Nat Hazards (2016) 84:S7–S18
DOI 10.1007/s11069-015-1957-6

ORIGINAL PAPER

Natural disasters in the Pacific Island Countries: new measurements of impacts

Ilan Noy[1]

Received: 28 February 2015 / Accepted: 9 September 2015 / Published online: 15 September 2015

Abstract We tabulate and measure the burden of disasters on the Pacific Island Countries in three ways. We start by aggregating and comparing the data found in the two global public datasets on disaster impacts. We show that the most commonly used dataset, EMDAT, greatly underestimates the burden of disasters on the Pacific Islands. Next, we describe a new index that aggregates disparate disaster impacts, and calculate this index for each Pacific Island Country. We finish by comparing the burden of disasters on 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.

Keywords Pacific Island Countries · Natural disasters · EMDAT · SOPAC · Lifeyears

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. 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° 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 of earthquakes, tsunamis, and volcanic eruptions. Given the additional high incidence of earthquakes in the surrounding continental boundaries, the PICs are also exposed to tsunamis generated far away on the edges of the Pacific Ocean.

✉ Ilan Noy
ilan.noy@vuw.ac.nz

[1] EQC-MPI Chair in the Economics of Disasters, School of Economics and Finance, Victoria Business School, POB 600, Wellington, New Zealand

Finally, 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 PICs 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 on the PICs. Next, we describe a new index that aggregates disaster impacts, and calculate this index for the PICs. We then compare the burden of disasters on 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, 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 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). For the low- and middle-income island countries of the Pacific, which, as we see below, suffer from more direct natural disaster impacts of all types, these indirect impacts most likely have an even greater adverse effect on the welfare of the average citizen. Here, however, we focus only on the direct impacts, while we note that understanding the history of disasters in the Pacific, and their indirect impact on longer-term development, is important necessary components of a thorough understanding of the region's economies.

2 The two datasets 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, in particular on the ability of staff member at EMDAT to identify 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.

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 come from SOPAC, the Applied Geoscience and Technology Division of the Secretariat of the Pacific Community (headquartered in Suva, Fiji); the data are 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 are 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, 2 and 3 compare the overall disaster burden, summed up over the period 1990–2012, for each of the three measures of direct disaster impact: mortality, the number of people affected, and the amount of

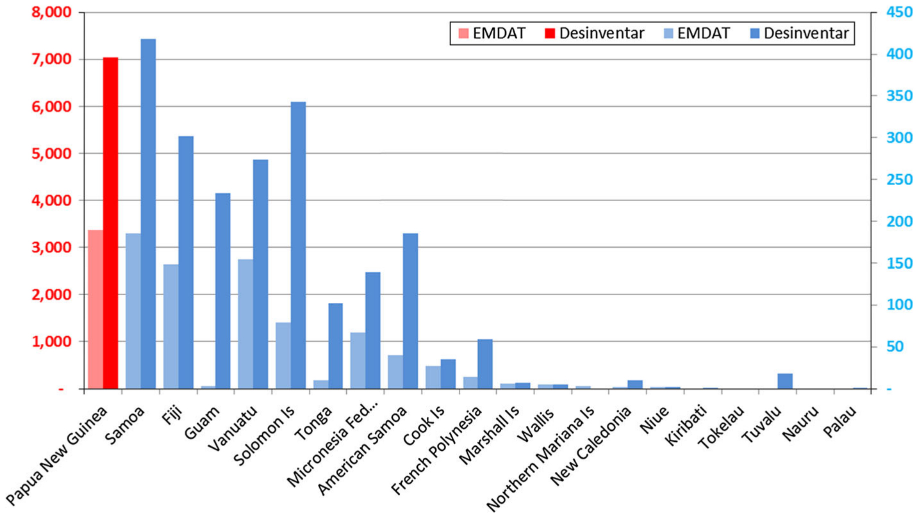

Fig. 1 The killed people reported in EMDAT and Desinventar 1990–2012. *Source*: EMDAT and Desinventar

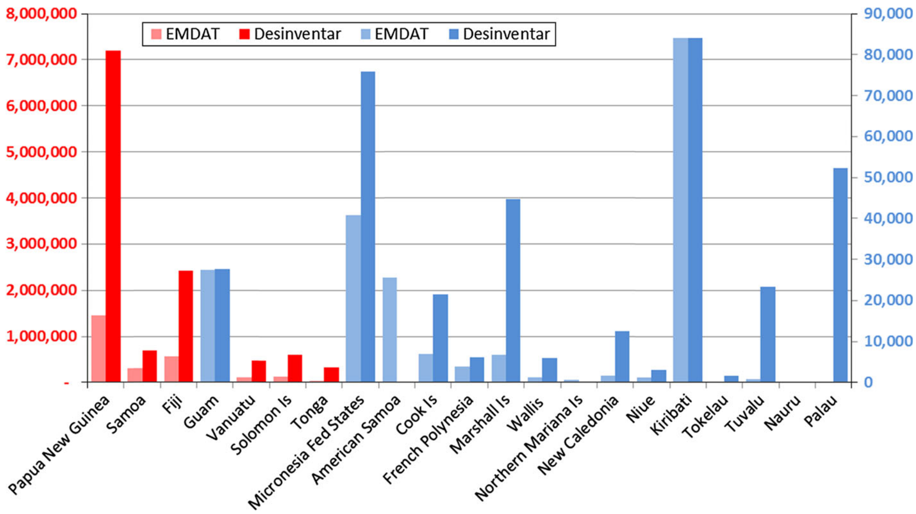

Fig. 2 The affected people reported in EMDAT and Desinventar 1990–2012. *Source*: EMDAT and Desinventar

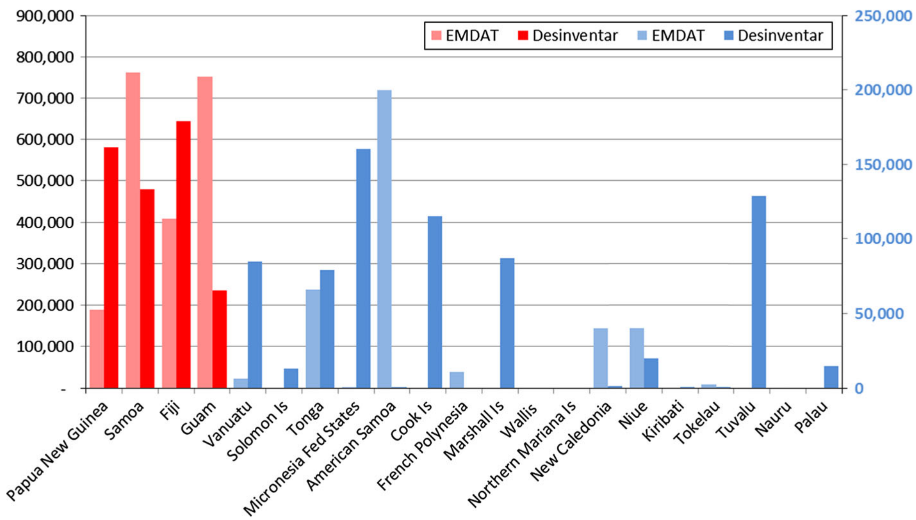

Fig. 3 The damage reported in EMDAT and Desinventar 1990–2012 in thousands USD. *Source*: EMDAT and Desinventar

monetary damages, respectively. These measures thus summarize the 'disaster burden'—i.e. the total direct impacts of disasters—for each country.

It is quite obvious from this comparison that the EMDAT data significantly underestimate the amount of burden the direct impact of these events represents. This is not a trivial observation; even PIFS (2009), a publication of the Pacific Islands Forum Secretariat, for example, uses the EMDAT data to summarize exposure of its country members to disasters in the past several decades.

Figure 1 compiles the relevant information from the two datasets on mortality associated with natural disasters. For most PICs, the Desinventar data include 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 Fig. 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 (again, the 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 generally underestimated in this dataset in comparison with Desinventar.

3 An aggregate measure of impacts: the lifeyears index

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 lifeyears lost to disasters. For details about this index, and the way it is calculated, see Noy (2015a) and UNISDR (2015).

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

$$\text{Lifeyears} = L\left(M, A^{\text{death}}, A^{\text{exp}}\right) + I(N) + \text{DAM}(Y, P) \quad (1)$$

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 lifeyears (DALYs). The WHO uses a life expectancy of 92 years at birth ($A^{\text{exp}} = 92$). 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 in country i due to disaster mortality is

$$L_i = M_i \times \left(92 - A_i^{\text{med}}\right) \quad (2)$$

$I(F)$ is the cost function associated with the people who were injured, or otherwise affected by the disaster. In principle, this should include serious injuries, 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).[1] 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. As in Noy (2015a), 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 two datasets. Our calculations are based on a 3-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,

$$\mathrm{DAM}_i(Y, P) = (1 - c)Y_i/P_i \tag{3}$$

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

$$\mathrm{Lifeyears}_i = M_i \times \left(92 - A_i^{\mathrm{med}}\right) + N_i eT + (1 - c)Y_i/P_i \tag{4}$$

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

When the total numbers are examined, in Fig. 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 Fig. 5, expose 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 countries in other regions at similar stages of

[1] For a case study with a richer information set, see Noy (2015b).

[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, i.e. Desinventar).

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

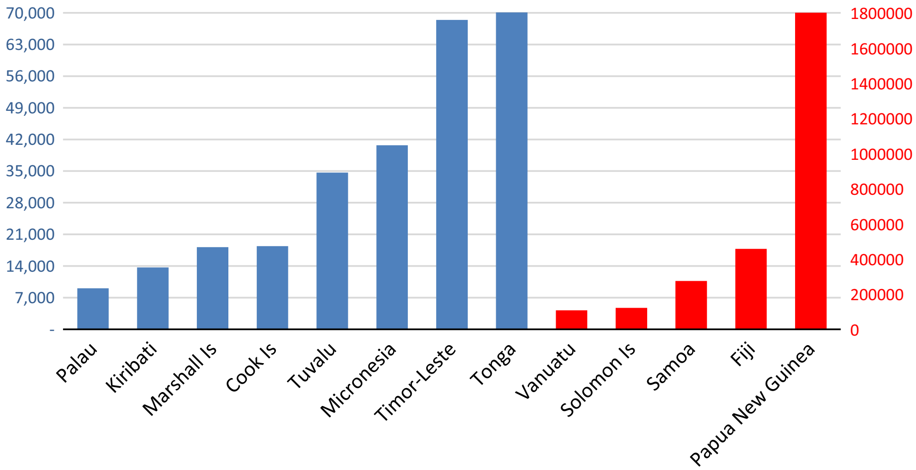

Fig. 4 Total lifeyears lost in Pacific Ocean Countries 1990–2012. *Source*: EMDAT and Desinventar; author's calculations

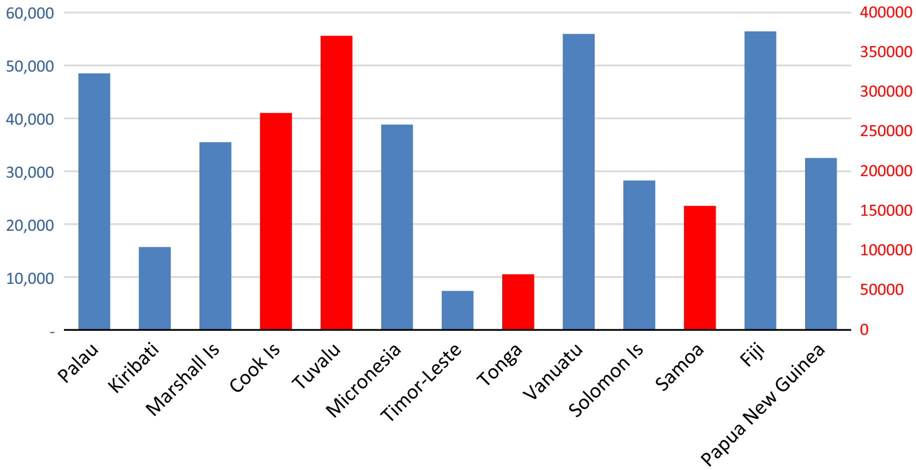

Fig. 5 Lifeyears lost per 10^5 people in Pacific Ocean Countries 1980–2012. *Source*: EMDAT and Desinventar; author's calculations

development and levels of income, all of the PICs are atypically heavily exposed (see Noy 2015c).

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 (e.g. Tuvalu and Kiribati). We conclude that while the SOPAC data are the best one available, it seems that the cross-country differences in data collection procedures are still quite material.

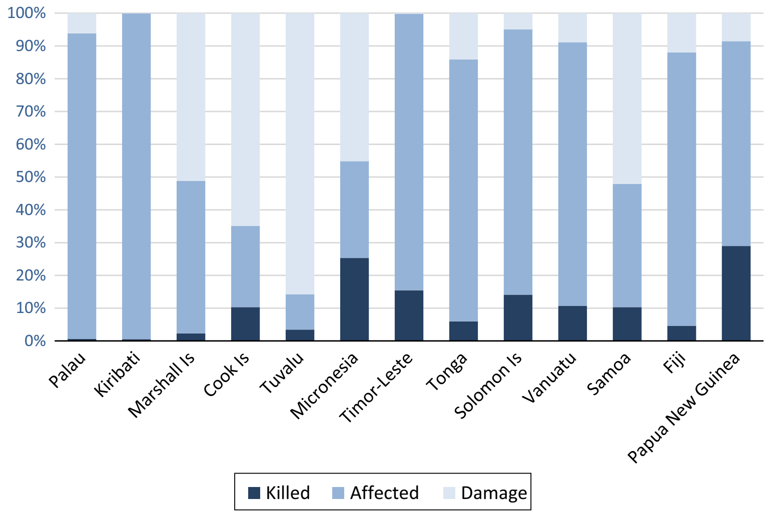

Fig. 6 Lifeyears lost by component in Pacific Ocean Countries 1980–2012. *Source*: EMDAT and Desinventar; author's calculations

4 Comparing costs with the Caribbean Island Countries

Kahn (2005) 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 rarer in lower-income countries. A significant literature finds that the indirect impacts of disasters are worse in Small Island Developing States (SIDS) than elsewhere (e.g. Heger et al. 2008). Kahn's finding, however, does not imply that higher damages in lower-income countries are inevitable. Poor countries can adopt successful mitigation policies, and within the Pacific context, there seems to be a difference in the level of prevention and mitigation policy undertaken in the various countries.

Collective action, a prerequisite for successful prevention and mitigation, is easier when social ties—social capital—are stronger (Aldrich 2012). 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.

Figures 7 and 8 compare the burden of disasters' impact on the Pacific region with the burden on the island countries of the Caribbean. This comparison is made for two reasons. One, and the most obvious, is that the two regions are often compared, as they constitute the two regions where Small Island Developing States (SIDS) are concentrated. Second, the theoretical literature, mentioned earlier, posits that SIDS should be particularly vulnerable to disasters with their concentrated geographical area, low levels of diversification, and exposures to coasts. The example of the Caribbean is typically being used in this context. If anything, the PICs appear to fit this description of vulnerability even more.

As data on the Caribbean are not available in Desinventar (except for Jamaica), we rely on the EMDAT data for that comparison. As can be seen in Fig. 7, the burden of disasters is higher in the Caribbean in levels and is dominated by the loss experienced in Haiti (its long-term experience is dominated by the 2010 Port-au-Prince earthquake). The Caribbean,

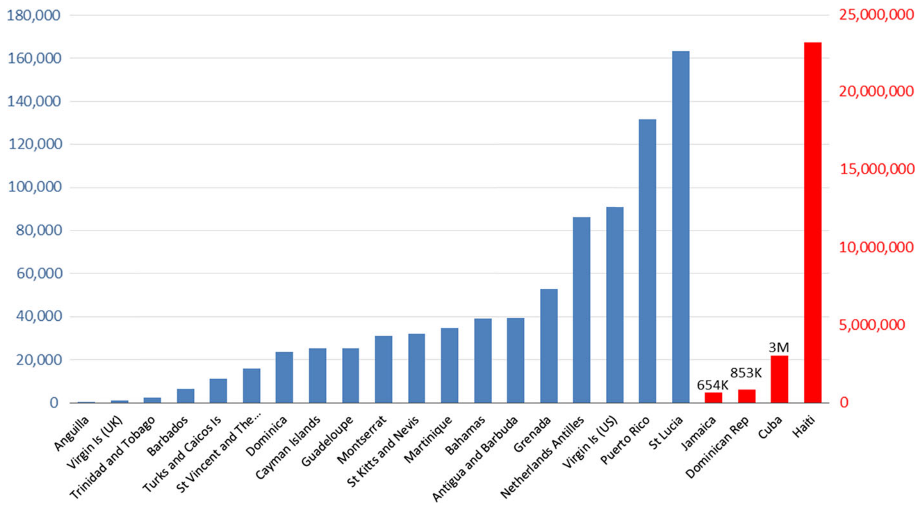

Fig. 7 Total lifeyears lost in Caribbean countries 1990–2012. *Source*: EMDAT; author's calculations

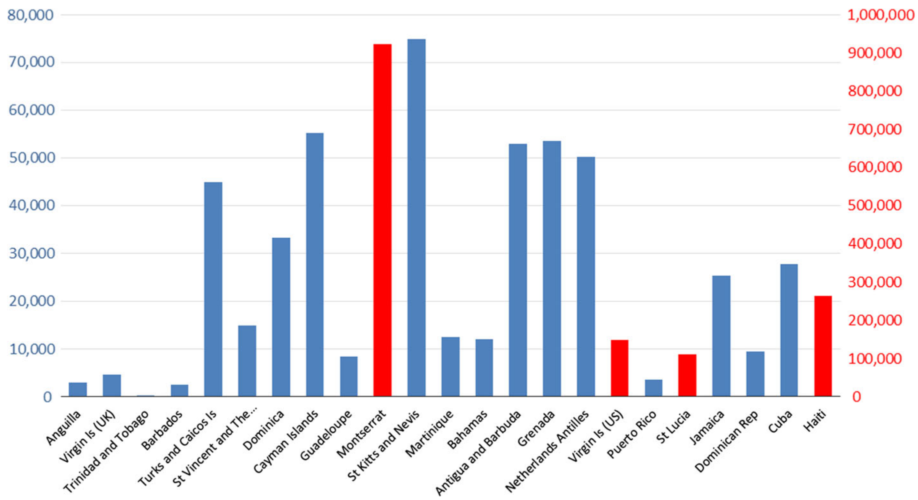

Fig. 8 Lifeyears lost per 10^5 people in Caribbean countries 1990–2012. *Source*: EMDAT; author's calculations

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 presents 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 the catastrophic 2010 earthquake that killed maybe a quarter of a million victims.

5 Policy and climate change

A disaster's direct impact burden is not its only adverse impact. Indirect impacts are, however, not preordained, and both prevention policy 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, 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, 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).

Mobility is another important characteristic that is uniquely relevant to the PICs. 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. Both intrastate and interstate mobility is quite high in the Pacific Islands, with many PICs having formal emigration agreements with the regional powers (the USA 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; for the available data, see Bedford and Hugo (2012).

These factors should enable the PICs to respond more flexibly to disasters. Still, the welfare implications of this willingness to move are not obvious. The fact that people may be moving voluntarily (their 'revealed preference' is to move) 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 require more information than we currently have.

A 2012 report by the Intergovernmental Panel on Climate Change summarized the state of the scientific literature regarding the link between climate change and natural hazards (IPCC 2012). It concludes the literature that trends are uncertain, as the historical record is not long enough to identify long-term trends in low-frequency events, and the models 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 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.

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 very alarming (e.g. Vermeer and Rahmstorf 2009 predict rises of up to 1.9 metres by 2100). These sea-level rises, besides posing ongoing difficulties to low-lying areas, will certainly also increase the damages caused by storm-wave surges and earthquake-induced tsunamis. 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. 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 confidence that the outlook for the region, in terms of exposure to natural hazards, is increasingly unfavourable.

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: the region faces many hazards, its population is also very exposed, and vulnerability is extremely high for reasons we have previously outlined.

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, is especially acute in the smaller island nations of the South Pacific, and is much higher than in 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 given the global resources available for disaster risk reduction, especially in conjunction with funding being currently negotiated for climate mitigation and adaptation, it can easily be viewed as a plausible test case, where preventive, mitigating, and adaptive efforts to create a more sustainable and resilient future can be put to their first tests.

Compliance with ethical standards

Author is receiving funding from the New Zealand Government (NZ Earthquake commission and the Ministry of Primary Industries). There are no potential conflicts of interest. The research did not involve human participants and/or animals.

References

Aldrich D (2012) Building resilience: social capital in post-disaster recovery. University of Chicago Press, Chicago

Becerra O, Cavallo E, Noy I (2014) In the aftermath of large natural disasters, What happens to foreign aid? Rev Dev Econ 18(3):445–460

Becerra O, Cavallo E, Noy I (2015) Where is the Money? Post-disaster foreign aid flows. Environ Dev Econ 20(5):561–586

Bedford R, Hugo G (2012) Population movement in the Pacific: A perspective on future prospects. New Zealand Department of Labour Paper

Heger M, A Julca, Paddison O (2008) Analysing the impact of natural hazards in small economies: the Caribbean case. UNU/WIDER Research Paper 25

Intergovernmental Panel on Climate Change (2012) Managing the risks of extreme events and disasters to advance climate change adaptation. http://www.ipcc.ch/pdf/special-reports/srex/SREX_Full_Report.pdf

Kahn ME (2005) The death toll from natural disasters: the role of income, geography, and institutions. Rev Econ Stat 87(2):271–284

Noy I (2009) The macroeconomic consequences of disasters. J Dev Econ 88(2):221–231

Noy I (2015a) A non-monetary global measure of the direct impact of natural disasters. Background paper for the UNISDR global assessment report

Noy I (2015b) Comparing the direct human impact of natural disasters in 2011: the christchurch earthquake and Bangkok flood. Int J Disaster Risk Reduct 13:61–65

Noy I (2015c). Disasters in the Pacific: an overview of economic and fiscal issues. Pacific economic monitor, The Asian Development Bank

PIFS (2009). Economic costs of natural disasters In the Pacific Islands Region and measures to address them. Pacific Islands Forum Secretariat, Forum Economic Ministers' meeting, Rarotonga, Cook Islands

Raddatz C (2009) The wrath of god: macroeconomic costs of natural disasters. World Bank policy research working paper #5039. World Bank, Washington DC

Stein S, Geller R, Liu M (2012) Why earthquake hazard maps often fail and what to do about it. Tectonophysics 562:1–25

Takasaki Y (2011) Do local elites capture natural disaster reconstruction funds? J Dev Stud 47(9):1281–1298

Takasaki Y (2013) Learning from disaster: community-based marine protected areas in Fiji. http://www.econ.tsukuba.ac.jp/RePEc/2013-001.pdf

Thomas V, Albert R, Hepburn C (2014) Contributors to the frequency of intense climate disasters in Asia-Pacific countries. Clim Change 126:381–398

UNISDR (2013), Global assessment report. United Nations, Geneva

UNISDR (2015), Global assessment report. United Nations, Geneva

Vermeer M, Rahmstorf S (2009) Global sea level linked to global temperature' In: Clark WC (ed) Proceedings of the National Academy of Sciences (PNAS)—Physical Sciences—Sustainability Science, pp 1–6

von Peter G, von Dahlen S, Saxena S (2012) Unmitigated disasters? New evidence on the macroeconomic cost of natural catastrophes. BIS working paper No. 394

WHO (2013) WHO methods and data sources for global burden of disease estimates 2000–2011. Global health estimates technical paper WHO/HIS/HSI/GHE/2013.4