ECONSTOR
Make Your Publications Visible.

A Service of
ZBW
Leibniz-Informationszentrum Wirtschaft
Leibniz Information Centre for Economics

Noy, Ilan; Edmonds, Christopher

Working Paper

The Economic and Fiscal Burdens of Disasters in the Pacific

CESifo Working Paper, No. 6237

Provided in Cooperation with:
Ifo Institute – Leibniz Institute for Economic Research at the University of Munich

Suggested Citation: Noy, Ilan; Edmonds, Christopher (2016) : The Economic and Fiscal Burdens of Disasters in the Pacific, CESifo Working Paper, No. 6237, Center for Economic Studies and ifo Institute (CESifo), Munich

This Version is available at:
https://hdl.handle.net/10419/149324

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

WWW.ECONSTOR.EU

Mitglied der Leibniz-Gemeinschaft

The international platform of Ludwig-Maximilians University's Center for Economic Studies and the Ifo Institute

CESifo Working Papers

www.cesifo.org/wp

The Economic and Fiscal Burdens of Disasters in the Pacific

Ilan Noy
Christopher Edmonds

CESIFO WORKING PAPER NO. 6237
CATEGORY 10: ENERGY AND CLIMATE ECONOMICS
DECEMBER 2016

An electronic version of the paper may be downloaded
- *from the SSRN website: www.SSRN.com*
- *from the RePEc website: www.RePEc.org*
- *from the CESifo website: www.CESifo-group.org/wp*

ISSN 2364-1428

CESifo
Center for Economic Studies & Ifo Institute

CESifo *Working Paper No. 6237*

The Economic and Fiscal Burdens of Disasters in the Pacific

Abstract

The Pacific Islands face the highest disaster risk, in per capita terms, globally. Examples of catastrophic events in the region include the 2009 tsunami in Samoa, the 2014 floods in the Solomon Islands, and the 2015 cyclone Pam in Vanuatu. Even without these catastrophic events, countries in the Pacific are affected by frequent natural hazards of smaller magnitude. We first evaluate the three main sources quantifying risk in the region: EMDAT, Desinventar, and PCRAFI. We describe these sources and conclude they all underestimate the risk, especially for atoll nations, and because of four important trends with respect to changes in natural hazards as a consequence of climate change. These are: (1) increasing frequency of extremely hot days; (2) changing frequency and intensity of extreme rainfall events causing flash flooding or droughts; (3) increasing intensities and changing trajectories of cyclones; and (4) sea-level rise and other oceanic ecological changes. Financial protection is the one policy area where the Pacific is the most exposed—given the very large role of the public sector in the region. It is also the area where there is probably the most room for easy-to-implement improvement. We end by analysing the applicability of various financial instruments to facilitate both ex-ante and ex-post disaster risk management in the region.

JEL-Codes: Q540.

Keywords: disaster risk, Pacific Islands, Small Island Developing States, SIDS.

Ilan Noy
School of Economics and Finance
Victoria Business School
Victoria University of Wellington
POB 600
Wellington / New Zealand
ilan.noy@vuw.ac.nz

Christopher Edmonds
Pacific Regional Department
Asian Development Bank
6 ADB Avenue, Mandaluyong City
Metro Manila / Pilippines
cedmonds@adb.org

November 2016
We call attention to the assistance of Tauisi Taupo, Adrien Vogt-Schilb, Mook Bangalore, and Stephane Hallegatte in modeling welfare impacts of disasters in Tuvalu. The authors also wish to thank Mosese Sikivou, Litea Biukoto, Norense Iyahen, David Abbott, Cristina Casella, and Isikeli Voceduadua (SPC-Geoscience in Suva), Olivier Mahul and Samantha Cox (World Bank), Charlotte Benson and Christian Ellerman (Asian Development Bank), and Julio Serje (UNISDR) for helpful conversations and insights.

1. The Nature and Frequency of Disasters in the Pacific

Many of the most destructive disasters of the past few decades occurred in the countries bordering the Pacific Ocean, but the Pacific itself is a more vulnerable region in per capita terms. Most of the Pacific island countries are located within or very close to the Cyclone Belt (roughly within the tropics but not within 5 degrees of the Equator). In the South Pacific, these countries are also located on or very near a tectonic boundary between the Australian and the Pacific plates; which makes the region seismically very active, with high risk for earthquakes, locally generated tsunamis, and volcanic eruptions. Given the high incidence of earthquakes in the surrounding continental boundaries, the countries are also vulnerable to tsunamis generated on the edges of the Pacific Ocean (the Ring of Fire).

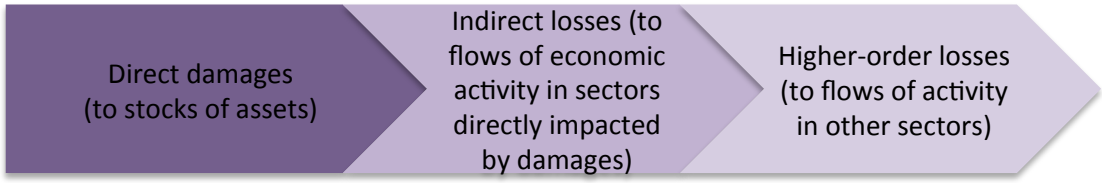
Many of the countries in the Pacific are highly reliant on rainfall for their water consumption and agricultural needs. They are very vulnerable to droughts and many live in river valleys where they are exposed to rain-induced flooding. Examples of catastrophic events in the region include the 2009 tsunami in Samoa, the 2009 floods in Fiji, the 2014 floods in the Solomon Islands, the 2015 cyclone Pam in Vanuatu (and Tuvalu and Kiribati), and the 2016 cyclone Winston in Fiji. Even without these catastrophic infrequent events, the countries are impacted by frequent natural hazards. Additional hazards include seasonal high tides (King tides), periodic droughts (often associated in the Pacific with the El Niño – Southern Oscillation (ENSO) phenomenon), and extreme heat days. In addition to all this disaster risk, the smaller coral atolls countries of the Pacific are very vulnerable to natural hazards and this vulnerability will be exacerbated by projected rise in sea levels.

The history of disasters in the Pacific, their impact on development, and the risks that the region faces in terms of future events and their likely consequences are important components of an understanding of the region's economies. A particular aspect of this issue is governments' role in DRM. Given the large role of the public sector in most of the Pacific economies, reducing the exposure of governments to disaster risk in the region is of paramount importance if the barriers to attaining sustainable prosperity in the region are to be surmounted.

A common typology of disaster impacts distinguishes between direct and indirect impacts. Direct damages are the damage to fixed assets and capital (including inventories), damages

to raw materials, crops, and extractable natural resources, and of course mortality and morbidity that are a direct consequence of the natural hazard (phenomenon). Indirect impacts—frequently termed 'losses'—refer to the economic activity, in particular the production of goods and services, that will not take place following the disaster and because of it. These indirect losses may be of a first order (i.e., directly caused by the immediate impact), or of a higher-order (i.e., caused by impacts that were themselves caused by the direct effects of the hazard). Higher-order impacts, for example, can be caused because post-disaster reconstruction pulls resources away from the usual production practices and thus damages suppliers of inputs for production that does not occur because of these re-alignments of economic activities (see figure 1).

Figure 1: Typology of Disaster Impacts



While damages are in theory easy to count, the losses can also be accounted for in the aggregate by examining the overall performance of the economy, as measured through the most relevant macroeconomic variables. These can be GDP, the fiscal accounts, consumption, savings, and investment. Other variables of interest that may be affected relate to international exposure, including the exchange rate, the trade balance and the various types of international capital flows as measured in the balance of payments.

Disaster losses can also be further divided, following the standard distinction in macroeconomics, between the short run (up to several years) and the long run (typically considered to be at least five years, but sometimes can also be measured in decades).

The conventional way to consider disaster risk is as a combination of three factors:

(1) The **hazard** profile faced by the country or region: This hazard profile is largely a function of the geographical location, the geo-physical characteristics and the climatic conditions faced by that region. This hazard profile is largely pre-determined, though anthropomorphic climate change may change that hazard profile over time. Given the location of many Pacific countries on or near tectonic plate boundaries, and within the

Pacific tropical cyclone zones, countries in the Pacific region are among the most hazard-prone countries on the planet.

(2) The **exposure** of population and assets to these hazards: Exposure is largely determined by the location of people and assets. So, for example, movement to urban centers, and especially to the more exposed areas—steep hillside neighborhoods or flood-plains—will increase exposure. As most Pacific populations are near coasts or in steep river valleys, the level of exposed population in the region is also extremely high.

(3) **Vulnerability** is the ability of the exposed population to withstand the hazard and reduce its social, economic and personal impacts. One can further differentiate between the vulnerability to the short-term impacts of an event, and to the event's long-term consequences.[1] Most Pacific countries are middle-income countries, which are spread out over very large areas and with a limited ability of the central government to provide timely assistance to outlying islands. As such, vulnerability in the Pacific is also quite high.

Risk is thus the combination of hazard events that endanger exposed communities and societies that are vulnerable to these events. Risk is viewed as the intersection of hazard, exposure and vulnerability.

Figure 2: Disaster Risks

As policy has no immediate impact on the pattern of hazards, at least not in time-horizon that is relevant for policies examined here, the focus of disaster risk reduction (DRR) has been on reducing exposure and vulnerability.[2] ADB's (2014) *Operational Plan for Integrated Disaster Risk Management 2014-2020*, sets ADB priorities on DRM, identifying three policy areas for which the ADB is committed to focus on the next years (2014-2020).[3] Those are:

(1) integrating DRR into development; (2) addressing the link between DRR and climate change and link the two policy priorities together; and (3) developing disaster risk financing (DRF) capabilities. This paper is focused mostly on the issue of DRF, and specifically its fiscal context, but will also touch on the other policies that can reduce exposure and vulnerability as they are related to DRF.

2. Data on Direct Costs of Pacific Disasters

2.1 EMDAT and DesInventar Data

The EMDAT, maintained by the Centre for Research on the Epidemiology of Disasters (CRED), is the most frequently used resource for disaster data. EMDAT defines a disaster as an event that overwhelms local capacity and/or necessitates a request for external assistance. For a disaster to be entered into the EMDAT database, at least one of the following criteria must be met: (1) 10 or more people are reported killed; (2) 100 people are reported affected; (3) a state of emergency is declared; or (4) a call for international assistance is issued. Importantly, thresholds (1) and (2) are stated in absolute levels, rather than in relative terms to the size of the population. Thus, it is the same threshold for India as it is for Tuvalu. Thresholds (3) and (4) are also, to some extent, dependent on scale, and in particular on the ability of staff member at EMDAT to capture the events remotely, as the data included in the dataset is captured by CRED's staff. The data include the number of people killed, the number of people affected, and the amount of direct damages in each disaster.

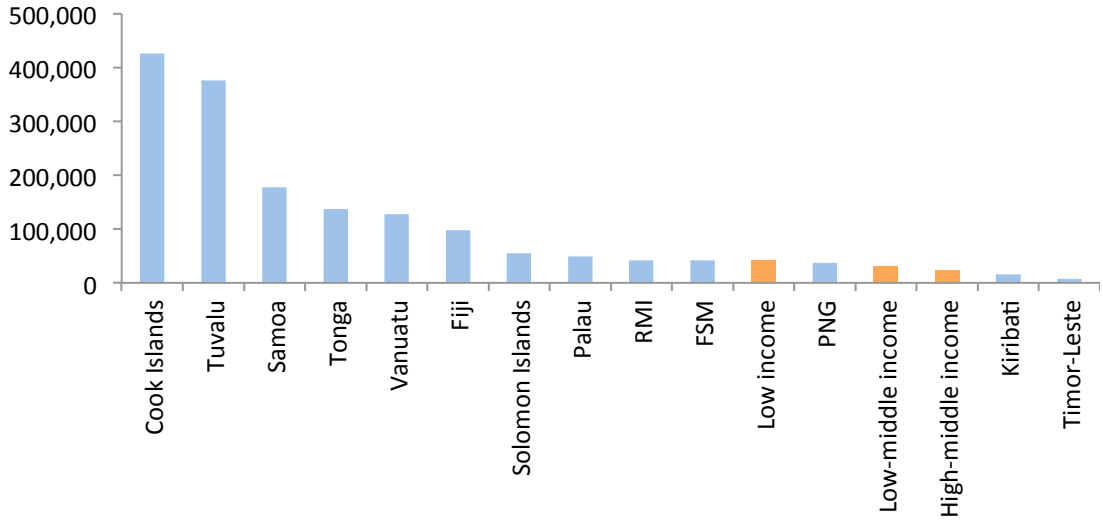
For the Pacific Island Countries, EMDAT includes relatively little information about disasters, and seems to miss much of the losses that the countries in the Pacific incur regularly because of natural hazards. It thus significantly understates the countries' levels of exposure. Examples of this abound, but maybe the most recent catastrophic event that is underestimated is cyclone Pam, the catastrophic cyclone that hit Vanuatu (and its storm surges also hit Tuvalu and Kiribati) in March 2015. EMDAT includes an entry on the storm. The entry notes there were 11 people who died in the storm in Vanuatu, but also notes nothing about injuries, nor about physical damage.[4] This under-reporting is not unique to cyclone Pam or to Vanuatu or to the Pacific region, so clearly EMDAT is not a sufficient source to quantify the recent disasters in the Pacific. Despite this, PIFS (2009) uses the

EMDAT data to summarize exposure of its Pacific members to disasters in the past several decades.

An alternative source of data is the Disaster Inventory System website (http://desinventar.net) provided by United Nations Office for Disaster Risk Reduction (UNISDR). The newer DesInventar data is potentially more comprehensive for the countries and more recent years it covers (including most of the Pacific) as it includes extensive (high-frequency low-impact) events that are not captured in EMDAT's lists of more intensive (lower-frequency higher-impact) events. For the PICs these extensive events are a significant portion of the overall fiscal burden, and more broadly a major impediment to development in the region. DesInventar usually links directly with national governments to obtain the relevant data on damages.[5] However, data on Pacific in DesInventar comes from the GeoScience Division of the Secretariat of the Pacific Community (SPC). The SPC data is collected in consultation with the UNISDR/DesInventar staff, so that the coverage and details collected are in principle supposed to be more comprehensive (historically less so). However, as was the case for EMDAT, this dataset's record of cyclone Pam also does not include any value for the monetary/physical damages (valued at $200 to $400 million).

In order to evaluate the total direct burden of disasters—mortality, people affected, and financial damages—over the last few decades, we aggregate the three measures into a total number of human years lost to disasters using the methodology described in Noy (2016). Figure 3 provides the total number of lifeyears lost per capita, per country, over the period for which data is available from Secretariat of the Pacific Community GeoScience Division (SOPAC, 1980-2012).

Figure 3. Lifeyears lost per person 1980-2012



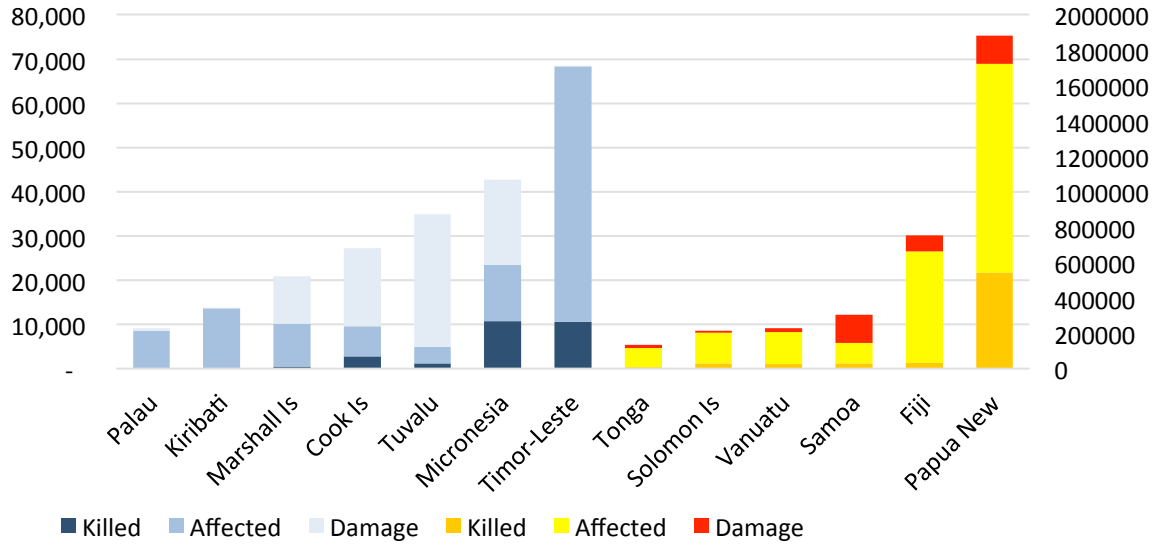
Notes and Sources: Figure from Pacific Economic Monitor (July 2015 issue) based on authors' calculations from DesInventar and Secretariat of the Pacific Community Geosciences Division data; RMI = Republic of the Marshall Islands, FSM = Federated States of Micronesia, PNG = Papua New Guinea.

The data identifies a set of countries in the Pacific region that have been particularly impacted. Based on this limited historical evidence, the Cook Islands and Tuvalu appear to face the highest disaster losses with Tonga, Vanuatu, Fiji, and Samoa also experiencing very significant losses. Relying on historical data that only goes back several decades will not provide an accurate estimate of the risk of low-probability high-impact events; as the historical record may or may not contain these events and thus may over- or under-estimate the risk. Countries that seemed to have faced fewer losses (at least in per capita terms) are all the Northern Pacific countries, and maybe surprisingly, PNG.

It is important to note, however, that when the region is compared relative to other regions, all of the Pacific countries are heavily exposed. Noy (2016) reports that the average lifeyears lost over the 1980-2012 period in low-income countries is 41,250 (similar to the Marshal Islands number), with lower numbers for high-middle and low-middle income countries – 31,515 and 22,836, respectively. These figures are much lower than the life year per capita losses in the most vulnerable Pacific countries with, for example, levels of 177,352 in Samoa, and much higher numbers for the Cook Islands and Tuvalu.

Using a different methodology, the *World Risk Index* ranks countries by their vulnerability and exposure to natural hazards. Vanuatu, Tonga, Solomon Islands, Timor Leste, Papua New Guinea and Fiji are all ranked in the top 20 most exposed countries (United Nations University - Institute for Environment and Human Security (UNU-EHS), 2013).[6]

Figure 4. Total Lifeyears lost by damage component (1980-2012)



Source: Author's calculations from DesInventar/SOPAC data. The blue bars refer to the Y-axis on the left, the Red-yellow bars refer to the Y-axis on the right.

Figure 5. Share of life years lost by damage component (1980-2012)

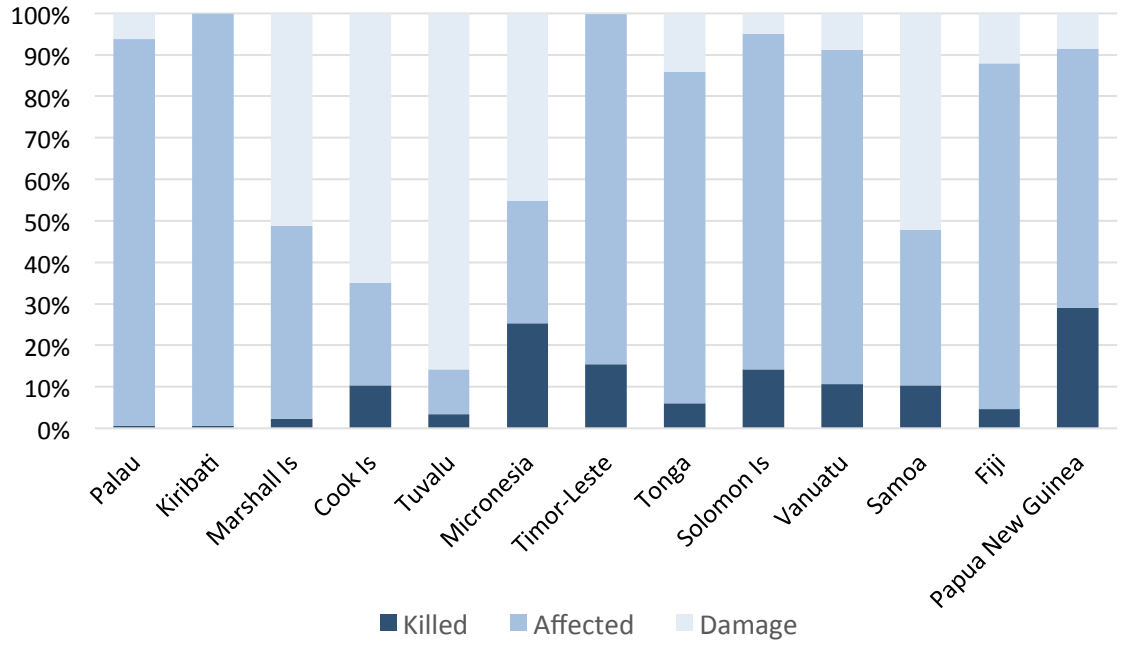
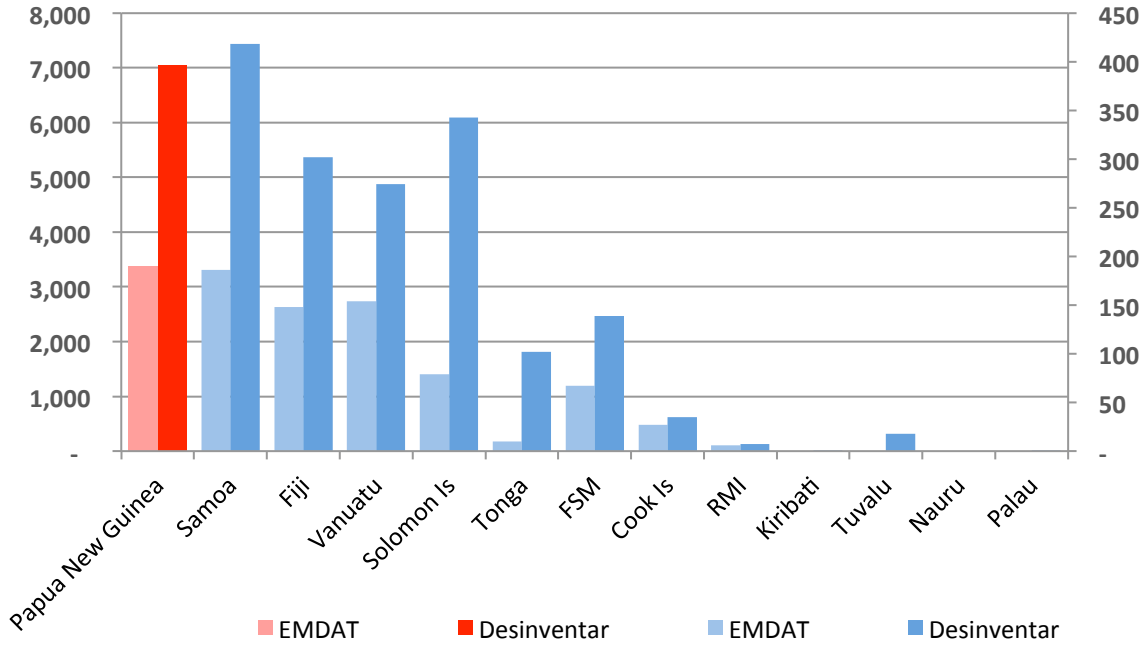


Figure 6. Mortality due to disasters in EMDAT and DesInventar databases



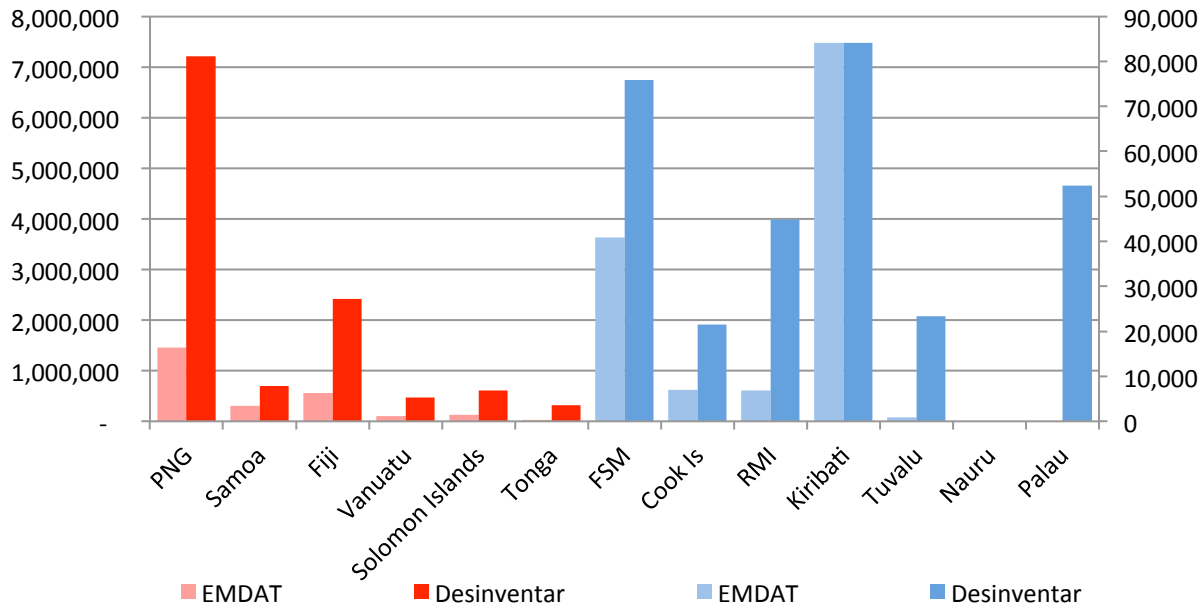
Note: First y-axis for Papua New Guinea, second y-axis for other countries.
Source: Author's calculations from DesInventar/SOPAC data.

The DesInventar data is likely to be imperfect, and the stark differences across countries exposed to similar hazards suggest there may be significant differences in data collection practices. As an illustration, the data for Palau suggests that disasters manifest only in their affect on people (with no mortality and little damage to physical assets), while for Tuvalu

the damage is almost only to physical assets (with very little impact on people). In short, while the SOPAC data is the best one available at the moment for the Pacific, it seems that the cross-country differences in data collection procedures are still quite important and prevent an adequately convincing comparison of past disaster burden across countries.

The DesInventar dataset is also unreliable with historical data. For Tuvalu, for example, the data appears to suggest one tropical cyclone in the early 1990s whose impact was an order of magnitude larger than other strong cyclones that hit Tuvalu about twice a decade. However, contemporary reports suggest this storm was not unusual. Neither dataset appears to cover floods sufficiently. Fiji, for example had several very destructive floods in the past decade, but very few of them are included in either dataset, and when they are included there is no information on damages.Figures 6-8 include a direct comparison of the two datasets for their figures for mortality, people affected, and damages aggregated in each country over the last two decades (1990-2012).

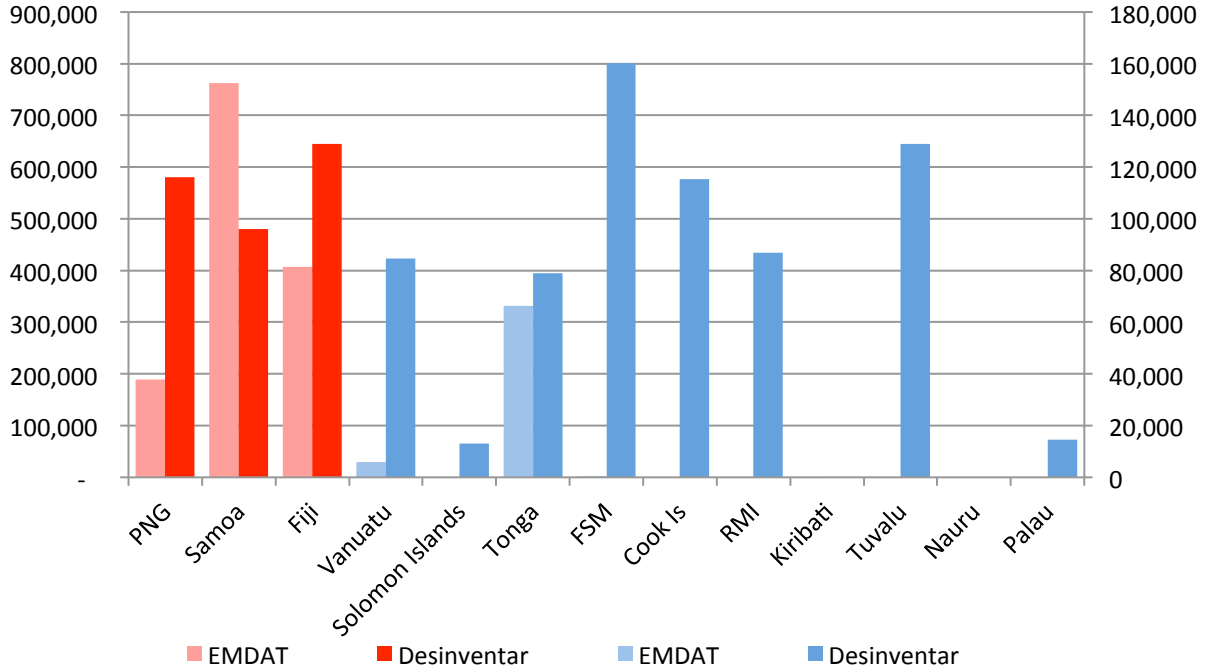
Figure 7. People Affected by Disasters in EMDAT and DesInventar databases



Three observations are apparent when examining this data. The first is that EMDAT counts a lot less impact than DesInventar, and the total figures for all three components of disaster impacts are quite significantly higher in the latter dataset. Second, this undercounting is not at all uniform across countries. In some countries, the data is only marginally higher in DesInventar while in others (e.g. PNG) the EMDAT data-estimates disaster risk at

significantly lower levels. Third, in some countries--notably the smallest ones--EMDAT does not count disaster damages at all, even when damages are high in per capita terms.

Figure 8. Damages (in '000 $) due to Disasters in EMDAT and DesInventar databases



The differences between the datasets can be explained not only by the absence of small-scale high-probability events from the EMDAT dataset. Counting disaster damages is inherently very difficult. There is little agreement on what is counted when people are defined as affected. EMDAT relies on various sources with differing definitions of that concept, and DesInventar relies on governments that also have different standards in counting affected populations.

Even more fraught with difficulty is any attempt to count disaster damages to assets and infrastructure. It is often not clear whether the amount cited includes both damages and losses, whether it is made up of the market value of destroyed assets, the imputed value of the services they provide, or their replacement costs. It is also often not clear whether the total includes any other incidental damage to environmental ecosystems or horizontal infrastructures, nor whether it accounts for the opportunity costs of using resources to rebuild and the stimulus that is produced by the rebuild itself.

The earliest attempt to produce a template for this accounting was made in the 1970s by the UN's Economic Commission for Latin American and the Caribbean, and the newest version of their manual forms the basis for the Post Disaster Needs Assessments (PDNA) done nowadays after most major events (ECLAC, 2014). However, it is not clear that any of

the two main available data sources follow this methodology as they rely mostly on third parties to collect their data. Third parties include government, multilateral organizations (especially the World Bank), and Non-governmental organizations (mostly non-for-profit aid organizations). All these organizations have their own incentives and procedures, and it is unlikely that their procedures yield comparable measures.

We conclude that although both the EMDAT and DesInventar datasets have much to offer, they both do not provide reliable picture of current disaster risk as it manifested itself in actual disasters over the past several decades. And without a good estimate of current risks it is even more difficult to attempt to predict future risk in the region.

2.2 PCRAFI Data

The Pacific Catastrophe Risk Assessment and Finance Initiative program (PCRAFI) has initiated the first comprehensive assessment of current disaster risk from the primary hazards in the Pacific—cyclones, earthquakes, and tsunamis—based on climate models of cyclones, on earthquake and tsunami modeling, and a comprehensive mapping of physical assets across the Pacific Ocean (PCRAFI, 2013). PCRAFI is essentially (though informally) two separate programs; the second includes the sovereign insurance product discussed later.

The risk assessment includes constructing a very detailed risk profile for each country member of the program (all the ADB DMCs in the Pacific region, as well as Niue). The assessed risks are earthquakes and tropical cyclones, and the program includes both an identification of exposure (the location of people and assets that are potentially vulnerable – see Air Worldwide, 2010), and an assessment of the hazard itself (such as the expected frequency, intensity and location of earthquakes and tropical storms in the region – see Air Worldwide, 2011). Combining the data on exposed assets, vulnerability curves, and the hazards, the initiative creates detailed risk profile, which includes estimated damages to various hazard scenarios including the cost to replace lost assets and the cost of emergency management (calculated as a fixed proportion of the replacement cost of destroyed assets).[7] This data collection effort also allows, for example, an assessment of the likely costs associated with cyclones should the frequency and intensity of cyclones change over time because of climate change and ocean warming (Siquiera et al., 2014).

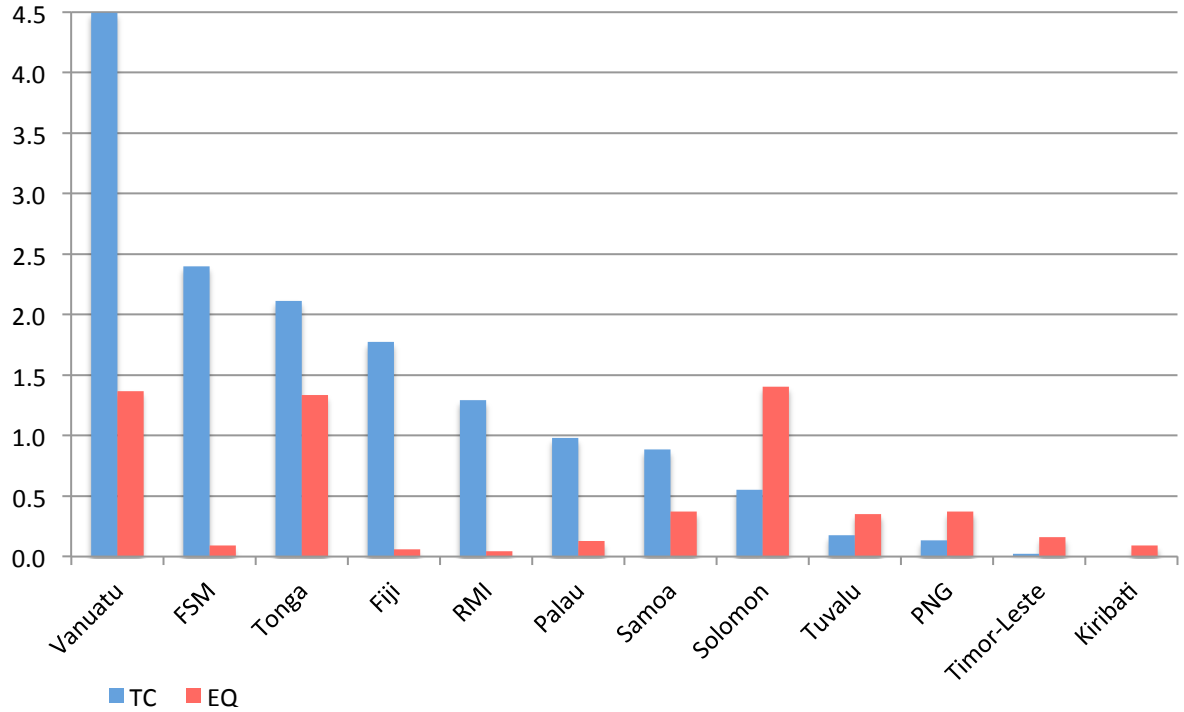
The result of this modeling is a set of predictions about the likely risk, in terms of destruction of assets (and mortality), that countries in the Pacific are facing with respect to cyclone and earthquake events. Figure 9 presents estimated average annual losses, given current climate conditions and the current location of physical assets, as a share of gross national product in each country (all using data from 2014). These estimates are available from PCRAFI separately for tropical cyclones and for earthquake (and tsunami) risks.

It is clear that Vanuatu is estimated to face the highest risk from cyclones (4.5% of GNP). All Pacific DMCs, except the Solomon Islands, face risks from cyclones that are calculated to be much more significant than the expected risk from earthquakes and tsunamis.

Some of the differences across countries in these estimates, however, do not seem easy to explain. Tonga is estimated to face more than twice as much risk of damage than Samoa in the PCRAFI estimates, both from earthquakes and from cyclones (and at a similar ratio). The two nations are not very far apart. The frequency of hazard occurrence (earthquakes and cyclones) may be higher somewhat for Tonga, but the historical record actually has significantly higher cumulative impacts on Samoa in recent decades (see figure 23 in AirWorldwide, 2010). The exposure and vulnerability of the assets and structures in the two countries are unlikely to be very different, as these two neighbors have about the same level of income per capita (and presumably similar standards of construction of exposed assets). Precise understanding whether the difference between the estimates of Tonga and Samoa originates from different hazard frequencies, or from other idiosyncrasies of their exposure and vulnerability, or from the modeling framework used, is difficult to determine in light of the non-disclosure policy regarding details of the model (AirWorldwide).

The model used also does not take into account the vulnerability of atoll islands to storm surges and tsunami waves generated by relatively distant storms or earthquakes. Therefore, it is likely that the data for Kirbati, Tuvalu, and RMI are not adequately reflecting the risk these countries are facing. This was confirmed in 2015 when both Kiribati and Tuvalu suffered significant damages as a consequence of cyclone Pam, even though the cyclone passed far away from both countries' shores, and wind damage was minimal. The PCRAFI modeling is unable to account for these types of effects.

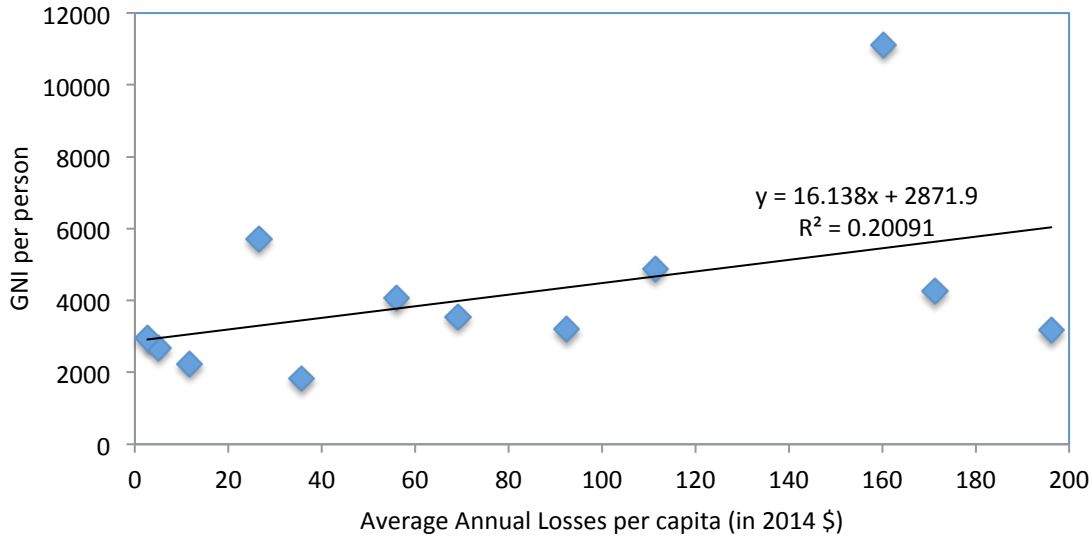
Figure 9. Estimated Average Annual Losses due to Disasters (% of GNP)



Source: Author calculations from PCRAFI and ADB data. Data for Nauru and Cook Islands are not available from PCRAFI. TC=Tropical Cyclones; EQ=Earthquakes.

There seems to be little correlation between wealth and income and the degree of disaster risk to which countries in the Pacific are exposed (figure 10). The expected average annual loss, per person, is dramatically different across countries – from close to zero up to $200. However, there is little correlation between that and gross national income (GNI) per capita. The richest Pacific country, Palau, is also facing one of the highest estimates of risk.

Figure 10. Estimated Average Annual Disaster Losses and GNI (per capita)



Source: Author calculations from PCRAFI and ADB data. Data for Nauru and Cook Islands are not available.

The PCRAFI data collection and modeling effort is the first and only attempt to obtain reliable and useable data that will enable improved disaster risk management in this very hazard prone region. With support from ADB, it uses the best modeling tools developed and refined in the Caribbean, Japan and New Zealand, and other regions exposed to earthquakes and tropical storms.[8] Appropriate refinements of these models, that will account for the uniqueness of the Pacific islands (and especially the atoll states), should lead to the creation of useful modeling tools that, if publicly available, can facilitate and enable improved land use policies, improved financial risk management, the prioritization of investing in resilient infrastructure and lifelines, and other necessary and beneficial disaster risk management efforts. At this point, it is not clear that there is sufficient continuing investment in the upkeep, update, improvement, dissemination and use of this resource.

3. Cross Country Studies of the Economic and Fiscal Impacts of Disasters

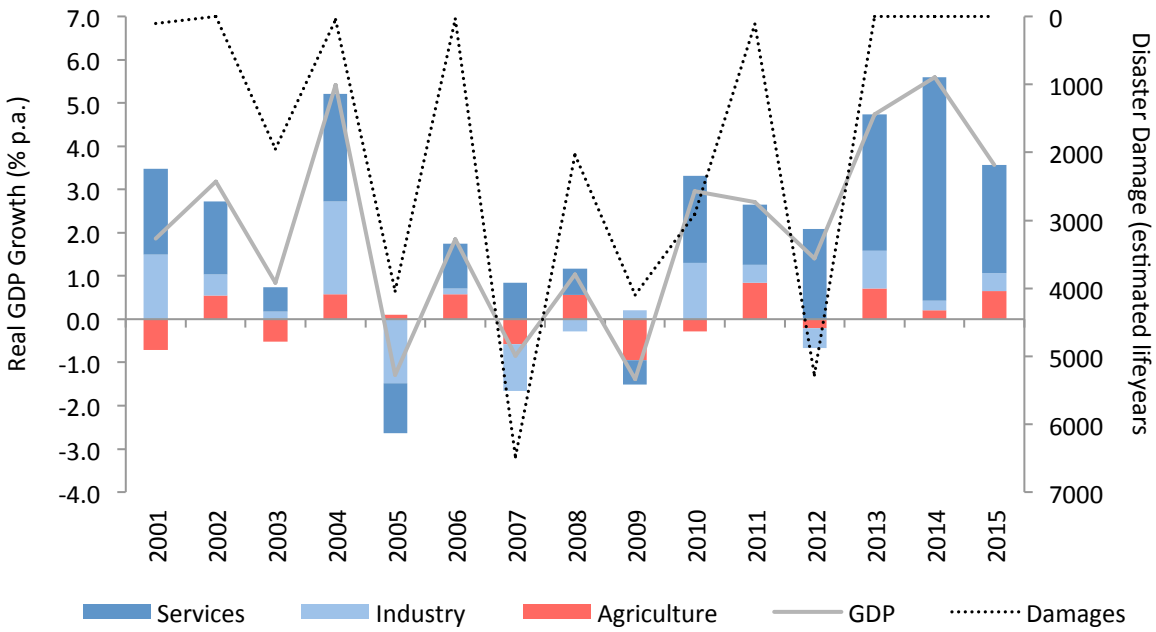
There is a large literature examining the overall (both direct and indirect) effects of disasters on the economic and fiscal performance of affected countries using cross sectional time series. Both short and long run impacts are assessed. However, none of these studies has focused on the Pacific island countries, where volatility of macroeconomic indicators and data scarcity (in terms of duration and frequency, as well as coverage) make it very difficult to obtain consistent, coherent, and statistically significant estimates.

In the case of selected Pacific countries that have experienced one or more disasters of large magnitude, the relation between GDP growth rates and disaster events is muddied, and time series are inadequate for estimating the statistical significance of disaster impacts on growth rates. Consider, for example, the case of Fiji in Figure 11 below.

The figure suggests that in Fiji's case, years of disasters were associated with lower rates of growth than was achieved in the prior (disaster-free) year (e.g., 2003, 2005, 2007, 2009. 2012), but the correlation between growth and the disaster measure used was -0.60. In addition, the disasters that affected the country every other year during the first decade of this century were associated with a generally lower multiyear average rate of growth during these years (i.e., average growths rates were 1.9%, 0.4%, and 3.6 during the years 2000-2004, 2005-2010, and 2011-2015, respectively). However, the picture is muddied, and

highlights the need for statistical analysis of larger datasets covering multiple countries and years to make clearer inferences regarding systematic relationships.

Figure 11. Fiji GDP Growth and Disaster Incidents



Next, the literature empirically estimating the relationship between disasters and growth, and its implications for the Pacific, are considered. Results regarding short run growth effects are examined first, then long run growth effects, and lastly we look at fiscal impacts.

3.1 Short run growth impacts

A detailed survey by Cavallo and Noy (2011) found that there was an emerging consensus that natural disasters have, on average, a negative impact on short-term economic growth in lower-income countries; a more recent survey that reached similar conclusions is Lazzaroni and van Bergeijk (2014). The studies reviewed were found to have provided an inconclusive picture of the reasons behind the negative impact of disasters on economic output dynamics, highlighting the need for further research to distinguish disaster impacts on residential housing, agricultural production, public services delivered through infrastructure, and manufacturing activity. The channels through which disaster events cause short run economic slowdowns have not been established, although understanding these channels is necessary for understanding whether these effects are transitory or permanent and what impact they have on well-being.

A number of papers have found that short run output declines associated with significant disasters are greater for less developed and smaller countries, although estimated impacts vary across the type of disaster—highlighting the heterogeneity of disaster impacts despite overall averages (Noy 2009, Fomby et al. 2013, Felbermayr and Groschl 2014).

3.2 Long run growth impacts

Noy and du Pont (2016) note a number of difficulties in efforts to assess the long run effects of disasters on growth, including the need for researchers to generate the counter-factual level of growth in the absence of the disaster; the determination of these counterfactuals heavily influences results. They conclude that most studies have found little to no impact of natural disasters in the long-term (especially when using aggregate country-level data); but with some notable exceptions. Poor countries as well as small island nations have been found to be less resilient in the long-term, and studies analyzing data collected at regional and local levels have found a much more nuanced set of results regardless of countries' wealth, income, or size.

This literature on the long-run local impacts of disaster events is very preliminary, with most of the research done in developed countries. It is therefore difficult to reach any definite conclusions regarding the likely long-term impacts of disasters in the Pacific. Negative effects on growth were clear in instances when disaster had triggered radical political change, and there is a surprising number of these cases. However, without political change, even very large disasters did not display significant effects on long run economic growth at the national level (Cavallo et. al., 2013). Evidence from cases such as the Kobe earthquake in Japan, however, is more nuanced. It suggests some very long-term declines in economic activity as a consequence of large shocks (e.g., du Pont and Noy, 2015).

3.3 Fiscal impacts

A smaller number of researchers have explored the impact of disasters on fiscal balances in affected countries. Noy and Nualsri (2011) find disparate behavior across developed countries—where counter-cyclical fiscal policy is observed—and developing countries—where pro-cyclical decreases in spending and rising revenues are observed. The paper reports estimates of the magnitude of these fiscal policy effects, noting that pro-cyclical

fiscal dynamics are likely to worsen the adverse consequences of disasters in middle- and low-income countries.

Lis and Nickel (2010) also examine disaster impacts on government fiscal positions using a different empirical methodology (least squares fixed effects rather than panel vector autoregressions), and find that large natural disasters are associated with larger budget deficits in developing countries only slightly and have no significant effects in developed countries. Other researchers have examined post-disaster fiscal demands to estimate country fiscal insurance or international reserve needs (Barnichon 2008 and Borensztein et al. 2009). More recently, Deryugina (2016) estimated the fiscal expenditure on welfare payments in the long-term after hurricanes in the United States. She identified very significant additional fiscal expenditures that were previously unidentified as they were part of regular welfare programs (such as unemployment benefits or food vouchers).

Taken together, this earlier research highlights the greater fragility of growth and fiscal balances in small developing countries (which characterizes most countries in the Pacific) to major disasters. Impacts are clear in the short run and differ across types of disasters and country contexts. Even in instances when the annual decline in growth as a result of disasters is relatively small or localized to only limited areas of a country, the present value of lasting declines may be quite large.

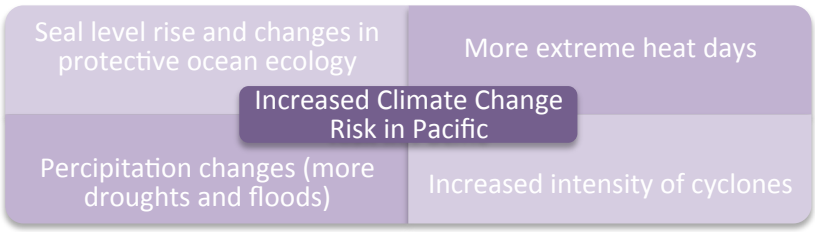
4. Disaster Hazards and Climate Change

The most recent Intergovernmental Panel on Climate Change (IPCC) report on disaster risk and its connection to climate change summarizes the state of the scientific literature and argues that it remains difficult to attribute the recent trends in catastrophic high-damage low-probability natural hazards to climate change. The historical record is not long enough to identify long-term trends in low-frequency events, and models, especially the Global Climate Models (GCMs), do not provide sufficiently consistent predictions (IPCC, 2012). However, an increasing number of recent research projects argue that specific extreme events that have occurred in the last several years are directly attributable to anthropomorphic climate change (see Herring et al., 2015 for numerous examples).

The four most important issues with respect to likely changes in hazards facing the Pacific Island countries over time are: (1) increasing temperatures (especially increasing frequency

of extremely hot days); (2) changing frequency and intensity of extreme rainfall events (causing flash flooding or droughts); (3) changes in the frequency, intensities and trajectories of tropical cyclones; and (4) sea-level rise and other ocean changes.

Figure 12: Climate Change Issues in the Pacific



One important issue for which there is very little agreement is the future incidence of ENSO events, whose impact on the Pacific Islands' extreme weather patterns is significant, potentially having an impact on all four main climate concerns described above. If ENSO events will occur more frequently or the events will be more severe (with larger increases in ocean temperatures), this may mean a higher frequency of both flash flooding and droughts in the region, an increased intensity of cyclones, and potentially maybe even further deterioration in ocean ecology (the 2015-16 ENSO is one of the strongest on record).[9]

The biggest risk for all the Pacific island countries is cyclones. The historical record of the past couple of decades suggests a significant increase in impacts associated with tropical cyclones globally; but this is largely due to increased exposure and vulnerability, rather than an increase in intensity or frequency of cyclone hazards.[10] [11]

Auffhammer et al. (2013) argue that averaging the forecasted changes from different scenarios and different models provides the most accurate forecasts. The Australian Bureau of Meteorology pursues this approach, and as such, its work is probably the most reliable current estimates of the likely impact of climate change on the region (agent-based modelling (ABM) and Commonwealth Scientific and Industrial Research Organisation (CSIRO), 2014). This work includes detailed predictions for each island country in the Pacific, but overall the predictions are very similar across islands. They predict no change/small decrease in the frequency of storms and some increase (2-11%) in wind intensity.[12] Since cyclone damage is non-linearly related to the storm's wind-speed, this increase in storm strength will likely result in a bigger increase in damages.

Beyond this increase in the intensity of cyclones, it is also likely that their 'typical' trajectories will change. In the North Pacific, some models predict equator-ward shift in trajectories, some predict an opposite pole-ward shift, and some predict an eastward shift. In the South Pacific, where hazard incidence is greater, most models predict a pole-ward shift in storm tracks.[13] Whatever is the case, these changing trajectories may end up being the most important shift for cyclone risk. Experience shows that by far most of the mortality, morbidity and damage from cyclones is experienced in regions that are unaccustomed and therefore unprepared for them. Most of the Pacific Island nations are accustomed to cyclones, and are therefore more prepared, at least in terms of reducing the mortality and morbidity associated with these events. For most, therefore, the changing trajectories may also not make a difference. This experience with storm DRM explains why, for example, the mortality associated with cyclone Pam (March, 2015), and cyclone Winston (February, 2016) was fortunately quite low considering the strength of these storms.

The most important climate change issue in the region, of course, is sea level rise. The 'consensus' estimate from several GCMs is for around 60-70 cm increase by 2100. Rises in the sea level will increase the damages caused by storm wave surges and earthquake induced tsunamis. These risks will be compounded by other deteriorations in the sea's ecology. In particular, the deterioration of coral reef ecosystems and mangrove forests will make coastal areas considerably more vulnerable to storms, regardless of their changing frequency and intensity.[14] This deterioration of the protective ecology along the coasts may turn out to be the most important climate phenomenon to have an impact on disaster risk in the region.

Two other potential factors affect the importance of sea level rise for the Pacific region. The first is that some recent predictions regarding global sea level rise are considerably more alarming than these consensus estimates, and in particular some models predict tipping points that will lead to collapse of ice sheets and consequently much more rapid sea level rise. The second is that the Pacific has several atoll nations and islands; these are particularly vulnerable even to increasing sea levels that will pose relatively minor risks to other areas, globally, and within the Pacific region as well. Sea level rises pose a risk to atoll islands both because of the potential salinization of freshwater lens used for consumption and land used for agriculture and because of the increased damages that will be caused by

high tides; the atoll islands already suffer damages when tides are exceptionally high ('King Tides'), and these will be exacerbated with high sea levels.

Slowly changing climatic trends in, for example, average temperatures or annual rainfall, will also lead to other economic impacts, especially on agriculture and on energy needs. These, however, are not much related to the issues discussed here, and are covered in the Asian Development Bank's climate change assessment for the region (ADB, 2013).

There is greater scientific consensus today that the intensity of ENSO events in the Pacific is increasing, and that this will increase the intensity of cyclones in the region. This, together with sea-level rise and the deterioration of protective ecosystems, worsens the outlook for the region, in terms of incidence and severity to natural hazards (ABM and CSIRO, 2014; Elsner et al., 2008; Kang and Elsner, 2015; Mei et al., 2015). This means there is an additional need to make sure that DRM policies are integrated with climate change policy at the regional, national, and local levels. Most of the Pacific islands are pursing this goal, at least in principle, by adopting Joint National Action Plans (JNAPs) that aim to combine DRM with climate change adaptation and sustainable development. These JNAPs are only now being formulated, however, so it is too early to determine whether they indeed will yield more effective disaster resilience.

5. Understanding Direct Damages

Kahn (2005) investigated what determines mortality from disasters, and concludes that mortality is maybe 5 times greater in poor (per capita GDP < $2000) than in richer (per capita GDP > $14,000) countries. In his view, this difference is most likely due to the greater amount of resources spent on DRR and preparedness efforts. In particular, some of the policy interventions likely to ameliorate disaster impact, including land-use planning, stricter enforcement of robust building codes and hard protections (such as protective sea walls or cyclone shelters), are rarer in lower-income countries.

This does not imply that higher damages in developing countries are inevitable; poor countries can adopt successful disaster risk reduction (DRR) and preparedness measures - they do not always require large amounts of financial resources. Cuba and Bangladesh, for example, are both often seen as poster-countries for successful tropical storm disaster risk reduction policies (especially emphasizing reducing mortality from these events). Even

within the Pacific context, there seems to be a difference in the scope of DRR and preparedness policies and related actions between the countries of the region when the resources available to them are not very different.

Much of these policies require collective action and these are easier when communal ties are stronger.[15] The strength of communities is one of the main sources of resilience in the Pacific context. However, community cohesiveness is not sufficient to reduce disaster impacts, as that cohesiveness needs to be supported by the political system. In most cases, including in the Pacific, it appears that the political process does not generates the optimal incentives to create resilient communities by reducing both vulnerability and exposure.

Besley and Burgess (2002) observe that disaster impacts are lower when politicians and governments are more accountable. Compounding this global problem of accountability is the apparent unwillingness of electorates (documented elsewhere[16]) to punish politicians who had under-invested in DRR. Without good information available, and with little incentive to invest in DRR pre-disaster, it is not surprising that the level of DRR is too low.

In contrast, the evidence from several countries outside the Pacific suggests that politicians are punished at the ballot box if they do not provide generous post-disaster assistance (e.g. Cole et al., 2012). Thus, even in much more developed democracies, politicians rarely face the optimal incentives in terms of disaster prevention and/or mitigation.

This preference for *ex post* assistance rather than *ex ante* DRR is not unique to governments. Remittances increase significantly post-disasters, as do private donations channeled through Nongovernmental Organizations (NGOs), and disaster-related official development assistance. All generally become available mostly in the aftermath of catastrophic events, and are not available beforehand to strengthen resilience and spending on DRM. This seems to be an especially grave problem in many of the countries across the Pacific region, given their reliance on remittances and Overseas Development Assistance (ODA) as significant sources for both governments and household financing.

To summarize, from what we know about the determinants of disaster damages, and the incentives faced by all the relevant actors, it is safe to conclude that investment in reducing impacts by decreasing vulnerability and/or exposure is too low. Yet, of course, if we are successful in reducing the direct damages, the indirect losses are also likely to be smaller.

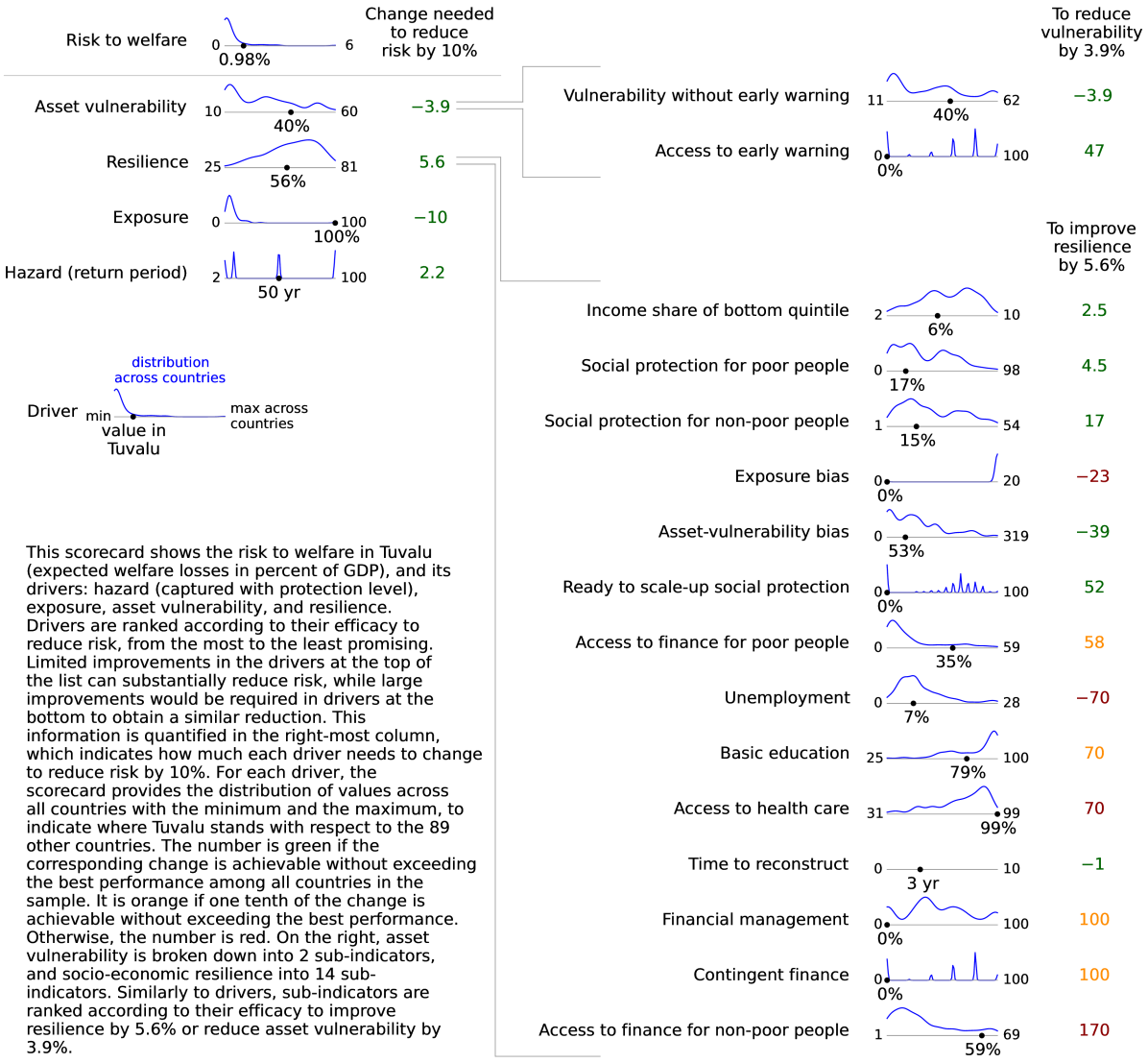
6. Modeling the Welfare Implications of Disaster Risk on Pacific Households

While much of the analytical work pertaining to the economic impacts of disasters considers ex post damages and repair costs, the World Bank initiated recently a model-based risk analysis that focuses on the welfare/wellbeing implications of disaster risk (Hallegatte et al., 2017). While the standard research focuses on damages, and their dependence on hazard, exposure and vulnerability; this risk analysis focuses on the more important implications of these damages to human welfare. In particular, the aim of this work is to measure the ways disaster damages lead to welfare (indirect) losses and what policies may mitigate this 'translation' from damages to welfare losses. The World Bank constructed a scorecard for several countries, using this framework and country-specific economic, financial, demographic, and meteorological data. However, owing to challenges in obtaining data inputs required for model estimation, this model has not previously applied to study the welfare implications of disaster risk in Pacific countries.

To illustrate the approach and its usefulness in assessing welfare impacts of disasters in the small, remote, and disaster prone island states of the Pacific, we collected data for Tuvalu and shared this with the World Bank to construct a scorecard for Tuvalu.

The first striking observation is that, for Tuvalu, the calculated overall risk to welfare (as defined above) is 0.98. The average for the 90 countries that the World Bank calculated was 0.57, with the country with the highest risk measuring at 0.81. Tuvalu is therefore significantly more at risk than even the country with the highest risk in this group of 89 countries. This implies that practically every dollar of damages to assets will also 'translate' into a dollar (98 cents) of lost welfare/wellbeing for Tuvalu.

Figure 13: Tuvalu Scorecard for Welfare Risk Reduction Policies



This scorecard shows the risk to welfare in Tuvalu (expected welfare losses in percent of GDP), and its drivers: hazard (captured with protection level), exposure, asset vulnerability, and resilience. Drivers are ranked according to their efficacy to reduce risk, from the most to the least promising. Limited improvements in the drivers at the top of the list can substantially reduce risk, while large improvements would be required in drivers at the bottom to obtain a similar reduction. This information is quantified in the right-most column, which indicates how much each driver needs to change to reduce risk by 10%. For each driver, the scorecard provides the distribution of values across all countries with the minimum and the maximum, to indicate where Tuvalu stands with respect to the 89 other countries. The number is green if the corresponding change is achievable without exceeding the best performance among all countries in the sample. It is orange if one tenth of the change is achievable without exceeding the best performance. Otherwise, the number is red. On the right, asset vulnerability is broken down into 2 sub-indicators, and socio-economic resilience into 14 sub-indicators. Similarly to drivers, sub-indicators are ranked according to their efficacy to improve resilience by 5.6% or reduce asset vulnerability by 3.9%.

Note: The scorecard was calculated from the model presented in Hallegatte et al. (2017) with data collected by Tauisi Taupo.

The scorecard, in as much as the model is robust, is useful in that it quantifies different ways in which asset vulnerability can be decreased or socio-economic resilience can be increased. Asset vulnerability can be reduced with limited policy options available: these are to increase building standards (through retrofitting or replacement over time), or to increase the ability to utilize early warning systems to move assets out of harm's way. Since the latter is not an option in Tuvalu, the only way to reduce asset vulnerability is to increase standards of construction for all physical assets (including both infrastructure and buildings, through "climate proofing" measures). Given the very high costs of protection, increasing the standards of buildings seems like an approach that will yield higher benefit-cost ratios but may still not be sustainable for longer horizons. Tuvalu can also reduce its exposure or

decrease the hazard – but both are virtually impossible in a country where exposure is 100% and the hazard is of cyclones (including very far away cyclones).

There are several policy options that appear promising as ways to increase socio-economic resilience, and are likely to have other benefits (that are not accounted for in this analysis). These options are ranked, in the scorecard, by their efficacy in improving resilience. The most efficient, in this model, is to increase the income share of the bottom quintile of the population. Currently, the bottom quintile's income share is 6%. Increasing this to 8.5% would yield the required increase in socio-economic resilience that will reduce overall welfare risk by 10% (to 0.88). Increasing social protection for the poor, and for the non-poor by 4.5% and 17%, respectively, will also reduce overall welfare risk by 10%.

Examining the case of Tuvalu using ex ante model-based risk analysis focusing on the implications of disaster risk at the level of household welfare/wellbeing suggests the effects of disasters on welfare in the Pacific may be among the highest in the world and models can yield useful insights in policy options to mitigating adverse impacts of disasters in the region.

7. Economic Losses – Are Disasters a Poverty Trap?

As noted earlier, disaster's initial impact causes mortality, morbidity, displacements, and damage to physical infrastructure: housing, public and commercial buildings, roads, telecommunication, electricity networks etc. These initial impacts are followed by consequent impacts on the economy. These indirect impacts, of course, are not pre-ordained, and the policy choices made in a catastrophic disaster's aftermath (and in many cases before) can have significant economic consequences. For example, Noy (2009) concludes that countries with higher levels of human capital and better institutions are better able to withstand the initial disaster shock and prevent further spillovers into the macro-economy. Similarly, von Peter et al. (2012) find that a successful post-disaster recovery is dependent on the extent of insurance coverage for the damages incurred.

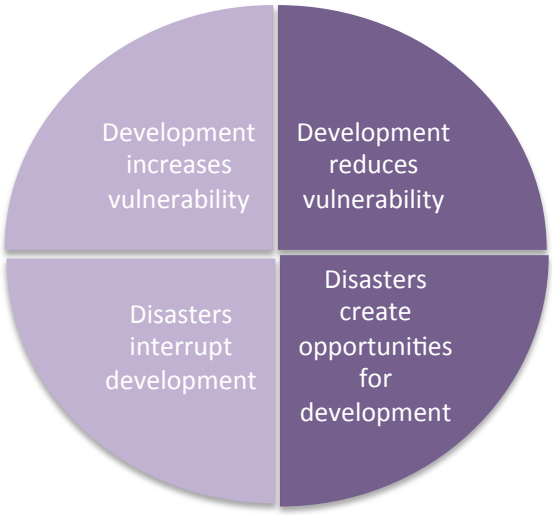
These findings suggest that access to early recovery, reconstruction resources and the capacity to utilize them effectively are of paramount importance in determining the speed and quality of recovery. Raddatz (2009) also concludes that smaller and poorer states are more vulnerable to the indirect impacts of disasters. His evidence, together with Becerra et al. (2014 and 2015), also suggests that, historically, aid flows have done little to attenuate

the output consequences of disasters, largely because their amounts have not been large enough relative to the magnitude of the damage incurred.

These losses are especially important to communities' welfare if they are long lasting. To date, the empirical work on the longer-run losses from disasters has largely failed to reach any consensus (see the review in Cavallo and Noy, 2011); and there has clearly been little attempt to examine this issue in the Pacific context.[17] One recent paper, Cabezon et al. (2015) estimated Vector Autoregressive systems of equations for Pacific Island countries using the EMDAT identification of disasters. They find very dramatic adverse national macroeconomic impacts (0.7 percentage points decline in GDP growth for every 1 percentage point in loss and damage). These are very large, but given the reported shortcoming of the EMDAT data on the Pacific (above), and the unlikely suitability of a linear VAR model to the macroeconomic volatility of the Pacific Islands, these results may exaggerate the real impact of these events at the national level.[18]

The most important insight, however, appears to be the local impacts can be quite prolonged, but their nature (or even whether they are positive or negative) is a function of the local circumstances, the local damages, and the local response. Coffman and Noy (2012), for example, identify a case where a hurricane led to out-migration, but no apparent declines in incomes. Hornbeck and Naidu (2014) describes a case that also triggered emigration, but that emigration led to scarcity of cheap labor and therefore to an increase in adoption of technological solutions and long-run labor productivity gains. Hornbeck (2012) identifies a case of emigration and long-term economic decline, while du Pont and Noy (2015) and du Pont et al. (2015) focus on a case with no long-term loss of population but with a loss of employment and reduces incomes. All of these cases were identified in high-income countries. We know very little about the long-term impacts of disasters, at the local-regional level, in geographically isolated small-island countries.

Figure 14. Sustainable Development and Disaster Risk



Note: Figure is adapted from Davis and Alexander, 2015.

As Figure 14 illustrates, the links between disaster risk and development are potentially complex. At their worst, disasters can decrease development prospects and inhibit them, and development itself can lead to increases in vulnerability and therefore ever higher damage and loss from disasters. At their best, development and prosperity may reduce vulnerability to disasters, and the destruction that disasters cause may itself lead to increasing opportunities for development (through a 'creative destruction' process). To some extent, all four possibilities have been observed somewhere and sometime, and the question we should be asking is the relative magnitude of each one of these processes in the Pacific.

Given previous evidence from elsewhere, and the lack of 'old' infrastructure that inhibits growth, it is most likely that the lower-right quadrant of this figure, the 'creative destruction' scenario, is less relevant within the Pacific context. It is clear that in the Pacific, development both increases and decreases disaster risk largely by increasing exposure (of both people and assets) and potentially decreasing vulnerability (by enabling the implementation of risk reduction and mitigation actions).

8. Fiscal Impacts

Post-disaster recovery implies multiple liabilities for the public sector. The public sector obviously pays some of the costs associated with the emergency response and recovery operations, but it also frequently bears a significant share of reconstruction costs. This can include the costs of reconstructing public infrastructure and buildings, under-insured or not-

insured residential housing (ideally mostly for low-income households), expenditures on social, employment and economic recovery programs (e.g. investment in new business ventures or social services), and payments for the explicit and implicit liabilities and investment needs of state-owned enterprises.

Post-disaster fiscal outlook can also often deteriorate because of a reduction of tax revenue as incomes and other taxable economic activities decrease, tax deductions or tax rate cuts are offered to assist in recovery, and funds are diverted to emergency needs instead of to programs supporting sustainable growth.

Overall, disasters can thus lead to deterioration in the government fiscal position, increases in public debt, increase in the cost of borrowing, and decrease in a government's credit rating. In cases where the government cannot borrow, the deterioration in the fiscal outlook may lead to monetization of deficits and consequent inflationary pressures.

Accurate estimates of the likely fiscal costs of disasters are therefore important for fiscal planning purposes. And, it is also important since, as we noted earlier, the fiscal space (the ability of countries to increase expenditures and pursue expansionary policy) is a key determinant of the ability of countries to recover rapidly and fully from disasters.

On the expenditure side, publicly financed reconstruction costs may be very different from the original magnitude of destruction of capital, and possibly very significantly larger. On the revenue side of the fiscal ledger, the impact of disasters on tax and other public revenue sources has seldom been quantitatively examined. Using panel VAR methodology, Lis and Nickel (2010), Noy and Nualsri (2011) and Melecky and Raddatz (2011) estimate the fiscal dynamics likely in an "average" disaster. They find heterogeneous dynamics, and argue that the impacts of disasters on revenue and spending depend on the nature of the destruction wrought by the disaster, on the country-specific macroeconomic consequences following the shock, the unique structure of revenue sources (income taxes, consumption taxes, custom duties, etc.), the fine details of the tax code, public sector and private insurance coverage, the size of the financial sector, and government indebtedness.[19] Ouattara and Strobl (2013), focus on the Carribean's fiscal vulnerability to modelled hurricane damage, and find short-lived increases in spending post-disaster, but without the plausible corresponding decline in tax revenue.

For most of the Pacific islands, revenue sources are less sensitive to the level of domestic economic activity than is typical in many other countries as income and corporate tax revenues are fairly limited. Much of the public sector revenue comes from exported natural resources (oil and gas, timber, fishing), from import taxes, and from official development assistance (ODA). Exports are unlikely to be affected, as the demand for them does not shift much, and they typically do not depend on vulnerable infrastructure (except for shipping ports). Most countries in the Pacific rely on currencies of larger global economies (e.g., the Australian or US dollar) or maintain fixed pegs through constraints on capital flows, so even exchange rate movements post-disaster are unlikely. Imports of consumption goods may be reduced, but imports of goods required for reconstruction typically increase so overall we do not observe large shifts in tariff revenues. ODA typically increases in a disaster's aftermath, so overall we do not observe much decrease in overall revenue in Pacific island countries hit by disasters.

On the expenditure side, reconstruction costs are oftentimes borne by the public purse, in the Pacific, as anywhere else, and the spending on reconstruction is added to the spending on providing emergency services and relief in the immediate aftermath of events. For example, the cost for delivering and supplying populations with both short-term survival needs and longer term reconstruction may be fraught with logistical expenses – see the discussion of the 2014 Solomon Islands earthquake below.

On the other hand, there are also reasons why the fiscal burden is sometimes less heavy on the public sector in the Pacific. For example, very strong social bonds characterize the Pacific, and these enable both large flows of remittances (often through community organizations such as churches) and mutual assistance that decrease the need of the government to intervene post-disaster.

There is a scarcity of detailed and timely data on fiscal spending in many Pacific countries, and there is even less timely and publicly available data on the government spending on DRR. We focus here on a few of the largest events in recent years, and describe the publicly available evidence regarding the fiscal accounts surrounding these events.

8.1 Samoa's Tsunami: September 29 2009

According to the Government of Samoa's official account of the disaster, there were 143 victims, 4 missing, and at least 5,000 people had been directly affected. Detailed information on damages incurred is available at Government of Samoa (2010, p. 12-14). The international EMDAT figures are 143 killed, 5,585 affected and $150M of damage.[20] DesInventar lists 241 killed, 37,010 being affected and $49M worth of damage.[21] GFDRR (2015) concludes that direct and indirect damages amounted to 20% of GDP ($20M), while World Bank (2015) cites a figure of $124.1M (about two thirds of that is direct damage, and the rest are economic losses). The most recent risk evaluation done by PCRAFI finds that Samoa has, annually, a 1% probability of incurring a $110M damage due to a tropical storm or earthquake/tsunami.

Donors provided $26.7M for tsunami reconstruction. Samoa has the ability to raise a maximum of $20.5M for disaster response from available fiscal sources, equivalent to 9 percent of total expenditures in 2013-2014 (GFDRR, 2015) This suggests a very large funding gap, as the Samoan government's report notes that the recovery plan, spread over three years, will cost over $100M. Of this sum, $20M have been allocated for first year activity by the government, so not much else remained to fund subsequent years (detail information in annex 6 p. 68-73).[22]

8.2 Fiji's Cyclone Evan: 17th December 2012

According to the Fijian government's PDNA, completed three months after the event, no lives were lost due to the storm. The total damage and loss was valued at $108M, while 60% of the population was affected by the storm. According to this report, most of the damage came from damage to agricultural stock (20%), hospitality sector (36%) and housing (26%). Overall, 5% of the available housing stock was damaged, with 1% estimated to have been completely destroyed. The PDNA includes assessment of both damage to stocks and estimates of future losses because of reduced economic activity. The PDNA further concludes that 17% of the total cost ($30.6M) fell on the public sector.

EMDAT and DesInventar produce estimates only of the direct estimated change in stocks (and not to losses of economic activity) – their numbers should therefore be smaller than the PDNA.[23] Fiji's PDNA concluded that the recovery, reconstruction and Disaster Risk Reduction Needs associated with the cyclone event were $77M (Government of Fiji, 2013).

Extra F$0.5M were collected from public donations and F$1M were allocated from the prime minister fund. Besides that, there were F$7M reallocated from the National Budget and F$9M was received from development partners, international organizations, local non-government organizations, businesses and individuals in the form of cash grants and aid-in-kind. This amounts to about $9.6M.[24] Fiji's expected annual exposure to cyclone damage, as calculated by PCRAFI, was $76M; though UNISDR (2012) observed an annual average of $50M over the last decade. Fiji has a Disaster Relief and Rehabilitation Fund, with a F$2M budget; which is much below Fiji's annual DRM needs (UNISDR, 2012).

8.3 Typhoon Pam 2015

Vanuatu was recently ranked as the most vulnerable country, worldwide, to disasters (caused by natural hazards).[25] The total cost of Cyclone Ivy in 2004 was estimated at $4 million. It was estimated that in 2005, tourism amounted to 75% of Vanuatu's total exports, making it especially vulnerable to a disaster that impacts the tourism industry (McKenzie et al. 2005). A more recent estimate by the Pacific Asia Travel Association calculated that Vanuatu's tourism receipts constituted over 36% of the country's gross domestic product in 2014.[26]

The IMF estimates that cyclone Pam caused damages and losses in the order of 50 percent of GDP ($400 million). The International Monetary Fund (IMF) is projected to approve emergency assistance to the government of Vanuatu of approximately $23.5 million in the form of concessionary loans.[27] The request was approved by the IMF's Executive Board in early June 2015, and funds disbursed to Vanuatu's Central Bank. In 2015, the United Nation's Financial Tracking Service recorded $38 million in disbursed aid (much of it in-kind).[28] The Vanuatu government has also received $1.9 million from its PCRAFI insurance policy, paid for by the commercial re-insurance companies that are underwriting the PCRAFI program.

Table 1: Estimated Value of Impact on Selected Sectors of the Vanuatu Economy

	Disaster effects ($ million)			Share of disaster effects (%)	
	Damage	Losses	Total	Private	Public
Productive sectors	78.9	96.3	175.2	98	2
Agriculture	13.2	43	56.1	93	7
Commerce and industry	11.1	19.9	31	100	0
Tourism	54.7	33.4	88.1	100	0
Social sectors	132.7	5.8	138.6	67	33

Housing (private)	87.5	40.7	128.2	100	0
Education	36.2	0.7	36.9	0	100
Infrastructure sectors	59.3	27.1	86.3	51	49
Transport	27.9	19.8	47.7	43	57
Communication	20.9	3.6	24.5	67	33
TOTAL	270.9	178.5	449.4	69	31

Notes: Damage refers to the economic and financial impacts resulting from damaged infrastructure and physical assets. Losses refer to economic and financial impacts resulting from changes in economic activities, such as reduced tourism numbers or higher prices for certain inputs to production. Exchange rate used is $1 = 108.04 vatu.
Source: From Pacific Economic Monitor, July 2015 issue, based on data from Government of Vanuatu. 2015c. Budget Policy Statement 2016. Port Vila.

9. Policy Recommendations

The Sendai Framework for Disaster Risk Reduction 2015-2030, adopted at the Third UN United Nations World Conference on Disaster Risk Reduction in March 2015 and endorsed by the UN General Assembly in June 2015, describes four priorities for action.

1. Understanding disaster risk
2. Strengthening disaster risk governance to manage disaster risk
3. Investing in disaster risk reduction for resilience
4. Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction

The GFDRR identifies five pillars for disaster risk reduction that are very similar to the four priorities agreed on in the Sendai agreement; and the ADB's Operational Plan for Integrated DRM is closely aligned with the Global Facility's plan and is equally comprehensive (ADB, 2014). The one addition to these priorities is their fourth pillar: Financial protection – ensuring that resources are available once a disaster strikes, through financial planning and financial instruments and tools.[29]

Progress on all four priorities for DRR is required for Pacific countries, as is true for all other countries that are signatories to this United Nations (UN) agreement. We have already highlighted the need to improve the measurment of current risk, as risk identification is incomplete in the Pacific. This task is going to only gain in importance as the pattern of risk is changing. This changing risk will manifest itself initially in countries like Tuvalu that are both on the edge of the cyclone belt, and as atoll nations are a lot more vulnerable to sea-level rise. Much of the effort, at this point, is targeted to priorities (2) and (3); while progress

on priority (4) – dealing with the process of recovery and 'build-back-better such as the work of the International Recovery Platform appears to be somewhat lagging. However, ADB has highlighted the design of climate proofing in the infrastructure project is supports in for the past several years. In the Pacific, and elswhere, more knowledged is needed about what kind of *ex ante* policies make recovery more successful, and what kinds of *ex post* interventions further push in that direction.

Early warning systems, probably a component of both priority (2) and (3) given the difficulties in implementing them, are the lowest fruit available for picking in the Pacific. However, the ADB and GFDRR focus on financial protection is the one policy area where the Pacific is the most exposed—given the very large role of the public sector in the region, and where there is probably the most room for improvement. We focus on financial protection in section 7.1 below. Yet, this focus on financial protectin does not imply that there are no other areas where significant progress can be made (see section 7.2). Regulating (mostly urban) development, maintaining or re-establishing protective eco-systems, or streghtening the provision of social protection in disasters' aftermath are all policy areas that have been emphasized before and are of particular interest in the Pacific.

9.1 Financial Protection

The World Bank outlines three risk layers that need to be dealt with in any DRF initiative: (1) self-retention of high-frequency low-impact risk, for such events as annual flooding, using contingency budget allocations, national reserves, and disaster funds; (2) a contingent credit mechanism for less frequent but more severe events, facilitated through a disaster fund and/or donor assistance; (3) disaster risk transfer (such as insurance) to cover major low-frequency disasters (GFDRR, 2015). Figure 13 provides a diagrammatic exposition of this sequencing.

Mexico's Natural Disaster Fund (FONDEN) was established in the 1996, and provides an early example of an ex-ante fiscal provisioning for (mostly) post-disaster reconstruction. A disaster fund, while prudent, amounts to a form of self-insurance, which may be very costly in the case of a developing economy with substantial borrowing costs. In order to encourage the purchase of explicit insurance to replace the implicit insurance provide by such a fund (or to increase the amount insured), FONDEN is set up so that it pays progressively less over

time for local government assets if the assets continue not to be insured by the local entity. FONDEN itself also issues Catastrophic Bonds and buy re-insurance for its excess budget obligations and thus transfers some of the risk to the international capital markets.[30]

Another example of a financial asset that can provide some service for ex-post disaster reconstruction is a sovereign wealth fund (SWF). Chile, for example, has used funds available in its SWF (the 'Copper Fund') to pay for reconstruction following the destructive Concepción earthquake of February 2010 (the most severe disaster to have hit the country since 1960).

Some of the financial instruments that are available to facilitate both ex-ante and ex-post disaster risk management are listed below. These are not mutually exclusive, and in principle should adhere to a framework in which the government reduces risk when that can be done cost-effectively.

a. Post-disaster budget provisions: Many of the region's countries maintain a disaster fund, but this fund typically pays for the recurrent costs associated with frequent events. This fund is typically under-funded, and gets depleted fully every year (e.g., in Fiji, where F$ 2 million is allocated annually). It is therefore not large enough to pay for costs of lower-probability higher-costs events. Given the development stage of most countries in the Pacific, the opportunity costs of maintaining a much larger disaster fund may be large, so enlarging the current size of disaster funds substantially is not be a viable strategy without significant assistance from bilateral and multilateral development institutions. An alternative is to establish provisions for obtaining funds for disaster emergency costs by re-directing funding from existing budget lines should that be necessary. This can entail a pre-specification of the sources for post-disaster spending (e.g., a cut in the budget of pre-agreed ministries). Establishing mechanisms to re-assign expenditures to emergency disaster costs does not transfer any of the risk, but at least allows governments to react to disasters effectively and rapidly.

b. Offshore funds: The offshore provident funds that many of the Pacific islands have established can also provide a source for accessible funds that can be moved rapidly on-shore for use in emergency management (especially for lower-probability high-impact events). Trigger mechanisms for the mobilization of some offshore funds can be established

so that the authorized managers of these provident funds can be allowed to release this funding rapidly in the immediate aftermath of a large event.

c. Contingent credit lines and multilateral loans and grant: The World Bank and the ADB have already or are planning to establish contingent credit facilities (pre-arranged loans that are disbursed if a pre-agreed triggering event occurs). All the multilaterals typically also extend loans and grants to countries hit by disasters. Whether these are sufficiently large, and can be mobilized sufficiently quickly remain open questions. Recent events in, for example, Vanuatu post-Pam indicate that there are still efficiency gains that can be had from streamlining this process. The purpose of these contingent grants and loans is to fund early recovery, and not the emergency phase. As such, speed of disbursement should be considered a priority, but it may not be the urgent in the disaster's immediate aftermath. The funds need to be provided, however, within a reasonable time frame so that recovery and reconstruction can start as soon as it is possible to do. Furthermore, even if this contingent funding does not transfer much of the risk (beyond the subsidization of interest rate margins), it allows governments to smooth their spending profile over time.

In the Pacific, as the risks are very high, and appear to be increasing because of anthropomorphic climate change, it seems sensible to convert some of these credit lines to grants, and thus transfer some of the risk to the international community. A plausible source that can provide multilateral contingent funding for disasters' fiscal risk, or even spending on DRM, is the climate change funding.

In the future, there are likely to be two main sources of external multilateral climate change funding (mostly paid for by high-income countries): (1) Funding for climate mitigation and adaptation from the Green Climate Fund; and (2) Funding for the damage and loss associated with climatic changes, through the Warsaw International Mechanism for Loss and Damage (WIM).[31 32]

The Green Climate Fund (GCF) is supposed to grow in importance, and will constitute a major part of the $100 Billion that was promised in the 21st yearly session of the Conference of the Parties (COP21) Paris meeting for annual climate change funding by 2020 (divided roughly and equally between spending on mitigation and adaptation). This money should, in principle, be coming mostly from the advanced countries. As of now, there is little evidence

that these large sums will materialize globally by 2020. Currently, a total of 44 countries have pledged a little more than 10% of that sum.

In the Pacific and elsewhere, smaller and poorer countries are finding it difficult to develop the elaborate proposals that will enable grant funding from the GCF.[33] It is now slowly becoming more established and apparent that many recent disasters can, at least in part, be attributed to climatic changes. In principle, countries in the Pacific should—given their extreme exposure to climate change risk associated with sea level rise and weather hazards such as droughts and storms—be able to access the climate change mitigation and adaptation funding (the GCF) more easily. If accreditation is the major obstacle to access, a facilitation of access through regional organizations that will provide the project management services should be a way to overcome this barrier without changing the process too much.[34]

In any case, once attribution of disasters to climatic changes is more established, another option for international funding may materialize. In particular, the recent Paris Agreement on Climate Change has approved, in principle, the establishment of the Warsaw International Mechanism for Loss and Damage (WIM) – an initiative that started in COP19 two years earlier. The development of the WIM process is only at its early infancy.[35] A United Nations (UNFCCC) executive committee is currently preparing a review of a possible WIM process, and a decision on its development is scheduled for the Conference of the Parties 22nd yearly meeting (COP22) at the end of 2016.

In the long-term, the WIM may prove to be a viable and very significant source of funding for post-disasters reconstruction spending (Noy, 2016b). The process of forming this WIM is now only in its infancy, and its exact size and form is as yet unclear. Nevertheless, some of the principles guiding the formation of this mechanism have already been established, and now is most likely the time to start advocating for access of Pacific countries to this future funding stream. The ADB and other multilaterals can collaborate with local institutions, such as the Secretariat of the Pacific Regional Environment Programme (SPREP), to develop the research and proposal development capacity that will eventually enable the countries of the Pacific region to access this WIM funding if and when it is established. Pacific countries, particularly the atoll nations, would be the ideal candidates for this type of funding given their obvious exposure to sea level rise and extreme weather events.

d. Insurance for public assets: Very few countries, in the Pacific and elsewhere, insure much of their public assets.[36] For small countries, with key publicly-owned access points (airports and ports) and lifelines whose reconstruction costs may overwhelm public resources, it may be advisable to purchase off-shore insurance for these key assets. This public insurance, currently limited to a very few government properties and no infrastructure, can be made cheaper if the cost of underwriting can be reduced by collaboration with the multilateral organizations.

e. Private insurance: Currently, there is significant underinsurance in the region (World Bank, 2015). This underinsurance is most likely the result of an inadequate supply of insurance products, and maybe also insufficient demand for these products that would allow for their development. Policymakers at all levels should develop interventions that increase private insurance coverage in the region. There are many possible interventions that can encourage more insurance provisions, but the two likely to be easiest are the public provision of data about risk, and the facilitation of financial tools and institutions that can provide this coverage. A lot of risk data is now available through the PCRAFI program; improving publicly available data collection and modeling may improve the willingness of financial companies to offer insurance products as risk is increasingly measured more precisely. As regional banks like Bank of the South Pacific (in the South Pacific), and the Bank of Hawaii (in the North Pacific) continue developing in the region, they should be encouraged to offer or broker a larger variety of financial services, including insurance coverage.

Both the World Bank and the ADB are involved in many initiatives to increase the size of the insurance sector in low – and middle-income countries, and that expertise should be used more in the region. Besides its potential benefits in providing resources for private sector reconstruction, private insurance is also important to alleviate the fiscal burden of post-disaster response. The more resources are available through the insurance sector, the less is the political and social pressure on government to provide for the reconstruction.

f. Sovereign insurance: As documented above, much of the disaster risk exposure for the Pacific island countries is fiscal, and sovereign insurance provides direct budget support to the government in the event of a disaster. Since the people of the Pacific have been living with hazards for centuries, they mostly are able to reduce large-scale mortality and

morbidity risk. However, with urbanization, population growth, and more development along the coasts, combined with the changes associated with changing climatic conditions, the exposure to physical damages has increased significantly. Since much of the costs of reconstruction and recovery are borne by the government, the fiscal risk associated with disasters is severe and increasing. In principle, governments can insure themselves against that risk. The biggest such triggered sovereign insurance case was more than $4 billion of re-insurance purchased by New Zealand for earthquake risk (through the state-owned Earthquake Commission[37]). Sovereigns can purchase insurance through several financial instruments: most obviously through insurance or re-insurance contracts, but also through issuance of catastrophic bonds (CAT bonds) or other types of financial derivative instruments. Countries can issue CAT bonds directly with private sector actors, or through the World Bank or other multilateral entities (the World Bank provides underwriting services for some types of CAT bonds, and can also issue its own bonds). These instruments require institutional capacity and financial market depth that without external multilateral assistance is probably not relevant even for the biggest economies of the region.

The vast majority of CAT bonds are still issued for high-income countries or specialized insurance companies. Governments of low- and middle-income countries, at the local or national level, do not yet appear to avail themselves of these insurance opportunities much. The only exceptions were Mexico (with an initial CAT bond issue in 2006), Turkey for its government-backed earthquake insurance facility, and as a backstop for the Caribbean catastrophe regional insurance arrangement (CCRIF). None of the Pacific Island countries is likely to issue CAT bonds by itself. One possibility would be to coordinate the issuance of CAT bonds with the multilateral development institutions, and have this process culminate in 'seal of approval' for DRM policies.[38] Once countries have issued a bond, and are thus the recipient of this explicit seal of approval, it may be the catalyst that will increase utilization of new financial tools for handling catastrophic risk, including private sector insurance. This 'seal of approval' process – whereby the government efforts in disaster prevention are explicitly recognized and approved – can facilitate one of the barriers to wider adoption of international insurance mechanisms, the fear of generating moral hazard (reducing the incentives of governments to invest in prevention).

g. Regional Pooling of Sovereign Insurance: Regional pools of insurance arrangement are a way to both pool resources and thus share risk across countries, and reduce the costs associated with the insurance underwriting (through the modeling of the risk, legal expertise, access to international re-insurance, etc.). A prominent global example of this regional pooling is the Pacific Risk Assessment and Financing Initiative (PCRAFI) program, which followed a similar initiative in the Caribbean (CCRIF). PCRAFI developed a subsidized insurance product that provides semi-parametric coverage to participating countries; this was launched in 2013. Unlike CCRIF, the pooling component of this arrangement is less fully realized, and PCRAFI is largely separate sovereign insurance contracts linked together to reduce underwriting costs. Currently, five countries participate: Cook Islands, Samoa, Tonga, Vanuatu and Marshall Islands. The exact coverage is a function of the risk profile constructed for each country (based on the data on hazard frequencies and exposure of physical assets reviewed above) and on the coverage choice of the participating country in terms of the attachment point/deductible and the annual aggregate limit.

Currently, the program provides insurance for two hazards: earthquakes (including tsunamis) and tropical cyclones (including both wind and water damage caused by floods and storm surges generated by the cyclone). The physical assets for whom damage is calculated include cash crops, public infrastructure, and buildings. The models used for this cover are static so they do not account for any change in hazard patterns associated with climate change, nor for any change to the exposure of assets associated with increasing incomes, urbanization, demographic changes and other developments.

During the three-year pilot phase that ended at the end of 2015 the insurance contracts were with international reinsurers, and the Government of Japan provided premium subsidies. During this phase, the insurance was triggered twice: Tonga in 2014 and Vanuatu in 2015. In 2016, the fourth year of operations for the insurance pool, each participant country is paying an annual premium of $40 thousand, while the rest is paid for by the World Bank.[39] The Cook Islands joined the pool in 2014 as a full paying member (as it is not eligible for official development assistance). Other countries in the Pacific that have expressed interest in joining the insurance pool are FSM, Fiji and Palau, but the last two are not members of the International Development Association (IDA)–part of the World Bank Group borrowing members. Non-IDA members cannot receive IDA funding, and thus their

PCRAFI premiums may not be covered by IDA grants or loans. At the end of 2014, Solomon Islands decided to withdraw from the program after being a member for the first two years of the pilot program.

The World Bank (2015) provides a preliminary assessment of the program, and concludes: "Lessons from the PCRAFI indicate that catastrophe risk insurance cannot cover all disaster losses and should be combined with other financial solutions as part of a comprehensive package for financial protection against natural disasters."[40] It is difficult to disagree with this understated assessment of the program's size. Most recently, after cyclone Pam hit Vanuatu in March 2015, estimates of loss and damage from the storm were between $200 and $400 million (M), and the PCRAFI insurance scheme paid the government about $1.9 million. The estimated fiscal cost of reconstruction was also in the tens of millions.

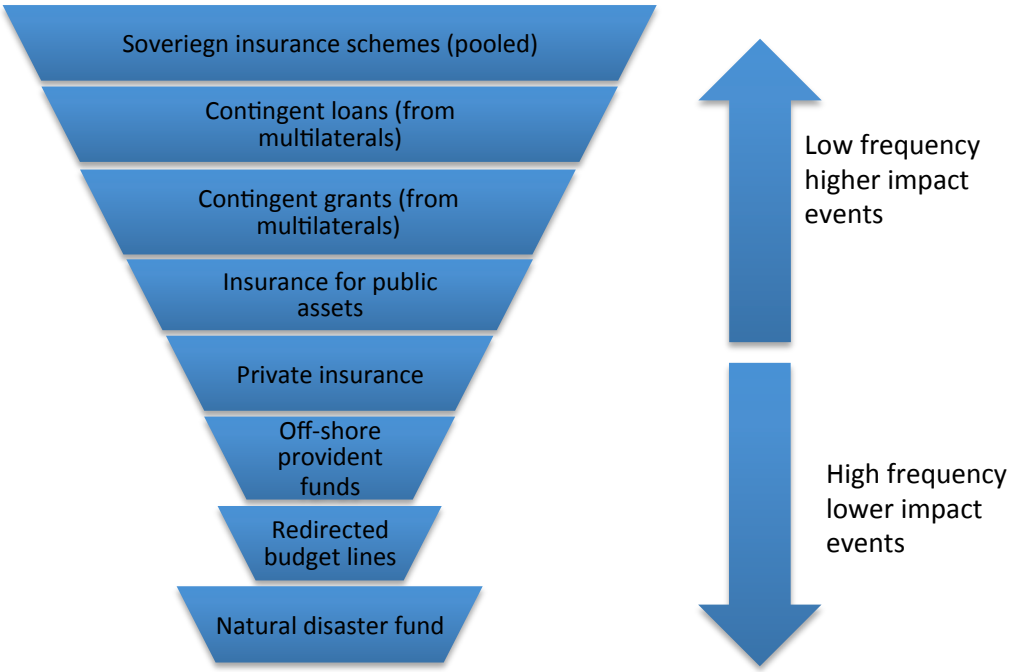
One notable aspect of the program is the speed with which funds are allocated – this speed is the justification for its semi-parametric structure of the insurance tool. The Pam payment to Vanuatu in 2015 was approved within about 3 weeks after the event. This speed should have assisted the government in its initial emergency phase and potentially relaxed any constraints that may have been inhibiting the government from implementing its emergency plans in the immediate aftermath.

This advantage of early and quick disbursement of funding for emergencies can also be accomplished through other ways of executing funds during a time of disaster. By all accounts, the Cook Islands government, for example, has adopted good practices in terms of emergency execution of extra-ordinary funding for disaster relief—including establishing its Disaster Emergency Trust Fund and the government's current effort to set up a disaster credit facility with the ADB--but these measures are still likely to be insufficient and there will likely be a substantial funding gap were it hit by a cyclone of the magnitude that have affected neighboring Pacific countries in recent years. Still, for Tonga when it was paid after the cyclone of 2014 the PCRAFI payment was the only near-immediate cash injection the government received at the time (as much of international emergency relief is received 'in kind' – later reconstruction funding is more typically 'in cash'). Still, there is little evidence that lack of liquidity was a factor in the emergency management phase in past large disasters in the region (including the most recent cyclone Winston in Fiji in 2016). Whether or not early recovery was cash-constrained in past events in the Pacific is an open question.

The semi-parametric structure of the program is attractive, however, it also lowers the administrative costs of loss-adjustment after events, and reduces moral hazard concerns. Most importantly, the PCRAFI insurance program is small relative to the magnitude of the risk, and involves significant administrative running costs. Scaling up of this program may be feasible, but with a larger program it becomes important to examine how correlated are the estimated modeled damages with the actual damage caused by the triggering events. Parametric insurance systems are potentially nothing more than lotteries if the correlation is very weak (i.e., basis risk is relatively large). Recent costly events that failed to trigger similar parametric insurance policies suggest that this indeed may be a relevant concern.[41] A semi-parametric system that also has a measured indemnity component may overcome some of these difficulties. At this point, however, given the 'black box' secrecy of the index trigger, it is difficult to evaluate what kind of semi-parametric arrangement may be productive.

Lastly, but may be most importantly in the context of multilateral policy priorities, the current PCRAFI insurance program is dramatically insufficient to deal with disaster risk in the region, but it seems to attract an amount of policy attention that does not closely correspond to its modest size. Rather than scaling up the PCRAFI insurance arrangement with its significant fixed costs and high premiums, it may be easier to accomplish the same goals through bilateral Contingent Funding arrangement agreements directly with the major development partners, including the Asian Development Bank. The newly established Phase II of the PCRAFI program, headquartered in the Cook Islands, may provide the platform from which these new arrangements can be established to allow improved country ownership of the program and improved accountability and transparency in terms of the risk-pooling component of this program.

Figure 15. Disaster Risk Fiscal Financing Priorities



9.2 Other DRM Tools?

Constructing efficient and timely warning systems is clearly a desirable policy that is uncontroversial and almost always very cost effective. Operating warning systems, however, requires significant capacity, and progress towards it can still be improved in cost-effective ways in most Pacific island countries. The difficulty of developing an effective early warning system should not be underestimated. On April 11, 2012, a powerful earthquake (8.6 on the Richter scale) occurred not far offshore Banda Aceh, Indonesia, the city that was inundated by the 2004 South-East Asian tsunami. By this time, there was an early warning system in place for tsunami hazard in Aceh, but since everyone attempted to evacuate at the same time, roads became gridlocked very quickly as people were frantically trying to flee (Rondonuwu, 2012). Luckily, the earthquake generated no significant tsunami, but the inadequacy of a system developed specifically to prevent mortality if a repeat of the 2004 catastrophe were to occur was demonstrated quite starkly. The Pacific Tsunami Warning Center, established in the late 1940s, and providing its first important early warning in the 1960 Pacific-wide tsunami that originated in Chile, still has only limited reach in many of the Pacific Islands. Most challenging is the 'last mile' transmission to the coastal communities that need to evacuate if a warning is issued; see, for example, the early warning system (EWS) in Tonga (ABC, 2013).

Investment in EWS is neither cheap nor easy, as it also requires securing an effective response to the warnings that are supplied. Yet, the magnitude of benefits, in terms of life saved per dollar spent, are very large if these systems manage to prevent the most catastrophic events. Retrofitting of lifeline assets such as electricity systems, transportation hubs, and air- and seaports, to ensure the maintenance of major services in the aftermath of catastrophic events is also almost always cost-effective.

The most obvious of the menu of policies that reduce exposure is risk-based land-use planning. In the Pacific region, the two most vulnerable areas are the river valleys (flash floods) and the coasts (tsunamis and storm surges). Environmental assessment of projected developments, which is required in many places, does not always include an assessment of future risks, especially the ones related to future sea level rise or heighted risks of flooding.

More generally, DRM considerations should also be included in policies on transport, energy, agriculture, tourism, health, education, or even fisheries management.[42] This in principle should be done in Joint National Action Plans (JNAPs) (SPREP, 2013). JNAPs were first developed in the region by Tonga in 2010, but have since been adopted by most of the other countries in the region with the support of SPC. These JNAPs, however, are typically high-level documents that outline the main climate change adaptation/DRM strategy rather than detail the actions that will provide better fiscal resilience in government operations.

References

ABC (2013). Tonga to Test Tsunami Warning Sirens. http://www.radioaustralia.net.au/international/2013-05-10/tonga-to-test-tsunami-warning-sirens/1128854

ABM and CSIRO (2014). *Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Report*s. Pacific-Australia Climate Change Science and Adaptation Planning Program Technical Report, Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation, Melbourne, Australia.

ADB (2004). *Disaster and Emergency Assistance Policy*. Asian Development Bank.

ADB (2013). *The Economics of Climate Change in the Pacific*. Asian Development Bank.

ADB (2014). *Operational Plan for Integrated Disaster Risk Management 2014-2020*. Asian Development Bank.

ADB (2015). *Pacific Economic Monitor Midyear Review: July*. Asian Development Bank.

Air Worldwide (2010). *Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) Component 1: Hazard Data and Loss Data Collection and Managemen*t. Technical Report Submitted to the World Bank.

Air Worldwide (2011). *Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) Component 2: Exposure Data Collection and Management*. Technical Report Submitted to the World Bank.

Auffhammer, M., Hsiang, S. M., Schlenker, W., & Sobel, A. (2013). Using weather data and climate model output in economic analyses of climate change. *Review of Environmental Economics and Policy*, 7(2), 181-198.

Barnett, J., (2001). Adapting to climate change in Pacific Island countries: The problem of uncertainty. *World Development*, 29(6), 977-993.

Barnichon, R. (2008), 'International reserves and self-insurance against external shocks', International Monetary Fund Working Paper 08/149, Washington, DC.

Becerra, O., E. Cavallo and I. Noy (2014). In the Aftermath of Large Natural Disasters, What Happens to Foreign Aid? *Review of Development Economics* 18(3), 445-460.

Becerra, O., E. Cavallo and I. Noy (2015). Where is the Money? Post-Disaster Foreign Aid Flows. *Environment and Development Economics*, 20(5), 561-586.

Besley, T. and R. Burgess. 2002. "The Political Economy of Government Responsiveness: Theory and Evidence from India." *Quarterly Journal of Economics* 117(4): 1415-1451.

Borensztein, E., E. Cavallo, and P. Valenzuela (2009), 'Debt Sustainability under Catastrophic Risk: The Case for Government Budget Insurance', *Risk Management and Insurance Review* 12(2), pp.273-294.

Cabezon, Ezequiel, Leni Hunter, Patrizia Tumbarello, Kazuaki Washimi, and Yiqun Wu. 2015. Enhancing Macroeconomic Resilience to Natural Disasters and Climate Change in the Small States of the Pacific. IMF Working Paper WP/15/125.

Caesar, J., L.V. Alexander, B. Trewin, K. Tse-ring, L. Sorany, V. Vuniyayawa, N. Keosavang, A. Shimana, M.M. Htay, J. Karmacharya, D.A. Jayasinghearachchi, J. Sakkamart, A. Soares, L.T. Hung, L.T. Thuong, C.T. Hue, N.T.T. Dung, P.V. Hung, H.D. Cuong, N.M. Cuong, and S. Sirabaha, 2011: Changes in temperature and precipitation extremes over the Indo-Pacific region from 1971 to 2005. *International Journal of Climatology*, 31(6), 791-801.

Cavallo, E., S. Galiani, I. Noy and J. Pantano (2013). Catastrophic Natural Disasters and Economic Growth. *Review of Economics and Statistics* 95(5), 1549-1561.

Cavallo, E., and I. Noy (2011), 'The Economics of Natural Disasters – A Survey', *International Review of Environmental and Resource Economics* 5(1), pp.63-102.

Chung, J., 2009: *Situation analysis for strengthening disaster information management systems in Fiji: baseline data preparedness and assessment methodologies*. A report prepared for the Fiji Government and Pacific Disaster Risk Management Partnership, UNISDR & SOPAC.

Coffman, M. and I. Noy (2012), 'Hurricane Iniki: Measuring the Long-Term Economic Impact of a Natural Disaster Using Synthetic Control', *Environment and Development Economics* 17, pp. 187-205.

Cole, S., H. Andrew, and E. Werker (2012), 'Do voters demand responsive governments? Evidence from Indian disaster relief', *Journal of Development Economics* 97(2), pp.167-181.

Crichton, D. (1999): The Risk Triangle. In: Ingleton, J. (ed.), *Natural Disaster Management*. Tudor Rose, London. 102-103pp.

Deryugina, Tatyana, 2016. The Fiscal Cost of Hurricanes: Disaster Aid Versus Social Insurance. NBER Working Paper 22272.

Doocy et al., 2007. Tsunami Mortality Estimates and Vulnerability Mapping in Aceh, Indonesia. *American Journal of Public Health*, 97, S146-151.

du Pont, W. and I. Noy (2015). What Happened to Kobe?' *Economic Development and Cultural Change.* 63-4 (July)

Durack, P. J., Wijffels, S. E., & Matear, R. J. (2012). Ocean salinities reveal strong global water cycle intensification during 1950 to 2000. *Science* 336(6080), 455-458.

ECLAC (2014). *Handbook for Disaster Assessment*. United Nations Economic Commission for Latin America and the Caribbean. http://caribbean.eclac.org/content/handbook-disaster-assesment.

Elsner, J., J. Kossin, and T. Jagger (2008), 'The Increasing Intensity of the Strongest Tropical Cyclones', *Nature* 455, pp.92-95.

Felbermayr, G. and Groschl, J. (2014). Naturally negative: The growth effects of natural disasters, *Journal of Development Economics*, 111: 92-106.

Fomby, T, Ikeada, Y., and Loayza, N.V. (2013) The Growth Aftermath of Natural Disasters, *Journal of Applied Econometrics*, 28: 412-434.

GFDRR, 2013. *FONDEN: Mexico's National Disaster Fund*. https://www.gfdrr.org/sites/gfdrr.org/files/documents/Mexico_FONDEN_final_GFDRR.pdf

GFDRR, 2015. *PCRAFI Country Note: Samoa*. International Bank for Reconstruction and Development.

Government of Fiji, 2013. *Post-Disaster Needs Assessment: Tropical Cyclone Evan.*

Government of Samoa, 2010. *An account of the tsunami disaster, the response, its aftermath, acknowledgement and the trek to recovery*.

Hallegatte, Stephane, Adrien Vogt-Schilb, Mook Bangalore, and Julie Rozenberg. 2017. *Unbreakable: Building the Resilience of the Poor in the Face of Natural Disasters*. Climate Change and Development Series. Washington, DC: World Bank. Available at: https://openknowledge.worldbank.org/handle/10986/25335

Hay, J., 2009. *Institutional and Policy Analysis of Disaster Risk Reduction and Climate Change Adaptation in Pacific Island Countries*. A report prepared for the United Nations International Strategy for Disaster Reduction (UNISDR) and the United Nations Development Programme (UNDP). UNISDR and UNDP, Suva, Fiji.

Herring, S. C., M. P. Hoerling, J. P. Kossin, T. C. Peterson, and P. A. Stott, Eds., 2015: Explaining Extreme Events of 2014 from a Climate Perspective. *Bulletin of the American Meteorological Society*, 96 (12), S1–S172.

Hsiang, S. and A. S. Jina. 2014. The Causal Effect of Environmental Catastrophe on Long-Run Economic Growth: Evidence from 6,700 Cyclones. NBER Working Paper. No. 20352.

International Institute for Environment and Development, 2015. *Briefing: The Green Climate Fund accreditation process: barrier or opportunity?* International Institute of Environment and Development, London.

Kahn M E. 2005. "The Death Toll from Natural Disasters: The Role of Income, Geography, and Institutions. *Review of Economics and Statistics* 87(2): 271–284.

Kang, Nam-Young, James B. Elsner (2015). Trade-off between intensity and frequency of global tropical cyclones. *Nature Climate Change* 5, 661–664.

Karim, A., & Noy, I. (2016). Poverty and Natural Disasters–A Qualitative Survey of the Empirical Literature. *Singapore Economic Review*, 61(1).

Lazzaroni, S., &. van Bergeijk, P. (2014). Natural disasters' impact, factors of resilience and development: A meta-analysis of the macroeconomic literature. *Ecological Economics,* 107, 333–346.

Lee, T. and M.J. McPhaden, 2010: Increasing intensity of El Niño in the central equatorial Pacific. *Geophysical Research Letters*, 37, L14603.

Li, Tim, Min Ho Kwon, Ming Zhao, Jong-Seong Kug, Jing-Jia Luo, and Weidong Yu (2010), 'Global warming shifts Pacific tropical cyclone location', *Geophysical Research Letters* 37, pp. L21804.

Lis, E.M. and C. Nickel (2010), 'The impact of extreme weather events on budget balances. *International Tax and Public Finance* 17: 378–399.

McKenzie, E., B. Prasad, and A. Kaloumaira, 2005: *Economic Impact of Natural Disasters on Development in the Pacific.* Volume I. SOPAC and USP, Suva, Fiji.

Mei' Wei, Shang-Ping Xie, François Primeau, James C. McWilliams, Claudia Pasquero (2015). Northwestern Pacific typhoon intensity controlled by changes in ocean temperatures. *Science Advances.* 1(4), e1500014.

Melecky, M. and C. Raddatz (2011), 'How Do Governments Respond after Catastrophes? Natural-Disaster Shocks and the Fiscal Stance', *World Bank Policy Research Working Paper* 5564. Washington D.C.: World Bank.

Mendelsohn, R., K. Emanuel, S. Chonabayashi, and Laura Bakkensen (2012), 'The impact of climate change on global tropical cyclone damage', *Nature: Climate Change* 2, pp.205-209.

Noy, I. (2009), 'The Macroeconomic Consequences of Disasters', *Journal of Development Economics* 88(2), pp.221-231.

Noy, I. (2016a), A Global Comprehensive Measure of the Impact of Natural Hazards and Disasters. *Global Policy* 7(1), 56-65.

Noy, I. (2016b), The Socio-economics of Cyclones. *Nature Climate Change* 6, 343-345.

Noy, I. (2016c). Natural Disasters in the Pacific Island Countries: New Measurements of Impacts. *Natural Hazards*, 84(1), 7-18.

Noy, I. and W. du Pont IV (2016), 'The Long-Term Consequences of Natural Disasters – A Summary of the Literature', School of Economics and Finance (SEF) Working Paper in Economics and Finance 02/2016 (Victoria Business School).

Noy, I. and A. Nualsri (2011), 'Fiscal Storms: Public Spending and Revenues in the Aftermath of Natural Disasters', *Environment and Development Economics* 16(1), pp.113-128.

Ouattara, Bazoumana, Eric Strobl (2013). The fiscal implications of hurricane strikes in the Caribbean. *Ecological Economics*, 85, 105-115.

PCRAFI (2013a). *Catastrophe Risk Assessment Methodology*. Pacific Catastrophe Risk Assessment and Financing Initiative, June.

PCRAFI (2013b). Current and Future Tropical Cyclone Risk in the South Pacific. Pacific Catastrophe Risk Assessment and Financing Initiative, June.

PIFS (2009). *Economic Costs Of Natural Disasters In The Pacific Islands Region And Measures To Address Them.* Pacific Islands Forum Secretariat, Economic Ministers' meeting, Rarotonga, Cook Islands.

Pacific Asia Travel Association (2015). *Asia Pacific Visitor Forecasts 2015-19* as reported in Edmonds and Radoc *Pacific Economic Monitor*, December 2015.

Raddatz, C. (2007), 'Are External Shocks Responsible for the Instability of Output in Low-Income Countries?', *Journal of Development Economics* 84(1), pp.155-187.

Raddatz, C. (2009), 'The Wrath of God: Macroeconomic Costs of Natural Disasters', *World Bank Policy Research Working Paper* #5039. Washington D.C.: World Bank.

Siqueira, A.A., Arthur, C., & Woolf, M. 2014. *Evaluation of severe wind hazard from tropical cyclones - current and future climate simulations.* Pacific-Australia Climate Change Science and Adaptation Planning Program: Record 2014/47. Geoscience Australia, Canberra. http://dx.doi.org/10.11636/Record.2014.047

Skidmore, M. and H. Toya (2002), 'Do Natural Disasters Promote Long-run Growth?', *Economic Inquiry* 40(4), pp.664-687.

Secretariat of the Pacific Community (2015). *Compendium of Case Studies on Climate and Disaster Resilient Development in the Pacific 2015*. Secretariat of the Pacific Community. http://www.pacificdisaster.net/dox/case_studies_pacific.pdf.

SPREP (2013). *JNAP Development and Implementation in the Pacific: Experiences, lessons and way forward*. Secretariat of the Pacific Regional Environment Programme, Apia, Samoa.

Takasaki, Yoshito (2011a). Targeting Cyclone Relief within the Village: Kinship, Sharing, and Capture. *Economic Development and Cultural Change* 59(2), 387-416},

Takasaki, Yoshito (2011b). Do local elites capture natural disaster reconstruction funds? *Journal of Development Studies* 47(9), 1281-1298.

Takasaki Y. (2014), How Is Disaster Aid Allocated Within Poor Communities? Risk Sharing and Social Hierarchy, *Journal of International Development* 26; 1097–1114.

UNISDR (2012). *Disaster Risk Reduction & Climate Change Adaptation in the Pacific: An Institutional and Policy Analysis*. Geneva: UNISDR, UNDP, and GFDRR.

UNISDR (2013), *Global Assessment Report*. Geneva: United Nations.

UNISDR (2015), *Global Assessment Report*. Geneva: United Nations.

UNU-EHS (2014). *World Risk Report 2014.* United Nations University.

World Bank (2012a). *Acting Today For Tomorrow: A Policy and Practice Note for Climate- and Disaster-Resilient Development in the Pacific Islands Region*. World Bank Group.

World Bank (2012b). FONDEN: Mexico's Natural Disaster Fund – A Review. World Bank Group, May.

World Bank (2015). *Advancing Disaster Risk Financing & Insurance In the Pacific: Regional Summary Note & Options for Consideration*. World Bank Group, February.

Von Peter, Goetz, Sebastian von Dahlen, Sweta Saxena, 2012. Unmitigated disasters? New evidence on the macroeconomic cost of natural catastrophes. BIS Working Papers No 394.

Warnock, A., 2007. Small island developing states of the Pacific and climate change: Adaptation and alternatives. *NZ Yearbook of International Law*, 4, 247-286.

WHO (2015). *Human health and climate change in Pacific Island countries*. World Health Organization Report.

End Notes

[1] Crichton (1999) provides an explanation of this 'risk triangle.' In many cases, vulnerability is defined as the opposite of resilience, though there is a lively debate about the definition of these terms.
[2] In this paper, we use the term 'disaster risk reduction' (DRR) broadly as any policy whose aim is to reduce or improve the management of disaster risk. Some distinguish between DRR and disaster risk management or disaster risk mitigation (DRM). We use the term DRR to include also DRM policies; in this, we follow the practice adopted by UNISDR and more broadly in the United Nations' international agreement signed in March 2015: the *Sendai Framework for Disaster Risk Reduction 2015-2030.*
[3] ADB (2004) is the principle document guiding ADB's policies in this area.
[4] EMDAT's dataset was accessed on 18/12/2015.
[5] DesInventar's definitions for damages, and collection methodology, are different from EMDAT
[6] Only two other PICs are ranked in this ranking of 172 countries. Oddly, Kiribati is ranked in this ranking as one of the safest countries in the world.
[7] 16% for earthquakes, and 23% for tropical storms and tsunamis (World Bank, 2013).
[8] ADB took lead responsible for creating the exposure databases used by PCRAFI.
[9] See Lee and McPhaden (2010) and Durack et al. (2012).
[10] Woodruff et al. (2013), for example, argue that there is no evidence on changing frequencies or intensities of tropical cyclones on the global scale. See also Weinkle et al. (2012) and Thomas et al. (2014).
[11] Crompton et al. (2011) find that one would need to have 260 years of hurricane data to identify any trends in hurricane frequency associated with anthropomorphic change in the North Atlantic Storm Basin. Since South Pacific cyclones are less frequent than Atlantic ones, the time series necessary to identify frequency trends there would be even longer.
[12] See Kang and Elsner (2015), Mei et al. (2015), and Bender et al. (2010). Siqueira et al. (2014) present forecasts of future changes in storm tracks for each Pacific island country, based on several general circulation models (GCM). The predictions are quite different across the GCMs, so there is little certainty associated with these predictions.
[13] See Ramsay (2014), Li et al. (2010), and Kossin et al. (2014).
[14] According to a recent estimate, based on a meta-study, existing coral reefs attenuate 97 percent of the storm wave power and reduce wave height by 84 percent (Ferrario et al. 2013)..
[15] See Aldrich (2012) for a discussion of linking, bridging and bonding social capital and their different roles in disaster impacts and disaster recovery.
[16] See Healy and Malhotra (2009 and 2010).
[17] Cavallo et al. (2013) provide one of the most recent attempts to examine this question for a cross-country comparison. They don't find any significant long-run effect of even very large disasters, except for very large events that were then followed by political upheavals. For the events followed by political change, they find economically very substantial and statistically significant negative long run effects on per capita GDP. The prototypical examples they identify is Iran with its 1979 Islamic revolution following the 1978 Tabas earthquake, and Nicaragua with its overthrow of the Somoza regime following the 1972 earthquake in Managua.
[18] Another paper that finds dramatically larger impact of cyclones than the earlier literature is Hsiang and Jina (2014).

[19] Noy and Nualsri (2011) find that fiscal behavior in the aftermath of disasters in developed countries is counter-cyclical, but pro-cyclical (decreased spending and increasing revenues) in developing countries following large disasters.
[20] The tsunami also caused the damages in other countries: In American Samoa 34 were killed, and 2,500 affected; in Tonga, 9 were killed, 507 affected and $9.5M of damages were incurred.
[21] 223 deaths, 310 injured, 18 missing, 30,000 affected, 502 houses destroyed, 360 houses damaged, 3,200 relocated, 3,500 evacuated, 7 education centers destroyed and 2 hospitals.
[22] The housing scheme cost $3.8 million for 862 homes (p. 28). Annex 2 (p.42-54) describes the Relief Assistance in-kind donations. Annex 3 (p.55-61) describes the Technical Assistance and estimated value. Annex 4 (p.62-66) gives detailed information of donations (total of or $6M) (Government of Samoa, 2010).
[23] EMDAT includes figures of 2 killed, but only 8,400 affected and modest damage of $8.4M. EMDAT also identified damages in other countries: In Samoa 12 people were killed, 12,703 were affected, and $133M of damages were incurred; while in Wallis and Futuna Islands 1,252 people were affected. Given the dramatically larger financial figures for Samoa, it is likely that the EMDAT data for Fiji is misstated. DesInventar, in contrast, provides an incredibly precise figure of 764,039 people affected and $42M of damages; 2,000 houses destroyed, 6,000 houses damaged, 750,000 people affected, 14,039 evacuated, and 150 education centers destroyed.
24 ADB provided $1 million for humanitarian relief through the Asia Pacific Disaster Response Facility, $12.5 million for a road reconstruction project and $5 million for a school reconstruction project. Reported figures in the PDNA on international assistance clearly appear not to capture everything.
[25] United Nations University (2016). *WorldRiskReport 2016*. http://collections.unu.edu/eserv/ UNU: 5763/WorldRiskReport2016_small.pdf.
[26] Pacific Asia Travel Association (2015).
[27] To be provided in equal shares through the Rapid Credit Facility (RCF) and the Rapid Financing Instrument (RFI). The RCF provides rapid concessional financial assistance as an outright disbursement without explicit program-based conditionality or periodic review, and a zero interest rate. The RFI is subject to the same financing terms as the standard IMF Stand-By Arrangement. As of April, 2015, the interest rate on the RFI is 1.05 percent.
[28] The UN Office for the Coordination of Human Affairs (OCHA), which is typically responsible for emergency response, issued a request for $30M support for Vanuatu's relief efforts post-Pam. The Vanuatu government's Humanitarian Action Plan, issued on 1/5/2015, called for an additional $15M of support.
[29] The GFDRR pillars are: (1) Risk identification – the measurement of risk and its communication to stakeholders; (2) Risk reduction – using infrastructure and non-structural measures (such as building codes) to reduce exposure; (3) Preparedness – making sure communities, organizations and governments are prepared for low-probability high-impact events with early-warning systems, contingent planning, etc.; (4) Financial protection; and (5) 'Build back better' recovery – ensuring that reconstruction post-event is creating more resilient societies.
[30] Details about FONDEN are available at World Bank (2012b). Through FONDEN, Mexico is one of the biggest issuers of catastrophic (CAT) bonds. Even so, the provisioning of FONDEN has been insufficient to cover the costs of disasters in quite a few years of its history.
[31] Domestic and bilateral funding for climate change is ignored here, as these sources are unlikely to be directed specifically for DRM. Similarly, private sector resources and the revenue from carbon markets are unlikely to be major sources of DRM funding.
[32] Currently, the GCF is aiming for high leverage, with only a minor part of the funding originating from the GCF resources. As such, it will not be a major source of DRM funding.
[33] ADB received funding from the GCF for an ADB urban water and sewage project in Fiji that was co-financed by the ADB and other loans. The smaller countries in the Pacific will necessarily need to be

assisted by the ADB or other multilateral or bilateral development partners to successfully access GCF funding.

[34] In early 2016, the Cook Islands became the first Pacific Island Country to access the GCF. The country was provided with GCF financing ($150,000) in order to "strengthen their capacity to access finance through GCF."

[35] The Loss and Damage Mechanism was initiated by the UNFCC at its meeting in Warsaw in 2013 (COP19). The international commitment to pursue this agenda of compensation for loss and damage caused by disasters associated with anthropogenic climate change received an additional confirmation in the climate change agreement signed at the COP21 meeting in Paris (December 2015).

[36] Even Fiji, Solomon Islands, and Vanuatu, some of the biggest countries in the region, have not purchased insurance for government assets (World Bank, 2015).

[37] The author of this report is partly funded by the Earthquake Commission.

[38] This 'seal of approval' for DRM can be attached to other financial support instruments, such as sovereign insurance or contingent credit agreements. CAT bonds, however, may be the most convenient way to adopt this model, as with CAT bonds countries receive the money (in the form of a contingent bond) before any event occurs. As such, they have the ability to target these additional resources for DRM spending. In the case of other instruments, countries will have to both pay the premiums on the insurance, for example, and spend additional scarce resources on DRM.

[39] The World Bank estimates that the cost of the PCRAFI insurance premium for Samoa, Tonga, Vanuatu and RMI is $0.5million per year for three years (2016-2018). The participating governments will be paying "at least $40,000" and incrementally increasing their contributions to $60,000 for the 2018 phase.

[40] World Bank (2015, p. 108)

[41] An earthquake in the Solomon Islands in 2013 failed to trigger coverage under PCRAFI, nor did the recent drought in Malawi trigger the drought insurance policy that Malawi bought through the Africa Risk Capacity initiative.

[42] See World Health Organization (2015) for an analysis of the related health issues facing the region within the context of climatic change.