

# Sustainable financing for climate and disaster resilience in Atoll Islands: Evidence from Tuvalu and Kiribati

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# Sustainable Financing for Climate and Disaster Resilience in 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 and an Auto-Regressive Integrated Moving Average model. We examine the long-term sustainability of SWFs, and the feasibility of extending their mandate for disaster recovery.

JEL: G17, Q54

Keywords: Sovereign wealth fund, disasters, Tuvalu, Kiribati, disaster fund, sustainability.

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## 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".

Response efforts for Tuvalu after TC Pam were led by the Government through the Disaster Committee, with support from humanitarian and bilateral partners. Based on situational assessments of the impact of the disaster, the government, and regional and international organizations responded to key areas of humanitarian need. There was neither disaster fund, nor any liquid financial instrument in place at that time to assist in this endeavour, apart from the Government's redirection of other expenditure lines.

Here, we propose to estimate the feasibility of a funding mechanism for disaster relief based on a Sovereign Wealth Fund model (SWF). For that purpose, we: (1) Quantify the need for such a funding mechanism; (2) suggest a way to structure this mechanism through the SWF of Tuvalu and Kiribati; and (3) examine the long-term sustainability of this proposed funding arrangement. We may ask why there is a need for a new disaster funding mechanism that supplements current official disaster assistance from development and donor partners. Autonomy, self-sufficiency, and predictability in relation to disaster response and recovery inspire this study. Because of this, we examine the two SWF of Tuvalu and Kiribati. The separation of Tuvalu from Kiribati, along with their independence from Britain, led to the establishment of the Tuvalu Trust Fund (TTF) while Kiribati's Revenue Equalizer Reserve Fund (RERF) had already been established.<sup>1</sup>

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<sup>1</sup> Tuvalu and Kiribati are categorized as Least Developed Countries (LDC) by United Nations (UN) classification.

As far as we are aware, no forecasts have been produced for the success of the TTF or 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.<sup>2</sup> 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 background of available disaster financing instruments. Section 3 discuss the SWF, section 4 describes the data and explains the methodology, section 5 details the results, and conclusions are presented in section 6.

## **2. Climate Change and Disaster Financing Instruments**

There are numerous financing instruments available for climate change and climatic disasters. Linnerooth-Bayer and Mechler (2009) discuss insurance and risk-financing mechanisms for managing disasters in developing countries.<sup>3</sup> One of these earliest instruments is the Caribbean Catastrophe Risk Insurance Facility (CCRIF), which is a pool of catastrophe insurance covering of small island states in the Caribbean region, with a ‘parametric trigger’ for immediate insurance disbursements to affected states in the event of a disaster for emergency relief.<sup>4</sup> To encourage and enforce disaster risk management and adaptation to climate change in PICs, the Pacific Catastrophe Assessment and Financing Initiative (PCRAFI) was devised to model disaster risks and assess financial options, aiming at reducing financial vulnerability to disasters and climate change. Interestingly, the intended formation of the Pacific Islands Climate Change Insurance Facility (PICCIF) has become a popular topic in

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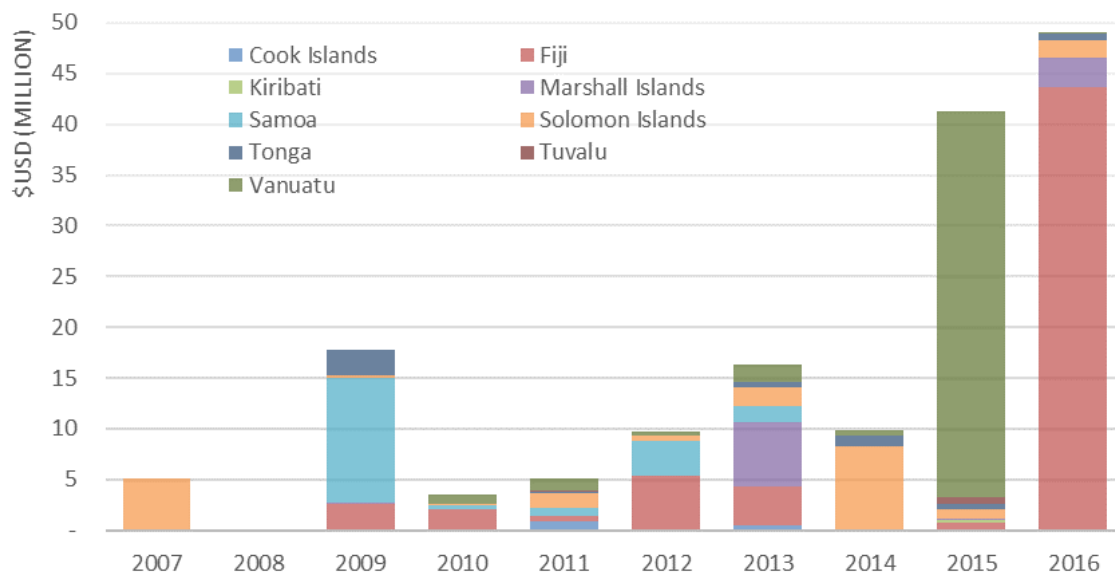
<sup>2</sup> This was raised in several meetings in Tuvalu, including the TC Pam Meeting, National Summit for Tuvalu for the new National Sustainable Development Strategy for 2015-2020 and the 2015 Tuvalu TTF Board Meeting (also mentioned in their 2015 TTFAC Report).

<sup>3</sup> Some examples of risk financing instruments are the Proshika scheme which offers the Participatory Livestock Compensation Fund (PLCF), the Afat Vimo disaster insurance program, the United States National Flood Insurance Program (NFIP), the Turkish Catastrophe Insurance Pool (TCIP), the Philippines crop insurance program, the BASIX index-based crop insurance scheme, the Mongolian index-based livestock insurance (IBLI) program, the Mexican catastrophe bond, the Caribbean Catastrophe Risk Insurance Facility (CCRIF), and the Mauritius crop insurance program.

<sup>4</sup> The Caribbean Catastrophe Risk Insurance Facility (CCRIF) was set up in 2007.

discourse within the Pacific region.<sup>5</sup> In reality, insurance is not a practical instrument for disaster response and recovery for some Pacific Islands like Tuvalu given its very small size (see Taupo & Noy, 2016).<sup>6</sup> Kiribati has an operating Insurance Corporation but it does not cover the sovereign and insurance penetration is comparatively low.<sup>7</sup>

Figure 1: Humanitarian Aid Flows for Disasters in Selected PICs



Source: Data from the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) website (<https://fts.unocha.org/countries/overview>). Retrieved on the 7<sup>th</sup> of April, 2017.

Figure 1 shows how some PICs are receiving post disaster assistance from foreign donors and development partners. We focus on a group of low-lying atoll nations, members of the Coalition of Low-Lying Atoll Nations on Climate Change (CANCC) that was organised at the UN SIDS Conference in Samoa in September 2014. This group consists of the five low-lying atoll states: Kiribati, Tuvalu, the Maldives, Republic of Marshall Islands, and Tokelau, all of which are at the frontline of climate change and sea level rise. Figure 2 illustrates humanitarian aid flow for disasters from donors to the CANCC in the past 10 years, amounting to approximately

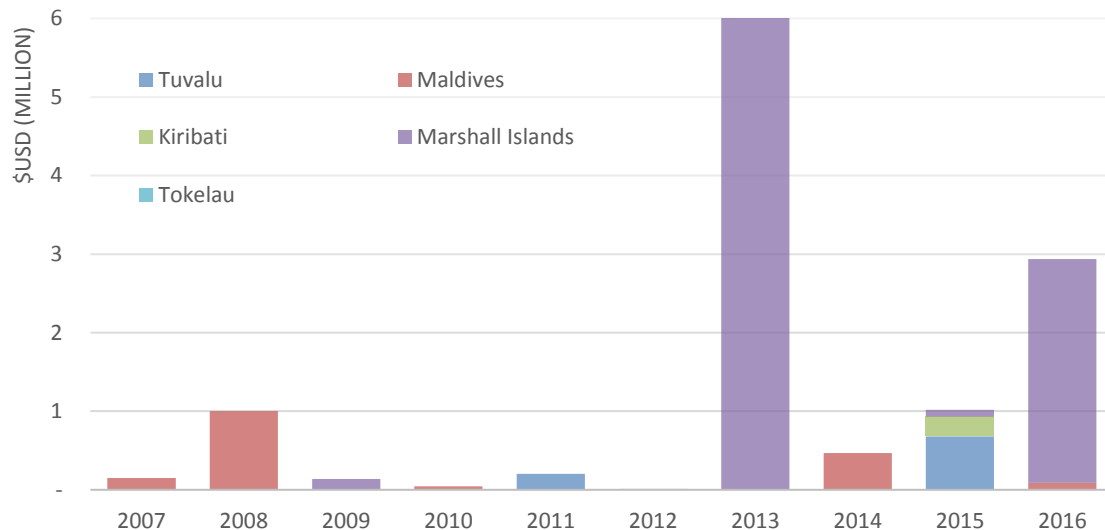
<sup>5</sup> The Prime Minister of Tuvalu, in his statement at the High-Level Meeting of the Conference of the Parties (COP22) on the 16<sup>th</sup> of November 2016, stressed that the Pacific region is progressing towards the development of a Pacific Island Climate Change Insurance Facility (PICCIF) to help in recovery efforts, with the help of the UNDP and the Pacific Island Forum Secretariat. He also called upon all donors and experts to help in this endeavour. See statement at <http://www.tuvalu-overview.tv/eng/topics/statement-cop22.html>. Another disaster insurance for some PICs is the Pacific Catastrophe Risk Insurance Company.

<sup>6</sup> Apart from the unavailability of insurance mechanisms and insufficient resources (low income), “charity hazard” is a concern possibility deterring donors and the national government recipients (see Raschky & Weckhannemann, 2007).

<sup>7</sup> The Kiribati Insurance Corporation was established in 1981 to compensate loss and damages under two main categories: Life insurance and General (Non-Life) insurance, including vehicles, motor cycles, marine and aviation, fire, liability, and miscellaneous. Refer to <http://www.kic.org.ki/index.php/about-us.html>.

USD\$12 million.<sup>8</sup> The Marshall Islands dominated humanitarian aid for CANCC within this period, due to the two droughts they experienced in 2013 and 2016.

Figure 2: Humanitarian Aid Flows for Disasters in Low-Lying Atoll Islands



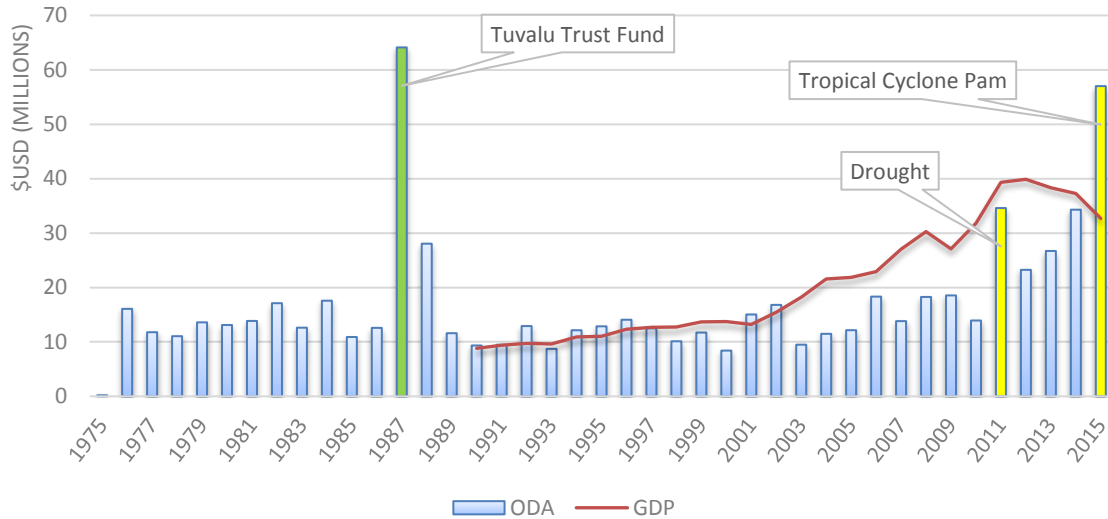
Source: United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) website (<https://fts.unocha.org/countries/overview>).

Tuvalu received USD\$681,284 for TC Pam in 2015. The Tuvalu Government (2015) approximated a total of AUD\$3.5 million from cash, in-kind, and pledge donations for relief and recovery efforts. Figure 3 displays spikes of net Official Development Assistance (ODA) for Tuvalu, corresponding to two state emergencies (in yellow bars): the 2011 drought and TC Pam in 2015. The year of the establishment of the Tuvalu Trust Fund is represented by the highest spike, in 1987 (green bar). Similarly, Figure 4 shows ODA and GDP for Kiribati. Kiribati was also affected by the 2011 drought and TC Pam in 2015, but not to the extent like Tuvalu where a state of emergency was declared for both events.

Figure 3: ODA and GDP for Tuvalu

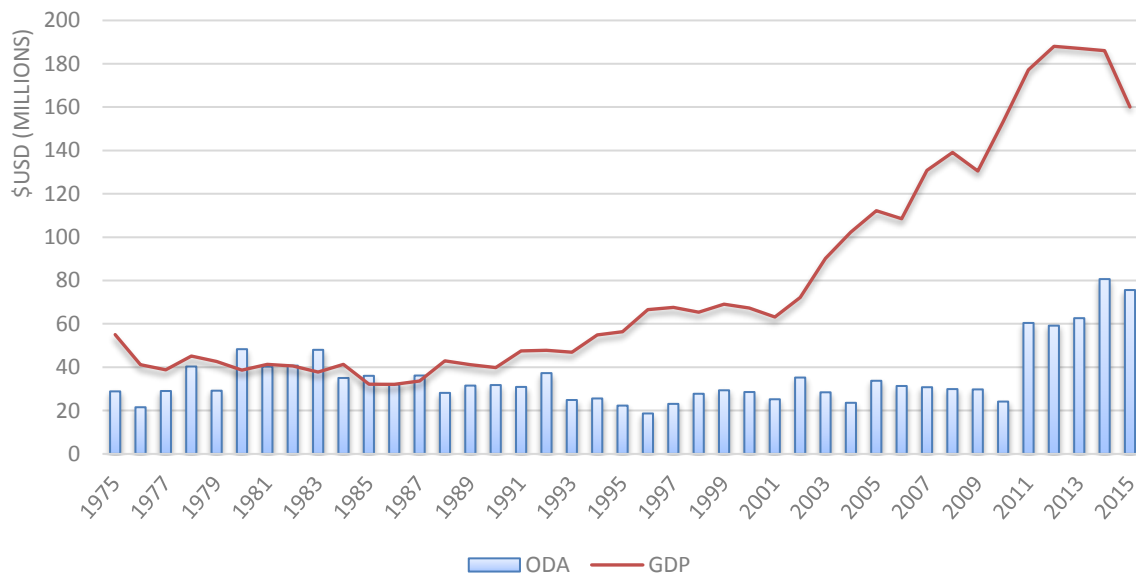
<sup>8</sup> We use Australian Dollar currency (AUD) throughout this paper, unless otherwise stated. AUD is the currency used by both Tuvalu and Kiribati.





Source: Data are from the World Bank Databank website (<http://databank.worldbank.org/data/>).

Figure 4: ODA and GDP for Kiribati



Source: Data are from the World Bank Databank website (<http://databank.worldbank.org/data/>).

PICs have received funding from other sources for climate change adaptation, mitigation, and resilience purposes. One of these sources are projects from the National Adaptation Programmes of Action (NAPA), which have provided limited funding assistance to some PICs like Tuvalu, Kiribati, Samoa, the Solomon Islands, and Vanuatu to enable effective responses

and adaptation to the effects of climate change.<sup>9</sup> Moreover, the Green Climate Fund (GCF) has approved a handful of projects for some PICs with the aim to assist vulnerable countries in building climate resilience, climate adaptation, and mitigation (see table 1).

Table 1: List of GCF Projects for the PICs

Approved	Number	Project	Country	Theme	Accredited Entity	Fund (USD\$ million)
11/2015	FP008	Fiji Urban Water Supply and Wastewater Management Project	Fiji	Cross-cutting	ADB	31
6/2016	FP015	Tuvalu Coastal Adaptation Project	Tuvalu	Adaptation	UNDP	36
12/2016	FP035	Climate Information Services for Resilient Development in Vanuatu	Vanuatu	Adaptation	SPREP	23
12/2016	FP036	Pacific Islands Renewable Energy Investment Program	Cook Islands	Mitigation & Adaptation	ADB	17
12/2016	FP037	Integrated Flood Management to Enhance Climate Resilience of the Vaisigano River Catchment in Samoa	Samoa	Adaptation	UNDP	57.7

Source: Green Climate Fund (GCF) website (<http://www.greenclimate.fund/projects/portfolio>).

Noy and Edmonds (2016) discuss risks in Pacific atoll islands and various financial instruments applicable to both ex-ante and ex-post disaster risk management: i) post-disaster budget provisions; ii) offshore funds; iii) contingent credit lines and multilateral loans and grants; iv) insurance for public assets; v) private insurance; vi) sovereign insurance, and vii) regional pooling of sovereign insurance.

### 3. Sovereign Wealth Funds

Alhashel (2015) discusses the recent popularity of SWFs, as they have amassed up to USD6.65 trillion in 2014.<sup>10</sup> Balding (2012) and Clark et al. (2013) focus on the management, politics, and economics behind them. However, there is very limited research on SWFs in the PICs.<sup>11</sup> Several PICs, including Kiribati, Tuvalu, Timor-Leste, Papua New Guinea, Nauru, Tonga, the Marshall Islands, Micronesia, and Palau have SWFs established from revenue sources ranging

<sup>9</sup> The preparation and implementation of NAPAs are financed by the Least Developed Countries Fund (LDCF). This fund supports the special needs of Least Developed Countries (LDCs) who are vulnerable to the adverse impacts of climate change (see Global Environment Facility Secretariat (2011)). Information on all NAPA Priority Projects are available on the United Nations Framework Convention on Climate Change (UNFCCC) website ([http://unfccc.int/adaptation/workstreams/national\\_adaptation\\_programmes\\_of\\_action/items/4583.php](http://unfccc.int/adaptation/workstreams/national_adaptation_programmes_of_action/items/4583.php)).

<sup>10</sup> The estimate was gathered from the Sovereign Wealth Fund Institute at <http://www.swfinstitute.org/fund-rankings/>. Similarly, when accessing <http://www.swfinstitute.org/sovereign-wealth-fund-rankings/> on the 15<sup>th</sup> November 2016, the total SWFs added up to USD7.3957 trillion, which is represented by Total oil and gas related (USD4.3213 trillion) and Total others (USD3.0744 trillion). In comparison, the USD0.7457 trillion increase from 2014 to 2016 is 11.21%.

<sup>11</sup> Limited quantitative research on SWFs in Pacific Island Countries partly due to strict access to data.

from non-renewable resources, revenue windfalls, and donor contributions. These funds have served their governments for short-term budget stabilization, long-term savings, and the improvement of self-reliance (see Le Borgne & Medas, 2007).

In general, structures (legal, institutional, and governance) and investment strategies vary between these SWFs.<sup>12</sup> These SWFs cover economic disturbances and long-term liabilities rather than natural shocks. Given the current circumstances of climate change and climatic disasters on Pacific Islands, the focus would need to be directed into the setting up of disaster funds if there are none, or contributing to existing disaster budget allocations.<sup>13</sup>

A globally accepted best practice for SWFs, such as the “Santiago Principles” can weigh how SWFs are performing in terms of good governance, accountability, transparency, and prudent investment practices.<sup>14</sup> The “Santiago Principles” consist of twenty-four Generally Accepted Principles and Practises (GAPP) that are supported by members of the International Working Group of Sovereign Wealth Funds (IWG)<sup>15</sup> as guidelines for proper, prudent and sound management of SWF. The International Working Group of Sovereign Wealth Funds (2008) broadly arranged the twenty-four GAPP into three pillars, namely: i) legal framework, objectives, and coordination with macroeconomic policies; ii) institutional framework and governance structure, and iii) investment and risk management framework.<sup>16</sup>

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<sup>12</sup> For instance, Tuvalu’s TTF operation and fiscal policy requires achieving certain sustainability benchmarks such as having balanced budgets on average over the medium term; budget deficits should be below 3 percent of GDP; assets in the CIF should be above 16 percent of the TTF’s assets over any four-year period; drawdown from the CIF that is compatible with the sustainability of TTF; and external debt should be below 60 percent of GDP (TTFAC Secretariat, 2003, 2006).

<sup>13</sup> Beyond this endeavour is the aim to sustain disaster funds into the long-term.

<sup>14</sup> The Principles were established in 2008 with inputs from the IMF, World Bank, OECD, and others.

<sup>15</sup> IWG consist of 26 IMF member countries with SWFs. The International Working Group of Sovereign Wealth Funds (2008) discusses the “Santiago Principles” in detail. The International Forum of Sovereign Wealth Funds (IFSWF) was an off spring of the ‘Kuwait Declaration’ in 2009, as the successor of the IWGSWF. IFSWF currently has 30 member countries.

<sup>16</sup> Furthermore, the International Forum of Sovereign Wealth Funds (2014) prescribed the “Santiago Principles” as follows: 1) sound legal framework; 2) well defined policy purpose and public disclosure of framework; 3) compliance with macroeconomic policies; 4) clearly defined policies and rules; 5) timely reporting and transparency to the owner(s); 6) clearly defined division of roles; 7) clear objectives and roles for governing bodies; 8) governing bodies to act in the best interest of the SWF; 9) independence and following procedures; 10) clear accountability framework; 11) timely annual reporting; 12) independent auditors; 13) upholding internal ethical standards; 14) clear outsourcing procedures; 15) compliance with rules of foreign countries; 16) clear governance framework; 17) public transparency; 18) clear investment policies and strategies; 19) investment decisions based on economic and financial grounds; 20) privileged information restrictions; 21) shareholder ownership rights policies; 22) reliable and effective risk management; 23) clear and proper reporting of performance, and 24) regular review of compliance with the “Santiago Principles”.

Table 2: Compliance with the Santiago Principles by Fund for selected PICs

	Countries (in descending order of compliance)			
	Timor-Leste (TLPF)	Tuvalu (TTF)	FSM & RMI (CTFs)	Kiribati (RERF)
2011 SWF Scoreboard*	73			
2013 SWF Scoreboard*	85			35
2014 Compliance Index Rating**	A			
2015 Rating***				
1. Legal Framework	Good	Good	Good	Good
2. Objectives and policy purpose	Good	Good	Good	Neutral
3. Domestic economic implications	Good	Good	Neutral	Good
4. Investment policy and risk management	Good	-	-	Poor
5. Governance framework	Good	Good	Good	Neutral
6. Professional and ethical standards, fiduciary and public responsibility	Neutral	Poor	Poor	Poor
7. Transparency	Good	Neutral	Neutral	Poor

*Source:* \* denotes scores (with a 100-point scale) calculated by Bagnall and Truman (2011, 2013), \*\* Santiago compliance index rating computed by GeoEconomica (2014), while \*\*\* refers to the rating classifications (Good, Neutral, Poor) determined by Edmonds (2015). “-” refers to insufficient information.

The Timor-Leste Petroleum Fund (TLPF) is the only SWF from the Pacific that is a member of the IWG. Not only has it performed well against the “Santiago Principles”, it has also improved over the years (see table 2). In contrast, the RERF has not performed well in 2013 relative to the other forty-eight SWFs assessed, with 19 points below the SWF average score (Bagnall & Truman, 2013). On the other hand, the TTF has not been thoroughly assessed in comparison to other SWF at the international level, but only at the Pacific regional level by Edmonds (2015), where he divided the twenty-four GAPP into seven<sup>17</sup> thematic areas and ranked the SWF for selected PICs including Timor-Leste, Tuvalu, Kiribati, the Federated States of Micronesia (FSM), and the Republic of the Marshall Islands (RMI). Table 2 shows that Tuvalu’s TTF was performing well overall in 2015, while underperforming in the categorised area 6. Likewise, Kiribati’s RERF was performing poorly in categorized areas 4, 6, and 7. The identified weaknesses should be key focus areas for improvement. Tuvalu on the other hand, requires a thorough assessment of its compliance to the “Santiago Principles” in the future.

<sup>17</sup> The 7 categorized areas are shown in Table 2.

However, with the inclusion of TTF contributions to the disaster fund, it will most likely deviate from the “Santiago Principles”.<sup>18</sup>

### 3.1 Tuvalu Trust Fund and the Revenue Equalizer Reserve Fund

The TTF is guided by its International Agreement for the Tuvalu Trust Fund with advice and monitoring from the TTFAC and Fund managers. According to the Tuvalu Government (2008, p. 6) “the purpose of the Fund is to contribute to the long-term financial viability of Tuvalu by providing an additional source of revenue for recurrent expenses of the Government of Tuvalu in order to: (a) assist the Government to achieve greater financial autonomy in the management of its recurrent budget; (b) enable the Government to maintain and if possible improve existing levels of social infrastructure and services; (c) enhance the capacity of the Government to receive and effectively utilize external capital development and technical assistance; (d) enable the Government to meet long-term maintenance and operating costs of social and economic infrastructure and services; and (e) assist the Government to develop the economy of Tuvalu”.

The RERF is a special fund under Section 107 of the Constitution where the Minister of Finance can directly wind up the Fund under section 13(2)(b) of the Public Finance (Control and Audit) Act.<sup>19</sup> Although we have not sighted<sup>20</sup> the objectives, mission, and policy purposes of the RERF, both the TTF and RERF, in general support their governments fiscally, providing reliable revenue sources (fiscal buffers) to offset recurrent national budget shortfalls and occasionally smoothing out relevant market fluctuations<sup>21</sup> when necessary.

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<sup>18</sup> Also, it does not state in the TTF Agreement.

<sup>19</sup> The Constitution and the Public Finance (Control and Audit) Act were both accessed on March 21<sup>st</sup>, 2017 through <http://www.paclii.org/ki/constitution/Kiribati%20Independence%20Order%201979.pdf> and [http://www.paclii.org/ki/legis/consol\\_act/pfaaa279/](http://www.paclii.org/ki/legis/consol_act/pfaaa279/). See Angelo et al. (2016) for more discussion on the overview of the SWF in the Pacific and how they are distinguished from one another.

<sup>20</sup> We assume that the information for RERF is either not publicly available or does not exist at all. However, in principle, the usage of RERF is reflected in their national budgets.

<sup>21</sup> The TTFAC Secretariat (2015, p. 11) identified potential “sources of fiscal risk from uncertainty include volatility in: 1) foreign exchange rates (notably USD/AUD), which affect several major USD-denominated revenue items (e.g. licence fees for fishing and ‘.tv, and the ROC budget support payments); 2) volume of traded items (e.g. fish harvested under a licence agreement); 3) market prices of traded items (e.g. VDS fishing days); 4) timing of cash flows (e.g. sales of various fishing licences); 5) capital markets (e.g. affecting

The TTF was formed in 1987 from initial investments from both donors and the national government, while the RERF was established purely from the national government’s contributions (Ministry of Finance & Economic Development, 2016; Toatu, 1993; Trease, 1993; TTFAC Secretariat, 2006, 2015; Tuvalu Trust Fund Board, 2007).

Figure 5: Tuvalu Trust Fund Resource Flow.

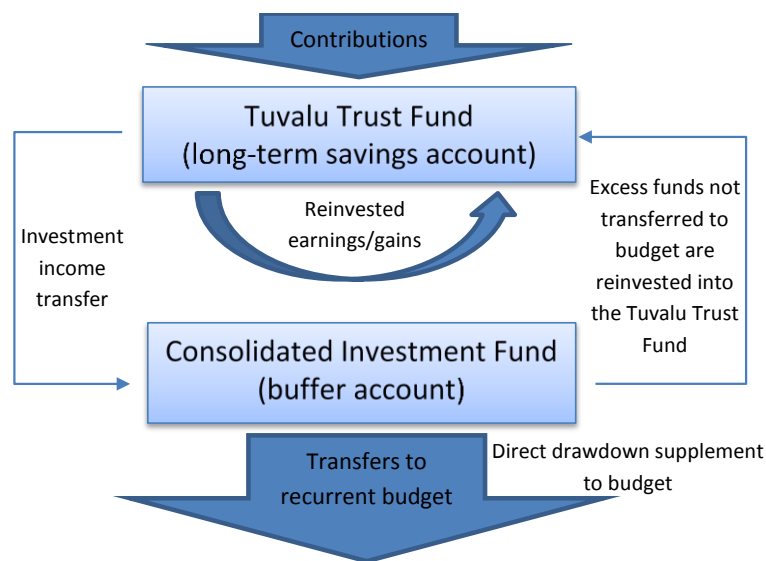
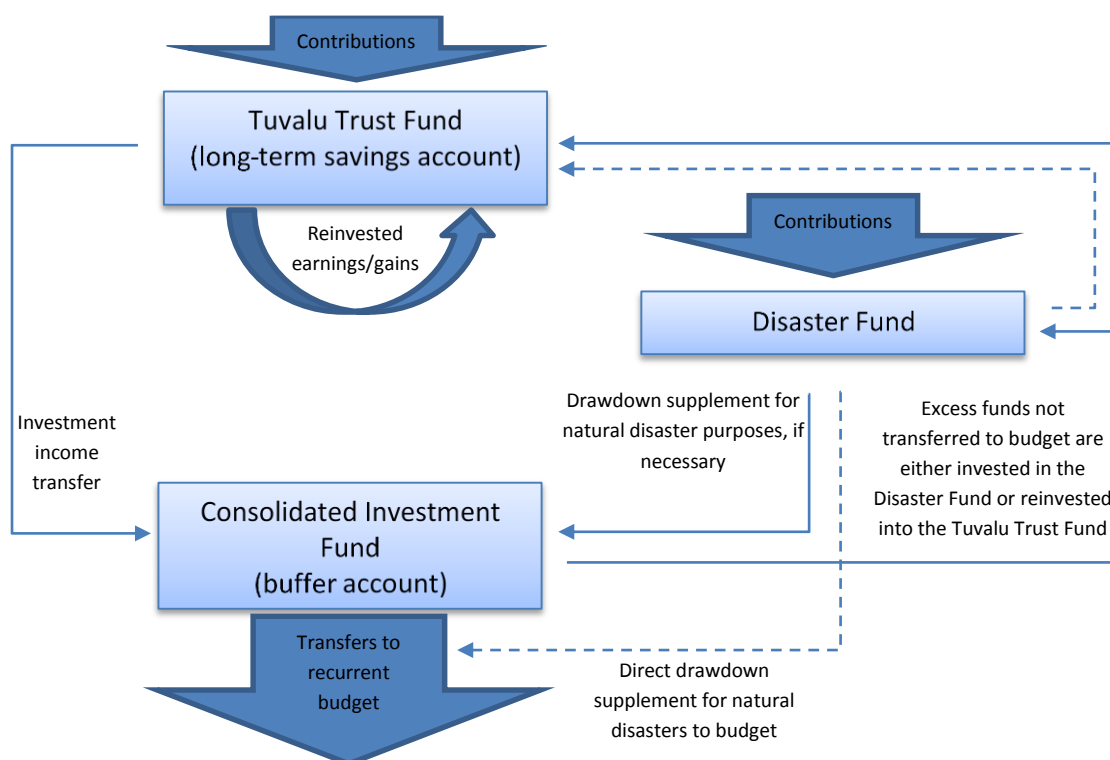


Figure 5 describes the current TTF structure that consists of contributions from the original donors and subsequent contributors including the Tuvalu government. Positive distributions or investment income are transferred to the Consolidated Investment Fund (CIF) for disbursement. The CIF acts as a buffer in the current structure.<sup>22</sup> Any excess of funds in the CIF that are not transferred to the government budget are either stored in the CIF or reinvested back into the TTF. Figure 6 shows a potential alternative structure for the SWF, proposing to connect the TTF to a disaster fund. In this proposal, the TTF will provide support to the disaster fund in terms of contributions.

investment returns); 6) demand driven, loosely constrained expenditure policies; and the incidence of random natural disasters affecting Tuvalu (e.g. Cyclone Pam).”

<sup>22</sup> Other Pacific Islands without SWFs and buffer accounts meet national budget deficits by borrowing at high interest rates.

Figure 6: Alternative Tuvalu Trust Fund Resource Flow.



One of the priority goals set out in the 2015 National Summit on Sustainable Development (NSSD) for Tuvalu is to protect the nation from the impacts of climate change through better resilience, mitigation, and adaptation. Parallel to this goal is the commitment of the government to establish in its national budget the ‘Tuvalu Survival Fund’, to financially support the building of resilience in communities, disaster response, and climate proofing infrastructure (Ministry of Finance & Economic Development, 2016).<sup>23</sup> Kiribati has a disaster fund in place.

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.<sup>24</sup> Suggestions have further emerged on the

<sup>23</sup> At the wake of TC Pam, the political will to establish a disaster fund known as the ‘Tuvalu Survival Fund’ surfaced.

<sup>24</sup> 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>).

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. Currently, the TTF is quite instrumental in providing responses to external economic shocks, but excludes natural disasters from its mandate. It could be argued that the TTF (or the CIF) should complement current preparation and response efforts to climatic disasters.

In relation to managing the performance of these funds, global market uncertainties and volatilities remains an issue. However, Tuvalu and Kiribati are mindful that strong fiscal performance can be attributed to projected fiscal surpluses, increase in revenues from grants and fishing licenses, and increasing contributions into their funds. Apart from other revenue sources, both countries earn from tuna catches, through fisheries agreements for foreign vessels to fish in their sea territories.

#### **4. Data and Methods**

We employed the Monte Carlo (MC) simulation method and an Auto-Regressive Integrated Moving Average (ARIMA) model to forecast the future of the TTF and RERF. The MC simulation method was used to model the probability of possible outcomes while the forecasting technique of the ARIMA model enabled us to project future values and/or trends 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.<sup>25</sup> Annual reports on the Funds and the national budgets were also used to complement these data.<sup>26</sup>

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<sup>25</sup> Data for RERF were gathered from both the Ministry of Finance & Economic Development and their official website (<http://www.mfed.gov.ki/>).

<sup>26</sup> Other Pacific Islands with SWFs were also approached for their data, but declined.



## 4.1 Monte Carlo Simulation Method

The MC simulation (or stochastic sampling) method generates random numbers with a given probability distribution.<sup>27</sup> Wulfsohn (2015) analysed the impact of investment 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.<sup>28</sup> 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).<sup>29</sup> 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,<sup>30</sup> assuming that we calculate the

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<sup>27</sup> 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 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.

<sup>28</sup> 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.

<sup>29</sup> 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.

<sup>30</sup> 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).

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

## 4.2 ARIMA Models

We used the ARIMA model proposed by Box and Jenkins (1970), which is an extension of the Auto-Regressive Moving Average (ARMA) model.<sup>31</sup> The ARMA is the combination of Auto-Regressive (AR) and Moving Average (MA) models (thus it combines both  $p$  autoregressive terms and  $q$  moving average terms), both of which model lagged values of  $y_t$  and  $\varepsilon_t$  past errors as predictors (see e.g., Diebold, 2006). The first component in the ARMA model is the AR model, where the value in a period is related to its values in previous periods. Hence,  $AR(p)$  is an autoregressive model with  $p$  lags where  $y_t = \mu + \varepsilon_t + \sum_{i=1}^p \gamma_i y_{t-i}$ . The second component is the MA model, which accounts for the relationship between a variable in a period and the residuals in previous periods. Therefore,  $MA(q)$  is a model of moving average with  $q$  lags, where  $y_t = \mu + \varepsilon_t + \sum_{i=1}^q \theta_i \varepsilon_{t-i}$ . Hence, we arrive on the ARIMA model where  $d$  is the required degree of differencing to make the series stationary (the number of times the data have had past values subtracted), for instance, a first order difference in  $y_t$  is the differenced variable  $\Delta y_t = y_t - y_{t-1}$  (Box & Jenkins, 1970; 1976; Hyndman & Athanasopoulos, 2014). Therefore, an  $ARIMA(p, d, q)$  represents a model with  $p$  autoregressive lags,  $q$  moving average lags, and a difference in the order of  $d$  as given in Equation 1:

$$y_t^d = \mu + \sum_{i=1}^p \gamma_i y_{t-i}^d + \varepsilon_t + \sum_{i=1}^q \theta_i \varepsilon_{t-i} \quad \text{Equation 1.}$$

Here, values of our dependent variable  $y$ , measured in time,  $t$ , that is represented by  $y_t$  are affected by the values of  $y$  in the past (or lags),  $\mu$  is a constant,  $\gamma_p$  is the coefficient for the

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<sup>31</sup> ARIMA is sometimes referred to as the integrated ARMA model. See Diebold (2006) for detail discussions on AR, MA, and ARMA models.

lagged variable in time  $t - p$ ,  $\varepsilon_t$  is the error term at time  $t$ , and  $\theta_q$  is the coefficient for the lagged error term in time  $t - q$ .

The stationarity condition is a requirement in modelling an  $ARMA(p, q)$  process, where the mean and variance does not change over time and the process does not have trends. When this condition is unmet, then non-stationarity is evident in the data and we cannot use ARMA. However, we can resort to the Box-Jenkins procedures (see Box & Jenkins, 1976) by using an ARIMA model (see equation 1), which is the reason we chose ARIMA instead of ARMA.<sup>32</sup> We follow the Box-Jenkins method for ARIMA model selection in our diagnostics, where we use the Dickey-Fuller tests for stationarity<sup>33</sup>, Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) for correlations, and Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) measures for goodness of fit of the model (see Box & Jenkins, 1976; Makridakis, Wheelwright, & Hyndman, 1997).

## 5. 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.

### 5.1 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.<sup>34</sup> 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

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<sup>32</sup> The Box-Jenkins procedures follows the four steps: 1) preliminary transformation; 2) identification; 3) estimation of the model, and 4) diagnostic checking. Makridakis et al. (1997) further discusses the use of Box-Jenkins methods for ARIMA models, while Nasiru & Olanrewaju (2015) employed these methods.

<sup>33</sup> This procedure requires the differencing of the time series until it is stationary, this will ensure the removal of any trend or seasonal components.

<sup>34</sup> 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.

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 loss and damages for Tuvalu at 10% of GDP based on both the ADB (2015) and Taupo & Noy (2016)<sup>35</sup>. 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.<sup>36</sup> According to the World Bank (2016), a Category 5 cyclone has been a 1 in 10 year event<sup>37</sup> for Fiji, Tonga and Samoa, while the cyclone return period for the Solomon Islands and Vanuatu is 1 in 5 year event.<sup>38</sup> In this connection, we used a 1 in 10 year scenario for our distant cyclone calculations.<sup>39</sup> 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%)

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<sup>35</sup> 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.

<sup>36</sup> 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.

<sup>37</sup> 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.

<sup>38</sup> 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)."

<sup>39</sup> 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).

for Tuvalu.<sup>40</sup> Similarly, we also adjusted the AAL for Kiribati to include distant cyclones, which amounted to \$1,219,704 (or an increase by 221%).<sup>41</sup>

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 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)<sup>42</sup>; 2) adjust for the cyclone damage related to the 3.8<sup>th</sup> 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.<sup>43</sup> 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.<sup>44</sup> Similarly, Kiribati will likely incur an overall AAL of \$1,567,461.<sup>45</sup>

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<sup>40</sup> 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).

<sup>41</sup> 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).

<sup>42</sup> Noy (2016) calculations on changes in frequency and intensity of cyclones are based from Siqueira et al. (2014).

<sup>43</sup> Since the cyclone intensity is about 30% stronger and the cyclone frequency is only -2%.

<sup>44</sup> 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<sup>3.8</sup> 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.

<sup>45</sup> Likewise, for Kiribati, we multiplied straight the distant cyclone AAL of \$840,301 with 1.09<sup>3.8</sup> 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.

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.<sup>46</sup> According to the DesInventar Database, Tuvalu suffered monetary losses of USD\$15 million due to the drought in 1998, which was around 117% of GDP.<sup>47</sup> 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.<sup>48</sup> 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.<sup>49</sup> Hereafter, the adjusted overall AALs for Tuvalu and Kiribati now correspond to \$1,021,879 and \$2,075,112, respectively.

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 A1). 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.<sup>50</sup> These AALs corresponds to 2.45% of GDP for Tuvalu and 1.06% for Kiribati.

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<sup>46</sup> 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.

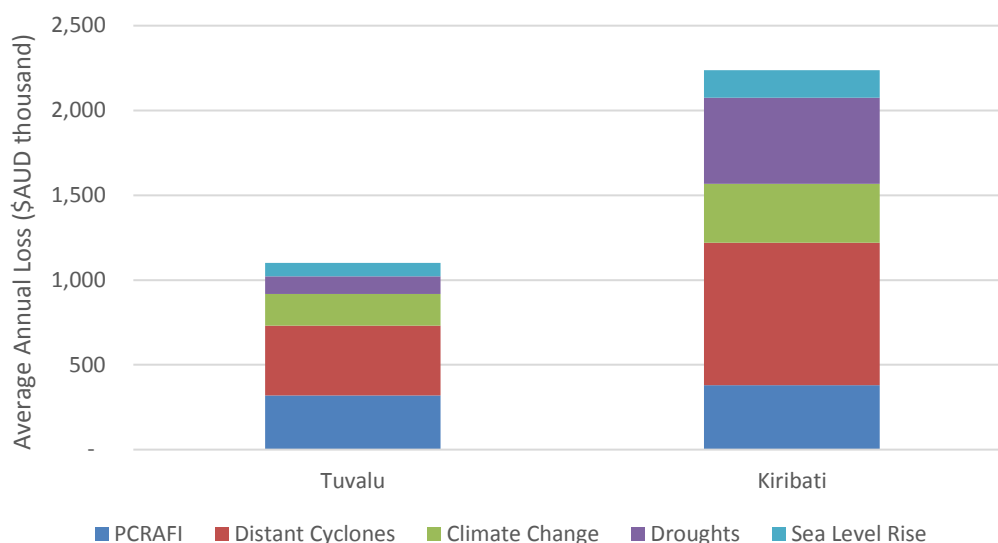
<sup>47</sup> DesInventar database also recorded the 2011 drought, but with no monetary losses. The EM-DAT database did not record the 2011 drought for Tuvalu, but recorded the 2009 drought for Kiribati.

<sup>48</sup> 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.

<sup>49</sup> 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%.

<sup>50</sup> Multiplied overall AAL with 1.078.

Figure 7: Annual Average Loss (AAL) Adjustments for Tuvalu and Kiribati.



Source: Author's calculations.

Figure 7 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.<sup>51</sup> 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.

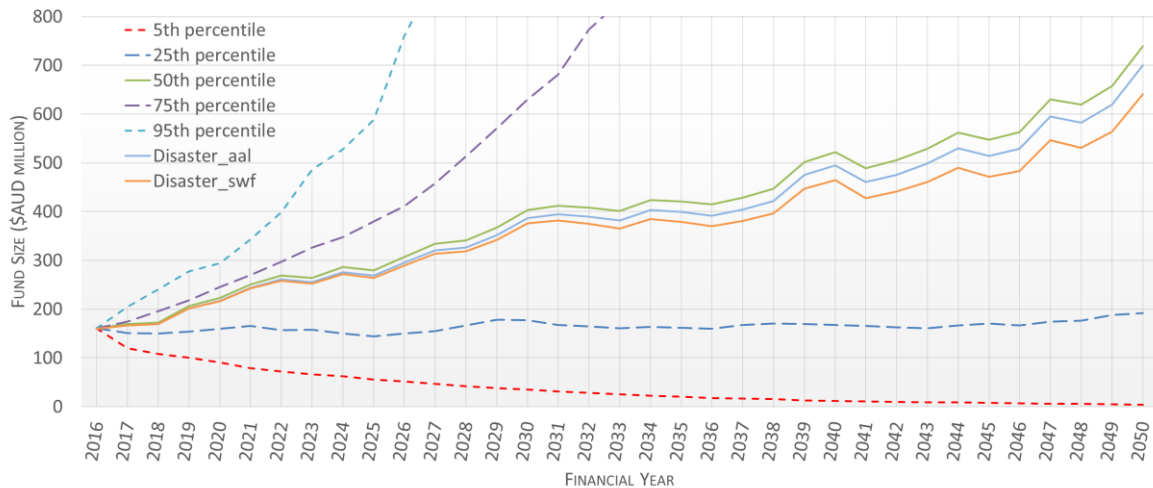
## 5.2 Investment Return Simulation

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 8 and Figure 9 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 95<sup>th</sup> percentile line can be interpreted as having 95% of simulations below it (and 5% simulations above). Likewise, 5% of simulations are below the 5<sup>th</sup> percentile line (and 95% simulations above). The median is represented by the 50<sup>th</sup> percentile. A customary perception for an investment portfolio is

<sup>51</sup> These figures are direct contributions from the TTF to the disaster fund in 2016 prices, excluding other contributions from other potential sources.

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 8 and figure 9).

Figure 8: TTF forecasted performance from 2017 to 2050 with contributions to the Disaster Fund.



Source: Authors’ calculations and modelling. The disaster\_aal is the 50<sup>th</sup> 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 50<sup>th</sup> 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.

As well as the forecasted median (50<sup>th</sup> percentile) of the SWF without any contributions to a disaster fund in Figure 8 and Figure 9, we added two other forecasted median scenarios, namely: 1) *Disaster\_aal* (unbroken blue line) representing the 50<sup>th</sup> percentile with contributions to a disaster fund using the adjusted AAL as the annual contribution over time; and 2) *Disaster\_swf* (unbroken orange line) representing the 50<sup>th</sup> percentile with contributions to a disaster fund derived from the adjusted AAL in relation to the SWF. The adjustments in (2) correspond to annual contributions as a percentage of the SWF.<sup>52</sup> 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.<sup>53</sup> Figure 8

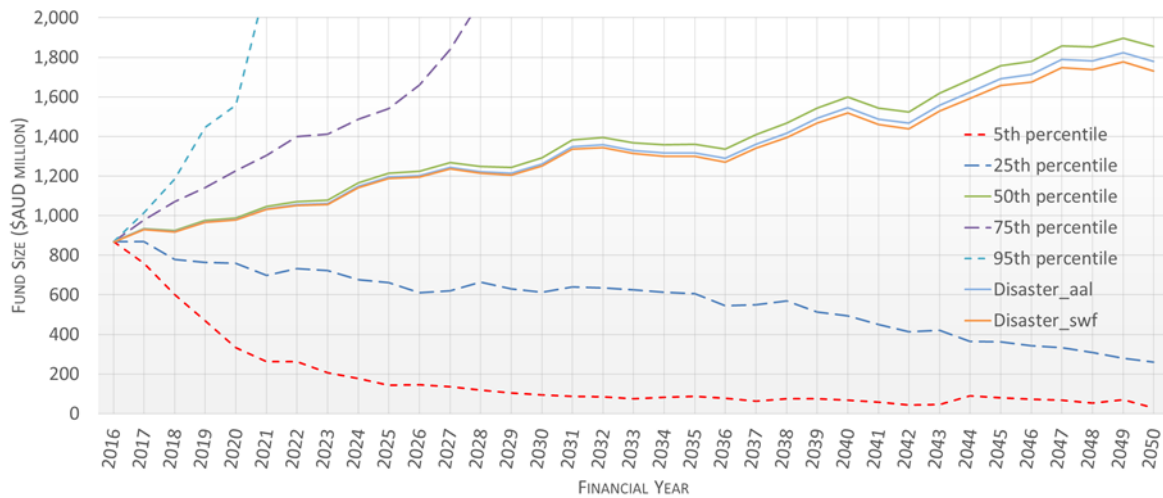
<sup>52</sup> We used the adjusted AAL as a percentage of SWF size in 2016 values for our annual contribution (i.e. 0.685% and 0.288% for TTF and RERF, respectively), thus continuously using this percentage over time, therefore the annual contributions changes over time based on the SWF size, which is sustainable in a sense.

<sup>53</sup> 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 23<sup>rd</sup> of March,



and Figure 9 reveal that the TTF and RERF have around a 50% chance of reaching \$0.73 billion and \$1.73 billion by 2050, respectively.<sup>54</sup>

Figure 9: RERF forecasted performance from 2017 to 2050 with contributions to the Disaster Fund.



Source: Authors' calculations and modelling. The disaster\_aal is the 50<sup>th</sup> 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 50<sup>th</sup> 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.

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. To further substantiate this argument, we plotted the ratio of the SWFs to projected GDP to examine how sustainable the size of the SWFs will be in relative to the GDP (see Appendix Figure 3 and Figure 4). However, contributing to disaster funds from a SWF poses risks to the growth and development of SWF itself.

2017, which was accessed on a live stream of the radio Tuvalu on <http://listen28radiocom.radiostream321.com/>. Based on the model, Figure 8 shows that the TTF has about 50% chance of meeting the Government's aim to reach \$200 million by 2020.

<sup>54</sup> TTF is much larger than RERF in per capita terms.

### 5.3 ARIMA Models

To formally test for stationarity for both TTF and RERF data, we used the Dickey Fuller test, with which the results showed that the original variables are not stationary, but that the differences variables are stationary (see table A1)<sup>55</sup>. Therefore, we resorted to the ARIMA model (as oppose to the ARMA model) where we used differences  $d = 1$ . Based on our selection criteria (see table A2 and table A3), we chose our parsimonious models of ARIMA (1,1,1)<sup>56</sup> and ARIMA (1,1,3) to forecast the TTF and RERF, respectively, since they both have significant coefficients and lowest AIC and BIC that indicate goodness of fit of the models. The regression equations for ARIMA(1,1,1) and ARIMA(1,1,3) for the TTF and RERF, respectively, are shown below:

$$y_t^1 = 4,558,357.1 + 0.89y_{t-1}^1 + \varepsilon_t - \varepsilon_{t-1} \quad \text{Equation 2 (TTF)}$$

$$y_t^1 = 20,553,135.9 + 0.677y_{t-1}^1 + \varepsilon_t - 0.632\varepsilon_{t-1} + 0.328\varepsilon_{t-2} - 0.696\varepsilon_{t-3} \quad \text{Equation 3 (RERF)}$$

Using the ARIMA model with 30 and 33 observations for the TTF and RERF respectively, we were able to generate forecasts for 10 periods (commencing from 2017 to 2026) out into the future with 90% confidence limits for both funds (see figure 10 and figure 11).<sup>57</sup> As expected, the forecast bands widen as we move further into the forecast horizon. These forecasts show how SWFs are likely to perform with or without the inclusion of contributions to disaster funds.

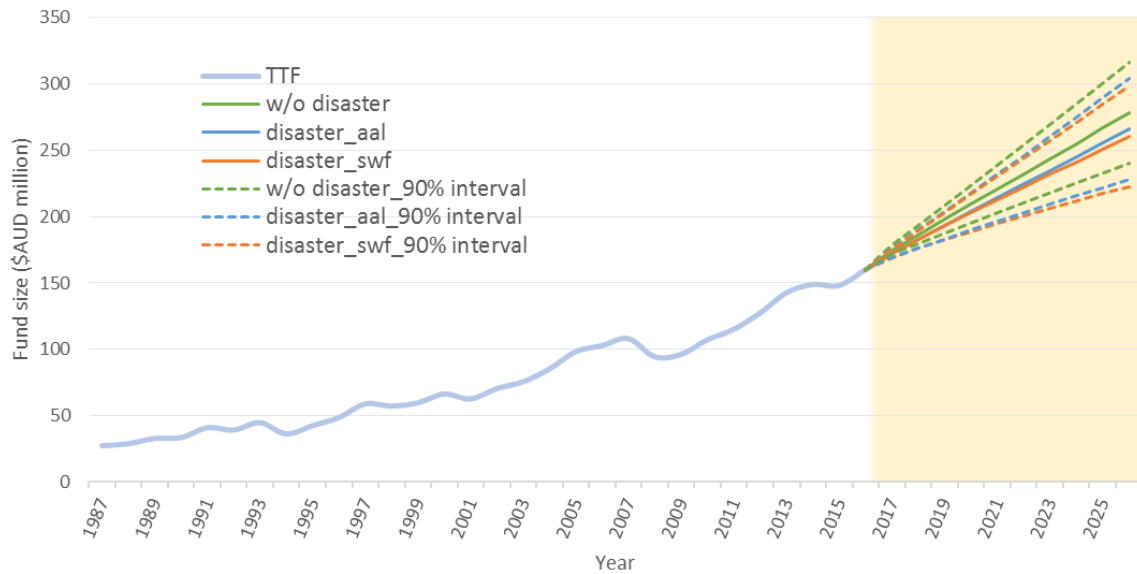
Figure 10: TTF forecast performance from 2017 to 2026 using the ARIMA model.

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<sup>55</sup> For TTF, we have  $\Delta y_t$  as our dependent variable and the independent variable is the first lag of  $y_t$  which is  $y_{t-1}$  where the coefficient of 0.0401 (see Table A1) is statistically insignificant, therefore it is not significantly different from 0. Therefore, the variables are non-stationary. Similarly, RERF has original variables that are not stationary. However, both  $y_{t-1}$  coefficients for TTF (-0.97) and RERF (-0.764) are highly significant, thus indicating that the variables are stationary.

<sup>56</sup> For example, an ARIMA(2,1,3) is where 2 is the order of the autoregressive, 1 indicates the order of difference and 3 is the order of the moving average process.

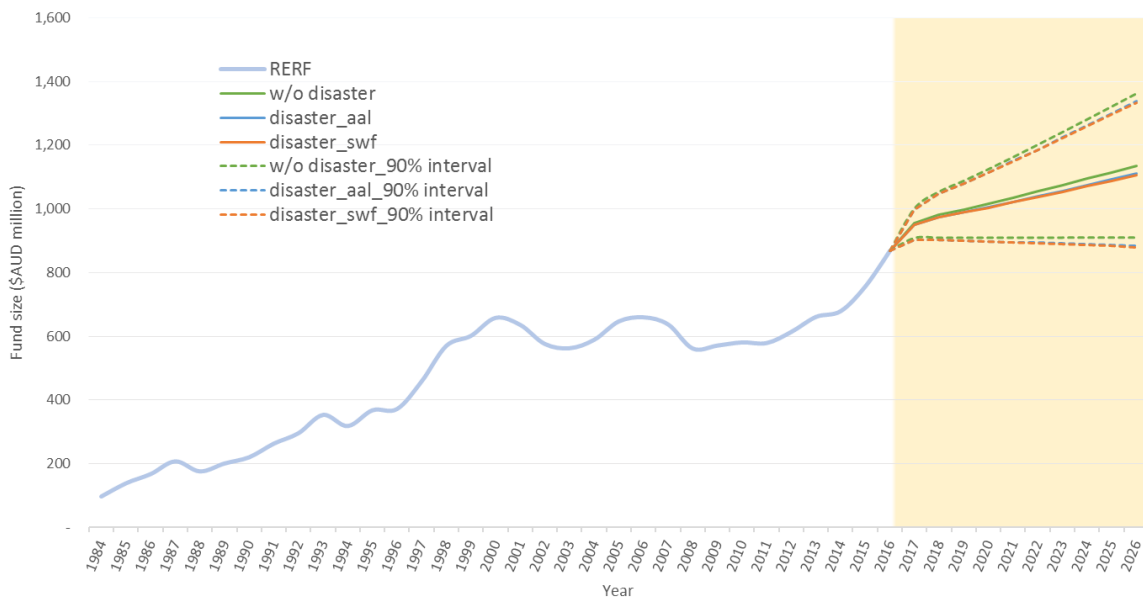
<sup>57</sup> We also generated forecasts of 34 periods from 2017 to 2050, but these may not be reliable given the limitations of our observations.



Source: Authors' calculations and modelling. The *disaster\_aal* is the 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 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.

Like most other SWFs, both portfolios are vulnerable to economic shocks, as was evident during the global financial crisis of 2007-2008 (see figure 10 and figure 11). The *w/o disaster* (in green colour) is the expected path of the SWF without annual contributions into the disaster fund. The *disaster\_aal* (unbroken blue colour) is the expected path where the TTF contributes the amount equivalent to the adjusted AAL annually into the disaster fund. Likewise, *disaster\_swf* (unbroken red colour) represents the expected path of an alternative scenario with contributions to the disaster fund derived from the adjusted AAL as a percentage to SWF, which may vary over time depending on SWF size. Nevertheless, both the TTF and RERF have positive trends that indicate sustainability. We also plotted the ratio of the SWFs to projected GDP to further examine how sustainable the size of the SWFs will be in relative to the GDP (see Appendix Figure 5 and Figure 6).

Figure 11: RERF forecast performance from 2017 to 2026 using the ARIMA model.



Source: Authors' calculations and modelling. The disaster\_aal is the 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 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 impact of the global financial crises of 2008/2009 was evident in the sharp fall of GDP (see figure 3 for Tuvalu) in 2009 and SWF sizes (see figure 10 for the TTF and figure 11 for RERF) in those periods. In 2010 it quickly recovered, and continued to increase in 2011 (see figure 3 for the 2011 drought period) when it started to increase at a decreasing rate. Following the 2011 drought event, GDP levels decreased until they were hit by another disaster (see figure 3 for TC Pam). Similarly, the TTF quickly recovered from a drop in 2008 and 2009, bouncing back in 2010, and has been increasing over time.<sup>58</sup> It is noticeable in Figure A2 that the TTF received the highest donor contributions in 2010 (AUD\$3.6 million) and 2011 (AUD\$4 million), excluding the outlier in 1987 when TTF was established.<sup>59</sup> There were no contributions from the government in those years, hence giving room for the government to divert or reallocate monies into accelerating other priorities and development projects.

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

<sup>58</sup> It took 5 years for RERF to recover back to normal and progress onwards (see Figure 10). Part of the problem was that from 2003 to 2013, the government withdrew annually without contributing into the RERF.

<sup>59</sup> Over time, the average annual donor contributions into TTF is AUD\$1.04 million.

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.

## 6. 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 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 23<sup>rd</sup> 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.<sup>60</sup> 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.<sup>61</sup> 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.<sup>62</sup> 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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<sup>60</sup> 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).

<sup>61</sup> 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.

<sup>62</sup> 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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## 8. Appendix

Table A1: Dickey-Fuller Tests

	TTF ( <i>D.y</i> or $\Delta y_t$ )	TTF ( <i>D2.y</i> or $\Delta\Delta y_t$ )	RERF ( <i>D.y</i> or $\Delta y_t$ )	RERF ( <i>D2.y</i> or $\Delta\Delta y_t$ )
<i>L.y</i> or $y_{t-1}$	0.0401 (0.0324)		-0.0414 (0.0367)	
<i>LD.y</i> or $\Delta y_{t-1}$		-0.970*** (0.202)		-0.764*** (0.180)
_cons	1562042.1 (2739254.4)	4595519.6*** (1537342.6)	40306992.2** (18401249.2)	15530515.0* (8212269.5)
<i>N</i>	29	28	32	31

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Source: Authors' estimations from TTF and RERF data

Table A2: Selected ARIMA models for TTF

	ARIMA (1,1,0)	ARIMA (1,1,1)	ARIMA (0,1,1)
TTF			
_cons	4605834.9*** (1508774.7)	4558357.1*** (1546884.8)	4618443.1*** (1505470.3)
ARMA			
L1.ar	0.0281 (0.327)	0.890** (0.394)	
L1.ma		-1.000 (112.9)	0.0255 (0.331)
sigma			
_cons	6382380.5*** (831111.7)	6201262.6 (349014100.7)	6378794.1*** (827276.1)
<i>N</i>	29	29	29
<i>AIC</i>	997.07	996.40	997.07
<i>BIC</i>	1001.17	1000.87	1001.17

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Source: Authors' estimations from TTF and RERF data

Note: L1.ar is the first lag of the autoregressive part and L1.ma is the first lag of the moving average component.

Table A3: Selected ARIMA models for RERF

	ARIMA	ARIMA	ARIMA
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	(1,1,3)	(2,1,1)	(2,1,2)
<b>RERF</b>			
_cons	20553135.9*** (3413232.1)	20304646.1*** (3578388.4)	21073122.4** (8967142.3)
<b>ARMA</b>			
L1.ar	0.677*** (0.231)	1.142*** (0.200)	0.970*** (0.289)
L2.ar		-0.292 (0.198)	-0.862*** (0.258)
L1.ma	-0.632* (0.367)	-1.000*** (0.310)	-0.743** (0.377)
L2.ma	0.328 (0.232)		0.803 (0.514)
L3.ma	-0.696*** (0.246)		
<b>sigma</b>			
_cons	33671439.8	36538536.3	35404298.1*** (7327269.8)
<i>N</i>	32	32	32
<i>AIC</i>	1212.91	1214.91	1216.06
<i>BIC</i>	1220.24	1220.77	1224.86

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Source: Authors' estimations from RERF data

Note: L1.ar is the first lag of the autoregressive (AR) part, L2.ar is the second lag of the AR part, L1.ma is the first lag of the moving average (MA) component while L2.ma refers to the second lag of the MA part, and L3.ma is the third lag of the MA component.

Figure A1: Flood Areas by sea-level on Funafuti Island.

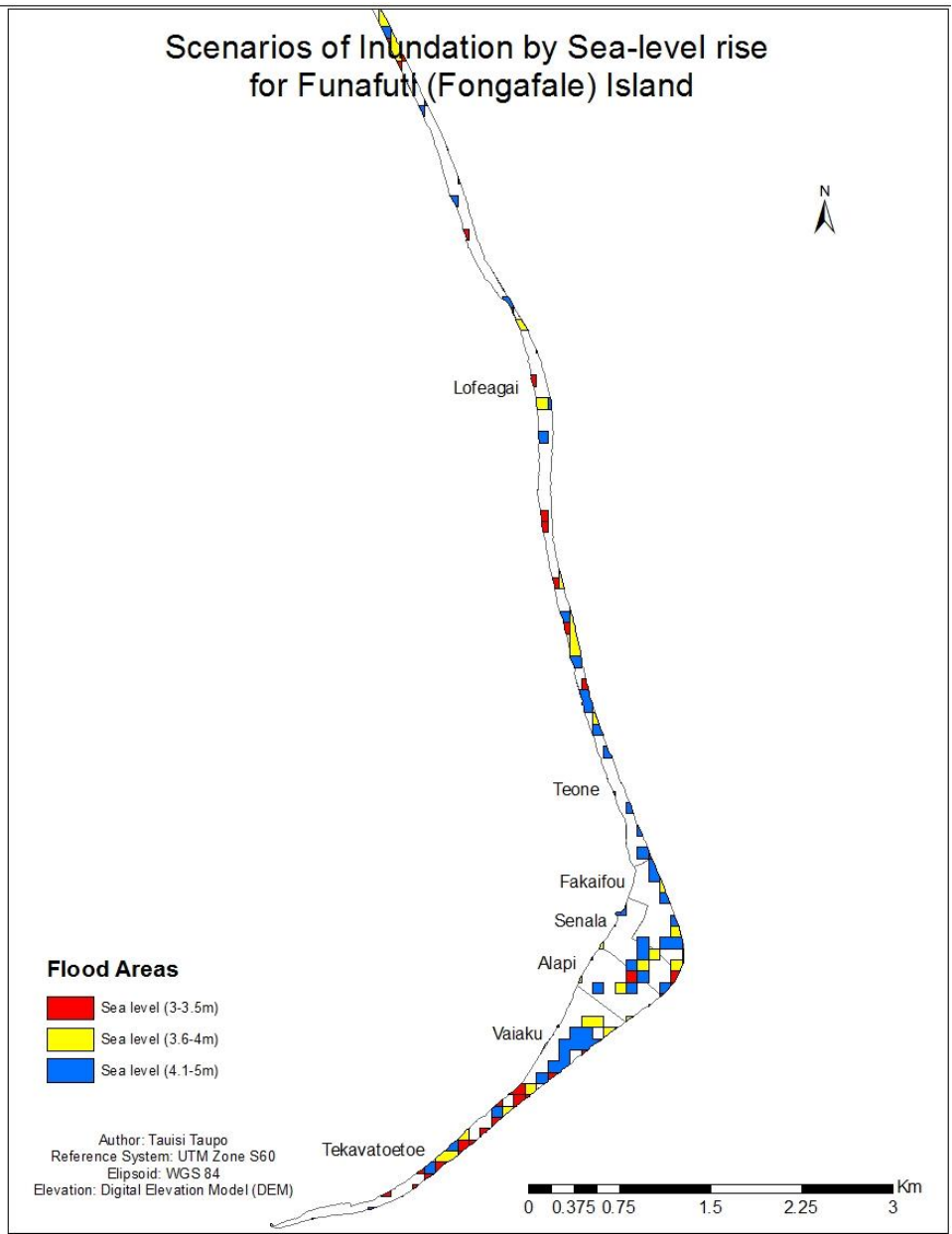
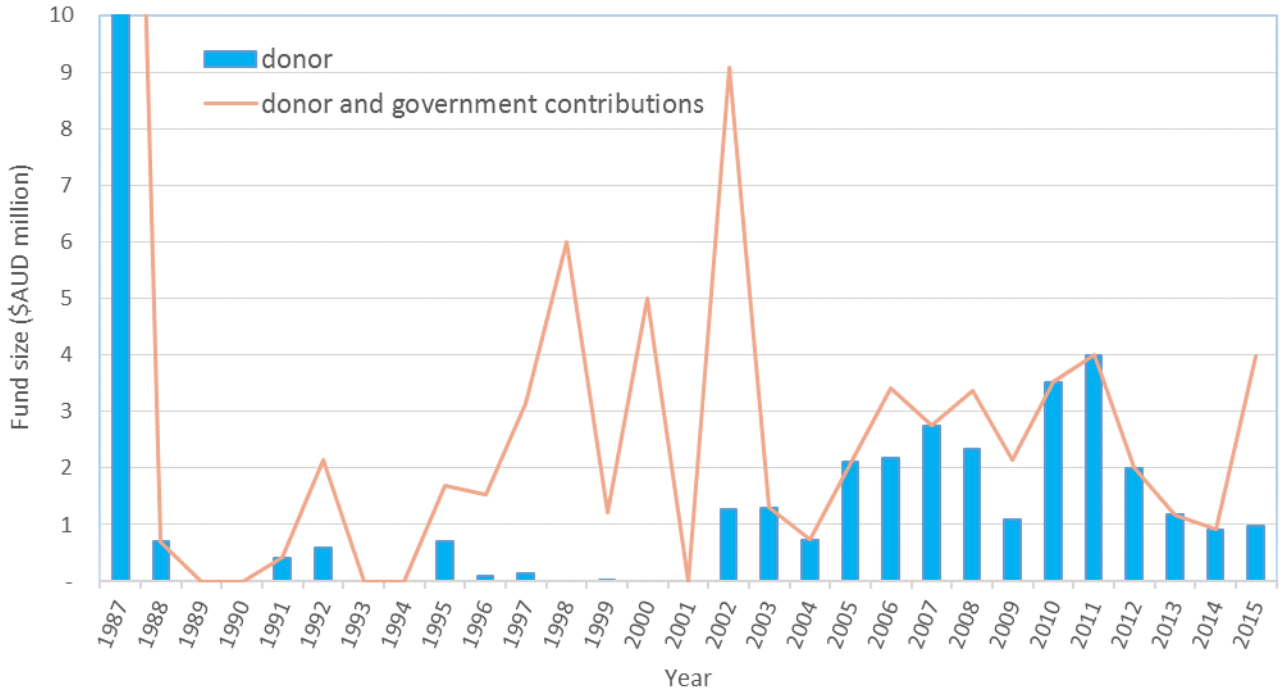
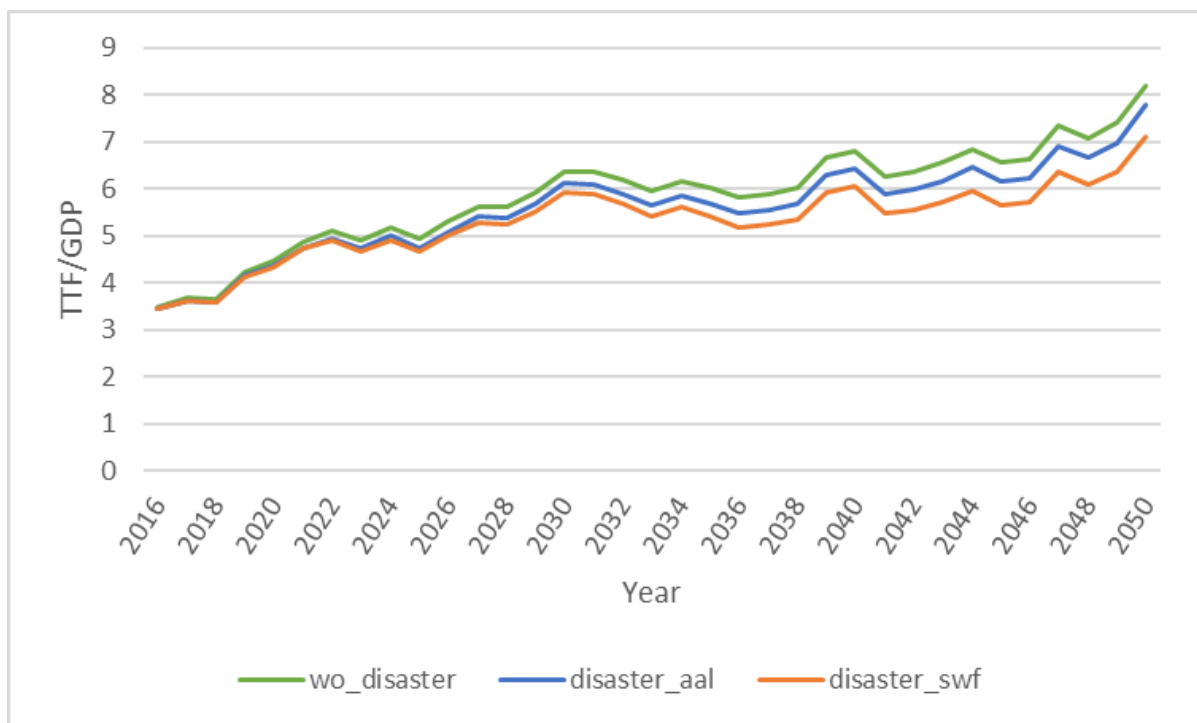


Figure A2: Contributions to the TTF.



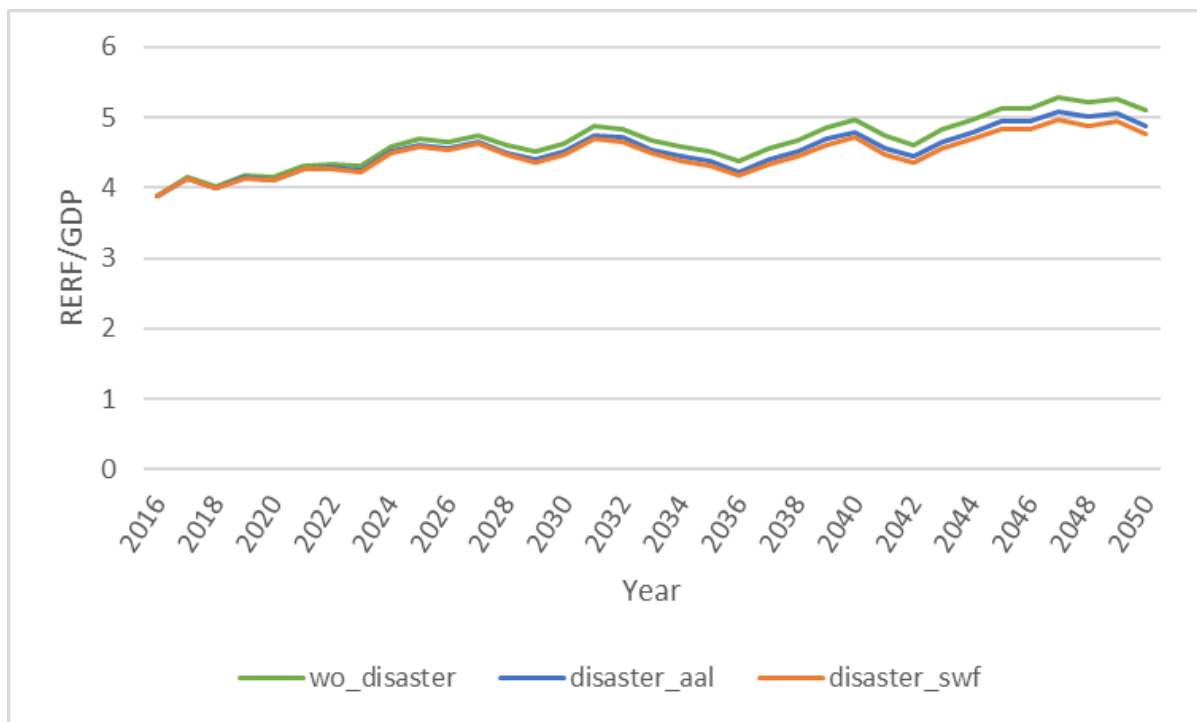
Source: TTF Advisory Committee Reports and National Budgets. Note that the outlier (1987) goes up to about AUD\$24 million, which was when the TTF was established.

Figure A3: TTF vs GDP under MC Simulation.



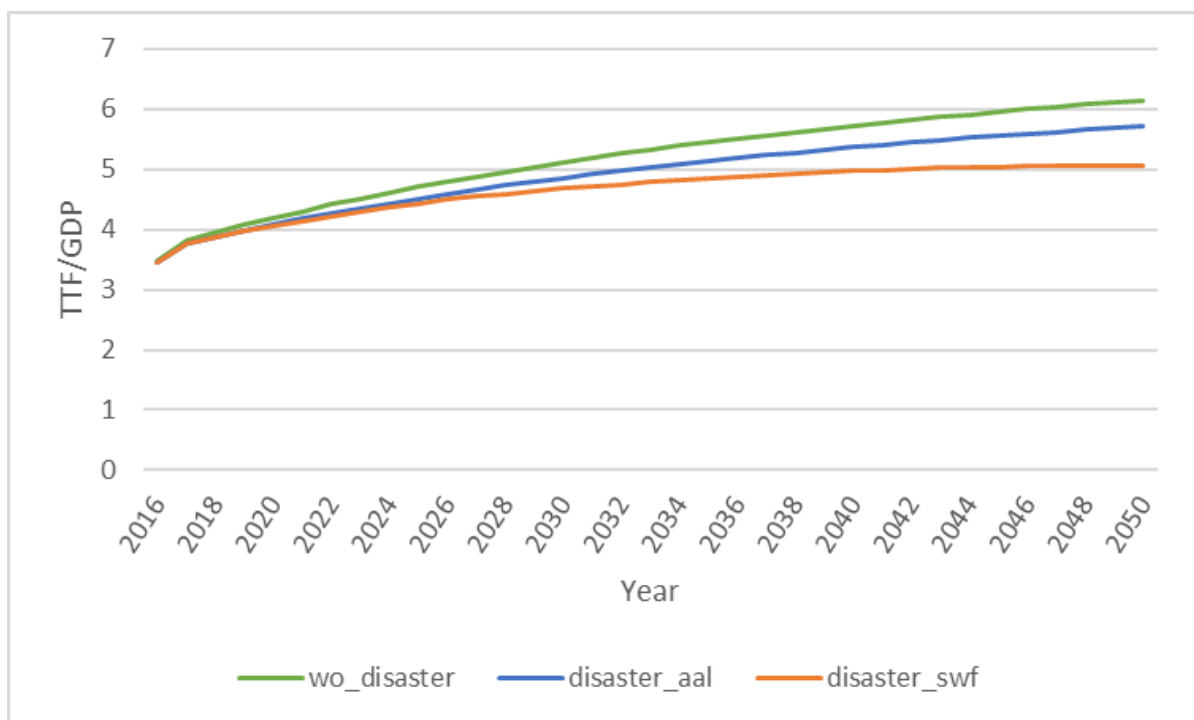
Source: Author's calculations.

Figure A4: RERF vs GDP under MC Simulation.



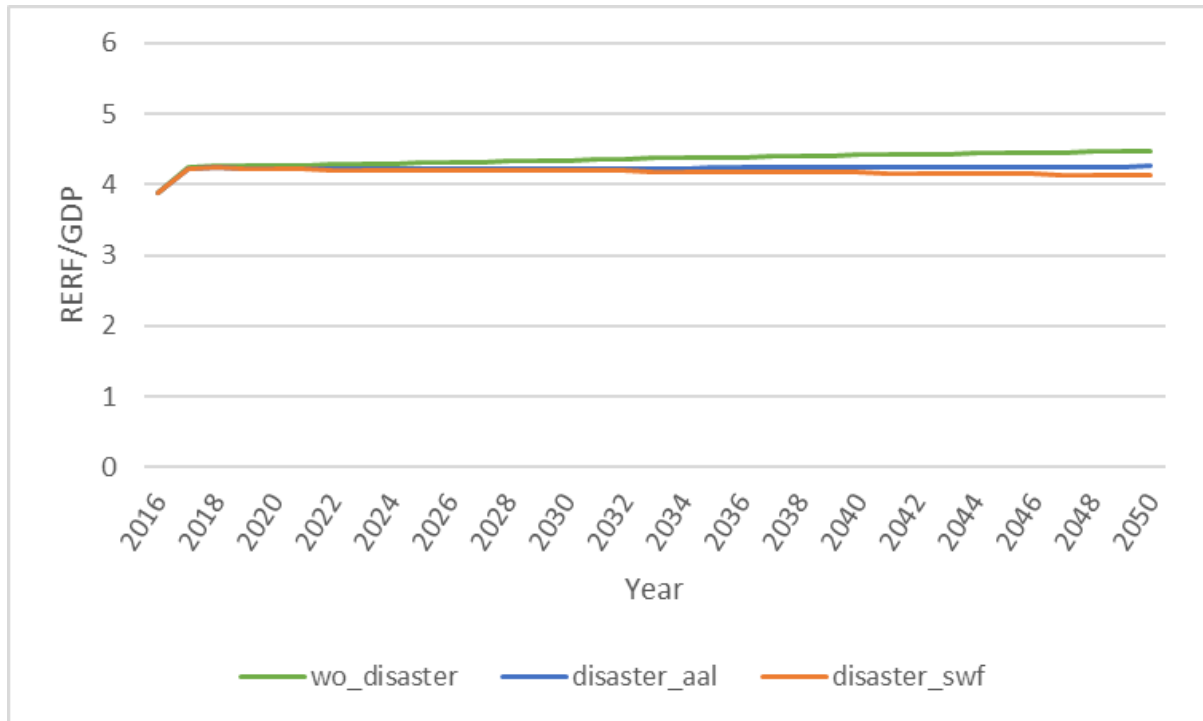
Source: Author's calculations.

Figure A5: TTF vs GDP under ARIMA.



Source: Author's calculations.

Figure A5: RERF vs GDP under ARIMA.



Source: Author's calculations.



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