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# The economics of disaster risks and impacts in the Pacific

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Economics of  
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and impacts

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## Abstract

**Purpose** – The Pacific islands face the highest disaster risk globally in per capita terms. Countries in the region have been affected by several recent catastrophic events, as well as by frequent natural hazards of smaller magnitude. The purpose of this paper is to quantify total disaster risk faced by Pacific island countries (PICs).

**Design/methodology/approach** – The paper evaluates the three main sources of data for quantifying risk in the region—the International Emergency Database (EMDAT), DesInventar and the Pacific Catastrophe Risk Assessment and Financing Initiative, evaluating the information available on indirect disaster impacts and their likely impacts on poverty and well-being.

**Findings** – The analysis suggests that the three available data sets contain inconsistencies and underestimate disaster risk, especially for atoll nations. It also identifies four trends with respect to changes in natural hazards that result from climate change and are likely to have the greatest long-term impact on Pacific islands. Focusing on Tuvalu, the paper also quantifies the likely consequence of some of the possible interventions that aim to reduce those impacts.

**Practical implications** – The paper's main conclusion is that improving the systematic collection of quantitative data on disaster events should be a basic first step in improving future policy decisions concerning resource allocation and efforts to insure losses from future disasters and climate change.

**Originality/value** – While a lot of research explored disaster risk in PICs, comparative analysis of quantitative information on disasters across the diverse countries of the region is limited.

**Keywords** Disaster risk, Small Island Developing States, SIDS, Pacific islands, Climate change implications

**Paper type** Research paper

## 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 in per capita terms, the Pacific itself is a higher risk region (Noy, 2016b). Most Pacific island countries (PICs) are located within or close to the Cyclone Belt (roughly within the tropics but further than 5 degrees from the equator), exposing entire nations to damage from high velocity winds, heavy rains and associated tidal surges in densely populated coastal areas. In the South Pacific, many of the most populated PICs (e.g. Papua New Guinea (PNG), Vanuatu, Solomon Islands) are also located on or near the tectonic boundary between the Australian and the Pacific plates, which makes most of the region seismically active, with high exposure to earthquakes, locally generated tsunamis and volcanic eruptions. The high incidence of earthquakes in the surrounding continental boundaries also exposes most PICs to tsunamis—this exposure is especially acute for the low-lying atolls (Solomon and Forbes, 1999). In addition to seismically related risks, many of

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the countries in the Pacific are highly reliant on rainfall for their water consumption (Mirti and Davies, 2005) and agricultural needs, making them vulnerable to droughts. In others, high proportions of their populations reside in river valleys where they are exposed to rain-induced flooding (Nunn, 2000).

Examples of recent catastrophic events in the Pacific region include the 2009 tsunami in Samoa and floods in Fiji, the 2014 floods in the Solomon Islands, the 2015 cyclone in Vanuatu, Tuvalu and Kiribati, the 2016 cyclone in Fiji and the 2018 cyclone in Tonga. Aside from these infrequent catastrophic events, Pacific countries are also impacted by frequent but less catastrophic events; including seasonal high tides (King tides), periodic droughts, and extreme heat days (e.g. Lin *et al.*, 2014). The smaller coral atoll countries of the Pacific are even more exposed to natural hazards, and their risk will be further exacerbated by the continuing rise in sea levels (Barnett and Adger, 2003; Barnett, 2001).

The history of disasters in the Pacific, their impact on development, and the risks that the region faces in terms of future disaster events represent vital information that can contribute to our understanding of the likely prospects of the diverse set of peoples, countries and circumstances that constitute this region.

In terms of disaster impacts, a typology adopted by the United Nations Office for Disaster Risk Reduction (UNISDR) distinguishes between direct and indirect impacts[1]. Direct damages refer to damages to fixed assets and capital (including inventories), damages to raw materials, crops, and extractable natural resources, and—of course—mortality and morbidity that are direct consequences of the disasters. Indirect impacts refer to the economic activity (in particular lost production of goods and services) that must be forgone due to the disaster. These indirect losses (or impacts) 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 interrupts input suppliers for production that does not occur due to post-disaster re-alignments of economic activities (Noy, 2016c). As such, indirect impacts can also affect communities and regions that were not directly impacted by the hazard itself (e.g. the flooding; see Noy and Patel, 2014).

While direct damages are easy to count, at least in theory, indirect losses should also be accounted for in the aggregate by examining the overall performance of the economy, as measured through the relevant macroeconomic variables (e.g. gross domestic product, growth rates, fiscal accounts, consumption and savings and investment), or by examining the indicators of household well-being before and after disasters. Other variables of interest in an economic assessment relate to international financial exposure, including the exchange rate, the trade balance and the various types of international capital flows measured in the balance-of-payments.

Indirect losses can also be 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 measured in decades).

In this paper, we explore the direct and indirect economic impacts of disasters as evidenced by past experience in the Pacific region. The basic premise of our paper is that, in order to prepare for and develop policies to reduce disaster risk, one must first understand and accurately measure the extent of the problem[2]. This paper aims to provide a quantitative exploration of disaster risk in the PICs using available data on disasters in the region.

We describe the available quantitative characterizations of disaster impacts in the Pacific, concluding that this information is flawed and inadequate for accurately capturing the breadth of impacts affecting the region. The paper begins by comparing the data available on direct economic impacts, and then explores the scant available evidence on the indirect impacts. It is important to emphasize that our focus here is on quantifiable economic

impacts of disaster events. Our aim in this paper is a complement to substantial and instructive literatures that examine social, cultural and environmental impacts of disasters in the Pacific, as well as a literature that describes, qualitatively and quantitatively, these impacts elsewhere (e.g. Rajapaksa *et al.*, 2017 on environmental capital; Ebi *et al.*, 2006 on health, Nunn *et al.*, 2014 on governance of environmental risk management; and Weir and Virani, 2011 on conflict).

We begin with a brief review of the approach economic analysis takes in examining disaster impacts. Following UNISDR terminology, disaster risk arises from the confluence of four factors: hazard, exposure, vulnerability and capacity[3]. The hazard profile faced by the country or region is largely a function of its geography, its geophysical characteristics and the climatic conditions it faces. These characteristics are exogenous and pre-determined, though anthropogenic climate change may change some characteristics over time. The location of many Pacific countries makes them among the most hazard-prone countries on the planet. Exposure is determined by the location of people and assets. For example, urbanization near hazard-exposed areas—steep hillsides, low-lying coastal areas, or flood-plains—increases exposure. As most Pacific populations reside near coasts or in steep river valleys (especially in Pacific countries in the Melanesia sub region), their exposure is high. While exposure is influenced by the same characteristics important in determining country exposure, it is endogenous—driven primarily by the decisions of households and governments that determine the extent to which individuals and property are located in areas likely to be affected by disasters.

Vulnerabilities are “the conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards” (again following UNISDR terminology). James Lewis puts it more succinctly by observing that “to be vulnerable to natural hazards is to be susceptible to their impacts and effects” (quoted in Lewis and Kelman, 2010, p. 192). Vulnerability is associated with peoples and places, as observed by Lewis and Kelman (2010), but can also be derived from historical processes, and current power dynamics within and between communities. Kelman *et al.* (2016) provide a brief and useful overview of some of the debates about these concepts, their definitions and their evolution in the past several decades.

Assessment of the vulnerability of the PICs is outside the scope of this paper, and there is a large and informative literature that describes and analyzes the vulnerabilities and capacities of Pacific island communities and societies to prevent, mitigate, adapt and recover from disasters and other shocks (e.g. Campbell, 2010; Gaillard, 2007; Gero *et al.*, 2011; Mercer *et al.*, 2007; Pelling and Uitto, 2001).

We note that, as is clear from review of a map of the region, most Pacific countries are spread out over large maritime areas. This stretches government resources and makes it difficult to develop adequate public infrastructure or to deliver basic needs (including water)—especially to residents in isolated outlying areas and islands. Housing is typically fragile and unable to withstand extreme winds or other occurrences common with major disasters. Despite these challenges, numerous observers have found that as the region has a long history of experiencing disasters, traditional knowledge successfully guides the development of practices that increase the capacity of communities to withstand, adapt and recover from shocks (e.g. Campbell, 2015; Nunn *et al.*, 2017).

Another concept that stands squarely in the center of this discourse is “resilience.” UNISDR defines resilience as “the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner [...]” This interpretation of the term is also at the center of much research effort and heated debates within the social science literature (e.g. Manyena, 2006).

Our contribution focuses on the measured economic impacts of these events—particularly focusing on the data collected by nongovernmental organizations (EMDAT), intergovernmental organizations (DesInventar) and multilateral development institutions (PCRAFI). We focus on economic impacts, and therefore do not discuss social, cultural, environmental impacts, nor do we focus much on distributive concerns (these are not measured well in the region). Although this paper does not address these topics and debates, this neglect is due to the focus of this research and does not reflect any presumption on the part of the authors regarding the relative importance of these areas of inquiry and quantitative cross country analysis that is the focus of this paper.

## 2. Data on direct costs of pacific disasters

Despite wide recognition of the critical impact disasters have, databases collecting quantitative information on disaster event impacts are few. This section describes data from the three main data sets capturing data on disaster impacts in PICs and identifies what they reveal regarding the disaster risks and damages PICs face. The EMDAT and DesInventar data sets are considered first, as these aim to systematically capture estimated impacts of past disaster events according to a few commonly used indicators (e.g. mortality, morbidity and damage to assets). Next, the paper examines PCRAFI data, which applies modeling to predict hazards and vulnerabilities at the country level based on a series of country characteristics (e.g. asset stock, geophysical characteristics, etc.) rather than capturing past disaster event outcomes.

### 2.1 *The EMDAT and DesInventar data*

The International Disaster Database (EMDAT), maintained by the Center for Research on the Epidemiology of Disasters, 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 database, at least one of the following criteria must be reported: (1) ten or more people killed; (2) 100 people 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, rather than in relative, terms. Thus, the same threshold applies to India as for Tuvalu. Thresholds (3) and (4) are also, to an extent, dependent on scale and in particular on the ability of staff member at EMDAT, in Belgium, to capture the events remotely, for the disaster incident to be included in the data set.

Data set records are supposed to include the number of people killed, the number of people affected, and an estimate of the value of direct damages for each disaster, but rarely include all three measures for disaster observations in the Pacific. The figures on estimated values of direct damage to assets are only available for the largest events—large events that usually trigger post-disaster need assessment (PDNA) or damage and loss assessment exercises by governments or multilateral institutions. The data set also seems to under-records losses in Pacific countries due to the higher frequency of hazards in the region. It thus significantly understates the full importance of countries' experiences with disasters.

Examples of under-reporting in the EMDAT abound. For example, Tropical Cyclone Pam (March 2015) was a catastrophic cyclone that hit Vanuatu, and its storm surges also hit Tuvalu and Kiribati (Taupo and Noy, 2017). EMDAT includes an entry on the storm, but the entry notes nothing about injuries, nor about physical damage. This under-reporting appears common based on review of known past disaster events in the Pacific, but EMDAT is still frequently used, mistakenly in our view, as a reliable source for quantitative information on disaster risk in the Pacific.

An alternative source of data is the Disaster Inventory System (<http://desinventar.net>) managed by the UNISDR. DesInventar data are potentially more comprehensive as it covers

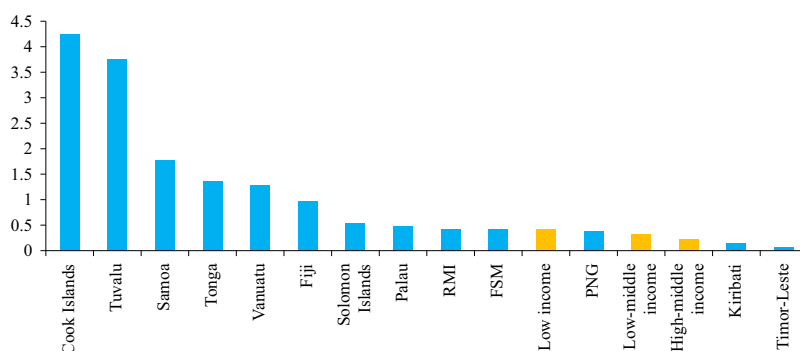
more countries (including most of the Pacific), and it explicitly includes extensive (high-frequency low-impact) events that are not captured in EMDAT's lists of more intensive (lower-frequency higher-impact) events. As noted earlier, these extensive events are a significant portion of the overall risk in PICs. Data on the Pacific in DesInventar come from the Geoscience Division of the Secretariat of the Pacific Community (SPC). However, as was the case for EMDAT, this data set's record of cyclone Pam also lack any estimate of value monetary/physical damages.

To characterize the total direct burden of disasters—mortality, people affected and financial damages—in a single measure and over the last few decades, we aggregate the three DesInventar measures into a total number of human lifeyears lost due to disasters using the methodology described in Noy (2016a). The lifeyears index consists of the following:

$$\text{Lifeyears}_i = L_i\left(M, A^{\text{death}}, A^{\text{exp}}\right) + I_i(N) + \text{DAM}_i(Y, INC),$$

where  $L$  (Mortality,  $A^{\text{death}}, A^{\text{exp}}$ ) is the number of lifeyears lost due to event ( $i$ ) mortality, calculated as the difference between the age at death ( $A^{\text{death}}$ ) and life expectancy ( $A^{\text{exp}}$ );  $I$  ( $N$ ) the cost function associated with the people who were injured, or otherwise affected by the disaster. Since we do not have information about how each individual was affected, we assume that affected people were experiencing what the World Health Organization calls “generic uncomplicated disease: anxiety about diagnosis.” The last component of the lifeyears index,  $\text{DAM}(Y, INC)$ , attempts to account for the number of human lifeyears lost as a result of the damage to capital assets and infrastructure. Figure 1 provides the total number of lifeyears lost per capita, per country.

Based on this indicator during the limited number of years for which data are available, the Cook Islands and Tuvalu appear to face the highest disaster losses (per capita). To clarify, this calculation suggests that eliminating disaster damages in the Cook Islands, for example, is roughly equivalent to increasing life expectancy in the country by about 4.3 years. Tonga, Vanuatu, Fiji and Samoa have also experienced significant losses measured in lifeyears. Countries shown to have suffered fewer losses (at least in per capita terms) are the Northern Pacific countries and PNG.



**Notes:** RMI, Republic of the Marshall Islands; FSM, Federated States of Micronesia; PNG, Papua New Guinea

**Source:** Figure from the Asian Development Bank (2015) based on authors' calculations from DesInventar

**Figure 1.**  
Total number of  
lifeyears lost per  
person, 1980–2012

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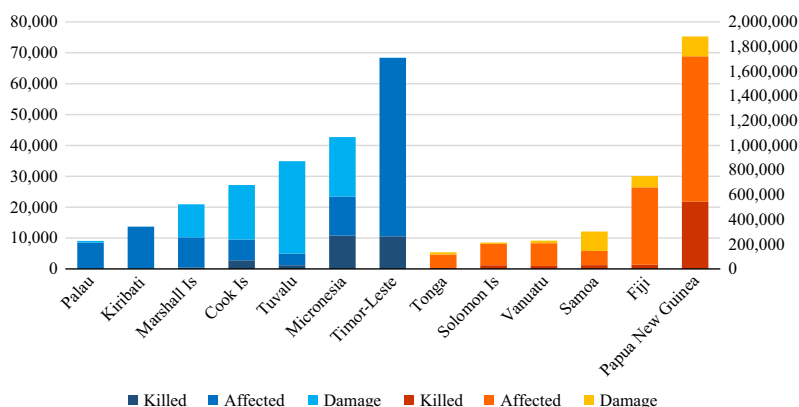
Comparing the Pacific to other regions, Pacific countries are shown to be at higher risk. Noy (2016a) reports that the total number of lifeyears lost per person over the 1980–2012 period in low-income countries was 0.41 (close to the number calculated for Marshall Islands). Numbers for high-middle and low-middle income countries are lower—0.32 and 0.23, respectively. As shown in Figure 1, all of these numbers are much lower than the per capita losses in the most vulnerable Pacific countries.

Analyzing data that only covers the last several decades will not provide an accurate estimate of the risk of low-probability high-impact events because of the limited years covered in the data. Because of that, a country that unfortunately experienced a recent rare event will be ranked as having much higher risk than a country that (fortunately) did not (even if the underlying risk is the same).

For the Cook Islands, one notable observation is that because it is a wealthier country, the value of assets destroyed in each event is much higher; indeed, in Figure 2 we observe that more of the lifeyears loss is associated with material damage in the Cooks than in the other countries covered in DesInventar. This underscores our general argument that by comparing the different data sets that claim to measure economic disaster risk in the Pacific, we find inconsistencies and shortcomings in all data sets.

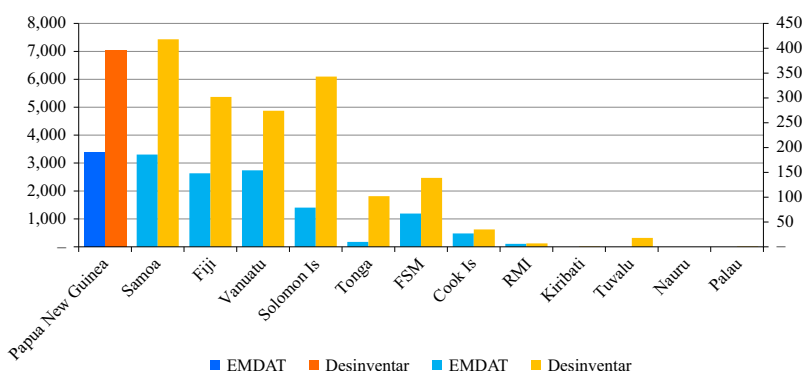
Figure 2 shows the calculations of total lifeyears lost separated across material damage and people affected and killed, for selected Pacific countries. Stark differences across countries exposed to similar hazards suggest there may be significant differences in data collection practices across countries. For example, the data for Palau suggests that disasters manifest only in their effect on people (with no mortality and little damage to physical assets), while for Tuvalu the damage is almost only attributed to physical assets (with little impact on people). Neither claim is convincing. DesInventar data also appear to have historical errors. For example, data for Tuvalu suggest the country suffered one tropical cyclone (TC) in the early 1990s whose impact was an order of magnitude larger than other strong cyclones that hit Tuvalu on average about twice a decade. However, contemporary reports suggest this storm was not unusual, and was similar to other storms that hit the country that decade.

Both the EMDAT and DesInventar data sets appear to cover flooding events inadequately. Fiji, for example, had several destructive floods in the past decade, but few of them appear to be included in either data set. When they are included, associated records lack information on estimated damages. Figure 3 includes a direct comparison of the two data sets for their figures for mortality[4].



**Figure 2.**  
Total lifeyears lost by  
damage component  
(1980–2012)

**Sources:** Authors' calculations from DesInventar data. The blue bars refer to the y-axis on the left, the red-yellow bars refer to the y-axis on the right



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

## Economics of disaster risks and impacts

**Figure 3.**  
Mortality due to disasters in EMDAT and DesInventar databases

Three conclusions can be drawn. The first is that EMDAT estimates much lower impacts than DesInventar, with the magnitude of each component of disaster impact significantly larger in the latter data set. Second, this undercounting is not at all uniform across countries. In some countries, the data are only marginally higher in DesInventar, while in others (e.g. PNG) the EMDAT data estimate disaster risk at significantly lower levels. Third, in some countries—notably the smallest ones—EMDAT does not count disaster damages at all.

The differences between the two data sets are explained both by the absence of small-scale high-probability events in the EMDAT data set, and the different sources of primary information and definitions the two databases use. Accounting for the cost of disaster damages to assets and infrastructure is difficult due to the number of qualitative assessments that go into a disaster accounting exercise. Data set records often fail to make clear: if the estimated cost includes both direct and indirect damages and losses; if the calculation prices assets at the original, current or replacement value of damaged and destroyed assets; and how the value the services provided by the infrastructure are imputed. It is also often unclear whether this total includes other incidental damage to environmental ecosystems or horizontal infrastructures, whether it accounts for the opportunity costs of using resources to rebuild, and whether the simulative effect of spending on the rebuild itself is considered in the estimate.

The earliest attempt to produce a template to guide the counting of disaster damage on infrastructure was developed in the 1970s by the UN's Economic Commission for Latin America and the Caribbean. The latest version of their manual forms the basis for the PDNA completed nowadays after most major events (ECLAC, 2014). However, it is unlikely that EMDAT or DesInventar data sources follow this methodology consistently, as both rely on third parties to collect their data[5].

### 2.2 PCRAFI data

The PCRAFI program initiated the first comprehensive assessment of current disaster risk across the primary hazards encountered 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, 2013b).

PCRAFI's risk assessment includes constructing a detailed risk profile for each member country (most PICs). The program both identifies exposure (the location of people



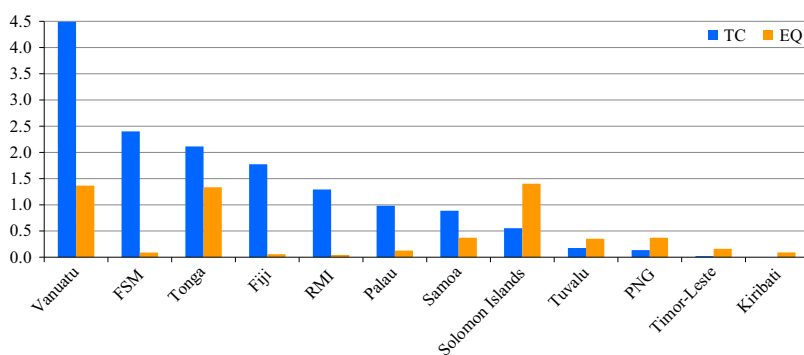
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and assets that are potentially vulnerable—AIR Worldwide, 2010) and assesses the hazards themselves (e.g. the expected frequency, intensity and location of earthquakes and tropical storms in the region—AIR Worldwide, 2011). Combining data on exposed assets, vulnerability curves and hazards; PCRAFI calculates detailed risk profiles including estimates of damages under various hazard scenarios. This calculation includes estimates of the replacement cost of lost assets and the cost of emergency management (calculated as a fixed proportion of the replacement cost of destroyed assets).

The output of PCRAFI's modeling is a set of predictions about risks faced by Pacific countries, measured in terms of expected destruction of assets (and mortality), from potential future cyclone and earthquake events of varying magnitudes. Figure 4 presents the estimated average annual losses as a share of gross national product for each Pacific country (all using data from 2014). These estimates are available from PCRAFI separately for TC, earthquakes and tsunami risks.

Figure 4 makes clear that Vanuatu is estimated to face the highest risk from cyclones (4.5 percent of GNP) according to the estimates. Most PICs face risks from TC that are calculated to be much more significant than the expected risk from earthquakes (EQ) and tsunamis. Some of the differences across estimates for these countries, however, seem difficult to explain. For example, Tonga is estimated to face over twice the risk of damage that Samoa faces from both earthquake and cyclone events (of a similar magnitude) in the PCRAFI estimates. However, these two nations are relatively close (less than 900 km separate the two countries' capitals), and the record of cyclones in recent decades in Samoa shows significantly higher cumulative impacts (Figure 23 in AIR Worldwide, 2010). Understanding the difference between the estimates of Tonga and Samoa is difficult given the non-disclosure policy regarding the modeling by AIR Worldwide.

The PCRAFI data collection and modeling effort is the first and only attempt to generate reliable data to inform improved disaster risk management in this hazard-prone region. Appropriate refinements of these models to account for the uniqueness of the Pacific islands (and especially the atoll states) could lead to the creation of other useful modeling tools that, if made publicly available, could facilitate improved land use policies, improved financial risk management, prioritization of investments in resilient infrastructure and lifelines and other beneficial disaster risk management efforts.



**Figure 4.**  
Estimated average  
annual losses  
due to disasters  
(percent of GNP)

**Notes:** TC, tropical cyclones; EQ, earthquakes

**Sources:** Authors' calculations from PCRAFI and ADB data. Data for Nauru and Cook Islands are not available from PCRAFI

### 3. The indirect economic impact of disasters

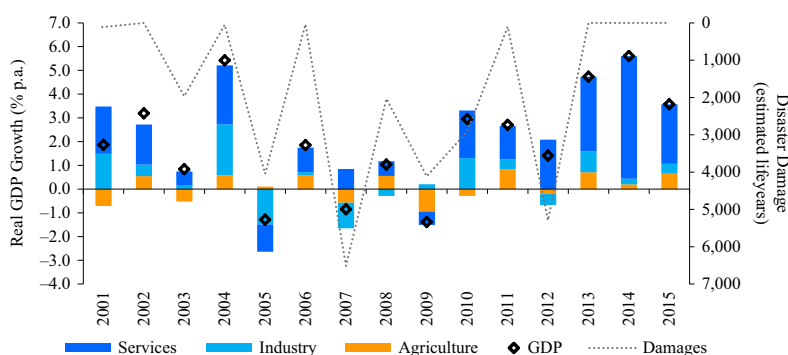
There is a large literature examining the overall (both direct and indirect) effects of disasters on the economic performance of affected countries using cross-sectional time series. This research considers both short- and long-run impacts. In the case of Pacific countries that have experienced one or more disasters of large magnitude, the relation between GDP growth rates and disaster events is muddled and the available time series for estimating the statistical significance of disaster impacts on growth rates is generally inadequate. Consider, for example, the case of Fiji illustrated in Figure 5.

The figure suggests that years of disasters were generally associated with lower rates of growth than in the prior disaster-free year (e.g. 2003, 2005, 2007, 2009, 2012) in Fiji. Further, disasters that affected the country were associated with lower multiyear average growth rates (i.e. growth averaged 1.9, 0.4 and 3.6 percent per annum during the years 2000–2004, 2005–2010 and 2011–2015, respectively). Despite these general observations that suggest negative growth impacts of disasters in Fiji, deeper statistical analysis of larger data sets covering multiple countries and years are needed to make clearer inferences regarding the relationships between disaster events and aggregate economic performance.

A detailed survey by Cavallo and Noy (2011) identified an emerging consensus that disasters have, on average, a negative impact on short-term economic growth in lower-income countries (see also Lazzaroni and van Bergeijk, 2014). The channels through which disasters cause short run economic slowdowns have not been established. Several papers have found that short run output declines associated with significant disasters are greater for lower income and smaller countries, although estimated impacts vary across the type of disaster—highlighting the heterogeneity of disaster impacts (Noy, 2009; Fomby *et al.*, 2013; Felbermayr and Groschl, 2014).

Noy and DuPont (2016) note a number of challenges faced in efforts to assess the long-run effects of disasters on economic growth—including the need for researchers to generate a counter-factual level of growth (i.e. estimates of macroeconomics performance in the absence of a particular disaster). Small island nations, however, have been found to be less resilient in the long-term, and studies analyzing data collected at regional and local levels have yielded much more diverse and nuanced results regarding the long-term adverse impacts of disasters.

Perhaps the most important insight from research on long-run effect of disasters on economic performance is that local impacts can be quite prolonged, but their nature (or even whether they are positive or negative) is a function of the circumstances, damages and response in the locality affected. Coffman and Noy (2012), Hornbeck and Naidu (2014)



**Figure 5.**  
GDP growth  
and disaster  
incidents in Fiji

Source: Pacific Economic Monitor database, various years and EMDAT

and Hornbeck (2012) provide case studies where a disaster led to persistent out-migration, while DuPont and Noy (2015) focus on a case of a disaster that resulted in no long-term population loss but that caused lower post-disaster employment and income. Examining disaster impacts at the micro individual level, Caruso (2017) and Caruso and Miller (2015) identify long-term declines in educational attainment, earning potential, and—most strikingly—the latter paper even identified an adverse impact that could be observed even in the second generation of disaster victims.

#### 4. Implications of disaster risk on the well-being of pacific households

The World Bank initiated recently a model-based risk analysis that focuses on the longer-term implications of disaster risk on household welfare/well-being (Hallegatte *et al.*, 2017). The aim of this work is to examine what policies may mitigate the costs of restoring households to their pre-disaster levels of well-being. 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, data for Tuvalu were collected and shared with the World Bank to construct a welfare risk reduction scorecard for Tuvalu (results summarized in Figure 6).

The scorecard shows the risk to welfare of households in Tuvalu expressed as a share of GDP, and the estimated drivers of declines, namely, changes in hazard (measured through an estimated protection level), exposure, asset vulnerability and resilience. These factors are ranked according to their estimated efficacy in reducing risk (from most to least efficient).

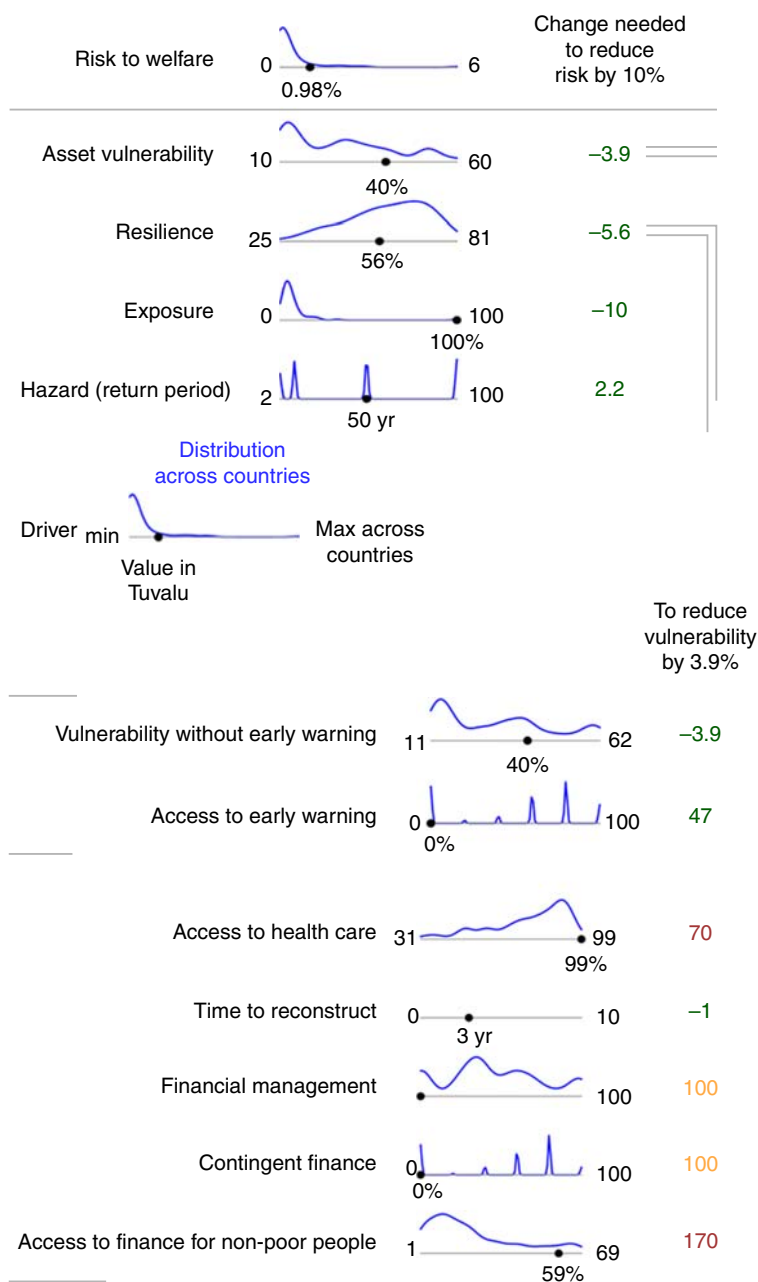
An initial striking observation that can be made from the Tuvalu analysis is that the calculated overall risk to welfare was 0.98. This number implies that in Tuvalu, there is nearly a one-to-one relationship between damages to assets and impacts on household welfare/well-being. This means that for every dollar of damage caused to household assets from a disaster, one can expect that the welfare/well-being for Tuvaluan households will decline by 98 cents. This is high compared to relationships calculated for other countries. The average for the 89 countries for which the World Bank calculated scorecards was only 0.57. The country with the highest risk in the World Bank study was measured at 0.81. This suggests, once more, that Tuvaluan families face significantly more risk, in terms of disaster effects on well-being. We suppose that similarly high levels of vulnerability would be found in other Pacific atoll nations (Kiribati, Nauru and the Republic of Marshall Islands).

The scorecard quantifies different ways in which asset vulnerability can be decreased and socio-economic resilience can be increased. Several policy options appear promising as ways to increase socio-economic resilience. The model suggests the most efficient option for increasing resilience is to increase the income share of the bottom quintile of the population. Currently, the bottom quintile's income share is 6 percent, and the model indicates that increasing this to 8.5 percent would reduce overall welfare risk by 10 percent. It is also worth noting that modeled policy options would have benefits to Tuvalu's economy beyond than those captured in the model. Overall, this model suggests the effects of disasters on welfare in Tuvalu, and by extension in other the Pacific atoll nations, are likely among the highest in the world.

#### 5. In conclusion—are disasters a poverty trap?

A disaster's initial impact causes mortality, morbidity, displacement and damage to physical infrastructure—including housing, public and commercial buildings, roads, telecommunication equipment, electricity networks, etc. These initial impacts are followed by consequent indirect impacts on the economy due to reductions in economic activity as a result of damaged facilities. These indirect impacts are not pre-determined, but result from the policy choices made before and after a disaster. The Pacific receives substantial international support, but Becerra *et al.* (2014, 2015) suggest that, globally, aid flows have done little to attenuate the consequences of disasters on economic output.

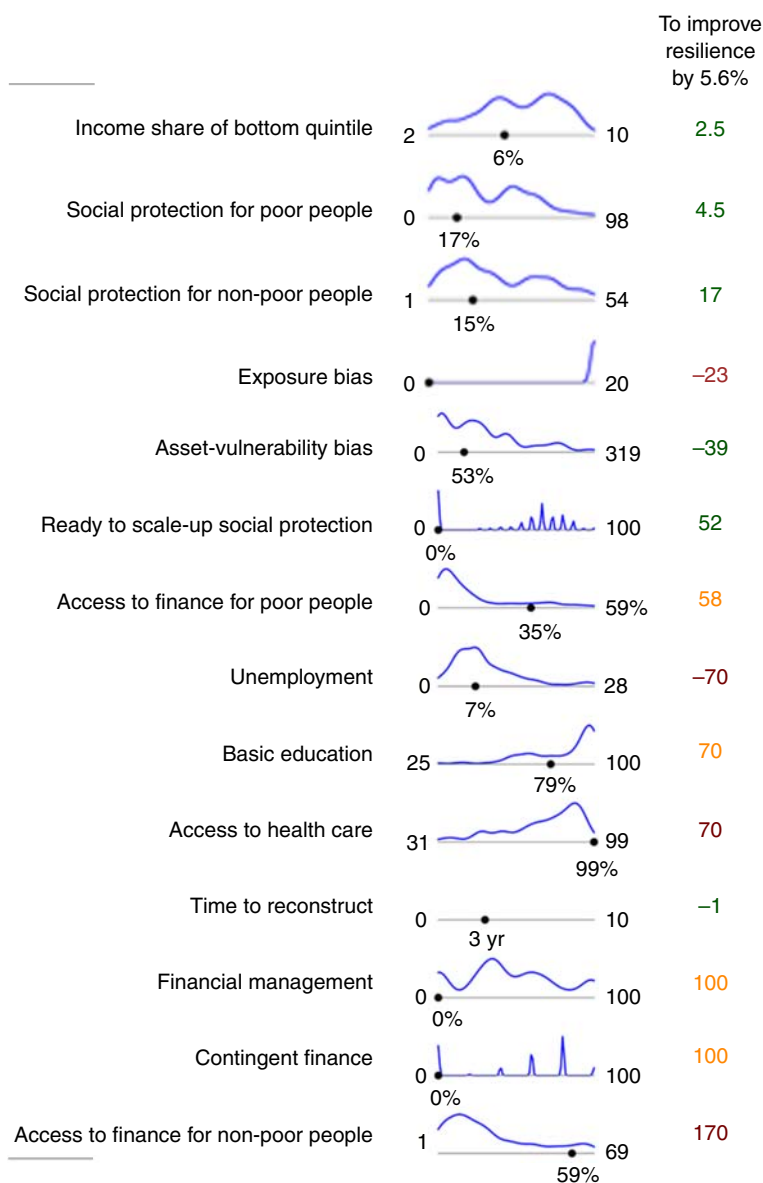
# Economics of disaster risks and impacts



(continued)

**Figure 6.**  
Scorecard for welfare  
impacts of disasters:  
Tuvalu

## DPM



**Sources:** The scorecard was calculated from the model presented in Hallegatte *et al.* (2017). We thank Adrien Vogt-Schilb and Taui Si Taupo for their help with data collection and processing

**Figure 6.**

The links between disaster risk and long-run development prospects are complex. At their worst, disasters can decrease development prospects and inhibit them, while development itself can increase vulnerability. 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). The question concerns the relative practical importance of each one of the four processes in the Pacific and what defines the circumstances under which each occurs.

Within this context of long-term disaster impacts, climate change also must be considered in relation to expected elevation of disaster risks in the Pacific. Existing climate change models suggest that the four most important issues with respect to how climate change is likely to influence hazards facing PICs in coming decades are: increasing frequency of extremely hot days; changing frequency and intensity of extreme rainfall events (causing both flash flooding and droughts); changes in the frequency, intensity and trajectories of TC; and sea-level rise and related ocean ecosystem changes. These effects will have long-term impacts on the region through disasters, affecting future development of the region.

The United Nations’ Sendai Framework for Disaster Risk Reduction 2015–2030 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; and
- (4) enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation and reconstruction.

The Global Fund for Disaster Risk Reduction identifies an additional pillar: financial protection[6]. Progress on all five priorities for disaster risk reduction is required for Pacific countries.

This paper has highlighted the need to improve the measurement of current disaster risk given the current status of risk identification in the Pacific. This task is going to grow in importance as the pattern of risk changes due to anthropogenic climate change. Much of the current effort in the Pacific region targets progress on priorities (2) and (3); while progress on priority (4) appears to be lagging. In the Pacific, and elsewhere, more knowledge 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.

Given the pattern of human settlements on most PICs, regulating development, maintaining or re-establishing protective ecosystems and strengthening the provision of post-disaster social protection stand out as priorities of particular importance given the preceding analysis. These considerations need to be included in developing Pacific island transport, energy, agriculture, tourism, health, education and even fisheries management policies. This should be done, in principle, through Joint National Action Plans (JNAPs). 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 are high-level documents that outline the main adaptation and risk reduction strategy and are only the first step in creating more detailed plans for actions.

## Notes

1. These distinctions emerged out of work undertaken in the 1970s at the Economic Commission for Latin America and the Caribbean. Mochizuki *et al.* (2018) provide a recent discussion of the confusions in the ways the DRR terminology is used. These definitions, including the distinction between direct and indirect impacts, are found at: [www.unisdr.org/we/inform/terminology](http://www.unisdr.org/we/inform/terminology). The UNISDR terminology uses the terms “losses,” “impacts” and “damages” interchangeably, and we follow this practice.

2. It is clear that many of the communities that are exposed to disasters understand these risk well based on native knowledge from centuries of experience shared across generations. This paper is not pretending to be informing these communities, rather, it is the intention of this research to shed light on the current state of disaster risk quantitative characterizations considered by national and international authorities making decisions about resource allocation priorities based on available data. We agree with the assessment in Kelman *et al.* (2011) that policies developed through participatory action provide a better approach for the design of successful disaster risk reduction programs whatever the resources available.
3. A similar framework was originally described in Crichton (1999).
4. Additional comparisons for the number of people affected, and damages aggregated in each country over the last two decades are available in Noy (2016b).
5. Bakkensen *et al.* (2018) conduct a similar comparative evaluation of disaster impact data from China and reach similar conclusions about their reliability.
6. The mechanisms available for enhancing the financial resilience of Pacific Island countries are the main focus of a companion paper (Noy and Edmonds, 2018).

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