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SEF Working paper: 08/2015

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Working Paper 08/2015

ISSN 2230-259X (Print)

ISSN 2230-2603 (Online)

Natural Disasters and Climate Change in the Pacific Island Countries: New Non-Monetary Measurements of Impacts

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February 2015

Abstract: We tabulate and measure the burden of disasters on the Pacific Island Countries (PICs) by aggregating and comparing the data found in the two global datasets on disaster impacts. We show that the most commonly used dataset greatly underestimates the burden of disasters for the Pacific islands. Next, we describe a new index that aggregates disaster impacts, calculate this index for the PICs, and then compare the burden of disasters for the island countries of the Pacific with the island countries of the Caribbean. This comparison demonstrates quite clearly that the burden of disasters is significantly more acute in the Pacific. Lastly, we discuss the evidence regarding the future impact of climatic change in the Pacific on the region's disaster burden. The Pacific is facing a very high degree of disaster risk, and that is only predicted to increase in the future. On the other hand, the region has a small population, and given the global resources available for disaster risk reduction, it can easily be seen as the frontier where attempts to create a more sustainable and resilient future can be put to their first tests.

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1. Disasters in the Pacific

Many of the most destructive natural disasters of the past few decades occurred in Pacific Rim countries. But, while it gets much less international attention, the Pacific itself, and the islands in its midst, is also a very vulnerable region. The Pacific itself is vulnerable for all the same reasons that make its Rim notoriously exposed to natural hazards. Most of the Pacific Island Countries (PICs) are located within or very close to the Hurricane/Typhoon Belt (roughly within the tropics but not within 5 degrees of the Equator). Many PICs are also located on or very near the tectonic boundary between the Australian and the Pacific plates; which makes the region seismically active, with high risk for earthquakes, tsunamis, and volcanic eruptions. Given the additional high incidence of earthquakes in the surrounding continental boundaries (the Ring of Fire), the PICs are also exposed to tsunamis generated on the edges of the Pacific Ocean. Many of the PICs are heavily reliant on rainfall for their water consumption and agricultural needs, and are thus very vulnerable to rainfall extremes associated with droughts and rain-induced flooding.

Here, we tabulate and measure the burden of disasters on the Pacific Island Countries by, first, aggregating and comparing the data found in the two global datasets on disaster impacts. We show that the most commonly used dataset vastly underestimates the burden of disasters for the PICs. Next, we describe a new index that aggregates disaster impacts, calculate this index for the PICs, and then compare the burden of disasters for the island countries of the Pacific with the island countries of the Caribbean. This comparison demonstrates quite clearly the that the burden of disasters is significantly more acute in the Pacific, even though disaster impacts in the Caribbean receive more media exposure. Lastly, we discuss the evidence regarding climatic change in the Pacific, and likely impact these anthropogenic changes are likely to make on the disaster burden in the region.

Examples of catastrophic events in the Pacific include, for example, the tsunami in Samoa in 2009 and the 2013 floods in Honiara, the capital of the Solomon Islands. But, even without these infrequent catastrophic events, some PICs are severely impacted by more-frequent but less-damaging natural hazards. Maybe most importantly, though, the island countries of the Pacific, and in particular the ones located on coral atolls, are also some of the most vulnerable to future disasters that may be associated with the changing climate, and especially the projected rise in sea levels.

A common typology of disaster impacts distinguishes between direct and indirect damages. Direct damages are the damage to fixed assets and capital (including inventories), damages to raw materials and extractable natural resources, and of course mortality and morbidity that are a direct consequence of the natural hazard. Indirect damages 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 damages 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).[1]

These indirect costs can be accounted for in the aggregate by examining the overall performance of the economy, as measured through the most relevant macroeconomic variables: GDP, the fiscal accounts, consumption, and investment. Other variables of interest relate to international exposure, but these are less relevant for the PICs who do not export many goods nor enjoy much access to international capital markets. These indirect costs 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 also measured in decades).

Barro (2009) has argued that the infrequent occurrence of disasters leads to much larger welfare costs in the long-run than continuous economic fluctuations of lesser amplitude. For the low- and middle-income island countries of the Pacific, which usually suffer from more frequent natural disasters of all types, and of greater relative magnitude than in the advanced economies Barro (2009) examined, these events have an even greater adverse effect on the welfare of the average citizen. Understanding 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

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[1] Higher-order impacts, for example, can occur when post-disaster reconstruction pulls resources away from the usual infrastructure investment schedule, damages supply-chains, or makes some production infeasible or too costly .

consequences are all important necessary components of a thorough understanding of the region’s economies.

2. Data on Pacific Disasters

The Emergency Events Database (EMDAT), maintained by the Centre for Research on the Epidemiology of Disasters (CRED) at the Catholic University of Louvain, 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 with their respective populations of 1.3 billion and 10,000. Thresholds (3) and (4) are also, to some extent, dependent on scale, and in particular on the ability of staff member at EMDAT to notice and note the events.

In EMDAT, natural disasters can be hydro-meteorological, including floods, wave surges, storms, droughts, landslides and avalanches; geophysical, including earthquakes, tsunamis and volcanic eruptions; and biological, covering epidemics and insect infestations. The data report 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 as is seen below, misses much of the risk that the PICs incur regularly due to natural hazards. An alternative source of data is the Disaster Inventory System website (desinventar.net) provided by United Nations Office for Disaster Risk Reduction (UNISDR). The *Desinventar* data include extensive (high-frequency low-impact) risk that is not captured in EMDAT's lists of more intensive (lower-frequency higher-impact) events (UNISDR, 2013). For the PICs these extensive events are a significant portion of the overall natural hazard burden, and pose, we argue, a major impediment to development in the region.

Desinventar usually links directly with national governments to obtain the relevant data on damages; their definitions for damages, and collection methodology, are different from EMDAT. However, for the PICs, the data in Desinventar comes from SOPAC, the Applied Geoscience and Technology Division of the Secretariat of the Pacific Community (headquartered in Suva, Fiji). The SOPAC data is collected in consultation with the UNISDR/Desinventar staff, so that the coverage and details collected are currently comprehensive. The data is publicly available.

We first evaluate the overall direct burden of disasters on the PICs. The direct impact is typically measured in mortality, morbidity, the number of people affected, and financial damages (to infrastructure, residential housing, etc.). Since the morbidity data is incomplete, and in order to facilitate comparison with the EMDAT data (that does not count morbidity), we use the data on mortality, people affected, and financial damages as calculated by both EMDAT and Desinventar. Figures 1-3 compare the overall burden, 1990-2012, for each of the three measures of direct disaster impact: mortality, the number of people affected, and the amount of monetary damages. It is quite obvious from this comparison that the EMDAT data significantly underestimates the amount of burden the direct impact of these events represents. This is not a trivial observation. PIFS (2009), a publication of the Pacific Islands Forum Secretariat, for example, uses the EMDAT data to summarize exposure of its Pacific members to disasters in the past several decades.

Figure 1 compiles the relevant information from the two datasets on mortality associated with natural disasters. It is easily observable that for most PICs, the Desinventar data includes mortality that is sometime more than twice as high as what is found in EMDAT. This is even the case for the countries with the highest numbers, Papua New Guinea, Samoa, and Fiji, but is also true for the smaller countries in the region. Figure 2 compiles the figures for the number of people affected, and here the differences are sometimes even starker. Papua New Guinea's record in EMDAT lists about 1.4 million people affected by disasters in the past two decades, while the equivalent figure from Desinventar is more than 7 million.

The quantities of financial damages, aggregated in figure 3, are more difficult to measure, and their comparison is less straightforward. The EMDAT records do not always include quantities for physical damages, thereby introducing a bias into any comparison, and the Desinventar numbers are obtained from models calculated by UNISDR that impute values to the reported damages. Because of the high costs of infrastructure in the Pacific (given the remoteness of the PICs), these imputed costs are likely to be underestimated. And indeed, we see conflicting evidence when comparing the various countries of the region. As in the mortality and morbidity measures, some countries have higher tallies in Desinventar (most important example is Papua New Guinea), but other countries have higher measures in EMDAT (e.g., Samoa).

To summarize, as can be suspected given EMDAT's difficulty in recording smaller events in small and remote countries, the burden of disasters is significantly underestimated in that dataset. The Desinventar data consistently records much higher totals for the overall measure we propose below

In order to evaluate the total direct burden of disasters over the last few decades, we aggregate the three measures into a total number of human years lost to disasters. For details about this index, and the way it is calculated, see Noy (2014) and UNISDR (2015).

In this aggregation approach, the total years lost is calculated as:

$$Lifeyears = L(M, A^{death}, A^{exp}) + I(N) + DAM(Y, P) \qquad (2)$$

where $L(M, A^{death}, A^{exp})$ is the number of years lost due to event mortality, calculated as the difference between the age at death and life expectancy. $L(M, A^{death}, A^{exp})$ thus requires not only information on the number of people who died, but also their age profile. In global datasets, information about the age at death is not available, so we use the median age in each PIC (A^{med}) instead of A^{death}. For life expectancy, we follow the WHO's approach in measuring Disability Adjusted Life Years (DALYs). The WHO uses a life expectancy of 92 years at birth ($A^{exp} = 92$). This number originates from projections made by the United Nations regarding the likely average life expectancy at birth in the year 2050 (WHO, 2013, p. 5). The rationale for using a high value for life expectancy, and one that is uniform across countries, is that the number represents a viable estimate of the possible frontier of human longevity in the foreseeable future. Thus, our measure for the number of lifeyears lost due to disaster mortality is $L_i = M_i * (92 - A_i^{med})$.

$I(F)$ is the cost function associated with the people who were injured, or otherwise affected by the disaster. In principle, this should includes serious injuries, and the cost of their care, time spent in hospital care and rehabilitation, impact on people's mental health, impact on those whose houses were destroyed or livelihoods were adversely affected, impact on those who were displaced (temporarily or permanently), and any other direct human impact. *F*, in this framework, is all the information available for each disaster that allows us to calculate, as closely as is possible, this component of the overall index. In most disaster cases, the only information available is on the number of people affected (*N*). This count includes a wide range of syndromes and impacts. Following the WHO methodology in calculating DALYs, we assume that the impact function is defined as $I_i(F) = N_i eT$. The coefficient, *e*, is the 'welfare-reduction weight' that is associated with being exposed to a disaster. There is no precedent to determining the magnitude of this weight, and there is much debate about the appropriate methodology to determine such weights when evaluating DALYs for diseases (see the discussion about the 'disability weights' in determining DALYs; WHO, 2013, p. 11). We adopt the WHO's weight for disability associated with "generic uncomplicated disease: anxiety about diagnosis" (*e*=0.054). *T* is the time it takes an affected person to return back to normality, or for the impact of the disaster to disappear; while N is the number of affected people as available in the global databases. Our calculations are based on a three-year horizon for return to normality (T=3).

The last component of the index, $DAM(Y,P)$, attempts to account for the number of human years lost as a result of the damage to capital assets and infrastructure. In principle, we aim to measure the opportunity cost of spending human resources (effort) on the reconstruction of these destroyed assets. Y, the amount of financial damages usually indicated in information about disaster impacts, should therefore only include the value of the destroyed or damaged capital, rather than the cost of replacement. P is the monetary amount obtained in a full year of human effort. We use income per capita (P) as an indicator of the cost of human effort, but discount this measure by 75% (c) in our benchmark calculations to account for the observation that much of our time is spent not in work-related activities. Thus, $DAM_i(Y,P) = (1-c)Y_iP_i^{-1}$.

Given the assumptions detailed above, our benchmark index is calculated as:

$$Lifeyears_i = M_i * (92 - A_i^{med}) + N_ieT + (1-c)Y_iP_i^{-1}.$$

Figure 4 provides the total number of lifeyears lost, per country, over the period for which data is available.[2] Figure 5 uses the same index but now provides this data in per capita terms (number of lifeyears lost per 100,000 people in each country).

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[2] We utilize the data from both datasets (EMDAT and Desinventar); for every year, we chose the dataset with the highest annual tally (in almost all cases that is Desinventar).

When the total numbers are examined, in figure 4, it is quite obvious that the bigger countries of the region show much higher direct impact: 1.83 million lifeyears in PNG, 0.12 million in Solomon Islands (or slightly less in the Vanuatu), and only 13.7 thousand in Kiribati and about 9 thousand in Palau.[3]

The data, when evaluated in per capita terms in figure 5, exposes a different set of countries in the Pacific region that are particularly unprotected. The Cook Islands and Tuvalu appear to be the most exposed countries with Tonga, Vanuatu, Fiji, and Samoa also experiencing a significant direct exposure. Countries that do not seem as exposed (at least in per capita terms) are all the Northern Pacific countries, and maybe surprisingly, PNG. It is important to note, however, that relative to other regions, all of the PICs are heavily exposed. Noy (2014) 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 exposure in the most vulnerable PICs with, for example, an exposure of 177,352 in Samoa, and much higher numbers for the Cook Islands and Tuvalu.

This index of exposure to the direct impact of disasters is composed of three parts, mortality, the number of people affected, and the physical damage (measured in financial terms). Figure 6 provides the breakdown, for each country, of the index into its three components. This breakdown is dramatically different across countries, even if these countries are fairly similar in their exposure and vulnerabilities (for example,

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[3] Timor Leste is the outlier here, with 'only' 68.4 thousand lifeyears lost to disasters; but, the Timorese data only includes very sporadic reports of direct costs of disasters before independence.

Tuvalu and Kiribati). These differences suggest that the SOPAC data (available through Desinventar) is far from perfect, and the differences across countries that are quite stark here suggest significant differences in data collection practices. As an illustration, the data for Palau suggests that disasters manifest there 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, it seems that the cross-country differences in data collection procedures are still quite important and may prevent an adequately convincing comparison of disaster burden across countries within the region.

3. Understanding the Costs from a Comparative Perspective

Kahn (2005) estimated an econometric cross-country specification with disaster costs as a dependent variables, and concludes that, in 1990, a poor country (per capita GDP<2000 US$) experienced on average 9.4 deaths per million people per year, while the equivalent number for a richer country (per capita GDP>14,000 US$) was only 1.8 deaths. This difference is most likely due to the greater amount of resources spent on prevention and mitigation efforts. In particular, some of the policy interventions likely to ameliorate disaster impact, including land-use planning, building codes and engineering interventions are more rare in lower-income countries. This finding, however, does not imply that higher damages in lower income countries are inevitable. The contrast between storm preparedness in Cuba vs. Haiti, or in Burma vs. Bangladesh, clearly demonstrates that even poor countries can adopt successful mitigation policies and that successful mitigation does not only depend on financial resources and the ability to mobilize them. Even within the Pacific context, there seems to be a difference in the level of prevention and mitigation policy undertaken in the various countries of the region.

It is in principle conceivable that much of the indirect adverse impact of disasters can be prevented by more successful disaster risk reduction policies. Many of these preventive policies, however, require collaboration and a concentrated use of resources and this is not easy to achieve. Collective action is easier when inter-communal ties are stronger (e.g. Aldrich, 2014). The importance of communities is one of the main sources of resilience in the Pacific context. Some recent research from Fiji has also suggested that the communitarian nature of many Pacific cultures generates more resilient policymaking in post-disaster contexts (Takasaki, 2013). This communitarian aspect can also, in this context, be a double-edged sword. It can also be characterized by strong hierarchical and paternalistic relationships, which make the distribution of post disaster allocations less equitable and less affected by need. Takasaki (2011), for example, shows that in some instances the elites manage to 'confiscate' much of the post disaster assistance.

Compounding the question of post-disaster allocation and accountability is the apparent unwillingness of electorates to punish politicians who had under-invested in preparedness while failure to provide generous post-disaster reconstruction funds is punished at the ballot box (Healy & Malhotra 2009 and 2010). Thus, even in countries where patronage may be less important, politicians rarely face the optimal incentives in terms of disaster prevention and/or mitigation.

In addition to all these incentive problems that makes optimal prevention unlikely in the Pacific and elsewhere, the resources needed are also typically only provided *ex post* rather than *ex ante.* Remittances, private donations channeled through NGOs, official development support, and public sector resources generally become available only in the aftermath of catastrophic events, and are not available beforehand to prevent or mitigate any likely event. Many of the PICs are heavily dependent on these sources of funding for their external financing, and as such are even more vulnerable to this over-emphasis on post-disaster emergency assistance rather than pre-disaster prevention and mitigation spending.

Figures 7 and 8 compare the burden of disasters' impact in the Pacific region with the burden in the island countries of the Caribbean. As data on the Caribbean is not available in Desinventar (except for Jamaica), we rely on the EMDAT data for that comparison. As can be seen in figure 7, the burden of disasters is higher in the Caribbean in levels, and is dominated by the loss experienced in Haiti (itself overwhelmed by the 2010 Port-au-Prince earthquake). The Caribbean, however, is much more populated than the Pacific (there are more people in Cuba or in Haiti than in all of the PICs combined). Figure 8 present the per capita burden. In this case, it is quite clear that the burden in the Pacific is more significant. In per capita terms, the burden experienced by the populations of Tuvalu or the Cook Islands is even higher, incredibly, than the one we calculate for Haiti, in spite of its catastrophic 2010 experience.

4. Economic Impacts – Are Disasters a Poverty Trap?

A disaster's indirect impacts are not pre-ordained, and the policy choices made in a catastrophic disaster's aftermath can have significant economic consequences. Noy (2009) concludes that countries with higher levels of human capital, better institutions, higher per capita income, higher degree of openness to trade, and an increased ability to mobilize resources in the aftermath are all associated with improved ability to recover more quickly and prevent further adverse spillovers. Similarly, von Peter et al. (2012) find that a successful post-disaster recovery is dependent on insurance coverage for the damages; with higher insurance coverage associated with quicker and more complete recovery.

These findings suggest that access to reconstruction resources and the capacity to utilize them effectively are of paramount importance is determining the speed and success 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 climatic disasters, largely because their amounts have not been large enough relative to the magnitude of the damage incurred. The Pacific region is heavily reliant on aid flows, especially official development assistance (ODA) from the regional powers (China, Taiwan, Japan, US, Australia, and New Zealand). ODA is, in general, less responsive to emergency events than private donations or remittances, increasing the relative vulnerability of the region.

Very little research has attempted to examine household data and determine the effects of natural disasters on household expenditures for the longer-term and none in the Pacific context. An important exception is Sawada & Shimizutani (2008) who examine household data after the 1995 Kobe earthquake in Japan. They find that, even in a rich country, credit-constrained households experienced significant reductions in consumption, while households with access to credit did not. Noy and Patel (2014) examine the short-run impact of floods in Thailand, and conclude that the adverse consumption affects are not limited to those households whose members or assets were directly affected. Households which were located in the affected areas, but did not experience any immediate adverse impact, were also experiencing declining incomes in the disaster's aftermath.

While the empirical evidence suggests no long-run national impact for countries affected by catastrophic events (Cavallo et al., 2013), the local impacts can be quite severe and prolonged. The nature of these enduring impacts (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 the disaster (a hurricane) led to emigration, but no apparent declines in per-capita incomes. Hornbeck (2014) describes a case (a flood) that triggered emigration, but that emigration led to scarcity of cheap labour and thereafter an increase in technological progress and labour productivity. Hornbeck (2012) identifies a case (a prolonged drought) of emigration and long-term economic decline, while duPont and Noy (2015) focus on a case (an earthquake) with no long-term loss of population but with a loss of employment and therefore per capita incomes. All of these scenarios were investigated in high-income countries. We know very little about the long-term impacts of disasters, at the local-regional level, in middle- and low-income countries.

One variable that seems to play a significant role in all of these long-term analyses is the question of mobility. How willing and able are people to relocate as a response to a natural shock and what are the consequences of these displacements to their well-being and prosperity. Clearly, mobility is as much a function of cultural practices, ethnic identities, and language, as it is a function of the natural hazards and their impacts. Both intra-state and inter-state mobility is quite high in the Pacific islands, with many PICs having formal emigration agreements with the regional powers (the US in the case of the Northern Pacific, and New Zealand and Australia in the South). Even when no formal arrangements are present, mobility is quite high.

These factors should enable the PICs to respond more flexibly to disasters than a situation with more rigid social reluctance to migrate or higher institutional barriers to that migration. Still, the welfare implications of this willingness to move are not obvious. The fact that people are moving voluntarily (their ‘revealed preference’ is to move – using the jargon common in economics) does not mean that they are not worse off as a result of that movement when compared to the counterfactual hypothetical of no catastrophic event. In order to fully evaluate the impact of disaster-induced displacements on Pacific populations, we need a lot more information than we currently have access to. This issue may become more pressing as the United Nations and various judiciaries are currently examining the legal underpinning of climate-refugees.

5. The Climate-Adjusted Future

A recent report by the Intergovernmental Panel on Climate Change, the *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*, summarizes the state of the scientific literature regarding the link between climate change and natural hazards (IPCC, 2012). It is fairly skeptical about the robustness of many of the predictions available in the scientific literature about trends in catastrophic high-damage low-probability natural hazards, as the historical record is not long enough to identify long-term trends in low-frequency events, and the models, especially the Global Climate Models (GCMs), do not provide consistent predictions. Geological hazards are equally difficult to predict, so our ability to divine future risk should be viewed as severely limited (e.g., Stein et al., 2012).

This IPCC report examines at length the evidence on the projected frequency, intensity, and geographical distribution of tropical cyclones and concludes there is not enough evidence to discern trends with any significant confidence. It also examines the incidence of the El Niño-Southern Oscillation (ENSO) phenomenon, whose impact on the Pacific Islands' weather patterns is significant. It concludes that there is "medium confidence in past trends toward more frequent central equatorial Pacific ENSO events." (IPCC, 2012, p. 119). It also observes "recent research…has demonstrated that different phases of ENSO (El Niño or La Niña episodes) also are associated with different frequencies of occurrence of short-term weather extremes such as heavy rainfall events and extreme temperatures [especially hot extremes – IN].” (IPCC, 2012, p. 155). These changes will mean a higher frequency of both flooding and droughts in the region.

While the IPCC report focused on these issues, a less examined possibility for the Pacific is that the range of hurricanes will increase to the north and south of the current “typhoon/hurricane belt” (e.g. Mendelsohn et al., 2012). For example, the islands of Hawaii, the Northern Mariana Islands, and the Cook Islands, may all see an increasing likelihood of tropical cyclones reaching their shores. Already, however, most of the PICs are within the belt, and current models do not predict that tropical storms will move closer to the equator than is currently the case.

The last issue that is extremely important for the region, of course, is sea level rise. Some recent predictions regarding global sea level rise are considerably more alarming as more information on glacial melting has become available and incorporated into climate models (e.g. Vermeer & Rahmstorf, 2009, predict rises of up to 1.9 meters by 2100). These sea level rises, besides posing ongoing difficulties to low-lying areas, and especially the coral atoll nations of the Pacific, will certainly also increase the damages caused by storm wave surges and earthquake induced tsunamis. Notwithstanding which climate models are used, there is wider agreement that the combination of sea level rise and deterioration in coral reef ecosystems will make coastal areas considerably more vulnerable to storms, regardless of whether storms will indeed be more frequent or more intense (or both, or neither).

More recent analysis—e.g. Thomas et al. (2014)—conclude more directly that the evidence seems to point to an associated relationship between higher levels of green gas quantities in the atmosphere and more climate hazards in the Pacific Ocean. On balance, one can therefore predict with some confident that the outlook for the region, in terms of exposure to natural hazards, is unfavorable.

6. A Summary

In the by now conventional interpretation of disaster risk, it is a function of the hazards (the physical phenomena), exposure (the presence of people and assets in harms' way), and societal vulnerability and resilience (the ability of society to successfully prevent, mitigate or recover when hazard and exposure are present). These three components of risk are acutely high in the Pacific context. As we have noted in the introduction, the region is faces many hazards. Its population is also very exposed, given the topography of most Pacific islands and the presence of most people on the coastal strips. Vulnerability is also extremely high, for reasons we have previously outlined, including the remoteness of the PICs, and the limited access to emergency assistance and resources for reconstruction.

This observation of the acute combination of hazard, exposure, and vulnerability in the region is borne out by looking at the past. We showed that the Pacific's exposure is typically severely underestimated, and is much higher than in other similar regions, such as the Caribbean. The Pacific is facing a very high degree of disaster risk, and that is only predicted to increase in the future. On the other hand, the region is sparsely populated, and the given the global resources available for disaster risk reduction, it can easily be seen as the frontier where our attempts to create a more sustainable and resilient future can be put to their first tests.

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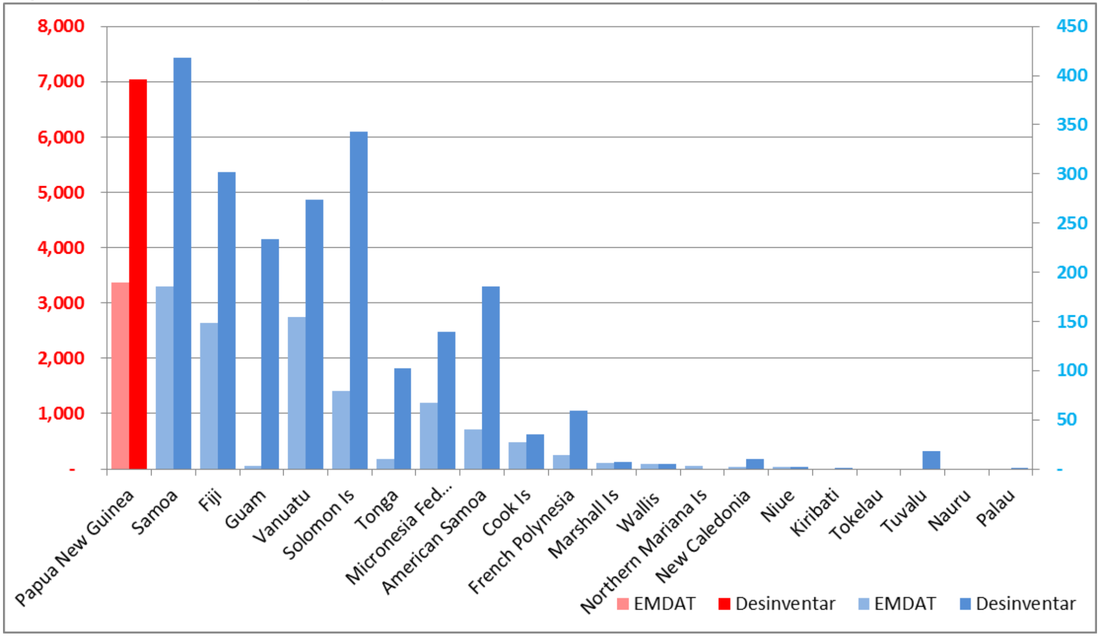
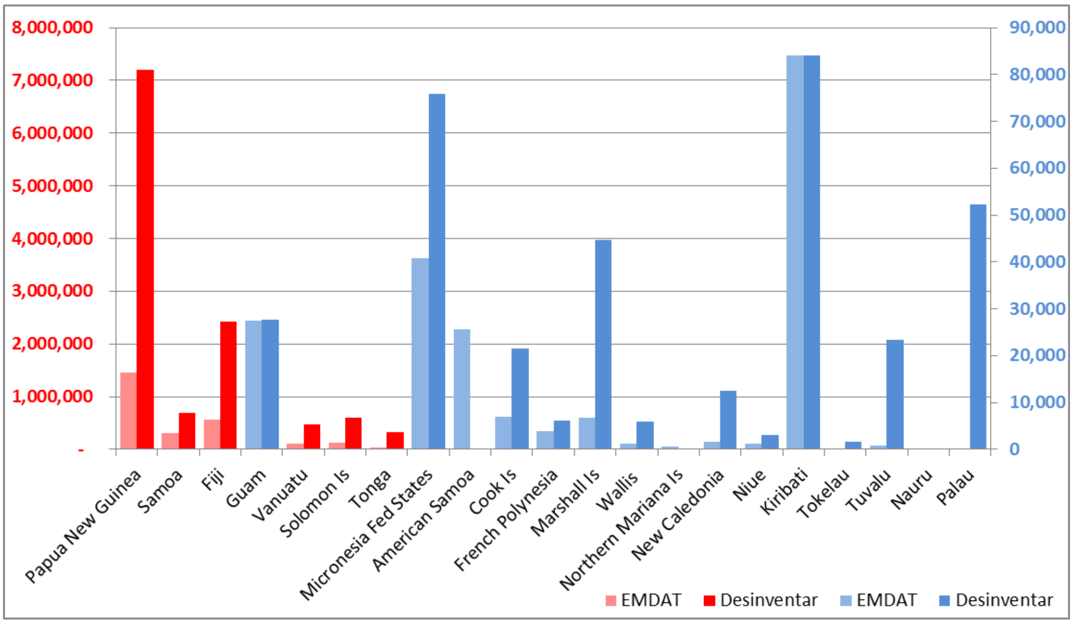
Figure 1. The killed people reported in EMDAT and Desinventar 1990-2012



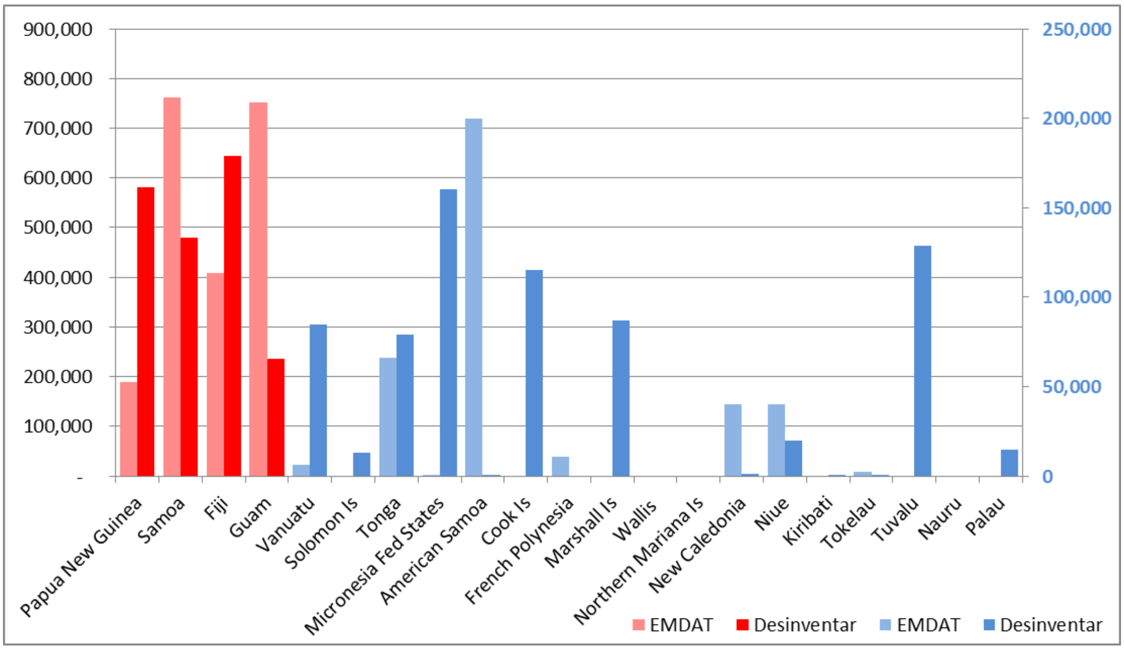
Source: EMDAT and Desinventar.

Figure 2. The affected people reported in EMDAT and Desinventar 1990-2012



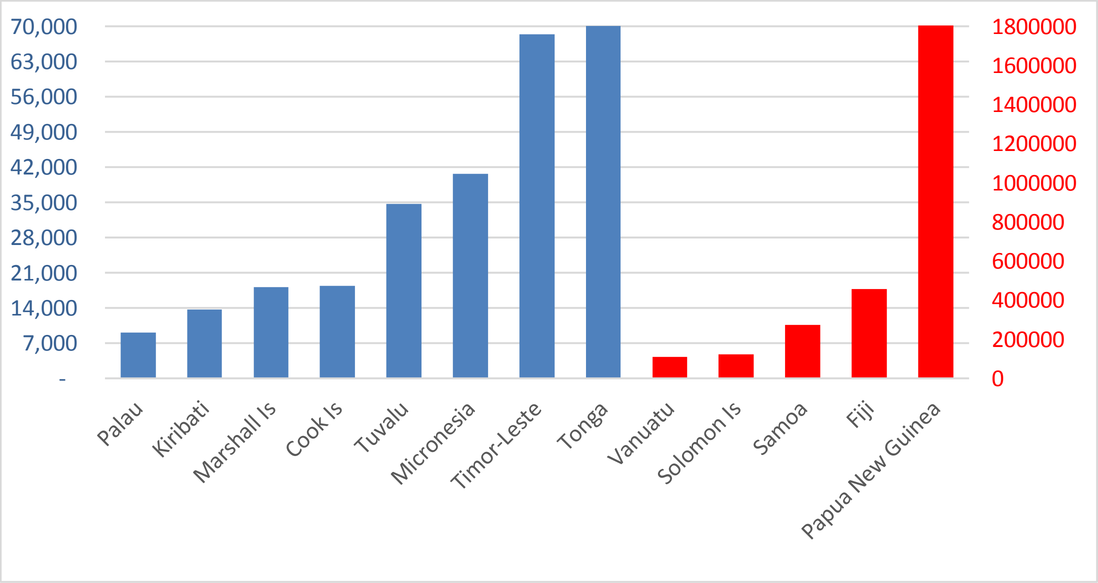
Source: EMDAT and Desinventar.

Figure 3. The damage reported in EMDAT and Desinventar 1990-2012 in thousands USD



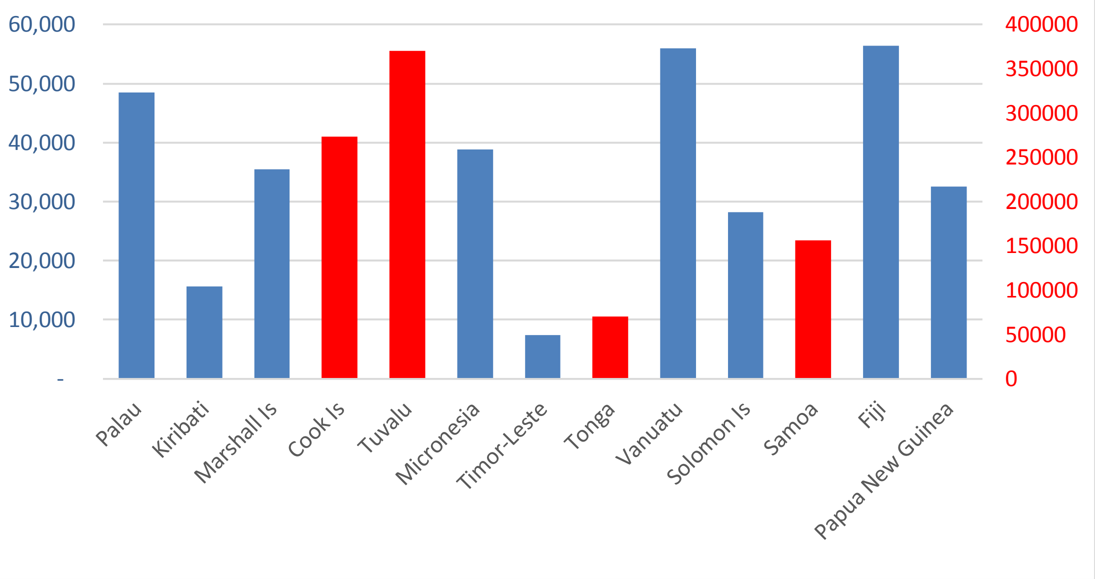
Source: EMDAT and Desinventar.

Figure 4. Total Lifeyears lost in Pacific Ocean Countries 1990-2012



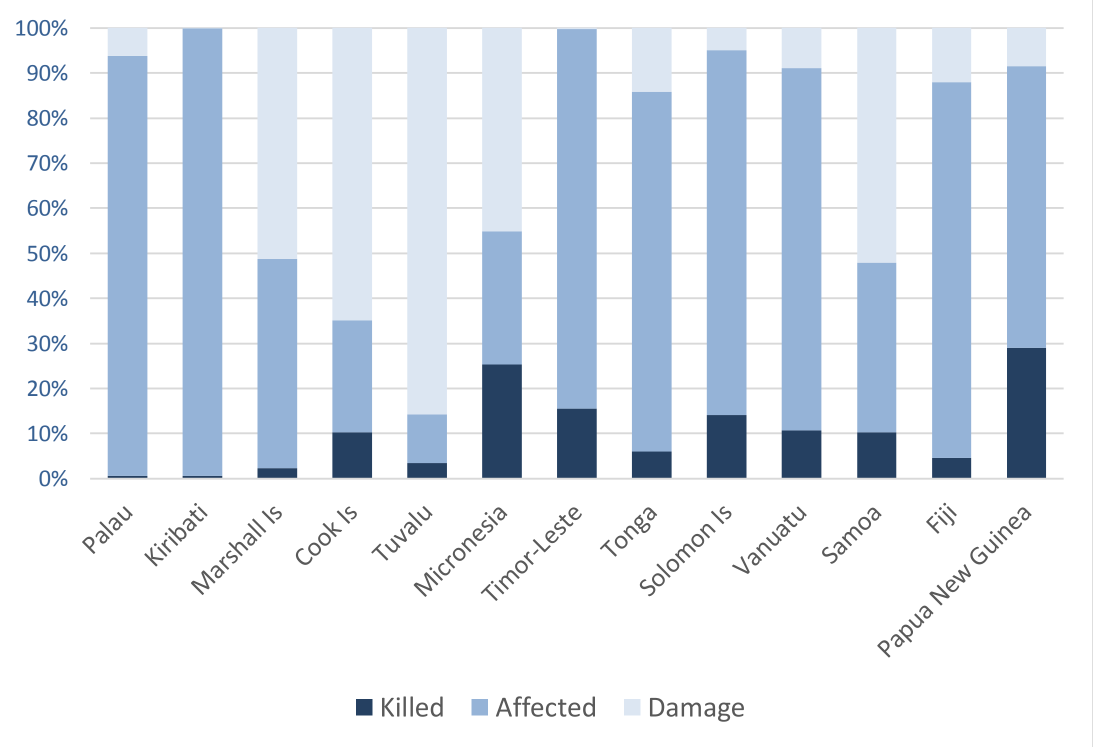
Source: EMDAT and Desinventar; author’s calculations.

Figure 5. Lifeyears lost per 10^5 people in Pacific Ocean Countries 1980-2012



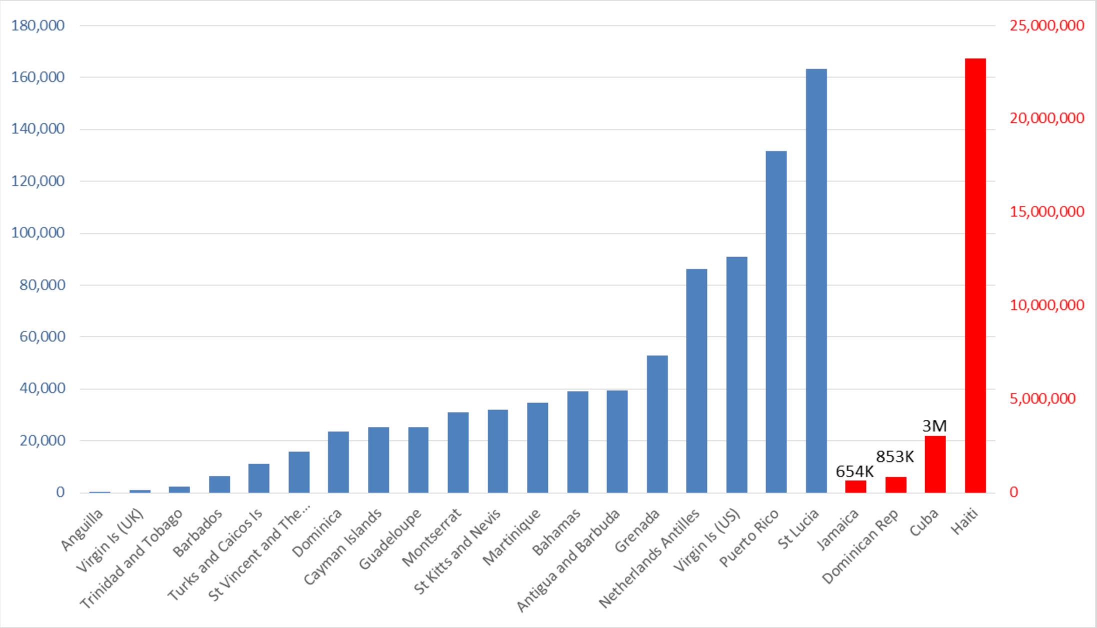
Source: EMDAT and Desinventar; author's calculations.

Figure 6. Lifeyears lost by component in Pacific Ocean Countries 1980-2012



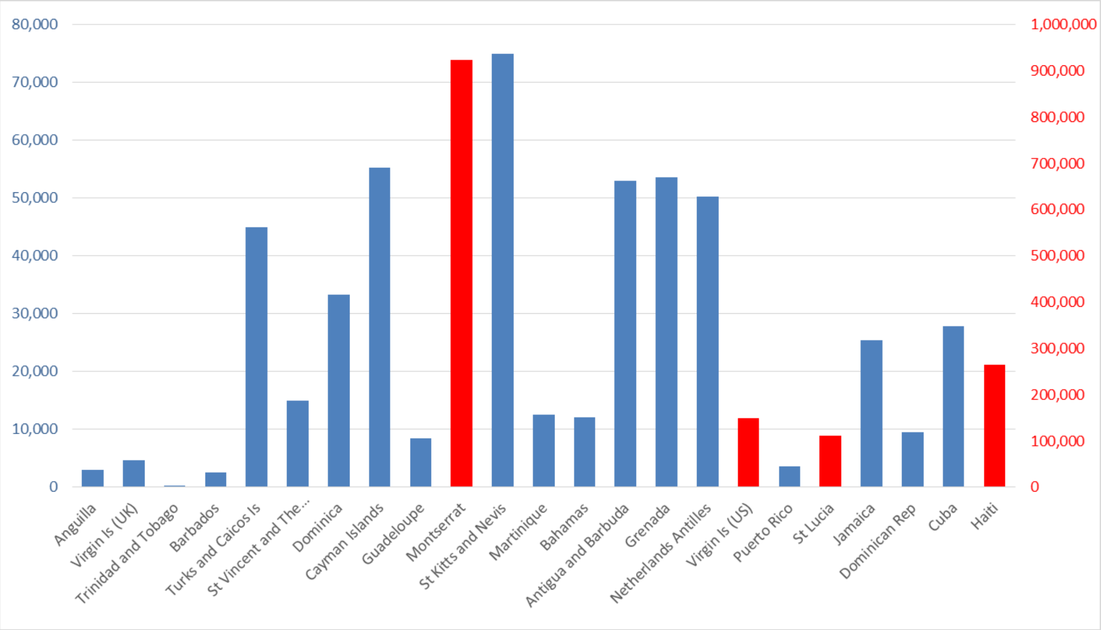
Source: EMDAT and Desinventar; author's calculations.

Figure 7. Total Lifeyears lost in Caribbean countries 1990-2012



Source: EMDAT; author's calculations.

Figure 8. Lifeyears lost per 10^5 people in Caribbean countries 1990-2012



Source: EMDAT; author's calculations.