwater catchment systems. Cost-benefit analysis could be used to compare the costs and benefits of operating the desalination plant to the costs and benefits of improving maintenance of private rainwater catchment systems. This could help to determine the most cost-effective option for providing drinking water during droughts 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.		

Box 5: Costs of desalination plant in Tuvalu

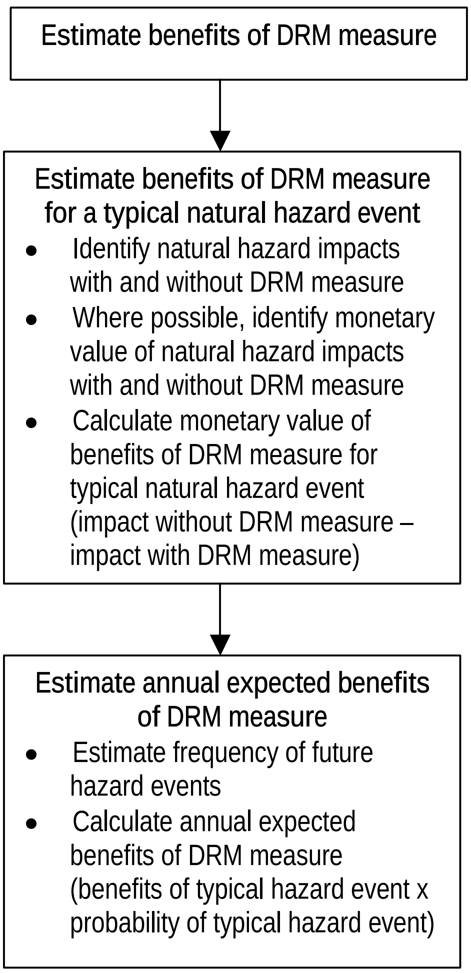
3. Step Three: Estimate the benefits of Disaster Risk Management measure(s)

The third step in cost-benefit analysis is to estimate the benefits of the DRM alternatives under consideration. The benefits of DRM measures will be the value of disaster-related damages, losses and casualties that are avoided due to the measure being in place. The benefits are estimated as the difference in the level of damage inflicted 'with the DRM measure' and the level of damage 'without the DRM measure'.

Cost-benefit analysis considers all the benefits to everyone that is affected by disaster-related damages and the DRM measure, not just the benefits to the government or those with insurance. In practice, if there are resource constraints on the analysis, for assessments of DRM measures with localised impacts the analysis can focus on the costs and benefits affecting the local population. If impacts beyond the local community are ignored, this should be explicitly stated in the cost-benefit analysis. Clarifying how benefits and costs are spread across individuals, area and time, allows the analyst to see the distribution of impacts, which may be useful for making decisions between the alternatives.

Estimating the benefits of a DRM measure is the most difficult step in cost-benefit analysis, because it involves estimating a number of uncertain aspects about the future, such as the incidence and severity of future natural disasters, and the level of damages that will be caused by future natural disasters with and without the DRM measure. This section of the toolkit outlines a logical process that can be followed, with standard tables to ease the process of data collection and analysis. Figure 3 shows the different stages involved when estimating the benefits of a DRM measure.

Figure 3: Estimating the benefits of a DRM measure



3.1. Estimate benefits of DRM measure for natural hazard event

Start by estimating the benefits of the DRM measure during a typical natural hazard event. Later, in Section 3.2, it will be explained how to convert estimates of the benefits of the DRM measure for a particular hazard event into annual expected benefits.

DRM measures can reduce disaster-related damages and losses, but generally do not completely eliminate them. The benefits of a DRM measure are therefore counted as the difference between disaster-induced damages 'without' and 'with' the DRM measure. In other words, the appropriate measure of benefits is the difference between the value of damages when the DRM measure is not implemented and the value of damages when the DRM measure is in place. This calculation is shown in Equation 1:

Benefits of DRM	=	Avoided disaster damages
	=	Damage without DRM measure – damage with DRM measure

Equation 1: Calculation of benefits of a DRM measure

For example, imagine a DRM project is being considered that will make a house more resistant to cyclone damage. If the DRM project is not undertaken it is estimated, on the basis of past experience of cyclone damage, that the cost of future damage to the house will be $5,000 during a typical cyclone. If the house is strengthened against cyclones, however, it is estimated, on the basis of past experience of cyclone damage, that future damages will fall to $500 during a typical cyclone. The DRM benefits of an average cyclone are calculated as the difference in estimated future damages with and without the cyclone proofing DRM measure. The benefits are calculated as:

Benefits of DRM	=	Avoided cyclone damages
	=	Damage without DRM measure – damage with DRM measure
	=	5,000 – 500
	=	$4,500 per cyclone

In the experimentally ideal cost-benefit analysis, it would be possible to compare the damages suffered by two very similar communities during a past natural disaster, one of which implemented a DRM measure and one community that did not. In the real world it is often difficult to find these sorts of examples. Furthermore, the analyst may wish to estimate the benefits of a DRM measure that has not yet been implemented. In most cases, estimates of damages must be made for hypothetical scenarios that have not occurred in the real world. For these hypothetical estimates, every attempt should be made to obtain the most accurate estimate possible on the basis of all available information on likely disaster impacts with and without DRM measures from many different sources.

3.1.1. Identify natural hazard impacts 'with' and 'without' the DRM measure

A good starting point for estimating the benefits of a DRM measure is to identify all of the hazard impacts that the DRM measure will reduce in future disasters. Start by identifying relevant hazard impacts with and without the measure in place, without worrying about putting a monetary value on those impacts. All direct, indirect and intangible impacts of natural disasters are relevant to a cost-benefit analysis but macroeconomic effects should not be included. The different types of natural disaster impacts are briefly discussed here but a more detailed explanation is available in Section 2 of the accompanying *Guidelines for Estimating the Economic Impact of Natural Disasters on Development in the Pacific*. Remember that DRM measures may also have negative impacts (externality costs), which should be included in Step 2 when estimating the costs of the DRM measure.

Direct impacts

Direct impacts are caused by a natural hazard during the actual event. Natural disasters can cause direct damages involving the complete or partial destruction of physical assets in both the public and private sectors. Examples of physical assets that may be damaged by natural disasters include infrastructure, buildings, installations, machinery, final goods, raw materials, equipment, transportation, farmland, agricultural crops and irrigation works.

Indirect impacts

Indirect impacts are flows of effects that occur over time after a hazard event and are caused by the direct impacts of a disaster. Indirect impacts include losses in production and income, higher operating costs, costs of demolition and debris removal, and relocation costs. Examples of indirect impacts might include a decline in agricultural harvest after flooding, or losses in industrial production due to damage to factories caused by an earthquake.

Intangible impacts

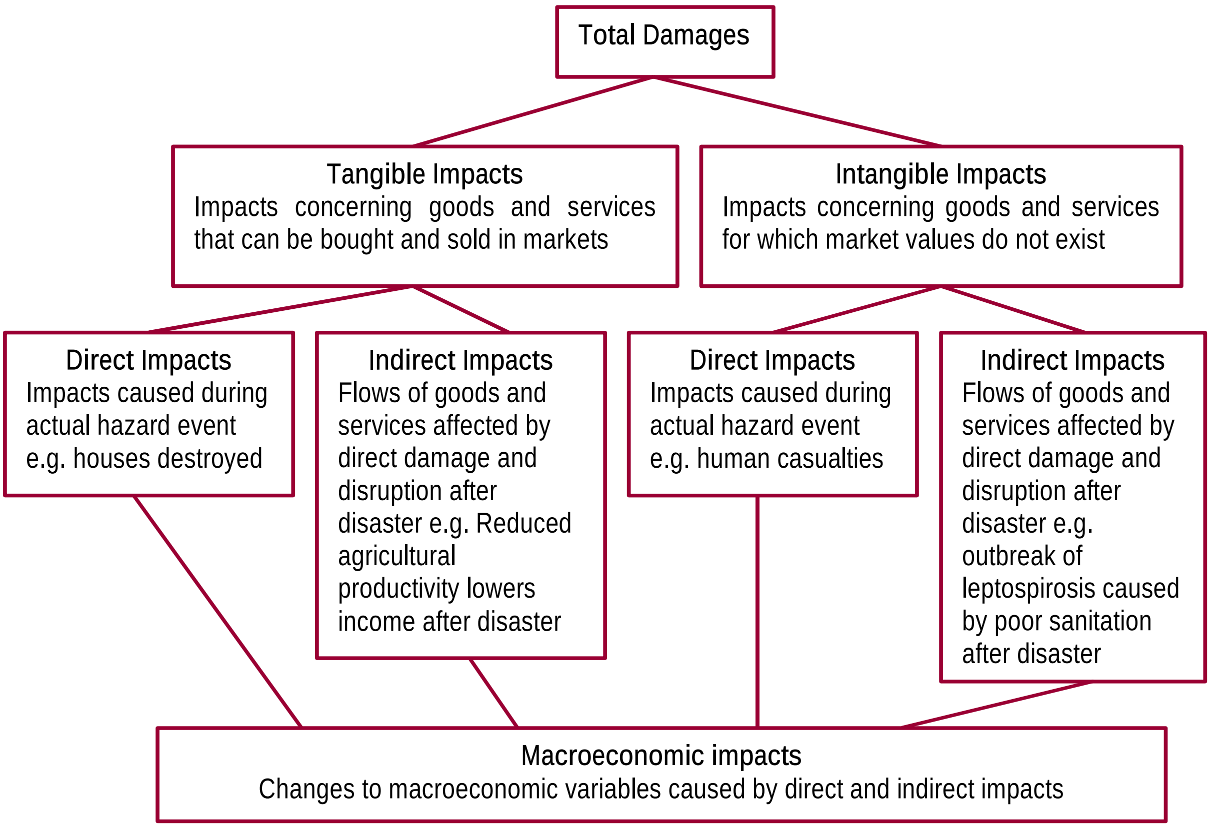
Intangible impacts concern impacts for which market values do not exist (as opposed to tangible impacts which concern goods and services that can be bought and sold in markets). This makes them particularly difficult to value in monetary terms. Intangible impacts can be direct or indirect. Direct intangible impacts occur during the actual disaster event, such as death and injury, environmental damage, and loss of memorabilia and cultural artefacts. Indirect intangible impacts result from the disruption after a natural disaster, such as health problems or negative psychological and emotional distress.

Macroeconomic impacts

There are also macroeconomic impacts, which are changes to the main economic variables caused by the direct damages and indirect losses resulting from a disaster. Typical macroeconomic impacts of natural disasters are the effects on economic growth, investment, public finances, inflation, employment and balance of payments. Macroeconomic effects are not included in cost-benefit analyses. Estimating macroeconomic impacts is a complementary way to assess direct damages and indirect losses from a different perspective, so they should not be included in a cost-benefit analysis because this would involve double counting impacts.

Figure 4 shows the categories of direct, indirect, intangible and macroeconomic impacts of natural disasters.

Figure 4: Direct, indirect, intangible and macroeconomic impacts of natural disasters



A number of approaches can be useful when gathering data on the impacts of natural disasters with and without DRM measures. Data on the economic impacts of past natural disasters can be used to estimate the likely extent of damage in different future natural hazard scenarios. Useful sources include focus groups among affected communities, government records, and local NGOs, particularly those that have been directly involved with the community in disaster reduction projects.

The Need for Improved Data on the Impact of Natural Disasters

Estimating the benefits of DRM measures is especially challenging when data on the impacts of previous natural disasters are inaccurate or incomplete, as is commonly the case in the Pacific Islands region. Information on the impact of past disasters is typically limited, focusing primarily on physical damage to public infrastructure.

Comprehensive assessments of the impact of natural disasters in the Pacific will enable systematic cost-benefit evaluations of DRM measures. This is one important reason why improving the collection of information on the impact of natural disasters is so important for Pacific Island Countries. Governments, communities and international aid donors should make every effort to gather data on the impact of future natural disasters in a systematic manner using the companion *Guidelines for Estimating the Economic Impact of Natural Disasters on Development in the Pacific.*

Box 6: The need for improved data on the impact of natural disasters

Table 2 can be used to collect data on the different impacts of natural disasters with and without a DRM measure, which divides up the impacts by direct, indirect and intangible impacts.

Table 2: Matrix for collecting information on disaster impacts with and without DRM measure

Type of Impact	Without DRM measure	With DRM measure
Direct Indirect Intangible		

Examples – DRM Measures in India and Fiji

Table 3 identifies the impacts of flooding with and without a DRM programme that was implemented in India to reduce the impacts of flooding. The DRM measures were assessed using cost-benefit analysis (Venton and Venton, 2004)[4].

[4] Venton, C. C., Venton, P. 2004. Disaster preparedness programmes in India: A cost benefit analysis. Humanitarian Practice Network, Number 14. Overseas Development Institute, London.

Table 3: Impacts of flooding with and without DRM measures in India

Type of Impact	Without DRM measure	With DRM measure
Direct	Houses destroyed	Houses still destroyed but village development fund has potential to provide loans in the future for rebuilding at lower rates than moneylenders
	Loss of household possessions	Minimal / no loss due to effective evacuation
	Loss of tools	Minimal / no loss due to effective evacuation
	Loss of livestock	Minimal / no loss due to effective evacuation
Indirect	Government hand pumps submerged and often rendered unusable	Raised hand pumps ensure clean water supply
	Loss of work on the embankment (no cropping, minimal alternatives)	No impact on work or cropping
Intangible	Loss of life due to drowning during floods	Reduced loss of life due to effective evacuation procedures / boats
	Injuries during evacuation	Reduced injuries due to effective evacuation procedures / boats
	Skin diseases prevalent on embankment	First-aid training helps in treatment of skin disease, but no reduction in level of disease
	Expenditure on boat rental	Provision of boat means community does not have to rent
	Loss of education	No impact
	Breakdown of relationships – survival focus	Community works together
	High stress for all groups	Greater confidence for evacuation reduces stress levels and women's self-help group builds confidence
	Destruction of crops and soil from water damage	Planting of trees to increase soil stability

Community Flooding Mitigation Project in Fiji

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 sometimes be deep enough to reach thigh height.

The community of Nabouciwa was asked 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:

a) Dredging the river delta;
b) Using sludge from the dredging to raise the level of the village;
c) Raising houses on stilts using local materials;
d) Village drainage system; and
e) Community mobilization.

A list was compiled during community discussions of some of the benefits that the village has gained from the mitigation project and the resultant reduction in flooding, as detailed in the table below.

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

Box 7: Impacts of flooding on Nabouciwa village in Fiji with and without DRM projects

3.1.2. Estimate monetary value of natural disaster impacts

In a cost-benefit analysis all of the impacts of natural disasters should be identified in both situations with and without a DRM measure. Whenever possible estimate the monetary value of those impacts. It may only be possible to estimate the monetary value of some impacts. Direct damage to physical assets is usually the easiest type of impact to value. It may be particularly difficult to place a monetary value on the intangible impacts of natural disasters, such as deaths and injuries, environmental damage, loss of cultural artefacts and psychosocial impacts. Some techniques for valuing intangible impacts are explained in Box 8 and some techniques for valuing disaster related deaths and injuries are outlined in Box 9, with further details in the accompanying *Guidelines for Estimating the Economic Impact of Natural Disasters on Development in the Pacific*. Once all of the impacts of the DRM measure have been outlined, the analyst must choose which impacts in the matrix can be valued in monetary terms within the time frame and resources available for the cost-benefit analysis.

Valuing Intangible Disaster Impacts

Difficulties arise in placing monetary values on certain intangible natural disaster impacts, such as environmental damage. Market prices cannot be used to assess the value of these impacts, because no markets exist for these goods and services. There are, however, a variety of non-market valuation methods that can be used to assess the value people attribute to intangible natural disaster impacts. Care is needed when using these methods to estimate the value of disaster impacts, as they can be complicated and time-consuming. If the methods are beyond the time and resource capacities available, simply list the important intangible impacts of a natural disaster in as much detail as possible. The two categories of non-market valuation methods are known as 'revealed preference methods' and 'stated preference methods':

1. Revealed preference methods

Revealed preferences occur when individuals make choices in markets that reveal their preferences for non-market goods and services.

a) Replacement cost method: The economic value of an intangible disaster impact can be approximated as the amount people have to pay to replace the good or service. For example the value of coastal erosion caused by sea surge and high waves during a cyclone may be approximated as the cost of rehabilitation of the coastal area affected.

b) Production method: Some intangible disaster impacts affect goods and services that are purchased in markets. For example, a tsunami may affect coral reefs and thereby alter the number of fish caught, or a cyclone may destroy trees and forests, thereby affecting the amount of timber available. The prices of the marketable goods (in these examples, the goods are fish and timber) can be used to estimate the economic value of the intangible impacts of natural disasters (in this case damage to the reef and forest).

c) Substitute or proxy method: Natural disasters may have intangible impacts on non-marketed goods and services that have close substitutes that are sold in the marketplace. The economic value of these impacts can be estimated using the price of the substitutes as a surrogate market price. For example, the value of damage to a subsistence crop harvest can be determined using the market price for closely related commercial crops.

d) Change in earnings: If human health is affected by a natural disaster, the economic value of this impact can be estimated using the resulting losses in earnings together with the cost of medical expenses needed for treatment. This approach, however, does not capture the economic impact of chronic health problems that do not result in losses in earnings, which may be the case for post-disaster trauma.

e) Hedonic pricing: This method estimates the value of intangible impacts on the basis of the amount that people are willing to pay for marketed goods and services of varying quality. For example, the value of environmental degradation may be estimated on the basis of the difference in house prices in areas where a natural disaster caused environmental damage as compared to house prices in unaffected areas.

f) Travel cost method: When a natural disaster affects the recreational and aesthetic value of an area, the economic value of the good or service can be estimated on the basis of the amount that people are willing to pay to visit the area.

2. Stated preference methods

Expressed preference methods use what people say about their preferences to derive their willingness to pay for a non-marketed good or service, and thereby determine the value of an intangible disaster impact that affects that good or service. Contingent valuation is one of the best-known stated preference methods. In a contingent valuation survey people are asked to state how much they would be willing to pay for a change in the quality of an intangible good (e.g. environmental quality). Respondents are given hypothetical scenarios and asked to indicate how much they would be willing to pay to either avoid the negative intangible impact or gain a positive intangible impact.

Box 8: Valuing intangible disaster impacts

Valuing a Human Life

Placing a monetary value on deaths and injuries is a particularly difficult task. Setting aside the suffering sustained by victims and their families, fatalities are a direct loss of productive human assets, and injuries entail the expense of health treatment. The value of injuries may be roughly approximated as the cost of treatment and, if the appropriate data is available, as the average loss of income of the injured person while recovering. There are two main techniques that can be used to value a human life, known as the ‘human capital’ and ‘willingness to pay’ approaches. Both of these methods have disadvantages and controversial aspects.

Human capital approach

A possible approach to estimate the value of a lost human life involves calculating the average expected future income that the deceased would otherwise have generated assuming that he or she had fulfilled their normal life expectancy. This method is controversial, because it implies that the human life of a low-income earner is worth less than the life of a high-income earner, and similarly a life lost in a developing country is worth less than a life in a more developed nation. It also ignores the intrinsic value of a life.

Willingness to pay approach

An alternative method for estimating the value of a human life is to conduct ‘willingness to pay’ surveys which assess how much an individual is willing to pay to reduce the risk of death. The survey can ask respondents questions about their willingness-to-pay for risk reductions in hypothetical scenarios. Alternatively surveys can examine wage premia paid to workers in dangerous jobs and estimate how much extra risk they are exposed to. On the assumption that the wage premium is paid for the risk increment, the value of the worker’s life can be calculated. Willingness to pay methods have an advantage over the human capital approach because the value is not exclusively related to losses in human production capacity. However, it does not eliminate the problem of assigning a different value to people in different income groups or in countries at different stages of development, as rich people are likely to be willing to pay more to reduce their risk.

Box 9: Valuing a human life

If some disaster impacts are too difficult to quantify in monetary terms within the time and resources available, the analyst should provide a qualitative discussion, identifying and discussing the impacts in as much detail as possible, comparing disaster impacts without the DRM measure to disaster impacts with the DRM measure. An explanation of why the impact could not be quantified in monetary terms should also be provided.

For each of the impacts that can be easily assigned monetary values, compare the relative impact of natural disasters without the DRM measure, to the improved situation with the DRM measure. Remember that the net benefits of the DRM measure are calculated by subtracting the expected losses with DRM from the expected losses without DRM (see Equation 1).

Table 4 can be used to estimate the monetary value of the natural disaster impacts that can be easily quantified with and without the DRM measure. The total benefit is calculated as the difference in the value of disaster impacts without the DRM measure minus the value of disaster impacts with the DRM measure.

Table 4: Matrix for estimating monetary value of DRM benefits

Type of impact	Impact without DRM measure	Approximate impact value	Impact with DRM measure	Approximate impact value	Total benefit of DRM measure*
Direct Indirect Intangible					
TOTAL					

* The total benefit of the DRM measure is equal to the value of the impact without the DRM measure minus the value of the impact with the DRM measure.

Table 5 quantifies the impacts of flooding with and without a DRM programme that was implemented in India to reduce the effects of flooding hazard events. The DRM measures were assessed using cost-benefit analysis (Venton and Venton, 2004)[5]. Monetary values have been given to direct, indirect and intangible disaster impacts. The intangible impacts of loss of life and injuries are evaluated in terms of the daily average wage rate and the cost of treatment of injuries.

[5] Venton, C. C., Venton, P. 2004. Disaster preparedness programmes in India: A cost benefit analysis. Humanitarian Practice Network, Number 14. Overseas Development Institute, London.

Table 5: Monetary value of flooding impacts with and without DRM measures in India

Type of impact	Impact	Impact without DRM measure	Approximate impact value	Impact with DRM measure	Approximate impact value	Total benefit of DRM measure
Direct	Reduced loss of possessions	All villages affected. 40% of households within each village lose household goods	Rs600 per household	No household possessions lost	Rs0	Rs129,600
	Reduced loss of tools	Approx 50% of the villages own their own tools, and about 40% of HH lose their tools in the flood	Rs100 per household	No tools lost	Rs0	Rs10,800
	Reduced loss of livestock	Approx 75% of households have at least one goat, and 20 % have a buffalo. About 5% is lost in the flood (drowning)	Rs400 – goat Rs7,000 – buffalo (Replacement values)	No livestock lost	Rs0	Rs45,900
Indirect	Raised hand pumps	20 % of villages have to repair government hand pumps, others are able to clear through pumping	Rs6,500 repair costs per government hand pump	No villages have to repair Disaster Committee (DC) pumps	Rs0	Rs39,000
	Boat rental	Approx 80% of all villages have to rent boat for evacuation.	Boat rental Rs2,500 per month	Boat provided by DC	Rs0	Rs30,000
Intangible	Reduced loss of life	10 people on average across all 5 villages	Daily average wage rate – Rs35	1 person across all 5 villages		Rs329,249
	Reduced injuries	10% of all people suffer injury	Rs25 per injury requiring bandage and injection. Rs10 bandage only. Assume 50/50 split	No one suffers injury	Rs0	Rs4,202
Total						Rs588,751

Cost-effectiveness of Relocation of Hospital in Niue

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 attend to 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 the table below:

Type of Impact	Impact without DRM measure	Approximate impact value	Impact with DRM measure	Approximate impact value	Total benefit of DRM measure
Direct	Total destruction of hospital building and equipment	NZ$4 million	Relocation of hospital inland reduces damage by two-thirds[6]	NZ$1.3 million	NZ$2.7 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	NZ$588,000
	Cost of temporary hospital extension	NZ$60,000	No need for temporary hospital extension	NZ$0	NZ$60,000
Intangible	Psychological trauma of health personnel and patients	Not valued	Reduced psychological trauma of health personnel and patients	Not valued	
TOTAL					NZ$3,348,000

Box 10: Cost-effectiveness of relocation of hospital in Niue

3.2. Estimate annual expected benefits

Finally, it is necessary to determine the annual expected impacts of natural disasters with and without the DRM measure. This is done by multiplying the annual probability of the hazard with the benefit of the DRM measure calculated in Section 3.1.

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

3.2.1. Estimate the frequency and severity of future hazard events

To calculate the annual expected benefits of a DRM measure, it is first necessary to estimate the likely frequency and severity of particular natural hazard events in the future. Records of the frequency and severity of hydro-meteorological natural disasters, such as cyclones, floods and droughts, are available from national Meteorological Offices, National Disaster Management Offices, or the regional Meteorological Service based in Nadi, Fiji[7]. National Seismology or Mineral Resources Departments, or National Disaster Management Offices should be able to provide data on the frequency and severity of previous geological disasters, such as earthquakes, tsunamis and volcanic eruptions. These offices may be able to make a probabilistic estimate of the likelihood of natural hazard events, although this may not always be possible as it is a difficult calculation, fraught with uncertainty.

If it is not possible to obtain a probabilistic estimate of the likelihood of the particular natural hazard event under consideration, the analyst will have to make a rough estimate using data on the frequency and severity of past events. A good way to start is to create a timeline showing when natural hazard events occurred in the area that the DRM measure will affect. Using the timeline of previous natural disasters in the area, you can make a very simple estimate of the probability of future natural disasters using Equation 2:

$$\text{Probability of future hazard event} = \frac{\text{Number of years hazard event has occurred}}{\text{Total number of years considered}} \times 100$$

Equation 2: Calculation of probability of future hazard event

Calculating the probability of future cyclones in Tuvalu

For example, imagine a DRM measure is being considered in Tuvalu that reduces the damage caused by cyclones. Records show that over the last fifteen years Tuvalu has been affected by seven tropical cyclones since 1990.

Cyclone	Year	Strength	Area
Ofa	1990	Hurricane	Central
Kina	1992	Hurricane	All islands
Nina	1993	Storm	All islands
Gavin	1997	Hurricane	
Hina	1997	Storm	All islands
Keli	1997	Hurricane	South
Ami	2003	Storm	

The probability of cyclones in any future year can therefore be roughly approximated by dividing the number of years in which a cyclone occurred by the total number of years considered.

$$\text{Probability of future cyclone} = (7/15) \times 100 = 47\%$$

In very simple terms based on historical frequency, there is a 47% chance of a tropical cyclone occurring in Tuvalu in any given year.

Box 11: Calculating the probability of future cyclones in Tuvalu

These calculations are very simplified, as probabilities are rarely based strictly on historical information but are usually adjusted to take account of currently available information. For example, the observation that tropical

[7] The regional Meteorological Service can be contacted at Fiji Meteorological Service, Private Mailbag NAP0351, Nadi Airport, Fiji Islands, Telephone: (679) 672 4888, Facsimile: (679) 672 0430, Home page: http://www.met.gov.fj. (Contact details as at April 2005)

cyclones have recently occurred in other parts of the world can lead experts to estimate a higher probability of a local cyclone than would be indicated by just looking at historical frequency. If possible it is best to refer to specialists in this area to get an estimate of the probability of future natural hazard events. The regional Meteorological Service in Nadi in Fiji may be able to provide a probabilistic estimate of future hydro-meteorological disasters in the area affected by the DRM measure.

3.2.2. Estimate annual expected benefits

Once the annual probability of a particular hazard event has been estimated, the annual expected benefit is calculated by multiplying the annual probability by the monetary value of the benefit of the DRM measure in a hazard event, as shown in Equation 3.

Annual expected benefits = Annual probability of hazard event x Benefit of DRM measure in hazard event

Equation 3: Calculation of annual expected benefits of DRM measure

Let us return to the example from Section 3.1. If the DRM project is not undertaken it is estimated, on the basis of past experience of cyclone damage, that the cost of future damage to the house will be $5,000 during a typical cyclone. If the house is strengthened against cyclones, however, it is estimated, on the basis of past experience of cyclone damage, that future damages will fall to $500 during a typical cyclone. The DRM benefits of an average cyclone are calculated as the difference in estimated future damages with and without the cyclone proofing DRM measure. The benefits for a typical cyclone are calculated as $4,500.

So what are the annual expected benefits. The annual probability of cyclones is estimated at 50%. The annual expected benefits of the DRM measure are estimated using Equation 3, as shown below:

Annual expected benefits = 0.5 x 4,500
= $9,000

So the annual expected benefits of the DRM measure have a value of $9,000 per year.

4. Step Four: Discount the estimated costs and benefits

The next step in cost-benefit analysis involves 'discounting' the costs and benefits that accrue at different points in time to account for the decreasing value of money over time. Why does money decrease in value over time? Most people prefer to receive money in the present rather than in the future. This decreasing 'time value of money' is not due to inflation - even if inflation were zero, people would virtually always prefer to receive money now than in a year's time. There are three main reasons for the decreasing value of money over time. First, most people have an expectation that their wealth will be greater in the future, so the relative value to them of a particular sum of money will be correspondingly less in the future. Second, money received now can earn a return so that in a year's time it will have increased in value. Third, the benefit of money received now is certain whereas, because there is no guarantee that you will be alive next year, the benefit of money received next year is uncertain. In the Pacific, many nations have a high time preference, meaning that money decreases in value very rapidly over time, because people need to meet immediate needs. Consequently, projects that do not generate benefits until a long way into the future may have little significance to Pacific communities.

Because of the decreasing value of money over time, the benefits and costs that are incurred by a DRM measure need to be valued in terms of when they occur, using a 'discount rate'. The discount rate is the rate required to compensate for the receipt of money in the future, rather than the present. Using the discount rate, future costs and benefits can be adjusted to be comparable with present costs and benefits. The discount rate that represents the time preference of a broad community or economy is called the 'social discount rate'. It is this rate that should be used for a cost-benefit analysis of a DRM measure. There is disagreement on which rate should be used for the social discount rate. Some studies in the USA recommend using a 3 percent social discount rate with additional sensitivity analysis at rates between 0 percent and 7 percent (see Step Six on Sensitivity Analysis)[8]. The Federal Emergency Management Agency mandates that a discount rate of 7 percent be used for all cost-benefit analyses of DRM projects. It is recommended that the chosen discount rate for cost-benefit analyses of DRM measures in Pacific Island Countries be based on the rate chosen for previous similar studies elsewhere or using a domestic benchmark, such as the real interest rate in the country concerned.

To account for the decreasing value of money over time, use the discount rate to calculate the 'present value' of costs and benefits. 'Present value' is the value today of a benefit or cost that occurs in the future. It is measured using the discount rate. In mathematical terms, the present value (PV) of a sum of money received or spent in some future period is calculated using Equation 4, where r is the discount rate, and n is the number of years in the future that the cost or benefit occurs:

$$\text{Present Value} = \text{Future Value} / (1 + r)^n$$

Equation 4: Calculation of present value

For example, the present value of $1000 received in five years time at a 4 percent discount rate is equal to $821.93, as shown below:

$$\begin{aligned}\text{Present Value} &= \text{Future Value} / (1 + r)^n \\ &= 1000 / (1 + 0.04)^5 \\ &= \$821.93\end{aligned}$$

The further in the future that a cost or benefit occurs, the smaller is its present value at the same discount rate. Also, the higher the discount rate, the smaller is the value of a cost or benefit at a particular future time.

Project costs and benefits are only relevant for as long as the project will last. It is therefore necessary to estimate the project lifetime, which is normally taken to be the operating life of the longest-lived major asset of the project. This establishes the timeframe for discounting the cost and benefit streams. For projects that continue

[8] Recommended by the US Panel on Cost-Effectiveness in Health and Medicine.

indefinitely, the project lifetime can usually be estimated around fifteen to twenty years. Beyond this time frame the costs and benefits are too far in the future to have significant present value. For each year of the project lifetime, the costs and benefits are discounted to calculate their present value.

To ensure that inflation does not alter the findings it is necessary to convert nominal values to real values using a price index (usually the consumer price index). Real values are corrected for changes in price over time (inflation), while nominal values are not. When measuring impacts in real values, a real discount rate should be used.

5. Step Five: Evaluate and rank Disaster Risk Management alternatives

Once the costs and benefits of the DRM measure(s) have been estimated and discounted, the next step is to estimate an overall 'value' of each alternative. This involves comparing the discounted benefits to the discounted costs. A number of different indicators can be used to evaluate and rank the alternatives. This can help to determine whether a particular DRM measure is worthwhile in terms of creating benefits greater than costs, and to rank alternative DRM measures to help choose the option with the greatest benefits relative to costs. These guidelines explain how to calculate two particularly useful indicators: net present value and the cost-benefit ratio.

5.1. Net present value

The net present value (NPV) of a project is the sum of the present values of all the benefits associated with a DRM measure, minus the sum of the present values of all associated costs. It is calculated using Equation 5:

Net present value = Present value of total benefits – Present value of total costs

Equation 5: Calculation of net present value

If the NPV is greater than zero, the DRM measure is a good investment because the expected total benefits are greater than the associated total costs in present value terms. If the NPV is less than zero, the DRM measure is not a sound investment because the total costs outweigh the expected total benefits.

Those DRM alternatives that have a positive NPV are viable, and can be ranked by comparing their net present values. The most cost-effective alternative will have the highest NPV (the greatest benefits over and above costs). Comparing the net present values of different alternatives can help to choose the most cost-effective DRM measure.

One disadvantage of using NPV to choose between DRM alternatives is that larger projects will often appear superior to smaller projects. A measure such as the cost-benefit ratio will avoid this scale problem.

5.2. Cost-benefit ratio

The cost-benefit ratio (CBR) is equal to the present value of the total benefits divided by the present value of all associated costs. The ratio gives an estimate of the benefits that will accrue for each dollar spent on a DRM measure. It is calculated using Equation 6:

Cost benefit ratio = Present value of total benefits / Present value of total costs

Equation 6: Calculation of cost-benefit ratio

Comparing the cost-benefit ratios of different alternatives can help decision makers choose the most cost-effective DRM measure. If the cost-benefit ratio is greater than one, the DRM measure is a good investment because the expected total benefits are greater than the associated total costs in present value terms. If the cost-benefit ratio is less than one, the DRM measure is not a sound investment because the total costs outweigh the expected total benefits.

Those DRM alternatives that have a CBR greater than one are viable, and can be ranked. The most cost-effective alternative will have the highest cost-benefit ratio (the greatest benefits relative to costs). Comparing the cost-benefit ratios of different alternatives can help decision makers choose the most economically-efficient DRM measure.

6. Step Six: Conduct sensitivity analysis

In a cost-benefit analysis it may be necessary to make certain assumptions about a number of factors that are uncertain. For example, you may have made assumptions about the frequency and severity of future natural hazards, the effectiveness of the DRM measure, the future value of benefits and costs of the DRM measure, the social discount rate, or the length of time that the DRM measure will remain effective. Uncertainties arise from data and knowledge limitations, a particular problem in the Pacific Islands region where data on the impacts of natural disasters is incomplete. It is very important to ensure all assumptions within the cost-benefit analysis are explicit, and to check the importance of these assumptions.

Sensitivity analysis is a technique that can be used at the end of a cost-benefit analysis to test the main assumptions. Sensitivity analysis can determine how different assumptions will affect the choice between alternative DRM measures. Sensitivity analysis is particularly important if the choice between alternative DRM measures is highly dependent on a particular assumption.

To conduct a sensitivity analysis, it is necessary to identify any assumptions that are uncertain and could have a significant impact on cost-benefit indicators such as net present value or the cost-benefit ratio. One assumed parameter is varied at a time, while holding other assumptions constant, to determine at what point the decision regarding the adoption of the DRM measure would change. A switching value can be calculated, which shows the percentage change in each assumed variable that would be required for the net present value for a DRM measure to become zero.

7. Step Seven: Make policy recommendations

The findings from a cost-benefit analysis can be used to make policy recommendations on the most cost-effective DRM measures. It may be that different DRM alternatives are recommended under different assumptions if that has been shown in the sensitivity analysis. According to economic criteria:

- If the NPV is greater than zero, the DRM measure is a good investment because the expected total benefits are greater than the associated total costs in present value terms. If the NPV is less than zero, the DRM measure is not a sound investment because the total costs outweigh the expected total benefits.
- If the cost-benefit ratio is greater than one, the DRM measure is a good investment because the expected total benefits are greater than the associated total costs in present value terms. If the cost-benefit ratio is less than one, the DRM measure is not a sound investment because the total costs outweigh the expected total benefits.

Cost-benefit analysis can be a useful tool for effective decision-making, but it is critical to keep in mind its limitations. Cost-benefit analysis only ranks DRM measures on the basis of economic criteria. Decision makers may also wish to consider other factors in choosing the final DRM measure. It is particularly important when making policy recommendations that the costs and benefits of the DRM measure that could not be measured in monetary terms are considered alongside those costs and benefits that are assigned a monetary value. When all the benefits of DRM measures are viewed as a whole, including qualitative benefits, the arguments for DRM may be different from what the cost-benefit analysis indicators suggest. The primary value of cost-benefit analysis lies in the information it can provide to decision makers. It is an input to a larger decision-making process rather than an end in itself. Cost-benefit analysis is not intended to be the sole criterion for investment in a DRM measure.

Assessments of DRM measures for mitigation of impacts of geophysical hazard events, such as earthquakes and tsunamis can also pose particular problems for cost-benefit analysis, which need to be considered when making policy recommendations. Geophysical hazard events often have very low probabilities of occurrence but high potential damages and casualties. In this case the findings of a cost-benefit analysis may indicate that a DRM measure is not worthwhile because the annual expected benefits are so low that they are outweighed by the costs. There may, however, still be ethical justifications for nevertheless implementing the DRM measure if the high potential damages, deaths and injuries, are deemed to be worth protecting against despite the low probability of such an event occurring.

In the long term it can be useful to replicate cost-benefit analyses after a number of years, to gather more detailed data and conduct revised cost-benefit analysis and demonstrate the benefits of DRM.

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