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Simulations of Sustainable Financing for Disasters in Pacific Atoll Islands: Evidence from Tuvalu and Kiribati*

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Abstract: This paper examines the financing of disaster risk management. Future climate and disaster risks are predicted to impose increasing financial pressure on the governments of low-lying atoll nations. The aftermath of a disaster, such as a cyclone, requires financial means for quick response and recovery. We quantify the appropriate levels of financial support for expected disasters in Tuvalu and Kiribati by building on the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) calculated likely costs for disasters. To these, we add estimates of the potential effects of distant cyclones, droughts, sea level rise, and climate change, as they are predicted to affect low-lying atoll islands. This paper focuses on the potential contribution of the sovereign wealth funds (SWFs) of Tuvalu and Kiribati in reducing reliance on foreign aid for ex-post disaster risk management. We forecast the future size of SWFs using Monte Carlo simulations. We examine the long-term sustainability of SWFs, and the feasibility of extending their mandate for disaster recovery.

JEL Codes: C53, E17, Q01, Q54, Q56

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Keywords: Disasters, sovereign wealth funds, atoll islands, disaster fund, resilience.

1. Introduction

The Intergovernmental Panel on Climate Change (2012; 2014) emphasized the increasing risks associated with extreme weather events due to climatic change. Increasing frequency of high intensity storms are results of climate change and global warming in sea temperatures (Mendelsohn et al., 2012; Mei et al., 2015). The negative effects of climate-related disasters are greatly felt by developing countries, causing financial losses to increase (Briguglio, 1995; Heger, Julca, & Paddison, 2008; Klomp & Valckx, 2014).

These events create significant budget volatility and fiscal risk to Pacific Island Countries (PICs) who lack the funding and capacity to ensure proper financial protection and adequate fiscal response to disasters. Most PICs face complexities in raising and accessing liquidity in the immediate aftermath of a disaster, due to constraints related to their sizes, borrowing capacity, limited access to international financial markets, narrow revenue bases, and heavy reliance on imports and aid (World Bank, 2015b). Climate-induced sea-level rise poses an additional and existential threat to small and low-lying atoll states in the Pacific like Tuvalu and Kiribati, with moving populations or protecting the atolls at very high cost the only long-term solutions (OECD & World Bank, 2016).

Numerous studies point out the unique exposure of Pacific Islands to risks due to their economic, geographical, and environmental vulnerabilities (see World Bank, 2014; Taupo, Cuffe, & Noy, 2016; OECD & World Bank, 2016). These intertwined vulnerabilities can reverse development efforts in these Pacific atoll islands (Victoriano, 2015). For instance, the IMF estimated that damage of 1% of GDP from a disaster could be expected to decrease growth by 0.7 percentage points for Pacific Islands (Cabezon, Hunter, Tumbarello, Washimi, & Wu, 2015).

Aid plays a pivotal role in Small Island Developing States (SIDS) development, climate change adaptation and disaster risk reduction. Low-lying SIDS like Tuvalu and Kiribati are well supported by development aid, but increasing impacts of disasters are seen as emerging issues that require further funding assistance. In terms of quick response to climatic disasters (e.g., cyclones and droughts), the smallness of the islands and distances between them, and resultant communication and transportation difficulties, are major issues impeding swift response and recovery efforts. For example, both Tuvalu and Kiribati were significantly affected by the Tropical Cyclone Pam (TC Pam) in 2015 even though the islands were a great distance away from the cyclone path (see Taupo & Noy, 2016; Noy & Edmonds, 2016). The fiscal response to such catastrophes as the 2015 TC Pam has further demonstrated Tuvalu's dependency on aid donors.

Noy and Edmonds (2016) calculated a welfare risk scorecard for Tuvalu based on the model used by Hallegatte et al. (2017) to produce disaster management scorecards for countries (Hallegatte, Bangalore, & Vogt-Schilb, 2016). Worryingly, they measured the overall risk to welfare for Tuvalu to be 0.98, higher than all other countries measured in this way by the World Bank. Noy and Edmonds (2016, p. 22) concluded that risk to welfare in Tuvalu is the highest implying that for "every dollar of damages to assets will also 'translate' into a dollar (98 cents) of lost welfare/wellbeing for Tuvalu".

The sizes of these SWFs and the increasing income they generate display their national importance. Therefore, safeguarding and ensuring that these funds are put into efficient, effective, and sustainable use is paramount.[1] Suggestions have further emerged on the potential of these funds to act as financial instruments to facilitate disaster risk reduction. Since small, low-lying atoll islands are vulnerable and exposed to climatic disasters, the focus on designing strong buffers with sustainable financing mechanisms to counter these unexpected shocks is imperative.

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[1] Over the years, these funds have gained a reputation for prudent management guided by explicit rules that are subject to parliamentary scrutiny. The Asian Development Bank (ADB) and Angelo et al. (2016) consider the Tuvalu Trust Fund (TTF) the most successful public fund in the Pacific, in terms of clear establishment structure by a treaty, clear purpose, and being a management and investment policy that deserves a model reputation for effective use of trust funds for small island state economic development (http://www.radionz.co.nz/international/pacific-news/155763/adb-says-tuvalu-trust-fund-considered-most-successful-in-pacific).

As far as we are aware, no forecasts have been produced for the success of the Tuvalu Trust Fund (TTF) or Revenue Equalizer Reserve Fund (RERF) in the long run, nor any analysis of their feasibility and sustainability in providing financing mechanisms for disaster preparation and response. The possibility of extending TTF coverage to disasters apart from the provision of government support has been proposed but remains unquantified.[2] This study aims to assess the feasibility and sustainability of these funds to support and contribute to disaster funds. Additionally, the paper intends to enhance understanding of potential options available for DRR and disaster response for Tuvalu and Kiribati. Current findings can then be generalised to other Pacific or SIDS settings. The next section describes the data and explains the methodology, section 3 details the results, and conclusions are presented in section 4.

2. Data and Methods

We employed the Monte Carlo (MC) simulation method to forecast the future of the TTF and RERF. The MC simulation method was used to model the probability of possible outcomes from our time series data. We used time series data on both the TTF and RERF. Data are yearly from financial years 1987 to 2016 and 1984 to 2016 for Tuvalu and Kiribati, respectively. Data on the TTF were gathered from the TTF Secretariat of the Tuvalu Government, while the RERF annual values were acquired from the Kiribati's Ministry of Finance and Economic Development.[3] Annual reports on the Funds and the national budgets were also used to complement these data.[4]

The MC simulation (or stochastic sampling) method generates random numbers with a given probability distribution.[5] Wulfsohn (2015) analysed the impact of investment

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[2] This was raised in several meetings in Tuvalu, including the TC Pam Meeting, National Summit for Tuvalu for the new National Sustainable Development Strategy for 2015-2020 and the 2015 Tuvalu TTF Board Meeting (also mentioned in their 2015 TTFAC Report).

[3] Data for RERF were gathered from both the Ministry of Finance & Economic Development and their official website (http://www.mfed.gov.ki/).

[4] Other Pacific Islands with SWFs were also approached for their data, but declined.

[5] There are two main categories of MC method, namely MC simulation (or stochastic sampling) and MC integration. For our case, we used the Monte Carlo simulation method which runs an algorithm that generates random numbers with given probability distribution. A function that returns the value of x such that, with the probability p, a normal random variable with mean mu and standard

return uncertainty on the long-term sustainability and stability of income from the Compact Trust Funds (CTFs) in the North Pacific, covering the Republic of the Marshall Islands (RMI) and the Federated States of Micronesia (FSM). He used a Monte Carlo investment return simulation model to simulate the effects of investment return volatility. In our case, we used it on an investment portfolio with a given starting value, an average annual return value, a standard deviation or volatility of return per annum, and assumptions on possible reinvestment and withdrawals.

An example is when we generate a random rate of return for one year from today by using a function that assumes that the rate of return follows a normal distribution. We get one by using a random function, where the average of that normal distribution is the average rate of return with a volatility or standard deviation of return.[6] There are many possible returns, therefore we can generate other possible returns a year from now. For the ending balance, we multiply the beginning balance by the annual rate of return and add assumptions (e.g., adding investment) by the end of the year. A stream of possible returns goes up to 34 years (i.e., from 2017 to 2050).[7] We then update and adjust beginning balances for the following years. Therefore, one possible outcome is ending with about $1 billion in 2050. We set up and generate 10,000 possible ending values for our portfolio, and from that we will have a reasonable idea of what our ending value could be,[8] assuming that we calculate the 5% percentile of possible ending values and get $300 million. So, based on this probability, we can say that there is a 95% chance that the TTF will have more than $300 million (or 5% chance

deviation sigma takes on a value less than or equal to x. See Glasserman (2003) and Kalos and Whitlock (2008) for discussion on the development of MC methods and their application to financial engineering. Generating of random numbers and random variables are comprehensive discussed in Bratley et al. (1987), Devroye (1986), Niederreiter (1992), Fishman (1996), Gentle (1998), and others.

[6] The average rate of return and standard deviation of return are based on past data. As percentage of SWF, the average rate of return is 7.06% and 4.7% for TTF and RERF, respectively. Likewise, the standard deviation of return is 5.04% and 3.5% for TTF and RERF, respectively.

[7] One could choose any ending year that they preferred, but for this case we set the end year to 2050 due to the fact that Ferris, Cernea, & Pertz (2011) argued that Pacific islands (particularly low-lying islands like Tuvalu and Kiribati) could possibly be forced to migrate and be displaced by 2050 due to the effects of climate change.

[8] The law of large numbers ensures estimate convergence to the true value as the number of draws increase, thus reducing sampling errors and uncertainty (Glasserman, 2003).

of having something less than $300 million) at the end of 34 years, if returns continue as they historically have.

3. Results and Discussions

In the following, we assess risk estimates supplied by the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) for Tuvalu and Kiribati to determine the required contributions into disaster funds before discussing the forecast results from the two models under discussion.

3.1 Assessing Risk and Determining Contribution to Disaster Funds

Predictions of cyclone risks have been underestimated in the Pacific, particularly for low-lying atoll islands (Noy, 2016). To compute appropriate values required for contributions from SWFs into disaster funds, we started with the current estimated Average Annual Loss (AAL) calculated by PCRAFI for the two countries.[9] The computed AAL from PCRAFI estimates that annual economic losses averaged over the 10,000 realisations of next-year activity. Moreover, the adverse consequences are measured from expected losses for three assets consisting of buildings, major infrastructure, and valuable crops (World Bank, 2013b). However, the models used by PCRAFI in risk analysis only calculate losses from earthquakes and tropical cyclones. Therefore, in addition to the AALs produced by PCRAFI, we consider unaccounted factors for low-lying atolls, namely: (1) distant cyclones; (2) climate change; (3) droughts, and (4) sea level rise.

Firstly, the PCRAFI model did not recognize distant cyclones such as Tropical Cyclone Pam (TC Pam) and Tropical Cyclone Ula (TC Ula) as potential disasters for low-lying islands like Tuvalu. They only accounted for nearby cyclones in their models. Recently, Taupo & Noy (2016) quantified the impacts of a distant cyclone (TC Pam) which passed about 1,000 km away from Tuvalu. We accounted for distant cyclones by using the estimated cost of damages from TC Pam, for instance, and the

[9] Hallegatte (2013) discusses the basic measure that assesses the exposure of assets during a catastrophe, called the Exceedance Probability (EP) curve, where the area below the constructed EP curve is the AAL, which is the expected amount of loss on average per year for a certain location.

loss and damages for Tuvalu at 10% of GDP based on both the ADB (2015) and Taupo & Noy (2016)[10]. Even Kiribati, which was much further away from TC Pam's path than Tuvalu, was severely affected, with damages estimated by IMF (2016) at around 4% of GDP.[11] According to the World Bank (2016), a Category 5 cyclone has been a 1 in 10 year event[12] for Fiji, Tonga and Samoa, while the cyclone return period for the Solomon Islands and Vanuatu is 1 in 5 year event.[13] In this connection, we used a 1 in 10 year scenario for our distant cyclone calculations.[14] Building onto the PCRAFI AAL, we then adjusted the current AAL to include distant cyclones, thus increasing it to $731,738 (or an increase of 128%) for Tuvalu.[15] Similarly, we also adjusted the AAL for Kiribati to include distant cyclones, which amounted to $1,219,704 (or an increase by 221%).[16]

Secondly, the expected changes in frequency and intensity of cyclones are of serious concern for low-lying SIDS. We therefore incorporated the effects of climate change over time into our calculations of AALs. In accounting for these characteristics

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[10] Estimated damages of $4.12 million for Tuvalu. The World Bank (2016) estimated more than USD$10 million in damage, which is equivalent to 27% of the GDP. The World Bank (2015a) had a higher estimate of overall costs, standing at $14 million or 33.6% of GDP.

[11] See International Monetary Fund (2016), IFRC (2016) and Radio New Zealand (2015) for details on the impacts of TC Pam, particularly on three of the Southern Islands of Kiribati.

[12] A 1 in 10-year event is the probability of occurrence in any given year which also means a recurrence interval of 10 years (or return period of 10 years) or a 10% chance of occurrence in any given year.

[13] According to the Australian Bureau of Meteorology and CSIRO (2011), "the tropical cyclone archive for the Southern Hemisphere indicates that between the 1969/70 and 2006/07 cyclone seasons the centre of 33 tropical cyclones passed within approximately 400 km of Funafuti. This represents an average of eight
cyclones per decade. Tropical cyclones were most frequent in El Niño years (12 cyclones per decade) and least frequent in La Niña years (four cyclones per decade)."

[14] Assuming that a Category 5 cyclone close to Vanuatu and the Solomon Islands are likely to be encountered as distant cyclones like TC Pam. Vanuatu was the closest to the TC Pam when it was within Category 5 strength, hence it was extremely affected with attributable loss and damages amounting to USD$449.4 million which is equivalent to 64.1% of GDP (Government of Vanuatu, 2015).

[15] For consistency, since both Tuvalu and Kiribati use Australian Dollars (AUD), unless stated in other currencies we will use the AUD with a currency conversion rate of USD$1=AUD$1.31197. The adjusted AAL for Tuvalu is derived from the sum of the current AAL USD$243,709=AUD$319,738 and the distant cyclone part of $412,000 (i.e. $4.12 million or 10% of GDP, divided by the distant cyclone return period of 10).

[16] In 2015 prices, Kiribati's GDP was USD$160,121,929 (or AUD$210,075,167). The adjusted AAL for Kiribati is derived from the sum of the current AAL USD$289,186=AUD$379,403 and the distant cyclone component of $840,301 (i.e. $8,403,006 or 4% of GDP, divided by the distant cyclone return period of 10).

of cyclones, we: 1) allowed for a 9% increase in intensity (or strength of winds) of cyclones within the South Pacific, as was calculated in Noy (2016)[17]; 2) adjust for the cyclone damage related to the 3.8th power of wind speed measure stated by Strobl (2012) in his paper on hurricanes in the Caribbean, and 3) account for the 2% decrease in cyclone frequency in the South Pacific that was argued by Noy (2016). Since the effects of the increase cyclone intensity are far more significant than the effects of the decrease cyclone frequency, the overall impact of climate change is likely to be highly destructive.[18] These expected changes are reflected in our cyclone AAL readjustments. To proceed, we separate the two AAL components of earthquakes and cyclones so we can readjust the cyclone part to account for distant cyclones, and for climate change in terms of potential changes in cyclone intensity and frequency. Hence, the adjusted overall AAL derived by accounting for earthquakes, cyclones, distant cyclones and climate change is $918,277.[19] Similarly, Kiribati will likely incur an overall AAL of $1,567,461.[20]

Thirdly, we accounted for droughts by using the estimated costs from a recent severe drought event and the expected drought return period. There are very few reports that assess the monetary costs of droughts in the South Pacific.[21] According to the DesInventar Database, Tuvalu suffered monetary losses of USD$15 million due to

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[17] Noy (2016) calculations on changes in frequency and intensity of cyclones are based from Siqueira et al. (2014).

[18] Since the cyclone intensity is about 30% stronger and the cyclone frequency is only -2%.

[19] Since our PCRAFI AAL represents the combination values of earthquakes and cyclones, we then split the cyclone component to enable us to compute the effects of cyclone intensity and frequency. First, we extracted the cyclone component, 33% of the original AAL ($106,579), and added the distant cyclone AAL of $412,000, which sums up to $518,579. Then we multiplied by $1.09^{3.8}$ to capture the cyclone intensity, thus arriving at $719,508. Then we multiplied by frequency change of 0.98 to arrive at $705,118, or the adjusted AAL (including cyclones, distant cyclones, cyclone intensity, cyclone frequency) without the earthquake component. So, adding the earthquake component of $213,159 back into the AAL corresponds to the adjusted overall AAL of $918,277.

[20] Likewise, for Kiribati, we multiplied straight the distant cyclone AAL of $840,301 with $1.09^{3.8}$ to capture the cyclone intensity effects, thus arriving at $1,341,353. Then we multiplied by the frequency change of 0.98 to come up at $1,314,526 or the adjusted AAL (including cyclones, distant cyclones, cyclone intensity, cyclone frequency) without the earthquake component. So, adding the earthquake component ($379,403) back into the AALs corresponds to the adjusted overall AAL of $1,567,461.

[21] Not only that, the impact of a drought depends on factors such as the drought's length, meaning it is often hard to quantify the impacts of droughts in monetary values in relation to agriculture and health associated costs.

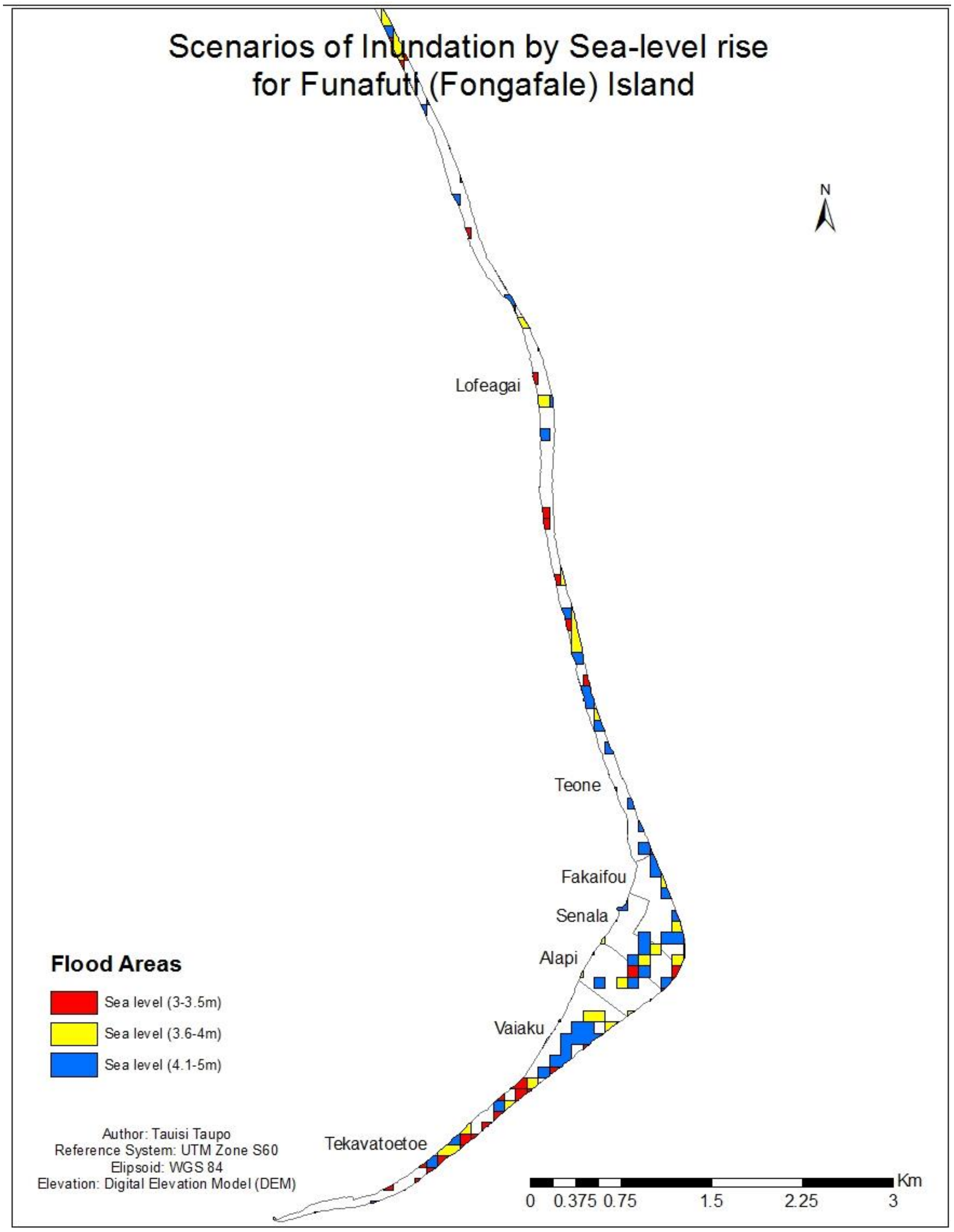
the drought in 1998, which was around 117% of GDP.[22] It seems that the calculated losses may have been overestimated, so we resorted to calculating the impact of the drought using available information from the most recent 2011 drought report by Sinclair et al. (2012). Based on our summations from the report, the estimated loss and damage to Tuvalu was $2,072,045, around 4% of 2011 GDP.[23] The Australian Bureau of Meteorology and CSIRO (2011) projected severe drought occurrence once every 20 years for Tuvalu. Therefore, our AAL for the drought in Tuvalu corresponds to $103,602. Extrapolating our computations from the case of Tuvalu for Kiribati results in expected costs of $10,153,021, with an AAL of $507,723.[24] Hereafter, the adjusted overall AALs for Tuvalu and Kiribati now correspond to $1,021,879 and $2,075,112, respectively.

[22] DesInventar database also recorded the 2011 drought, but with no monetary losses. The EM-DAT database did not record the 2011 drought for Tuvalu, but recorded the 2009 drought for Kiribati.

[23] GDP of USD$39,312,016 or AUD$51,576,185, according to the World Bank. Note that the calculated costs from the 2011 drought only include impact on agriculture, while excluding health due to its complexity in translating to monetary values. For agriculture, we used ArcGIS software to compute plantation areas and used market prices in our calculations.

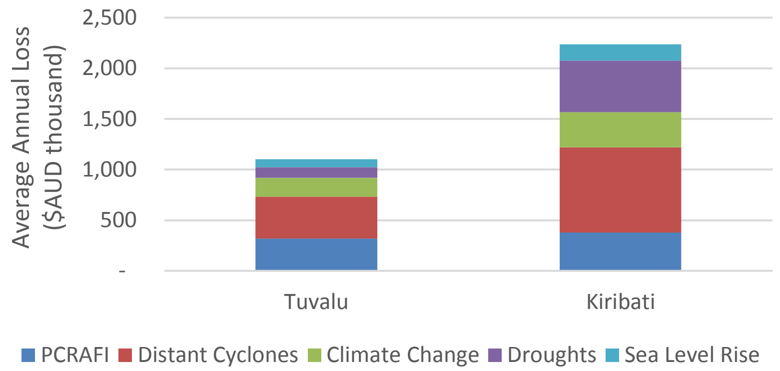
[24] In 2015 prices, Kiribati's economy is 4.9 (i.e. USD160,121,929/USD32,673,277) times bigger than Tuvalu's economy. Multiplying the cost of the drought (AUD$2,072,045) by 4.9 results to AUD$10,153,021 (i.e. 4.83% of GDP), which is the expected cost of the disaster for Kiribati. Therefore, dividing the drought's estimated cost of AUD$10,153,021 by the Kiribati's GDP of AUD$210,075,167 then multiply by a 100 to convert to percentage, we get 4.83%.

Figure 1: Flood Areas by sea-level on Funafuti Island.



Lastly, we used the effects of an increase in sea level for the case of Funafuti (capital of Tuvalu), where an increase by one meter in sea level would leave 15% of the land inundated on Funafuti Island (see map in Figure 1). Noy (2016) shows that the sea level in Tuvalu is projected to rise up by 24cm by 2050. Arguably, this increase would inundate 7.8% of the land. Sea level rise would exacerbate the impact of cyclones and tsunamis in this context. Therefore, we factored the expected increase in sea level into the AALs. This is reflected in an increase in overall expected AALs to $1,101,586 and $2,236,971 for Tuvalu and Kiribati, respectively.[25] These AALs corresponds to 2.45% of GDP for Tuvalu and 1.06% for Kiribati.

Figure 2: Annual Average Loss (AAL) Adjustments for Tuvalu and Kiribati.



Source: Author's calculations.

Figure 2 illustrates the adjusted AALs for Tuvalu and Kiribati, built on current PCRAFI AALs and adjusted to account for distant cyclones, climate change, droughts, and sea level rise. Under these conditions, the TTF and RERF would have amassed overall estimated contributions to their disaster funds at the end of the financial year 2050 in the order of $37.5 million and $76.1 million, respectively.[26] In the following section, we will present the forecasting results for the two SWFs together with scenarios including estimated contributions to their disaster funds using the two forecasting approaches discussed below.

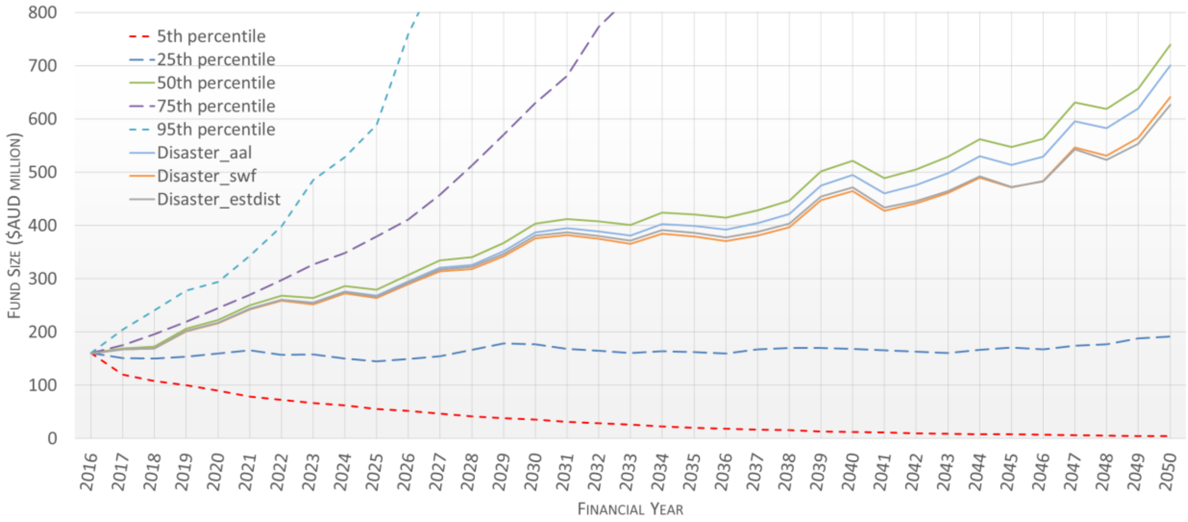
3.2 Investment Return Simulation

The progression of the size of these SWFs over time, including inputs of drawdowns and investments according to their account structure and rules are set out in Figure 3 and Figure 4 for the TTF and RERF, respectively. Generally, they show the distribution and spread of possible values (or ending outcomes) of the funds over time. The 95th percentile line can be interpreted as having 95% of simulations below it (and 5%

[25] Multiplied overall AAL with 1.078.
[26] These figures are direct contributions from the TTF to the disaster fund in 2016 prices, excluding other contributions from other potential sources.

simulations above). Likewise, 5% of simulations are below the 5th percentile line (and 95% simulations above). The median is represented by the 50th percentile. A customary perception for an investment portfolio is the notion of increasing uncertainty as we stretch time further into the future, which is portrayed by the widening gap between the different percentile lines (see figure 3 and figure 4).

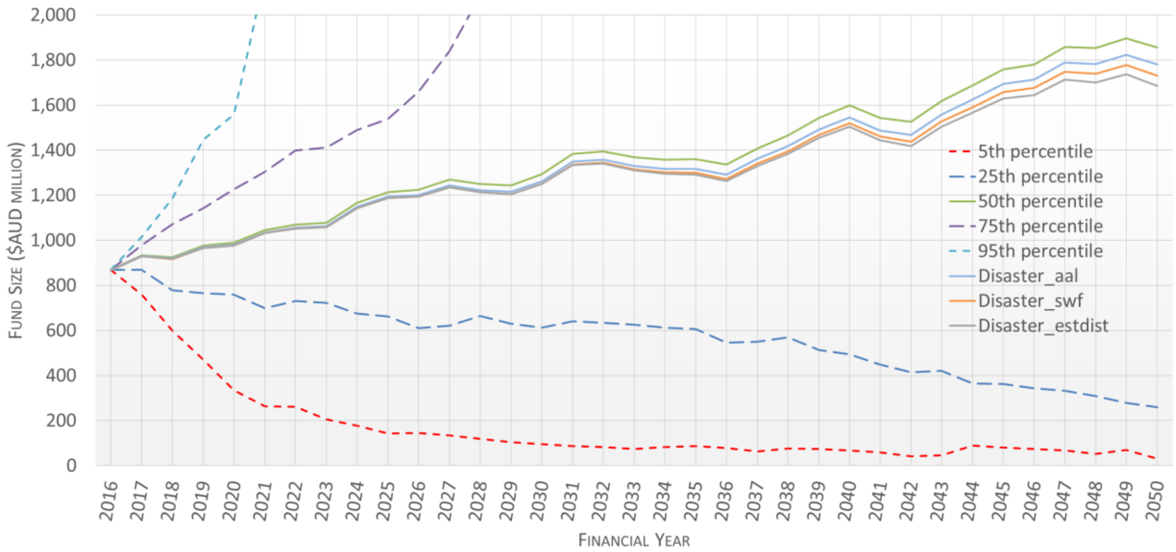
Figure 3: TTF forecasted performance from 2017 to 2050 with contributions to the Disaster Fund.



Source: Authors' calculations and modelling. The disaster_aal is the 50th percentile of TTF with incorporated contributions to the disaster fund using the adjusted AAL (fixed based on the calculated AAL in 2016 prices) as the annual contribution over time. The disaster_swf is the 50th percentile of the TTF with adjusted calculations to include the adjusted AAL as a percentage of the TTF, so that it changes overtime based on forecasted values of the TTF. The disaster_estdist is the 50th percentile of the TTF with estimated distribution of annual losses.

As well as the forecasted median (50th percentile) of the SWF without any contributions to a disaster fund in Figure 3 and Figure 4, we added two other forecasted median scenarios, namely: 1) *Disaster_aal* (unbroken blue line) representing the 50th percentile with contributions to a disaster fund using the adjusted AAL as the annual contribution over time; 2) *Disaster_swf* (unbroken orange line) representing the 50th percentile with contributions to a disaster fund derived from the adjusted AAL in relation to the SWF; and 3) Disaster_estdist (unbroken grey line) representing the 50th percentile with contributions to a disaster fund derived from the estimated distribution of annual losses. The adjustments in (2) correspond to annual contributions as a percentage of the SWF.[27] This pathway of using the percentage of AAL on SWF would accumulate total estimated contributions by 2050 of about $97 million for the TTF and $126 million for RERF.[28] Figure 3 and Figure 4 reveal that the TTF and RERF have around a 50% chance of reaching $0.73 billion and $1.73 billion by 2050, respectively.[29]

Figure 4: RERF forecasted performance from 2017 to 2050 with contributions to the Disaster Fund.



Source: Authors' calculations and modelling. The disaster_aal is the 50th percentile of RERF with incorporated contributions to the disaster fund using the adjusted AAL (fixed based on the calculated AAL in 2016 prices) as the annual contribution over time. The disaster_swf is the 50th percentile of the RERF with adjusted calculations to include the adjusted AAL as a percentage of the RERF, so that it changes overtime based on forecasted values of the RERF. The disaster_estdist is the 50th percentile of the RERF with estimated distribution of annual losses.

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[27] We used the adjusted AAL as a percentage of SWF size in 2016 values for our annual contribution (i.e. 0.685% and 0.288% for TTF and RERF, respectively), thus continuously using this percentage over time, therefore the annual contributions changes over time based on the SWF size, which is sustainable in a sense.

[28] This aim for the TTF maintained value to reach $200 million by 2020 was raised in the 2015 TTF Board Meeting (I attended this closed meeting on November, 2015) and later became a goal in the 2017 National Budget of Tuvalu (see Ministry of Finance & Economic Development, 2016). This target was also raised by the Minister of Finance & Economic Development (Hon. Maatia Toafa) in the recent parliament session on the 23rd of March, 2017, which was accessed on a live stream of the radio Tuvalu on http://listen28radiocom.radiostream321.com/ . Based on the model, Figure 2 shows that the TTF has about 50% chance of meeting the Government's aim to reach $200 million by 2020.

[29] TTF is much larger than RERF in per capita terms.

Intuitively, the effects of contributing to a disaster fund in the forecasted performance of the SWFs are displayed by a downward shift in the median with an increasing gap as we move into the future. Both the TTF and RERF are sustainable in the long run without any contributions to their disaster funds as they have upward trends in the median over time. Similarly, these SWFs are also sustainable in the long-term if they contribute to their disaster funds but at a lower median over time. However, contributing to disaster funds from a SWF poses risks to the growth and development of SWF itself.

Under the current structures, the TTF and RERF experienced average annual drawdowns of 7.395% of GDP (or 2.06% of TTF size) and 5.3% of GDP (or 1.44% of RERF size), respectively. However, the alternative structures that contribute into disaster funds would increase annual drawdowns of the current structure by 2.6 (0.68% of TTF size) and 1.1 (0.29% of RERF size) percentage points for Tuvalu and Kiribati, respectively. On the other hand, the current average contributions into SWFs for the TTF is approximately 7.422% of GDP, which is only $0.011 million above the average annual drawdowns. By contrast, the average annual contributions into the RERF for Kiribati are far lower than the average annual drawdowns, by approximately $8.2 million. With the newly assumed responsibility of contributing into disaster funds, the alternative structures for drawdowns and contributions will change. The average annual drawdown as a percentage of the SWF would likely to increase by percentage points of 0.68 for the TTF and 0.29 for the RERF.

4. Conclusion

While much focus in the Pacific has been on improving economic sustainability, partly through strengthening the management of reserves in SWFs, the establishment of solid and sustainable disaster funds for preparedness and response is indispensable for SIDS like Tuvalu and Kiribati. To refrain from reallocating budget earmarked for development purposes to be utilised for immediate disaster response, Tuvalu and Kiribati can rely on disaster funds to provide an adequate financial buffer. Without contributions from SWFs to disaster funds, both the TTF and RERF are sustainable in the long run. Based on our forecasts on imposed scenarios, they are also likely to be feasible and sustainable even if they contribute to disaster funds.

One argument for not allocating money from the SWF for disasters is that it would decrease aid. Consequently, we ask who should fund the disaster fund? The international community could contribute to the disaster fund, but will that conflict with its willingness to pay for recovery after a disaster.

Several other possible ways to fund the disaster fund might be possible. First, the government can have full ownership of its disaster fund, maybe through a loan from the Asian Development Bank (ADB) or World Bank (WB) to provide the start-up resources (e.g. $5 million for the establishment of the Falekaupule Trust Fund) and invest the fund off-shore, leaving it to develop and build on its own interests without drawing out its gains. To boost the growth of the disaster fund, the government will need to invest money into it from its own revenues (including the TTF). If income from the TTF is used, it would probably be necessary to have the support of Australia and NZ, as board members of the TTF and continuing contributors.

In principle, the TTF responds well to external economic shocks, but it does not extend a consistent treatment for natural disasters. Natural disasters are often left to be dealt with by the government, people, and aid. In fact, economic shocks and natural disasters are both disruptions that affect the economy and the people, and so could be treated the same. It is clear that the TTF was established to broadly meet national budget deficits, support national economic development and achieve greater national financial autonomy, then why natural disasters as a great threat is excluded. However, it is not clearly stated in the TTF agreement that natural disasters are explicitly excluded. Given the recent threat from disasters (more than economic shocks), there should be a trigger clause in the TTF mandates to include disasters or they should revise and expand the TTF mandates to include some form of DRM function in it.

Second, the government can ask the international community to build and/or even contribute into the disaster fund. There are available and limited funds to tap into. However, the development should start from the national level with the government, i.e. through the Development Coordinating Committee (DCC) and the Cabinet levels. Then it could be raised and promoted in the donors' round-table meeting (DRM) with trusted development and diplomatic partners. This can be raised by the Ministry of Finance in collaboration with the Climate Change & Disaster Unit. At the international level, one way for example, is to be raised by the Prime Minister in his speech during the United Nations General Assembly (UNGA) in New York, then followed by advocating and promoting through side events with trusted representatives at the UN. This strategy can also be applied to other offices where Tuvalu is a member (World Bank and ADB) and represented (European Union (EU), NZ, Taiwan, and others) to advocate to the Diplomatic Corps especially their allies and those willing to help and contribute. We can also extend it to other international meetings focusing on climate change and disasters like the Convention of the Parties (COP) Meetings, UN World Conference on Disaster Risk Reduction, European Union Meetings and others. An example of a nearby event is the 23rd session of the COP (or COP 23) to the UN Convention on Climate Change (UNFCCC) that will be organised by Fiji and hosted by the UNFCC Headquarters in Germany. It has to be strategic in nature and with the awareness of the members of the AOSIS (Alliance of the Small Island States) who will all attend. If there is a need for technical support, then the government can always turn to the Pacific Islands Forum Secretariat (PIFS) and South Pacific Commission (SPC) as they both have Disaster Units too.

Last but not the least, the government can have a mix strategy, where the government can start up the disaster fund by establishing it, and ask the international community who are willing to contribute into the fund. It can be seen as a responsibility to the main emission polluters (industrial nations) and a donation (for others). This disaster fund is part of building resilience to both climate change and disasters (since climate change induce disasters and their impact) which is an urgent need for small island countries in particular, and part of increasing adaptation and mitigation efforts.[30] The Green Climate Fund and maybe a future Loss-and-Damage compensation mechanism are other potential sources of funding.

Nevertheless, these disaster funds could be converted into long-term investment funds comparable to the TTF and RERF when deemed viable and applicable.[31] In this fashion, they could be operated separately in a sustainable manner that builds upon its capital with good governing rules to guide management and encourage prudent reinvestment and drawdown. It is also vital to allow space and time for the disaster funds to build-up in their initial phases as they transit to a sustainable stage with a sufficient principal value able to provide future sustainable revenue streams for supporting disaster risk reduction and management.[32] With good governing rules, proper management, and prudent and relatively conservative fiscal policies for both of these funds, they should successfully achieve set targets and be sustainable in the long run. There should also be a buffer account to meet immediate response to disasters. Thus, they could contribute to DRR through disaster preparation, response, and recovery.

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[30] There are other options too such as establishing a climate and disaster insurance facility and the "crowd funding" that is defined by the World Bank as an "internet-enabled way for businesses or other organisations to raise money in the form of either donations or investments from multiple individuals" (World Bank, 2013a, p. 14).

[31] A good example is the Falekaupule Trust Fund (FTF) which was purposely established for outer-island development. Its management and operation is very similar to the TTF. For the disaster fund, it could similarly be managed and operated in the same manner, but with the sole purpose of financing disaster preparedness, response, and recovery. Its governing rules should be set up in a way that manages the Fund in a prudent and sustainable way.

[32] Given prudent management and the fact that the Fund has reached a sustainable phase with the capacity to provide a sustainable flow of public revenues, we can permit drawing from the Fund in a manner that would not jeopardize their overall performance.

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