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Pacific Catastrophe Risk Insurance Pilot

FROM DESIGN TO IMPLEMENTATION

Some Lessons Learned

GFDRR WORLD BANK GROUP JICA

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Acknowledgments

This report has been jointly prepared by the Japanese International Cooperation Agency (JICA) and the World Bank—Global Facility for Disaster Reduction and Recovery (GFDRR) Disaster Risk Financing and Insurance (DRFI) Program.

The DRFI team is grateful to JICA for its continued interest in the Pacific DRFI Program. This paper will serve to inform the program's design and implementation in the future.

About the Pacific Catastrophe Risk Insurance Pilot: The Pacific Catastrophe Risk Insurance Pilot is designed to increase the financial resilience of Pacific Island Countries (PICs) against natural disasters by improving their capacity to meet post-disaster funding needs. This is done by using insurance to access immediate cash in the aftermath of a disaster. The pilot began in January 2013 and will enter its fourth season on November 1, 2015. The pilot is one of two components of the DRFI program. The second component focuses on advising PICs on the public financial management of natural disasters, including:

(i) the development of a national disaster risk financing strategy that recognizes the need for ex ante and ex post financial tools;

(ii) post-disaster budget execution to ensure that funds can be accessed and disbursed easily in the event of a disaster; and

(iii) the insurance of key public assets to contribute to post-disaster reconstruction financing.

About the Pacific Catastrophe Risk Assessment and Financing Initiative: The Pacific DRFI Program is part of the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI), a joint initiative of the World Bank, Secretariat of the Pacific Community, and Asian Development Bank, with financial support from the government of Japan, the GFDRR, and the European Union. PCRAFI, launched in 2007, aims to provide the PICs with disaster risk assessment and financing tools for enhanced disaster risk management and climate change adaptation.

The Pacific Island Countries involved in PCRAFI are the Cook Islands, the Federated States of Micronesia, Fiji, Kiribati, the Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, the Solomon Islands, Timor-Leste, Tonga, Tuvalu, and Vanuatu.

For further information, please visit pcrafi.spc.int.

Acronyms and Abbreviations

CCRIF	Caribbean Catastrophe Risk Insurance Facility
DRFI	Disaster Risk Financing and Insurance
GDP	gross domestic product
GFDRR	Global Facility for Disaster Reduction and Recovery
IDA	International Development Association
IMF	International Monetary Fund
ISDA	International Swaps and Derivatives Association
JICA	Japanese International Cooperation Agency
PCRAFI	Pacific Catastrophe Risk Assessment and Financing Initiative
PIC	Pacific Island Country
SOE	State-Owned Enterprise
SOPAC	Pacific Islands Applied Geoscience Commission
SPC	Secretariat of the Pacific Community

Executive Summary

In January 2013, the World Bank placed on the international reinsurance markets a portfolio of catastrophe swap contracts that transferred catastrophe risk from five Pacific Island Countries (PICs)—the Marshall Islands, Samoa, the Solomon Islands, Tonga and Vanuatu. The pilot was supported by the government of Japan, the World Bank Group, the Global Facility for Disaster Reduction and Recovery, and the Secretariat of the Pacific Community (SPC). The placement was a result of extensive technical work taking place over a period of more than one year and including design, implementation, and intermediation of the catastrophe swap contracts. The program has been renewed twice since its initial setup, and country participation and coverage have evolved. The Cook Islands, the Marshall Islands, Samoa, Tonga, and Vanuatu all joined the third season of the pilot, which started on November 1, 2014.

This insurance pilot is part of a broader program, the Pacific Disaster Risk Financing and Insurance (DRFI) Program, which aims to increase the financial resilience of PICs to natural disasters and to improve their post-disaster financial response capacity.

The Pacific Catastrophe Risk Insurance Pilot and the Pacific DRFI Program form an integral part of the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI), which aims to develop a comprehensive program on disaster risk management and climate change adaptation in the Pacific.

Table 1– The Pacific Catastrophe Risk Insurance Pilot–Key Facts

Perils	Tropical cyclone, earthquake, and tsunami
Contract Form	Catastrophe swap contract, with risk intermediated by the World Bank/International Development Association, and mirror transactions with the international reinsurance markets
Trigger	Modelled-loss trigger–losses estimated based on physical event parameters
Risk Layers	10-, 15-, or 20-year return period attachments per peril and country; 150-year return period exhaustions with a portion of losses in the layer ceded

Introduction

On November 1, 2014, the World Bank transferred US$43 million of catastrophic tropical cyclone, earthquake, and tsunami risk from five Pacific Islands Countries (PICs) to the international reinsurance markets through a series of financial transactions (catastrophe or "cat" swaps). This was the third renewal of the Pacific Catastrophe Risk Insurance Pilot since its initial transaction on January 17, 2013. The project received technical support from the Applied GeoScience Division (SOPAC) of the Secretariat of the Pacific Community (SPC) and from the catastrophe risk modelling firm AIR Worldwide, as well as financial support from the government of Japan.

PICs are highly exposed to adverse natural events, including tropical cyclones, earthquakes, volcanic eruptions, and tsunamis, which can result in disasters affecting their entire economic, human, and physical environment. These events also impact PICs' long-term development agendas. From 1950 to 2009, storm and earthquake damage cost PICs an estimated US$7.2 billion (World Bank 2010). An 8.1 magnitude earthquake and tsunami that hit the Solomon Islands in April 2007, for example, caused losses estimated at 95 percent of the government budget and created a short-term liquidity crunch until donor assistance was received. A tsunami that hit Samoa in September 2009 generated damage and losses in excess of US$120 million, or 22 percent of gross domestic product (GDP); and a tropical cyclone hitting the country two years later caused damage and losses in excess of US$195 million, or 35 percent of GDP (SIG, 2014).

SECTION

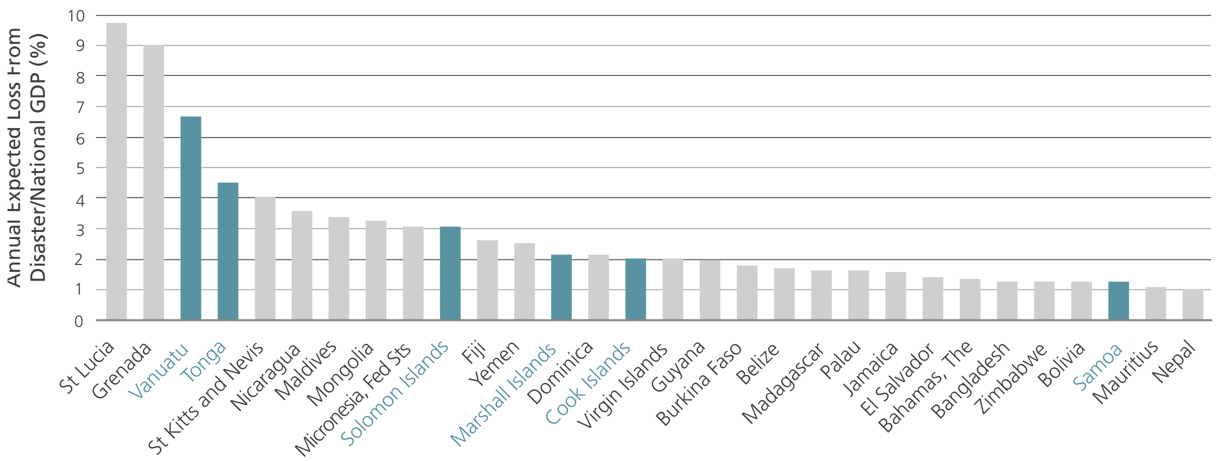
01

The five PICs currently involved in the Pacific Disaster Risk Financing and Insurance (DRFI) Program—the Cook Islands, the Marshall Islands, Samoa, the Solomon Islands, Tonga, and Vanuatu—are in the top 30 countries most vulnerable to natural disasters, ranked according to annual expected disaster losses scaled by GDP. Of the five, Vanuatu and Tonga experience the largest annual expected disaster losses, with 6.6 and 4.4 percent, respectively (see figure 1).

Critical challenges confronting PIC governments in the aftermath of a disaster include access to short-term immediate liquidity for emergency response and maintenance of essential government services until additional resources become available. PICs are restricted in their options for raising quick liquidity at the onset of a disaster because of their small size, limited borrowing capacity, and limited access to international insurance markets. The small size of PICs also tends to rule out geographic diversification of risk: subsidizing affected regions using revenues from unaffected regions is nearly impossible. High transaction costs, the inability to spread risk over a large territory, and the relatively small size of local economies keep insurance penetration in the region to a minimum. In the absence of easy access to debt and well-functioning insurance markets, a large proportion of the economic losses stemming from adverse natural events is borne by governments and households.

Natural disaster impacts are identified in the World Bank's Pacific Regional Strategy and in Country Assistance Strategies as a key contributor both to the high percentage of populations living below the poverty line and to the moderate growth performance exhibited by PICs in recent years. Poor populations are less resilient than others to exogenous shocks, including natural disasters, and when shocks occur the poor tend to suffer larger damages relative to their livelihoods. This

Figure 1 – Estimated Average Annual Losses for PICs (percentage of national GDP)



Source: World Bank 2010; PCRAFI 2013.

is because the poorer segments of the population often live in the most vulnerable locations and in inadequately constructed housing. In addition, the poor have limited labor skills, fewer assets, and little or no savings. They have little opportunity for risk diversification and restricted access to credit. Thus they are less able to cushion the impact on consumption of disruptions to income. Exogenous shocks can also increase poverty indirectly through the effects of lower economic growth, higher inflation (the poor are more vulnerable to inflation), and consequential lower government spending for social services. These impacts are exacerbated where governments experience a lack of liquidity for post-disaster response and recovery, due to the impacts of delayed response on vulnerable populations and the diversion of funds from high-priority development initiatives.

The Pacific Catastrophe Risk Insurance Pilot is part of the Pacific DRFI Program, which was launched as an application of the Pacific Risk Assessment and Financing Initiative (PCRAFI). It builds on more than five years of technical work in the Pacific under the PCRAFI program to develop technical capacity—including catastrophe risk modelling tools—for disaster risk management.

The Pacific DRFI Program aims to (i) increase the financial resilience of PICs against natural disasters, and (ii) improve their capacity to meet post-disaster funding needs while protecting their long-term fiscal balance. Access to budget in the aftermath of a disaster is essential to ensure immediate and effective response. While donor funds will always be required, overdependence on international relief as a source of post-disaster financing can delay the provision of initial relief. The Pacific DRFI Program builds on two main components:

(i) Pilot implementation of market-based sovereign catastrophe risk insurance solutions. This component provides participating PICs with insurance coverage against major tropical cyclones and earthquakes/tsunamis to ensure an immediate—yet limited—injection of liquidity following an eligible event.

(ii) Technical assistance to help with public financial management of natural disasters. This component provides PICs with technical assistance to build capacity in the public financial management of natural disasters, specifically, post-disaster budget mobilization and execution.

Under the Pacific Catastrophe Risk Insurance Pilot, sovereign catastrophe insurance coverage in the form of catastrophe swaps was designed to provide participating PICs with rapid liquidity for emergency

Box 1– The Pacific Catastrophe Risk Assessment and Financing Initiative

PCRAFI began at the request of PICs at the 2006 World Bank/International Monetary Fund (IMF) Annual Meetings. It is an innovative program that builds on the principle of regional coordination and provides PICs with disaster risk modelling and assessment tools for enhanced disaster risk management and improved financial resilience against natural disasters and the effects of climate change. This initiative builds on close collaborations between the World Bank, the SPC, and the Asian Development Bank, with financial support from the government of Japan, the Global Facility for Disaster Reduction and Recovery, and the Africa Caribbean Pacific (ACP)–European Union (EU) Natural Disaster Risk Reduction Program, and with technical inputs from GNS Science, Geoscience Australia, and AIR Worldwide.

The PICs involved in PCRAFI are the Cook Islands, the Federated States of Micronesia, Fiji, Kiribati, the Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, the Solomon Islands, Timor-Leste, Tonga, Tuvalu, and Vanuatu.

relief and early recovery efforts in the event of extreme disasters; the objective was not to cover 100 percent of the losses incurred but rather to provide rapid, flexible funds within weeks of an event to be used by affected countries as budget support. Risk was transferred using catastrophe swap contracts, and the World Bank acted as the intermediary, being the transaction counterpart for PICs and passing 100 percent of the risk onto the international reinsurance markets through mirror cat swap contracts. A parametric trigger was selected, which meant that the product was triggered based on a modelled representation of the event losses and not based on an assessment of actual losses incurred, as under a traditional indemnity-type insurance contract. The trigger in this case was based on hazard parameters collected from third-party reporting agencies and used to create a modelled event footprint from which modelled losses could be derived.

The implementation of the catastrophe risk transfer was made possible by a set of specific preconditions that existed for the Pacific Islands:

- Clear rationale for regional pooling and transfer of catastrophic risk due to the limited ability of small island state PICs to spread and absorb disaster-related losses
- Strong regional political collaboration
- Existence of international market standard catastrophe risk models for the perils and countries in question
- Strong appetite for Pacific risk in the international markets
- Framing of the pilot in the context of broader strategies for disaster risk management and climate change adaptation, following five years of prior dialogue with PICs under the PCRAFI initiative

The first Pacific pilot year ran from January 17, 2013, until October 31, 2013. The pilot has been renewed for two additional seasons, the latest beginning on November 1, 2014, for a one-year period. See table 2.

To date, the pilot has made two payouts for an aggregate amount of US$3.2 million, both occurring within 10 days of the disasters. Tonga received a payout of US$1.3 million following Tropical Cyclone Ian in January 2014. Vanuatu received a payout of US$1.9 million following Tropical Cyclone Pam in March 2015. The payouts were the first injections of cash received in the immediate aftermath of each disaster. Vanuatu received its payout within 7 days of being affected by the tropical cyclone, and Tonga received its payout within 10 days.

Box 2– Insurance Payouts

On January 11, 2014, Tropical Cyclone Ian hit Tonga with devastating force, passing close to the country's Vava'u island group and making landfall on the main islands of Ha'apai. The cyclone had intensified to Category 5 before landfall, and its arrival led the prime minister of Tonga to declare a state of emergency for Vava'u and Ha'apai. The cyclone damaged or destroyed more than 1,000 buildings in Ha'apai, and caused significant damage to infrastructure and agriculture across the worst-affected islands. More than 2,000 people sought refuge in evacuation centers (OCHA 2014). On January 13, an event Calculation Notice was sent to AIR Worldwide, the calculation agent for the Pacific Catastrophe Risk Insurance Pilot. AIR Worldwide performed a calculation of the modelled losses from the event under the terms of the pilot, and on January 20 the Calculation Report was sent to the pilot counterparties to notify them that the modelled loss was large enough to trigger a payout for Tonga under the policy. A payout of US$1.27 million was made to Tonga on January 27; the amount was equivalent to more than the country's 2013 contingency budget, and more than half of the reserves of the Tonga National Reserve Fund. The payout from Tropical Cyclone Ian was the first under the pilot, and it successfully demonstrated the core principle of rapid disbursement anticipated under the program. The entire process, from Calculation Notice to receipt of funds, was executed in less than 15 days.

Tropical Cyclone Pam hit Vanuatu on March 13, 2015, and triggered an insurance payout of US$1.9 million for the government of Vanuatu. This insurance payout provided a rapid cash injection into the government's budget. As a comparison, the payout amount was equivalent to eight times Vanuatu's emergency provision. The Calculation Notice was sent to AIR Worldwide by the World Bank/International Development Association (IDA) on March 14; the Calculation Report, which includes the calculation of the insurance payout amount, was released on March 20; and the payout was received by the government of Vanuatu on March 24. The insurance payout is consistent with the severity of the loss and the contract selected by the government of Vanuatu. While the tropical cyclone reached Category 5 (and was estimated to have return a period of 150 years), the eye of the cyclone passed 45 km away from the capital city, so the storm did not generate as much damage as it might have. The damage loss is estimated to have a return period of 40 years. Interestingly, the modelled physical losses estimated from the catastrophe risk model within six days after the event were commensurate with the estimated damage from the post-disaster loss assessment conducted a month later (US$182 million versus US$220 million). The relatively low payout is mainly due to the fact that Vanuatu had relatively low coverage (given that their premium was not very high).

Table 2– Evolution of the Pilot Program

	Pilot Year One 2013	Pilot Year Two 2013 –2014	Pilot Year Three 2014–2015
Period	*January 2013 –October 2013*	*November 2013 –October 2014*	*November 2014 –October 2015*
Participating Pacific Island Countries	Marshall Islands, Samoa, Solomon Islands, Tonga, and Vanuatu	Cook Islands, Marshall Islands, Samoa, Solomon Islands, Tonga, and Vanuatu	Cook Islands, Marshall Islands, Samoa, Tonga, and Vanuatu
Participating reinsurers	Sompo Japan Insurance, Mitsui Sumitomo Insurance, Tokio Marine & Nichido Fire Insurance, and Swiss Re	Sompo Japan Insurance, Mitsui Sumitomo Insurance, Tokio Marine & Nichido Fire Insurance, and Swiss Re	Sompo Japan Insurance, Mitsui Sumitomo Insurance, Tokio Marine & Nichido Fire Insurance, Swiss Re, and Munich Re
Reinsurance capacity	US$45 million	US$67 million	US$43 million

Country Engagement

Work with PICs under the Pacific DRFI Program revealed that countries were using a variety of ex ante (contingent) financing sources to manage unforeseen losses such as those related to disasters. Table 2 details the ex ante DRFI instruments utilized by PICs. All of the countries surveyed held some level of contingency budget, and many had also established dedicated reserves to help meet early recovery costs. The Pacific Catastrophe Risk Insurance Pilot offered a supplement to these existing financing sources designed to help countries manage more severe, less frequent disaster events.

Coverage under the Pacific pilot was available to any country covered under the PCRAFI initiative, as catastrophe risk modelling was available for them. Countries that wished to participate in the pilot were asked to provide a formal Expression of Interest to the World Bank. Five countries expressed interest—the Marshall Islands, Samoa, the Solomon Islands, Tonga, and Vanuatu—at the 2011 World Bank/IMF Annual Meetings in September 2011 in Washington, DC. Each country then confirmed its participation through a letter of Expression of Interest signed by the Minister of finance and sent to the World Bank.

SOPAC served an important role as facilitator, technical advisor, and convener alongside the World Bank. A program to build PICs' capacity was in effect throughout 2012 and continued for the full three years of the pilot. Part of the broader engagement with countries through the Pacific DRFI Program, this capacity-building program explained the options for risk transfer and highlighted the strengths and limitations of the different modalities of risk transfer presented.

Selecting cover

For the pilot to be sustainable and successful, the decision makers from each participating country had to possess the tools and information required for making informed decisions, specifically about (i) whether to participate in the pilot; and (ii) what level of coverage would be most appropriate given the country-specific context.

Extensive technical capacity building was undertaken with countries to help them select cover under the pilot. Engagements included a workshop in May 2012, during which countries presented their existing arrangements for financing disaster losses and discussed options for cover. Since disaster risk profiles were already available for countries through PCRAFI, it was possible to estimate both the cost of cover for different layers for the pilot and where attachment and exhaustion points would sit in dollar terms, given the preferred frequency of use of cover.

A series of national workshops was also convened in participating countries for the second season (during 2013) to review the progress of the pilot and to help countries assess their needs for the forthcoming season. A further regional peer-to-peer DRFI workshop was convened in March 2014. During the workshop, the agenda was broadened from the insurance pilot to include other DRFI instruments (e.g., insurance of public assets). This gave countries the opportunity to discuss past experiences, lessons learned, and ways to optimize post-disaster financial tools to improve post-disaster budget execution. Options for the evolution of the pilot program were also discussed, including countries' interest in a regional facility for catastrophe risk insurance.

A series of options for coverage (table 3) were presented to countries several months before the

Table 3– Pacific Island Countries' Ex Ante DRFI Instruments

	Reserve Fund (Us$, 1,000S)	Contingency Budget As A Percentage Of Total Appropriations	Selected Layer Of Coverage From The Pacific Catastrophe Risk Insurance Pilot (2014–2015 Season)	Pacific Catastrophe Risk Insurance As A Percentage Of Contingency Budget	Traditional Disaster Insurance
Cook Islands	462	1.5%	1-in-10-year attachment	200%	Government and state-owned enterprises (SOEs)
Fiji	2,107a	Discretionary	n.a.		SOEs
Marshall Islands	1,500	US$200,000	1-in-15-year attachment	>300%	Government and SOEs
Samoa	Needs basis	3%	1-in-20-year attachment	188%	Government and SOEs
Solomon Islands	n.a.	2.5%	n.a.	185%	SOEs
Tonga	2,400	5%	1-in-10-year attachment	>300%	SOEs
Vanuatu	256	1.5%	1-in-20-year attachment	>300%	SOEs

Source: PCRAFI 2015.

Note: Ex ante instruments are contingent instruments, established before an event occurs. These contrast with ex post instruments, which involve reactive sourcing of financing in the aftermath of a disaster. n.a. = not applicable.

[1] Country-specific catastrophe risk models (tropical cyclones and storm surge, earthqualke, and tsunami) were developed by Air Worldwide under PCRAFI.

policies' target inception date. Options included different attachment-point scenarios as well as a "bespoke" option that allowed countries to specify exactly what cover they would prefer.

To support countries in making a choice, decision makers were given detailed analytics and an interactive tool as well as training in the use of this information. Scenario analysis, which allowed countries to see how the different policy options would respond to different hypothetical/historical events, formed an important part of the technical capacity–building process. To demonstrate these responses, stochastic events were selected from the catastrophe risk models produced by AIR Worldwide.

The interactive tool allowed countries to test how different levels of emergency response cost would impact the policy under different scenarios. It used an Excel interface (developed by the World Bank) to allow countries to test different severities of disaster and to view the outcomes in terms of insurance payout for each policy scenario (see box 3).

Countries were then asked to send the World Bank a Commitment Letter signed, by the minister of finance, in which they formally requested cover and detailed the option they had selected.

Securing approval to participate

All of the participating PICs sought cabinet approval prior to joining the pilot to ensure that the upper echelons of government understood how the pilot was structured and how it worked—and to formally confirm that the country should participate. The pilot was discussed and approved by the cabinet of each government on the basis of papers drafted by the members of government engaged with the relevant stakeholders on the pilot preparation. This process ensured support for participation at the highest level of government, and built heavily on the technical capacity building carried out with

Table 4– Initial Options for Cover Presented to Countries

Option	Coverage
A	1-in-10-year attachment; 1-in-150-year exhaustion for tropical cyclone and earthquake
B	1-in-15-year attachment; 1-in-150-year exhaustion for tropical cyclone and earthquake
C	1-in-20-year attachment; 1-in-150-year exhaustion for tropical cyclone and earthquake
D	Bespoke coverage

government counterparts directly engaged in the pilot preparations.

Verifying country capacity to enter into transaction under relevant legal framework

The process of determining countries' legal ability to enter into the transaction involved a World Bank mission to the countries before the launch of the pilot. During this mission, meetings were held with the relevant legal officers—in the ministries of finance and justice, central bank, and attorney general's chamber or state law offices—to discuss the requirements of the transaction and ensure that no provision of national law would prevent the execution of a catastrophe swap derivative between the country and the World Bank. The World Bank requested that the PICs issue a legal opinion confirming the validity of the derivatives documentation and the authority of the minister of finance to sign the documentation.

Box 3– Interactive Policy Selection Tool

A Microsoft Excel tool was developed to allow countries to test different scenarios of emergency response cost against different policy options. The tool used each country's catastrophe risk profile from the catastrophe risk models used for the transaction. Policy options A, B, and C were displayed in the tool, along with an advanced option (policy option D) that allowed entry of bespoke policy terms that countries could themselves determine.

Input fields were set such that countries could vary the level of emergency response cost and select the peril of interest. The tool then calculated the insurance payout in each case. The interface for the tool is shown in figure 2.

Figure 2– Interactive Excel Tool Interface

Inputs

Modeled government emergency loss from event in USD	20,000,000
Modeled Peril	Tropical Cyclone
Display style: select 'Advanced Display' to show Strategy D, which allows the user to input a custom insurance purchase strategy.	Normal Display

Colour coding

Input - feel free to change
Formula - do not change

Calculations

A loss from a tropical cyclone at least this large is expected to occur with annual probability...	0.68%
A loss from a tropical cyclone at least this large is expected to occur on average approximately once every...	145 years

	Strategy A: 1-in-10 year per-peril attachment points	*Strategy B: 1-in-15 year per-peril attachment points*	*Strategy C: 1-in-20 year per-peril attachment points*
The insurance claim payment under each strategy would be:	9,230,000	10,440,000	11,450,000
The retained loss under each strategy would be:	10,770,000	9,560,000	8,550,000

Details of three different strategies

	Strategy A		*Strategy B*		*Strategy C*	
	Earthquake and Tsunami cover	*Tropical Cyclone cover*	*Earthquake and Tsunami cover*	*Tropical Cyclone cover*	*Earthquake and Tsunami cover*	*Tropical Cyclone cover*
Attachment point (years)	10	10	15	15	20	20
Attachment point (USD)	4,000	780,000	8,000	1,520,000	12,000	2,270,000
Exhaustion point (years)	150	150	150	150	150	150
Exhaustion point (USD)	850,000	20,320,000	850,000	20,320,000	850,000	20,320,000
Annual average loss in layer (USD)	10,000	410,000	10,000	340,000	10,000	300,000
Full loss limit (USD)	850,000	19,540,000	840,000	18,800,000	840,000	18,060,000
Ceding Percentage	48.0%	48.0%	56.5%	56.5%	64.6%	64.6%
Coverage Limit (USD)	410,000	9,390,000	480,000	10,620,000	540,000	11,660,000
Annual probability that a claim payment occurs from at least one element of cover	19%		13%		10%	

Note: Figures are highly indicative. Coverage limit may change depending on market conditions. Under all strategies the Ceding Percentage is set so that the total expected claim payment (over both policies) is US$200,000.

Payment of premiums

Participating countries received premium support grants through funding from the government of Japan. Premiums for the first pilot season were fully covered by the grants. For the second pilot season (2013–2014), participating countries made a nominal contribution of US$20,000 to the cost of premiums, except for the Cook Islands, which paid its premium in full. The country premium contribution was increased to US$40,000 for the third season of the pilot; the Cook Islands opted to participate again in the third year and again paid the full amount of its premium.

Although the contribution from the majority of countries accounted for only a small part of the total premium cost (5 percent in the second season pilot season and 16 percent in the third pilot season), it was an important demonstration of demand for the program and countries' commitment to participate. Payment of premiums for the second and third year of the pilot was complicated by the introduction of this additional source alongside the trust fund established for the government of Japan's contributions. In particular, it took extra time for countries to carry out the additional administrative requirements involved in transferring funds to the World Bank—a change that had to be accounted for in the process of executing the contracts before the inception date of the coverage.

Table 5– Evolution of Countries' Coverage and Participation Over Time

Pilot Year One		Pilot Year Two		Pilot Year Three	
January 2013–October 2013		*November 2013–October 2014*		*November 2014–October 2015*	
Cook Islands	No cover	Cook Islands	10-year attachment	Cook Islands	10-year attachment
Marshall Islands	15-year attachment	Marshall Islands	15-year attachment	Marshall Islands	15-year attachment
Samoa	20-year attachment	Samoa	20-year attachment	Samoa	20-year attachment
Solomon Islands	10-year attachment	Solomon Islands	10-year attachment	Solomon Islands	No cover
Tonga	10-year attachment	Tonga	10-year attachment	Tonga	10-year attachment
Vanuatu	10-year attachment	Vanuatu	15-year attachment	Vanuatu	20-year attachment
US$45 million aggregate coverage		US$67 million aggregate coverage		US$43 million aggregate coverage	

Source: PCRAFI 2015.

Note: Ex ante instruments are contingent instruments, established before an event occurs. These contrast with ex post instruments, which involve reactive sourcing of financing in the aftermath of a disaster. n.a. = not applicable.

The evolution of the portfolio

Country participation in the pilot program has evolved over time, as shown in table 4.

In the second season, the Cook Islands joined the pilot, increasing the overall risk transferred from US$45 million in the first season to US$67 million in the second. In the third season, the Solomon Islands decided to withdraw, reducing the total amount of risk transferred to US$42 million.

Countries' coverage choices did not vary significantly over time, with the exception of Vanuatu, where the government decided to increase the threshold for attachment across both season renewals. The total amount covered fluctuated year over year. This was largely a function of available funds for the premium, which determined how much risk countries decided to transfer.

Transaction Preparation

Structuring a product

Selecting a contract form

The decision to transfer the risk in the form of a catastrophe swap was driven by multiple factors. First, at the 2011 World Bank/IMF Annual Meetings, the participating countries asked for the World Bank to be involved in the transaction; they felt they themselves lacked experience accessing international reinsurance markets and dealing with sovereign disaster-risk transfer more generally. Once the decision was made to have the World Bank intermediate between the countries and the market, it was necessary to use a capital markets instrument, since the World Bank could not underwrite insurance policies. The transaction was therefore executed as a financial derivatives contract–catastrophe swap. The World Bank had some experience transacting in this form, and as the product did not require collateralization (as a catastrophe bond would) and allowed use of standard documentation prepared by the International Swaps and Derivatives Association (ISDA) as the basis for negotiation, a catastrophe swap made sense as a simpler product to implement.

Establishing a payout mechanism

A parametric trigger was selected because the risk to be covered was atypical and because no suitable risk market infrastructure—one allowing for effective post-event loss estimation--existed; under these circumstance, an indemnity-type product would have been difficult to implement. Another consideration was the wish for the product to cover some portion of the modelled damage as a result of the disaster. It was deemed more practical to use the correlation between the government's emergency response cost (estimated as a percentage of total ground-up loss; see box 5) and physical event severity than to establish an independent third-party system to estimate the government's actual emergency post-disaster costs (which would need to be applied systematically across all participating countries).

A parametric-type trigger also had the benefit of faster payouts. As past events have demonstrated, it can take considerable time for the full extent of physical damage and affected population to be assessed, and any indemnity-type product could not have paid out before this assessment was complete.

Box 4– The International Swaps and Derivatives Association Contract Form

The ISDA is an industry trade association formed in 1984. It provides standardized documentation for derivatives transactions, and once the decision was made to implement the Pacific Catastrophe Risk Insurance Pilot via a derivatives contract, an ISDA Master Agreement was chosen to form the basis of the trade.

The ISDA Master Agreement has a modular form, comprising a number of key legal documents, including collateral documentation, legal opinions, and definitions. A key component of the documentation is the Long-Form Confirmation, which outlines the economic terms of the transaction and which in conjunction with the definitions specifies the terms of payout and covered events.

Box 5– Parametric Insurance

Parametric insurance is unlike traditional insurance, which requires an assessment of individual losses on the ground for settlement. Parametric insurance instead assesses losses using a predefined formula based on variables that are exogenous to both the individual policyholder and the insurer–that is, the physical parameters of the event–but that are strongly correlated to losses. Parametric instruments allow for fast claims settlement (usually within two to four weeks) and are less exposed to moral hazard and adverse selection. However, parametric products are exposed to basis risk–that is, the possibility that claims payments may not perfectly match individual losses.

The key disadvantage of any parametric-type trigger is basis risk—the risk that the payout from the product does not match the actual losses sustained. In this case, the goal of the product was to provide rapid liquidity for some portion of the government's emergency response costs. Having payments match sustained emergency response costs was important, but not as important as some other factors, namely speed of payout and the ability to implement the product in the near term (which would not have been feasible for an indemnity-type trigger).

Once the decision to use a parametric trigger had been taken by PICs, it was necessary to select triggers from within the range of parametric options and test them. A range of simple index formulae based on hazard parameters was tested alongside a modelled-loss approach, where the hazard parameters were fed into a catastrophe risk model to create an event footprint.

Given that a state-of-the-art regional catastrophe risk model had been developed for the perils in question under PCRAFI, it was determined that a modelled-loss approach using the PCRAFI models and third-party reported hazard parameters would form the basis of the product trigger. One of the advantages of the modelled-loss trigger over the indexed parametric options was the explicit capture of tsunami in the post-event process. It was critical to agree before the insurance period to the provision of multiple licenses for the catastrophe risk model that would form the basis of the transaction trigger. These licenses are needed for other parties, such as the transaction counterparties or a successor calculation agent, which might require access to the model in case of a payout dispute or failure of the original calculation agent.

Creating and validating a post-event loss calculation process

Once the nature of the payout mechanism had been fixed, it was necessary to determine a post-event process through which the payout calculation would be undertaken. This required considering (i) the roles that different parties should undertake; (ii) the timeline under which actions should be delivered; and (iii) the best way to access and use hazard parameters so as to both remove any subjectivity in the calculation and allow timely capture of the best data possible.

Two critical roles in the post-event loss calculation (PELC) process were identified: the initiator and the calculation agent. Given their direct financial interest in initiating a calculation process after a disaster, the countries were identified as the most appropriate parties to take responsibility for initiating calculation in the event of a disaster. However, because participating countries were not familiar with the initiation process, a safety net was built in that also allowed the World Bank to initiate a calculation if no country made a calculation request following a significant event. As each calculation would incur a cost from the calculation agent, it was agreed outside

Box 6– Key Challenge: Estimating Government Emergency Losses Caused by Natural Disasters

The pilot provides coverage against post-disaster emergency losses, which are a portion of the total losses experienced by government, which are themselves a portion of the total economic losses suffered by the affected country. Because the pilot was structured as a modelled-loss (parametric) risk transfer–as opposed to the indemnity risk transfer typical of traditional insurance–the catastrophe risk model had to be able to estimate government emergency losses.

The government's emergency losses will vary for each disaster depending on a number of factors, including the location and size of the event and the type of damage caused. In order to capture this perspective, the catastrophe risk modelling firm used a "bottom-up" modelling approach. The model captures the total damage to buildings, infrastructure, and cash crops ("ground-up loss"), and then defines the government emergency cost as a proportion of this. AIR Worldwide drew on research to define a fixed percentage per peril; thus government emergency loss is defined as 23 percent of the total ground-up loss for tropical cyclone events, and 16 percent for earthquake and tsunami events.

Catastrophe risk models are necessarily simplifications of highly complex interactions between physical phenomena and assets, occurring at a highly localized scale. This methodology for determining the government's post-disaster emergency losses therefore gives a best estimate in the context of model limitations but is not 100 percent accurate. The significant variations in how governments are required to respond to each individual disaster mean that basis risk has been evident in the transaction structure.

Basis risk has been higher where large specific costs not explicitly captured in the model have been incurred, or where losses have been concentrated away from the largest concentrations of housing and population (e.g., rural areas) that form the basis of the underlying loss estimate (ground-up loss). According to one participating country, for example, high inter-island transport costs incurred during emergency response resulted in substantial basis risk between modelled emergency costs and those actually incurred after the disaster.

of the structure of the transaction that SOPAC would indicate its availability to advise participating countries on initiating the calculation process.

Precedents for such transactions dictated that the calculation itself be undertaken by an independent third-party calculation agent, or, in the event that a counterparty included in the deal was to undertake the calculation, that it be verified by an independent third party. The independent risk modelling firm AIR Worldwide was engaged to undertake the calculation.

Box 7– Key Challenge: Acquiring Appropriate Real-Time Event Data

Parametric triggers require reliable, independent sources of real-time event data of sufficient scope to calculate loss. Global and regional third-party reporting agencies were surveyed early on in the process of establishing the Pilot to ensure that a credible and reliable source of hazard parameter data would be available.

The Joint Typhoon Warning Center and the National Earthquake Information Center of the U.S. Geological Survey were selected as third-party hazard parameter providers. Reputed back-up data providers were also identified in case the requisite information was not available from the primary agencies.

Box 8– Key Challenge: Ensuring Consistency between the Risk Analysis and Post-Event Process

One critical challenge in designing the trigger was to ensure that the process for calculating a loss after an event was replicable for the risk analysis; the probabilistic calculation of expected loss and probable maximum loss to the transaction layers. As the transaction involved a modelled-loss trigger, it was critical that the event footprint used for the purpose of determining a payout under the transaction in the event of a disaster was consistent with the stochastic event footprints underpinning the catastrophe risk models. If the live and stochastic event footprints were inconsistent, the risk analysis would not be a best view of the expected loss to the transaction layers, and could not be used as the basis of pricing.

Setting timelines for the calculation process

To make the product effective, a payout as early as possible was critical. However, it was necessary to allow the different actors in the process sufficient time to carry out their duties. The following time windows were set for different steps in the calculation process; the timeline is further illustrated in figure 2.

- Country initiates calculation process by sending Notice of Applicable Event (Calculation Notice) to the World Bank. This should occur immediately after the event and must occur within 40 business days of the date of the disaster.
- World Bank instructs calculation agent to begin calculation by sending Calculation Notice. This should occur immediately after receipt of Notice of Applicable Event and must occur within five business days of receipt.
- Calculation agent produces Calculation Report containing results. This should occur as soon as possible following instruction from the World Bank and must occur within 10 business days of receipt of Calculation Notice.

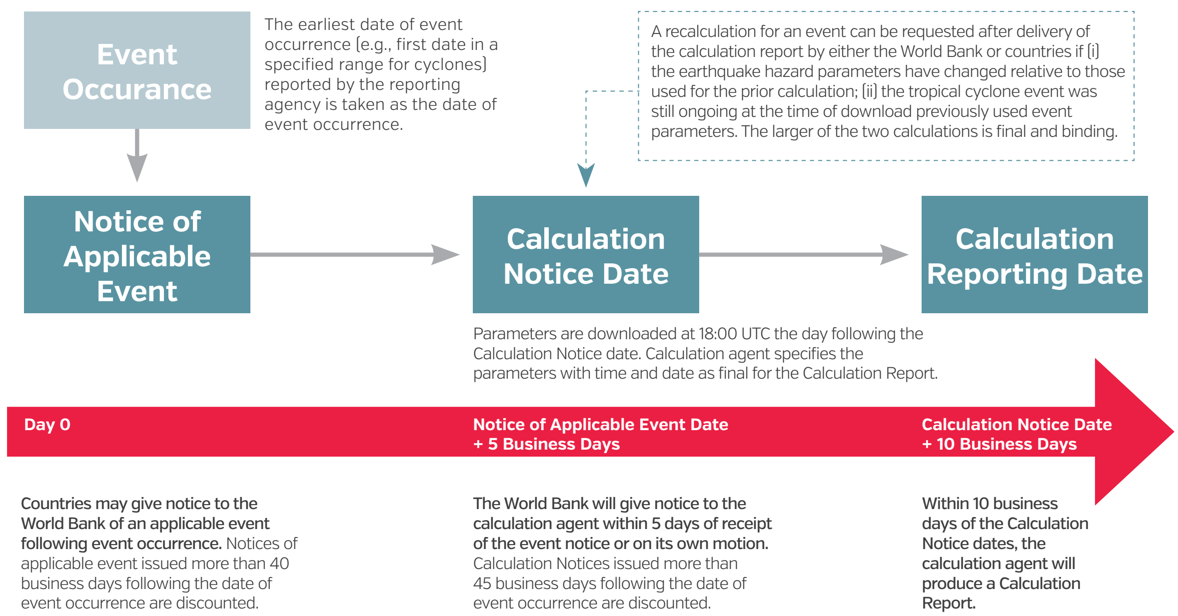
Access and use of hazard parameters

To remove subjectivity in the calculation, and thus make disputes over payouts less likely, the hazard parameters used in a post-event calculation needed to be downloaded from the third-party reporting agencies at a predetermined time and defined as final on that date. That date was fixed as 18:00 UTC on the day after the calculation agent is instructed to undertake the calculation. However, a mechanism to allow a repeat calculation was built in to allow for meaningful changes in the hazard data after the download for the first calculation. This is detailed further in box 9.

Box 9– Division of Liability

In determining the roles under the PELC process, it was necessary to take into account both conflicts of interest related to the calculation output and the reputational and financial liability associated with undertaking the various roles. Liability issues proved a particular challenge for the transaction, and it is vital that in future these be discussed early on so that all parties' expectations about indemnification by transaction counterparties are clear at the outset.

Figure 3– Post-Event Calculation Process



Mitigating credit risk within the structure

In order to ensure that the World Bank Board of Executive Directors would allow the World Bank to undertake its role as intermediary between countries and the market, it was necessary to carefully mitigate credit risk (i.e., the risk that one of the parties would default) within the structure. The World Bank mitigated credit risk to itself (and indirectly to participating countries) through the following inclusions:

- Portfolio diversified across several reinsurers
- Reinsurers required to have a minimum credit rating of A+
- Premium paid in arrears

The last condition, premium payment in arrears (every quarter), required flexibility on the part of reinsurers, since it involved working according to a nonstandard premium payment schedule driven by the nature of the institutions involved in the transaction.

The World Bank/IDA had few precedents to draw on for limiting its credit risk (the Malawi weather derivative, for example, was executed on an exception basis due to the small size of the trade so was not relevant). The Pacific pilot was thus the first transaction that the World Bank/IDA scrutinized with respect to its institutional limitations for managing its balance sheet and risk appetite.

Establishing and securing relevant parties

The decision to use a parametric trigger along with a catastrophe swap contract to transfer risk brought additional third parties into the picture. The World Bank took on the role of intermediary between the two ultimate counterparties (the countries and the market), but it was also necessary to contractually engage a calculation agent and escrow agent and to identify appropriate third-party hazard data reporting agencies.

Box 10– Key Challenge: Accommodating Changes in Recorded Hazard Data

The dynamic nature of hazards required that some mechanism be included to allow updating of the hazard parameters.

It was clear that hazard parameters downloaded early on and used for a calculation might not provide the best view of the event: for example, tropical cyclones could return to the same islands to cause additional damage after a first landfall, or a larger shock in an earthquake sequence could occur after an earlier shock had been calculated. At the same time, it was necessary to fix the parameters early on to allow a quick calculation and rapid payout.

The solution was to build in a recalculation mechanism, whereby countries or the World Bank could issue a second (or later) notice for the same event, initiating another post-event process window. This meant that payouts could be adjusted through an additional calculation, with the difference between the first and latest calculated payout amount forming the basis of an incremental subsequent payout. This mechanism allowed for the changing nature of hazard data and also made it possible to correct any significant reporting errors initially made by third-party reporting agencies.

It should be noted that to simplify the transaction, the incremental payout adjustment from second (or later) notices was limited to positive adjustments. This meant that a later calculation could produce additional payments to countries but not a refund to reinsurers. The market feedback on this restriction was generally negative, and future transactions of this type should involve early engagement with reinsurers on this topic.

Calculation agent

The calculation agent needed the technical capacity and bandwidth to perform rapid calculations after a disaster event. It also had to be able to perform the risk analysis for the transaction that would form the basis of the technical price, and to advise on the catastrophe risk terms for the transaction documentation. For the purposes of the transaction, the World Bank assumed responsibility for engaging the calculation agent and selected AIR Worldwide. It was also necessary to provide for engaging a successor calculation agent in the event that AIR failed to perform the required services.

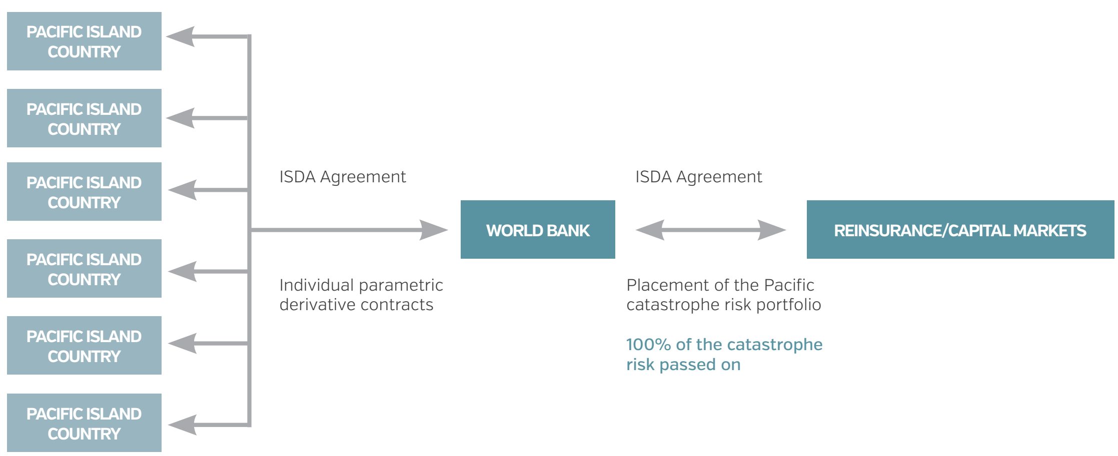
Escrow agent

The escrow agent is responsible for holding the catastrophe risk model (as software) plus the procedures to perform a calculation if an event should occur during the transaction risk period. This arrangement allows the counterparties to test calculations in the event of a dispute, and ensures that the requisite materials are protected in case of a failure on the part of the calculation agent. It also removes any ambiguity around model versions or versions of the procedural document. There are multiple possible agencies to perform this task. The escrow agent in this case was engaged through the calculation agent.

Box 11– Key Challenge: Defining the Successor Agent

A key challenge was arriving at a sufficiently flexible definition of successor agent: it was necessary to ensure that in the remote event that AIR Worldwide could not undertake the task, it could be replaced, but without infringing on its intellectual property rights, since the successor would be using the catastrophe risk model AIR developed for the transaction. In the end, legal language was agreed upon that allowed use of a "leading entity engaged in catastrophe risk management in the Pacific that is not a competitor" of the calculation agent.

Figure 4– Transaction structure



Drafting of legal documentation

Drafting the legal documentation that constituted the product itself required the establishment of a document drafting and review structure to coordinate across the necessary stakeholders. Key documents are outlined below.

- Long-Form Confirmations. The catastrophe swap terms were presented in the form of a Long-Form Confirmation. The World Bank took overall responsibility for drafting of this document, with feedback from the other transaction counterparties, and with specialist inputs from the calculation agent (for provision of text and review of catastrophe-specific terms).
- Calculation Agency Agreement. The Calculation Agency Agreement describes the responsibilities of the calculation agent, and expands on the catastrophe-specific terms in the Long-Form Confirmation where relevant. It contains the detailed procedures for the execution of a calculation after an event, which must be sufficiently specific to allow a replacement calculation agent to undertake the calculation

Box 12– Key Challenge: Coordinating the Transaction Process

The introduction of additional parties into the transaction preparation process increased the amount of coordination needed. One central party had to ensure that the structuring was completed with the necessary inputs from all sides and in a timely manner. In this case, the World Bank created a technical transaction team that undertook this role. Formally identifying contacts (and contact details) within each stakeholder organization was critical to the delivery of the pilot, as the execution of the transaction documents required review and signature from multiple parties.

relying exclusively on the instructions contained in the agreement. The Calculation Agency Agreement was drafted collaboratively by the World Bank and the calculation agent AIR Worldwide.

- Escrow Agent Agreement. The Escrow Agent Agreement contains the terms under which the escrow agent will hold the escrow materials—in this case the catastrophe risk models and procedures required to undertake a calculation. Terms of access to the escrow materials are also defined in the document. The escrow agent will typically provide a template agreement for contribution and review by the calculation agent and the transaction counterparties (on a limited number of terms).

Risk analysis

A risk analysis is typically required for capital markets transactions to form the basis of the technical price. The transaction risk analysis presented key metrics such as expected and probable maximum losses, which were calculated using a probabilistic catastrophe risk model.

Scope of risk analysis

The content of the risk analysis for the transaction was determined in consultation with all stakeholders and comprised the following:

- Exceedance probability curves for the underlying risk to be covered (in this case the emergency costs incurred by government arising from tropical cyclones, earthquakes, and tsunamis), including both annual aggregate loss and individual occurrence loss

Box 13– Key Challenge: Negotiating Terms

Agreement on key terms must be reached early in the process of structuring, as negotiation can take several weeks. It is critical that the structuring entity engages the transaction counterparties (and particularly the reinsurers taking the risk) early on.

It is possible, for example, that multiple events will occur during the transaction term. The term sheet must clearly delineate which events are distinct and which form part of a series of impacts from a single event (e.g., must separate earthquake foreshocks and aftershocks). If reinsurers are not satisfied that the defined terms sufficiently remove the risk of bias or subjectivity in the post-event process, they may not engage in the transaction, or may require that the contract be redrafted, leading to delays.

Box 14– Key Challenge: Ensuring Validity of the Risk Analysis

To ensure the validity of the risk analysis, the production and presentation of transaction metrics had to be carefully scrutinized with respect to multiple criteria, with particular emphasis on the following questions:

Has the stochastic event catalog been produced using a methodology consistent with the production of event footprints used to determine a payout under the transaction (particularly with respect to the treatment of earthquake aftershocks)?

Has seasonality been appropriately calculated for perils exhibiting seasonal variation in risk, and where the transaction risk period is less than a full calendar year?

Have the limitations of the risk analysis been made clear to transaction counterparties (e.g., accepted alternative views of risk acknowledged)?

- Exceedance probability curves for the covered layers themselves (i.e., after application of the transaction structure)
- Expected losses (average annual loss) and associated uncertainty of the transaction layers calculated on an annual basis
- Historical and stochastic event scenarios demonstrating the potential impact of events on the transaction
- Underlying event loss tables used to derive the exceedance probability curves to allow reinsurers to perform their own analyses

Production of risk analysis

The risk analysis was carried out and validated by the calculation agent, with inputs from the World Bank team.

Approaching the Market

The approach to the market was managed by the World Bank team with assistance from the World Bank Treasury. It followed several stages.

- Early briefing sessions on the Pacific catastrophe risk model that would be used as the basis of product structuring and pricing were held with the international reinsurance market. The preliminary results from the model and the methodology for its development were presented in these technical sessions; the firm that had developed the model (AIR Worldwide) was available to answer questions. These technical sessions were followed with individual training sessions on the model, held live or via webcast. All potential market counterparts had the opportunity to interact directly with AIR staff and raise any question.
- A two-stage process was used in order to filter the interest of market counterparts. First the market was asked to submit expressions of interest. Those companies that expressed interest were then screened for approval based on predefined criteria (including rating, reputation, etc.).

Appetite for the risk from the reinsurance market

A couple of factor exerted some control over what markets were available to participate in the transaction. One was the regional context of the transaction. Another was the fact that the clients were small island developing states. It was not enough for markets to have the ability to support the transaction from a technical and capacity standpoint; previous experience with sovereign client transactions was considered a critical prerequisite, since markets with such experience were less likely to be surprised by the transaction processes.

In this respect, the closest previous transaction was the Caribbean Catastrophe Risk Insurance Facility (CCRIF) reinsurance program, which had been placed six times by mid-2012. It used a modelled-loss parametric approach, its clients were sovereign small island states, and it was at least partially a nonpeak catastrophe risk transfer program. The CCRIF reinsurance panel thus provided a starting point for market engagement. Strong appetite from Japanese reinsurers was also established early on, partly due to their history of development cooperation with the Pacific region, and the support from the Japanese Ministry of Finance for the project.

Another factor influencing which markets would participate was the involvement of the World Bank. While many traditional reinsurance markets have

Box 15– Key Challenge: Accounting for the Markets' Own Transaction Processes within the Structuring and Placement Time Frame

Engagement with the market began before and continued throughout the structuring process. In essence, by the time the official transaction documentation for the deal was issued to counterparts, most of the technical discussions had taken place already. This approach simplified the negotiation process.

Although the contract form (cat swap) was relatively familiar to the majority of participating reinsurers, its nature as derivative required coordination among different departments as well as methods for accounting and reporting that differed from those of traditional insurance. The process of securing internal approval to engage in the transaction was therefore complicated. Some reinsurers also asked external counsel to review the contracts, and in some cases, engagement with the regulator was needed to secure permission to transact on the basis of the cat swap. Early engagement was therefore vital, and the form of the contract was presented to participating reinsurers well before the transaction documentation was finalized.

specialized divisions dealing with capital market transactions, some parties faced particular challenges in executing catastrophe swap deals with the World Bank—just as the World Bank faced challenges in executing deals with some parties. In one case, a reinsurer interested in the transaction was unable to participate because it writes its global catastrophe business out of a jurisdiction that the World Bank deemed unacceptable from a counterparty risk perspective, and internal mechanisms at the company were too complex to facilitate the necessary actions and decisions for such a small transaction.

Model validation

A series of major catastrophe losses to the global reinsurance markets from nonpeak zones (including the 2010 Chile earthquake, the 2010 and 2011 New Zealand earthquakes, and the 2011 Thailand floods) changed the approach of the international reinsurance markets toward assessment of nonpeak risk. By early 2012 it was generally accepted that nonpeak zone risk was poorly understood. This awareness led in turn to a growing requirement

Box 16– Pacific Catastrophe Risk Model

The Pacific catastrophe risk model was built using state-of-the-art modelling techniques well known to the reinsurance markets. Such models comprise three main elements: a hazard module, which generates the hazard conditions for a specific real-time historical or simulated event; an exposure module, which assigns value and characteristics to the assets at risk; and a vulnerability module, which aims to convert the hazard parameter for each asset (depending on its characteristics) to a loss rate that is then applied to the asset value.

Each of those modules was created from scratch. The hazard modules (tropical cyclone, including wind, storm surge, and rainfall elements, and earthquake, including tsunami) were built using established techniques but from a relatively limited set of input data with which to parameterize and validate the models. The exposure module was the result of a substantial investment by the PCRAFI project in data collection and management; the final output is not just suitable as the exposure module for the parametric loss model; it also provides a rich database for the Pacific islands useful for a variety of purposes. The vulnerability module was constrained in terms of input information and experience: different types of construction are susceptible to very different degrees of damage, theoretical or laboratory-based research on Pacific building types it limited, and almost no claims data are available through which to build empirical relationships.

for better catastrophe risk modelling and loss information to underpin pricing in nonpeak zones and so reduce the possibility that future nonpeak catastrophe losses would be a surprise (in both the occurrence of events and the premium levels being charged to support the losses). This requirement meant that the reinsurance market had to invest a significant amount of time in order to validate the risk and modelling being presented for the Pacific transaction.

As previously indicated, the Pacific transaction was designed as a modelled-loss parametric program, where the catastrophe risk model underpinning the transaction was a new model developed by one of the main catastrophe model vendors specifically for the Pacific project. With no available catastrophe risk model against which to benchmark the new model, and little or no claims data for the covered perils (earthquake plus tsunami and tropical cyclone) in the target region (small Pacific islands), reinsurers were required to build a ground-up understanding of the modelling processes, the input data and assumptions used for the model, and the uncertainties in outputs from the model when deployed for real-time loss estimation.

For this particular transaction and use of the model, the following four areas were of particular interest:

(i) Parts of the model that are important for a parametric deal. The use of a catastrophe risk model for estimation of indemnity risk is a rather different modality than its use to underpin a modelled-loss parametric deal. For the former, understanding the uncertainties in loss estimates is critical, whereas for the latter, the modelled loss is the basis of payout; thus from the reinsurer's perspective, the understanding of the model needs to focus more on whether the stochastic hazard data set is a fair representation of the likely frequency and severity of event occurrence. The other modules (exposure and vulnerability) are of relevance in product design—that is, in determining whether the modelled losses are likely to reasonably approximate actual event losses (so making basis risk acceptable to the countries).

(ii) New parametric tsunami element. The inclusion of tsunami losses in a parametric deal was a global first, and reinsurers were keen to fully understand both the real-time tsunami calculation methodology and the probabilistic assessment. They did not want to be surprised either by the contribution of tsunami losses to the overall event loss or by possible basis risk between the tsunami model and on-the-ground tsunami impacts.

(iii) Understanding of synthetic earthquake/tropical cyclone event generation. As indicated above, understanding hazard is critical in a modelled-loss parametric deal, and given that this Pacific model was the first stochastic earthquake or tropical cyclone event set generated for the region, reinsurers needed to fully understand and become comfortable with the overall stochastic event set and its generation methodology.

(iv) Discrepancies between probabilistic model and real-time loss calculation. These discrepancies can be a crucial uncertainty factor in parametric deals, where the methodology used to calculate losses from historical events and from the stochastic event set (built from the historical event set) is not fully replicated in the real-time calculation of event losses for payout purposes. Systematic differences between the two methods can lead to mispricing and also to added basis risk in the real-time calculations, as noted above.

Presenting an unconventional structure

The Pacific risk transfer program differed in two key ways from most conventional reinsurance programs: (i) it had no retention by the reinsured (World Bank), and (ii) it did not include any "tranching" of the required reinsurance capacity.

Retention by the reinsured usually serves two purposes. First, risk sharing at the high-frequency end of the risk spectrum is seen as a way of aligning the interests of the reinsurer and its client, and it leads to a lowering of reinsurance claims volume. This element is less important in a parametric deal, where the calculation of loss is entirely remote from the reinsured party and its processes. The second purpose of retention is to avoid the use of reinsurance in the part of the risk spectrum where regional and international diversification has little value. Global reinsurance markets are most efficient when used to cover high-severity, low-frequency events that can be pooled such that the lack of correlation between different pools reduces the cost of capital required to cover claims. The World Bank passed 100 percent of the catastrophe risk onto the markets in this case, as its role was purely to intermediate, not to accept, risk. However, the risk presented by participating countries involved a significant amount of retention in the transaction layers.

The second difference from a conventional reinsurance transaction was the lack of layering—tranching—within the transferred risk, meaning that all participating reinsurers had to take a slice of the entire transferred risk. Although the relatively small size of the transaction mitigated this issue to some extent, there was still reluctance on the part of some reinsurers to quote the entire program. Reinsurers develop different appetites for catastrophe risk, some preferring the lower layers with more frequent, smaller claims, and others preferring the high layers where claims can be very large but don't happen often. It is not possible to leverage this appetite differentiation when no layering is present. In practical terms, however, this feature did not lead to the withdrawal of any particular reinsurer from quoting on the program.

Executing the Transaction

This section concentrates on various aspects of the transactions completed between PICs and the World Bank and, in turn, between the World Bank and the reinsurance markets. The client–World Bank transaction comprised ISDA swap transactions (one for each participating country) executed simultaneously, each with the specific coverage terms required by the client country. The World Bank–reinsurer transaction comprised ISDA swap transactions (one for each participating reinsurer), again executed simultaneously, each with the same conditions except for the share of the risk. In theory, these two sets of simultaneous transactions have to happen simultaneously themselves, as the World Bank was unable to hold any risk at any time.

Establishing a process for negotiation

Given the complexity of the deal completion process and the challenges in coordinating both multiple clients (across a very large geographical area) and multiple reinsurance markets (across time zones spanning most of the globe), it was necessary to fix the terms of the client–World Bank transaction before seeking reinsurance quotes and executing the reinsurance side of the deal. This in effect meant that the World Bank had to make an assumption about reinsurance pricing so that the coverage selections made by countries led to the transfer of an amount of risk that the reinsurers would take for close to, but always less than, the available premium financing amount.

During the placement for the first pilot season in early 2013, the World Bank was conservative in estimating the cost of cover for participating countries, as any premium not spent for the 2013 coverage could instead be spent in the second year of placement. At the same time, however, the World Bank was keen to ensure that the amount of risk transferred from participating countries to the reinsurers was maximized to best demonstrate the value of the program.

Once the client coverage was fixed, analytics for the reinsurance program were completed in the form of the risk analysis, and a framework was developed for facilitating quotes, allocating shares, and fixing the reinsurance premium.

Determining priorities for the reinsurance program

One of the development objectives of the Pacific pilot was to test global reinsurance appetite for sovereign risk of Pacific island states. The goal was not only to determine reinsurers' general capacity and pricing, but also to test their acceptance of certain technical aspects of the program, such as a new model in a previously unmodelled zone and a parametric tsunami element (a global first). Given this objective, it was necessary to prioritize the various elements of the reinsurance program so that as many pilot aims as possible were met.

Price of coverage (premium) was a key factor, and it was critical to achieve pricing at a level which its benchmarking showed could be reasonably viewed as fair market price. Establishing a competitive price at first placement had the benefit of maximizing value for money to the client, but it also set a precedent that can be used in negotiating future pricing (recognizing that pricing is also controlled by other factors such as market cyclicality and model or program adjustments).

However, counterbalancing pricing was a desire to have a diverse panel of reinsurers such that the pilot truly tested global appetite.

Creating a flexible but transparent process

The reinsurance quoting process is traditionally a negotiation; it is not generally undertaken in a particularly transparent manner, nor does it follow prescribed rules. Completing a reinsurance program is a constant trade-off between price and capacity. In the case of the Pacific pilot, the process needed to be more structured and transparent than is the norm.

The World Bank team discussed various methods for receiving quotes, allotting shares of risk based on price and capacity, and executing the placement. Reinsurers themselves put conditions on their quotes. For example, most quoted different prices for in-arrears and up-front payment of premium; because the World Bank preferred in-arrears premium payment to minimize its counterparty credit risk, it had to try to assign a value to in-arrears premium payment. Most markets quoted a price for a fixed amount of risk and did not implicitly guarantee the same price for a lower (or higher) share of risk than that quoted. Most, but not all, quoting markets were open to a single price or differential pricing (in which different markets charged different prices).

In the final framework for negotiating the deal, price was the main driver, but some differentiation in pricing was allowed to ensure a fully subscribed program and—if possible and within boundaries—diversified regional participation. The World Bank established a view of fair market pricing based on benchmarking with recent reinsurance and capital market deals that had at least some similarities to the Pacific deal. A simple pricing approach was used that included accounting for a catastrophe load as well as an expense load on top of the expected loss premium, although there were not sufficient data in all comparative cases to avoid making some assumptions. The World Bank team also looked primarily at cases where the general terms and conditions of the transaction were similar to the Pacific deal, although the limitations of the proxies applied were acknowledged and understood as arising from the atypical nature of the risk presented.

Bringing any transaction to market is a complex process, and the Pacific deal had a number of unconventional complexities (described above). The deal completion date of November 1, 2012, was thus always a target rather than an absolute constraint on executing the deal. It became apparent in late October 2012 that several sources of delay would make the November 1 date impossible, and that the start-up date should be postponed until January 2013. Subsequently, the program was renewed as expected on November 1, 2013, and on November 1, 2014.

Box 17– Timing Challenges

A number of timing challenges had to be met in finalizing the transaction.

Coordinating signatures. Long experience in incepting or renewing complex reinsurance programs has led the reinsurance industry to develop a set of common practices that allow for closure of a deal without having all the paperwork completed. However, the nature of the risk transfer aspects of this deal required that all the paperwork be completed up front, which in turn required that the World Bank receive top-copy signatures on several documents from a specific senior official in each of the five participating governments prior to deal execution.

Seasonality in perils. The dominant factor driving the November target date was the start of the Pacific tropical cyclone season. Tropical cyclone risk is seasonal, the goal was to have countries covered from the first day of the official season. Not only does the risk faced by countries ramp up very quickly from November 1 onward, but any time missed would have a significant downward effect on price, which if not captured in a premium price reduction would result in countries getting a worse deal.

Reinsurance renewal seasons. Another constraint on the timing of the deal was the wish to avoid the peak renewal season for the participating reinsurance markets. For European reinsurers, January 1 is the main renewal date for global reinsurance programs, while for Japanese markets it is April 1. As the time available for reinsurer analysis and pricing of new and/or small deals is usually highly limited in the months prior to these dates, an effort was made to avoid them. In the case of the Pacific deal, all analytics and pricing work had been completed by late October, so that avoiding January 1 became less critical; ultimately the deal was completed on January 18 and thus did not coincide with any major renewal date. It is notable that the deal ends on October 31. For this reason, the renewal of the program will take place on November 1, which has been identified as the best renewal date for the program going forward.

Window of validity of the risk analysis. A delay in the start date of the coverage complicated the final negotiations. After the initial inception on November 1 was pushed back, the markets' quoted price was pushed back several times, and each change led to a change in the risk profile of the portfolio, given the fixed end-date (October 31, 2013) for the program and the nonuniform distribution of tropical cyclone risk through the year.

These changes meant that the analytics had to be re-presented to reinsurers during the quote process. The calculation agent developed a month-by-month estimate of the tropical cyclone risk so that the removal of first November, then December, and then some of January could be converted into an adjustment of the risk analysis. This estimate was then presented to reinsurers in order to obtain repricing of the now-reduced coverage period. (On the other hand, earthquake risk is not seasonal, so a prorated reduction of risk was possible for this peril.)

Window of quote validity. For reinsurers, an additional concern about executing the transaction was the duration of the quote window and the possibility that they would need to go through a complete repricing exercise. The shorter time period of the coverage, and thus lower risk, would normally translate to a price reduction; but repricing under these circumstances can also lead to a price increase (relative to risk at least), as reinsurers seek to recoup some of the additional costs incurred in repricing and face larger fixed costs relative to the size of the deal, meaning an increase in per-risk cost. Furthermore, repricing a deal right after January 1 renewals opens up the possibility that the global renewal season itself will have led to a reevaluation of the overall pricing strategy within an individual reinsurer or across the market, and this can lead to upward pressure on pricing.

Timing obligations laid out in the term sheet. The terms of the transaction included reference to the materials that would be held in escrow to support the calculation process after an event. Under the terms of the transaction, materials required for performing a calculation had to be placed in the escrow account by the start of the risk period in order to avoid ambiguity about the appropriate version of the model and procedures for a calculation.

Catastrophe Events

Several recent cases in the Pacific argue for providing immediate liquidity post-disaster from instruments such as the Pacific Catastrophe Risk Insurance Pilot. To cite some examples: In the immediate aftermath of Tropical Cyclone Pat in 2010, a delay in the receipt of travel funds for key government personnel meant that the initial damage assessment could not begin immediately in the Cook Islands. Following Tropical Cyclone Vania in 2010, Vanuatu had to reallocate a significant amount of the national budget to address post-disaster needs. Similarly, Fiji and Samoa had to reallocate budgetary funds in the wake of Tropical Cyclone Evan in 2012 and 2013. The Santa Cruz earthquake in the Solomon Islands in February 2013 drained the annual budget for the national disaster management office and used the majority of the national contingency budget.

To date, the pilot has made two payouts for an aggregate amount of US$3.2 million, in each case within 10 days of the disaster. Tonga received a payout of US$1.3 million following Tropical Cyclone Ian in January 2014. Vanuatu received a payout of US$1.9 million following Tropical Cyclone Pam in March 2015. The payouts were the first injections of cash received in the immediate aftermath of the disaster. Vanuatu received its payout within 7 days of being affected by the tropical cyclone; Tonga received its payout within 10 days.

To explain the basis of the payouts made Event briefs are produced to provide more detail on the event characteristics and modelled damage. Event Briefs were produced for both Tropical Cyclone Ian and Tropical Cyclone Pam, (see annexes 2 and 4). These briefings formed an important part of the process of providing information to the relevant government after each tropical cyclone event.

Recent events have suggested the disadvantages of using a parametric trigger as opposed to a traditional indemnity-type trigger. For example, the Solomon Islands suffered a magnitude 8.0 earthquake during the term of the pilot that caused loss of life and damage to infrastructure, but it did not generate a payout under the pilot. The earthquake occurred far from the economic center of the Solomon Islands, which meant that there was limited impact on core government services, the country's economy, and the country's future economic development. But the event's remote location also meant that the Solomon Islands government experienced significant travel costs associated with the relief efforts. The pilot functioned as expected under the conditions of the earthquake, but this case demonstrated the need for countries to use a comprehensive mix of financing sources to manage disaster losses.

A similar point was demonstrated in April 2014, when flash flooding in Honiara, Guadalcanal, Isabel, Malaita, and Makira-Ulawa in the Solomon Islands caused damage and loss of SI$787.3 million (US$107.8 million), equivalent to 9.2 percent of GDP. A slow-moving tropical depression caused persistent heavy rains with over 732 mm of rainfall recorded over four days at the Honiara rain gauge. These floods caused 22 fatalities across the country, internally displaced some 10,000 people initially, and affected approximately 52,000 people in total. It also damaged major infrastructure and fully destroyed some 675 houses and their food gardens, which many people depend upon for their livelihood. But under the conditions of the pilot, the event did not trigger a payout: the policy response depended on the category of the storm, which was considered a tropical depression as opposed to a tropical cyclone.

The possibility of using parametric triggers to capture rainfall damage from tropical depressions has been extensively considered under the Caribbean Catastrophe Risk Insurance Facility. In 2014, an excess rainfall product was introduced for participating countries to supplement the existing earthquake and tropical cyclone coverage. In the event of a catastrophe event, the excess rainfall product uses satellite data to determine payouts. The two principal challenges in the introduction of a parametric excess rainfall product are basis risk and event reporting. Basis risk tends to be harder to minimize for rainfall-induced flooding and landslide, as the on-the-ground hazard levels experienced tend to exhibit higher variation across smaller spaces (because of the strong influence exerted by highly localized features of the physical terrain as well as other factors). This high spatial variation makes it more challenging to model the hazard, and demands a dense network of recording stations on the ground to capture the footprint of the catastrophe event, which is typically not available. Appropriate direct data from a reporting agency are therefore often unobtainable, and proxies of hazard levels need to be used instead, such as those derived from satellite data.

Lessons Learned

Catastrophe risk insurance can provide quick payouts in the wake of a major disaster. As explained previously, the pilot has to date made two payouts for an aggregate amount of US$3.2 million, in each case within 10 days of the disaster. Tonga received a payout of US$1.3 million following Tropical Cyclone Ian in January 2014. Vanuatu received a payout of US$1.9 million following Tropical Cyclone Pam in March 2015. The payouts were the first injections of cash received in the immediate aftermath of the disaster. Vanuatu received its payout within 7 days of being affected by the tropical cyclone, and Tonga received its payout within 10 days. These events demonstrated the pilot fulfilling its purpose: to provide governments with a quick, but limited, cash injection in the aftermath of a major disaster to finance immediate expenditures.

Catastrophe risk insurance cannot cover all disaster losses and should be combined with other financial solutions. The pilot is not designed to cover the government against all disaster losses; instead, it is intended to cover some portion of the losses from major disasters caused by tropical cyclones, earthquakes, and tsunamis that may disrupt the operations of the central government and the provision of basic public services. In the Solomon Islands, no payout was triggered by the February 2013 Santa Cruz earthquake (in which the level of physical damage was relatively low) or the March 2014 flooding (in which losses were caused by a tropical depression, an ineligible event under the pilot). These two events demonstrate the need to complement catastrophe risk insurance with other financial solutions to cover more frequent, less severe events. Such solutions can be developed through the Pacific DRFI Program, which provides the PICs with technical assistance to help them increase their post-disaster financial response capacity.

Catastrophe risk insurance products could be refined to allow for more comprehensive coverage. Market-based catastrophe risk insurance products rely on parametric triggers to allow for rapid claims settlement. Softer triggers, like a declaration of natural disasters by the affected country, could be considered to allow the PICs to access immediate but limited funds after a disaster. However, such triggers might not be accepted by the private reinsurance market in the short term and would require dedicated regional funds.

Risk pooling can be highly beneficial but requires strong discipline and coordination among participating countries. There are significant benefits to be gained from working together to form a risk pool. First, pooling creates a critical mass of business that makes the offer more attractive to the market than dealing with multiple individual policies, and that allows for significant reductions in operating costs. Second, as it is highly unlikely that several countries will be hit by a major disaster within the same year, the diversification among participating countries creates a more stable and less capital-intensive portfolio, which is less costly to reinsure. Those benefits will translate into lower insurance premiums and/or higher insurance coverage. However, in order to reap the full benefits of regional risk pooling it is important that countries work together to ensure that all administrative steps are processed according to the agreed-on schedule so that any delay at the start of the program year can be avoided. Delays from one country will create delays for all of the participating countries.

The Pacific DRFI Program has received high-level government support. The Pacific DRFI Program has been discussed and approved by the cabinet in the respective PICs, showing support at the highest level of government. Senior government officials have expressed their support at key international and regional meetings, such as the UNISDR Global Platform for Disaster Risk Reduction, the Joint Pacific Platform for Disaster Risk Management and Climate Change, and the Pacific Forum Economic Ministers Meeting.

The Pacific DRFI Program has contributed to the improved dialogue and cooperation between finance ministries and national disaster management offices. The ex ante nature of an integrated DRFI strategy has required that the ministries meet to discuss how the existing procedures can be improved; these interactions have in many cases improved their relationship. Several PICs now require the reallocation of a staff member from the ministry of finance to the national disaster management office to manage the post-disaster procurement and acquittal of relief supplies.

Further institutional capacity building in public financial management of natural disasters is required. The required development of a post-disaster budget mobilization and execution document as part of the integrated DRFI strategy helps reduce the time it takes to purchase necessary relief goods and requires a detailed acquittal process on how the funds were spent. In addition, national and regional peer-to-peer DRFI workshops have been convened where countries discuss past experiences, lessons learned, and ways to optimize post-disaster financial tools to improve post-disaster budget execution. An integrated DRFI strategy should be developed that features additional financial resources, such as national reserves or contingent credit, to complement the insurance program.

The private sector has expressed interest in the country-specific risk models for its own future use. Local insurance companies could use the models and standards that have been established to build their capacity to provide insurance against the catastrophic perils of tropical cyclone and earthquake/tsunami. This practice would benefit both the public and private sectors, as local insurers would be in a better position to price these perils more accurately within the domestic market place. It might also encourage increased uptake of insurance from private individuals and thus help to reduce some of the post-disaster financial burden on the public purse.

Next Steps

One of the outcomes of this paper is the identification of potential collaborations with the Japanese International Cooperation Agency (JICA) that could be undertaken in the future. Three options are presented below, but further discussion is needed before any of these steps is taken.

(i) Update the PCRAFI exposure database. The catastrophe risk insurance pilot is underpinned by the vast data collection effort that was conducted in 2010 prior to implementation and that helped to create the Pacific Risk Information System (PAcRIS). This database should be updated and maintained regularly; the existing information on the stock of assets in each PIC is based on 2010 information and should be updated in the next one to two years. This effort will require funding to build the capacity of the countries to conduct this work themselves in the future.

(ii) Develop a Mutual Insurance Fund to cover losses "below the insurance deductible." The Mutual Insurance Fund will be designed to finance disaster events that result in mid-level damage, that is, events that are not covered by catastrophe risk insurance because they are "below the insurance deductible," but yet are too large to be financed solely by domestic reserves. This product is being developed at the request of PICs and will require identifying sources of seed capital and working with the private sector.

(iii) Investigate the potential to provide contingent credit to Pacific Island Countries. To date there has been limited uptake of credit within PICs, but as many of the PIC economies have experienced consistent economic growth in the past few years, contingent credit is increasingly becoming an option for them. The trigger for the release of the funds would need to be established up front and could either be parametric or use a softer trigger such as the declaration of disaster. Developing a contingent credit facility for PICs would provide them with an injection of cash within one to two days after a disaster, as all of the necessary arrangements would have been made in advance.

References

OCHA (UN Office for the Coordination of Humanitarian Affairs). 2014. "Tonga: Tropical Cyclone Ian Situation Report No. 3 (as of 23 January 2014)." http://reliefweb.int/sites/reliefweb.int/files/resources/OCHA_Tonga_TCIan_Sitrep3_20140123.pdf.

PCRAFI (Pacific Catastrophe Risk Assessment and Financing Initiative). 2013. "Catastrophe Risk Assessment Methodology." World Bank, Washington, DC.

———. 2015. *Advancing Disaster Risk Financing and Insurance in the Pacific* (Washington, DC: World Bank).

Solomon Islands Government (SIG). 2014. "Post Disaster Needs Assessment: Floods April 2014", World Bank, Washington, DC.

World Bank. 2010. "Financial Protection of the State against Natural Disasters: A Primer." Policy Research Working Paper 5429, World Bank, Washington, DC.

Annex 01:
Hedge Request

Request for IDA Risk Management Products
Catastrophe Swaps

Client's Explanatory Statement for the Hedge Request

The client's hedge selection, as requested, and the reasons for this selection, are as follows:

Hedge Selection: As per the coverage selection letter sent on September 4, 2012.

Reasons for this selection: PLEASE EDIT AS NEEDED: "As part of the development of our strategy to increase our financial resilience and post-disaster response capacity against natural disasters, we are using this catastrophe swap to test the transfer to the private reinsurance markets of the catastrophe risks we face from tropical cyclones. The transaction is expected to provide immediate (but limited) liquidity upon the occurrence of a major natural catastrophe that might disrupt the operations of the central government and the provision of basic public services."

We represent that:

(a) we have made our own independent decision to request this hedging transaction;

(b) we are not relying on any communication or confirmation from the World Bank as a recommendation to request such hedging transaction;

(c) unless expressly agreed with the World Bank by separate agreement, the World Bank is not acting as a fiduciary for, or an advisor to, us in respect of such hedging transaction;

(d) we are capable of evaluating and understanding, and understand and accept the terms, conditions and risks of such hedging transaction, and we are also capable of assuming, and assume, the financial risks of such hedging transaction;

(e) we are undertaking the hedging transaction in order to facilitate prudent risk management as further specified above; and

(f) our representative signing this Request is authorized to do so.

Swap Details

Effective Date (as applicable): As soon as practical

Swap Type: Catastrophe Swap

Maximum Premium Amount: $XXX,XXX   Premium Currency: USD

Premium Payment Date: On or before Effective Date

Perils Covered: Tropical cyclones

Special Requests / Instructions (use this space for non-standard requests)
(In addition, please contact the IDA regarding any non-standard requests)

We hereby instruct IDA to draw the premium from the Grant Account on our behalf, and use the proceeds to pay itself the premium for this hedging transaction, as specified in the Grant Agreement #TF XXXXX for the Pacific Catastrophe Risk Insurance Project Grant GFR# XXXX.

Payment Instructions

Name of Beneficiary Bank:

Address:

Account Number:

Swift Code:

Name of Beneficiary Entity:

Address:

(in case payment currency corresponds to a country different from the beneficiary country):

Name of Correspondent Bank:

Address:

Account Number:

Swift Code:

Special Instructions:

ANNEX

01

PCRAFI
PACIFIC CATASTROPHE RISK ASSESSMENT & FINANCING INITIATIVE

Annex 02:

Event Briefing Tropical Cyclone Ian

JANUARY 29, 2014 // COUNTRIES AFFECTED: TONGA

SPC Secretariat of the Pacific Community

ADB

GFDRR Global Facility for Disaster Reduction and Recovery

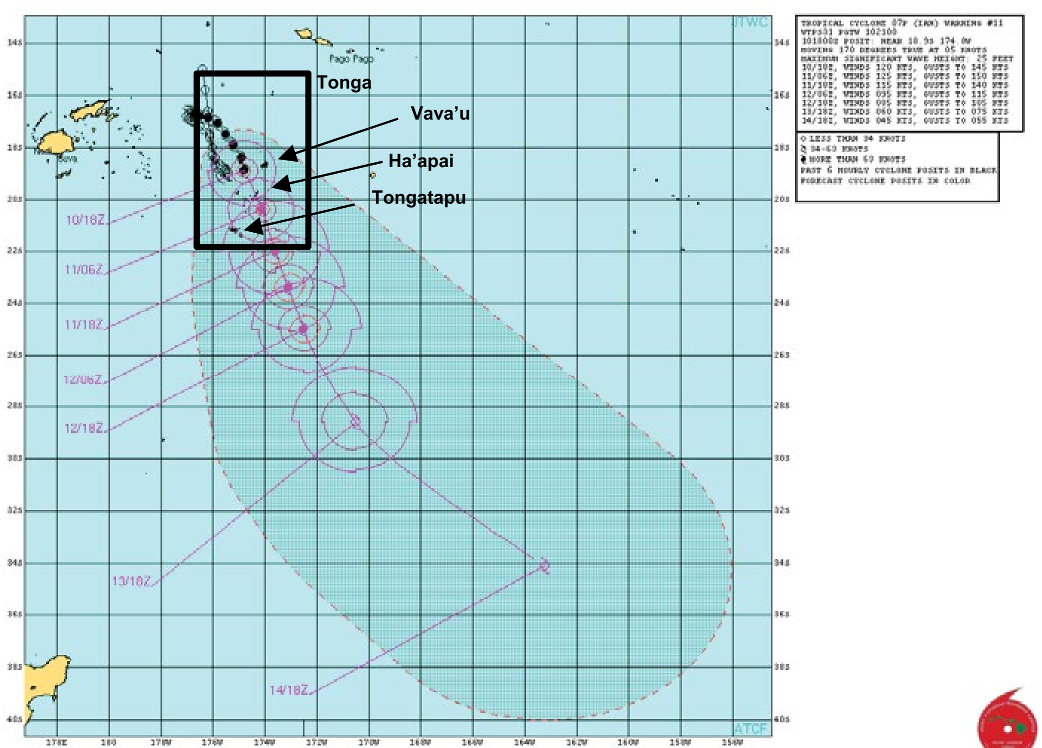
WORLD BANK GROUP

Event Description

On January 2, 2014 the Fiji Meteorological Service's Regional Specialized Meteorological Center in Nadi, Fiji (RSMC Nadi) reported that Tropical Disturbance 07F had developed to the southeast of Futuna Island. Over the next day the system gradually developed further underneath an upper level ridge of high pressure, within an area of moderate vertical wind shear, as it slowly moved towards the southwest. RSMC Nadi subsequently classified the disturbance as a tropical depression early on January 4, as the system's low level circulation center consolidated. Over the next day the system continued to move towards the southwest, before the United States Joint Typhoon Warning Center (JTWC) designated the system as Tropical Cyclone (TC) 07P late on January 5, and subsequently designated it TC Ian early on January 6.

Early on January 9, the JTWC reported that TC Ian had intensified with maximum sustained winds of 85 knots, equivalent to a Category 2 tropical cyclone on the Saffir–Simpson Hurricane Scale (SSHS). During the next day the system's organization significantly improved with JTWC reporting at 1800 UTC on January 10 that TC Ian had become a Category 4 (major) tropical cyclone (see Figure 1). Over the next day the system developed a cloud filled eye and intensified with maximum sustained winds of 125 knots, as it passed close to Vava'u and made direct landfall on the main islands of Ha'apai (see Figure 2). On January 12, the JTWC reported that TC Ian started to weaken as it quickly moved southeast away from Tonga.

Figure 1– Tropical Cyclone Ian Track Information on 1800 UTC January 10, 2014

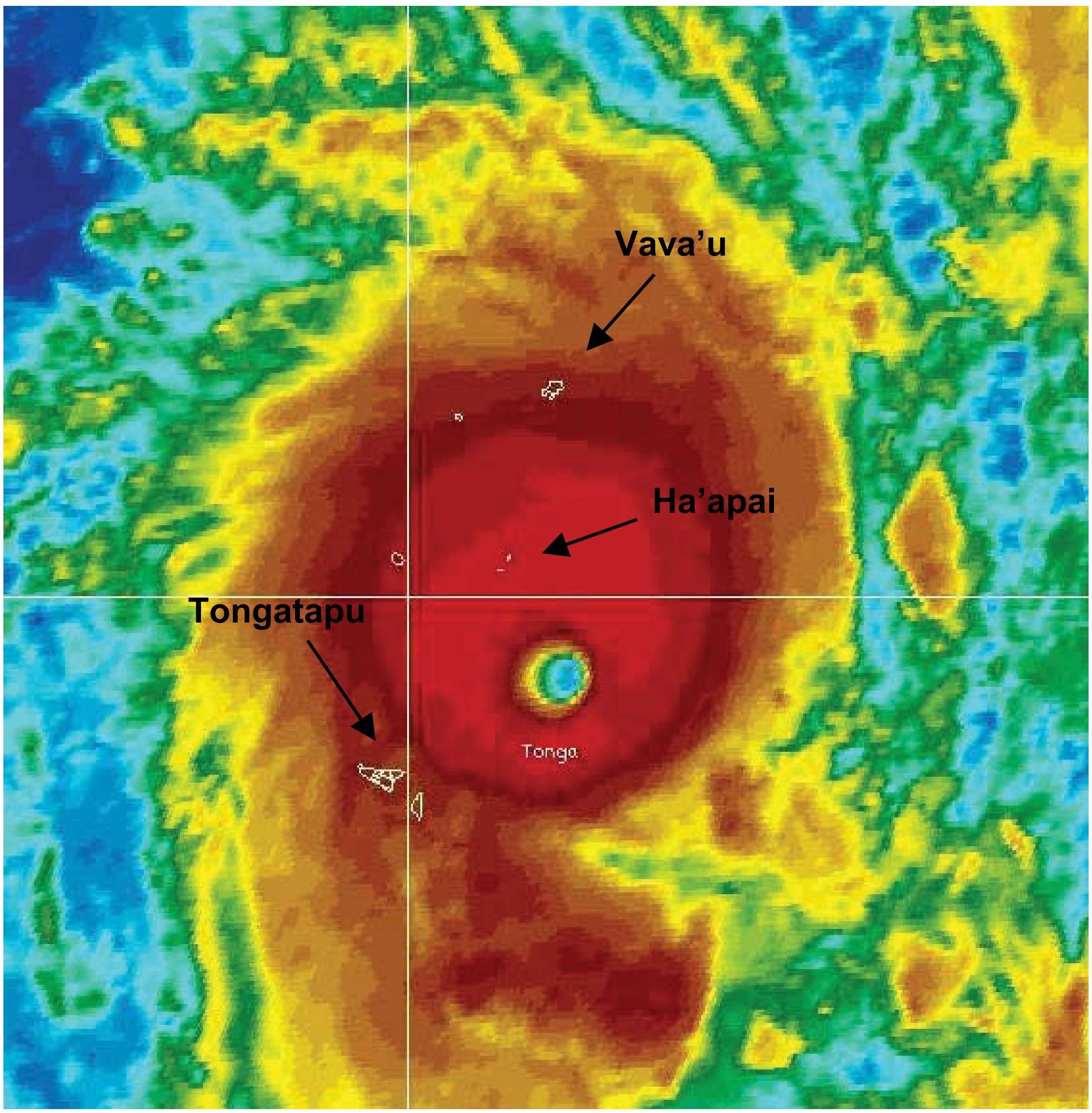


Source: JTWC

Post Event Loss Calculation Results

Under the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI), a post event loss calculation (PELC) protocol has been developed, which determines modeled ground-up mean loss estimates for impacted countries based on the catastrophe loss models (earthquake, tsunami, and tropical cyclone) developed by AIR Worldwide Corporation (AIR) for 15 Pacific Island Countries (PICs[1]). These modeled mean loss estimates are used for the Pacific Catastrophe Risk Insurance Pilot Program for six countries (Samoa, Tonga, Marshall Islands, Vanuatu, Solomon Islands, and Cook Islands), which aims to increase the financial resilience of PICs against natural disasters. The modeled loss calculation was conducted by AIR Worldwide Corporation.

Figure 2– Infrared satellite image of Tropical Cyclone Ian taken over Tonga around 600 UTC January 11, 2014



Source: NOAA

Table 1– Modeled Mean Losses from Post Event Loss Calculation (PELC)[3]

Country	Modeled Ground-up Losses (USD million)	Modeled Emergency Losses (USD million)
Tonga	49.3	11.3

Under this protocol[2], for a tropical cyclone event, country-wide modeled ground-up mean losses (defined as the estimated cost to repair or replace damaged assets, including residential, commercial, industrial, and public buildings, major cash crops, and major infrastructure) caused by a TC induced wind, flood from storm surge, and flood from TC induced precipitation are calculated. In addition, estimates of modeled emergency losses that national governments may sustain as a result of providing necessary relief and undertaking recovery efforts are calculated as a fraction (23 percent) of the modeled ground-up mean losses. TC parameters are obtained from JTWC-issued TC warning data archived by the Automated Tropical Cyclone Forecasting (ATCFTM) System. See Appendix B and C for modeled hazards and track data.

Based on a strict application of the PELC protocol, Tonga sustained US$49.3 million in modeled ground-up mean loss with an associated modeled emergency loss of US$11.3 million (see Table 1).

It must be emphasized that these estimated mean losses are only one view of the potential loss as the estimated mean losses are from a single representation of the storm track and intensity based on the JTWC parameters as required by the PELC protocol. These losses represent averages which have uncertainty associated with them. The uncertainty (or range) around the mean value can be significant due to multiple sources of uncertainty such as observation uncertainty (in track location and reported wind speed) and uncertainty around damage functions used to derive the modeled mean value, among other sources of uncertainty in the calculations. Additionally, it should be noted that the reported modeled mean loss values can differ from reported government estimates. This is due to many factors including differing definitions, methodologies and sectors covered in the assessments and vice-versa (see Figure 7 for breakdown of modeled losses by sector). Thus, any comparison between modeled mean loss estimates and reported government estimates should be done with caution and with a full understanding of the limitations on both sets of loss estimates. It should also be noted that any payout resulting from the Pacific Catastrophe Risk Insurance Program pilot is based on the results of the PELC only, not the government assessments.

1 Cook Islands (CK), Federated States of Micronesia (FM), Fiji (FJ), Kiribati (KI), Republic of the Marshall Islands (MH), Nauru (NR), Niue (NU), Palau (PW), Papua New Guinea (PG), Samoa (WS), Solomon Islands (SB), Timor–Leste (TL), Tonga (TO), Tuvalu (TV), and Vanuatu (VU).
2 The protocol of the Post Event Loss Calculation Process is specified in the Calculation Agency Agreement.
3 Note that these modeled loss estimates are based on JTWC-issued storm information obtained from the ATCF on January 14, 2014 at 1800 UTC (see Appendix C). http://www.nrlmry.navy.mil/atcf_web/docs/warnings/2014/. Estimated losses shown are rounded.

Event Impacts

Of the 15 PICs, Tonga is the only PIC that exhibited significant modeled mean loss estimates and actual reported damage (see Figure 3 for the track of TC Ian relative to the PICs). As such, the impact of TC Ian on Tonga is discussed in further detail below.

Figure 3– Track Data for Tropical Cyclone Ian from JTWC Advisories Overlaid on the PIC Domain (Pilot Countries Shown in Red)

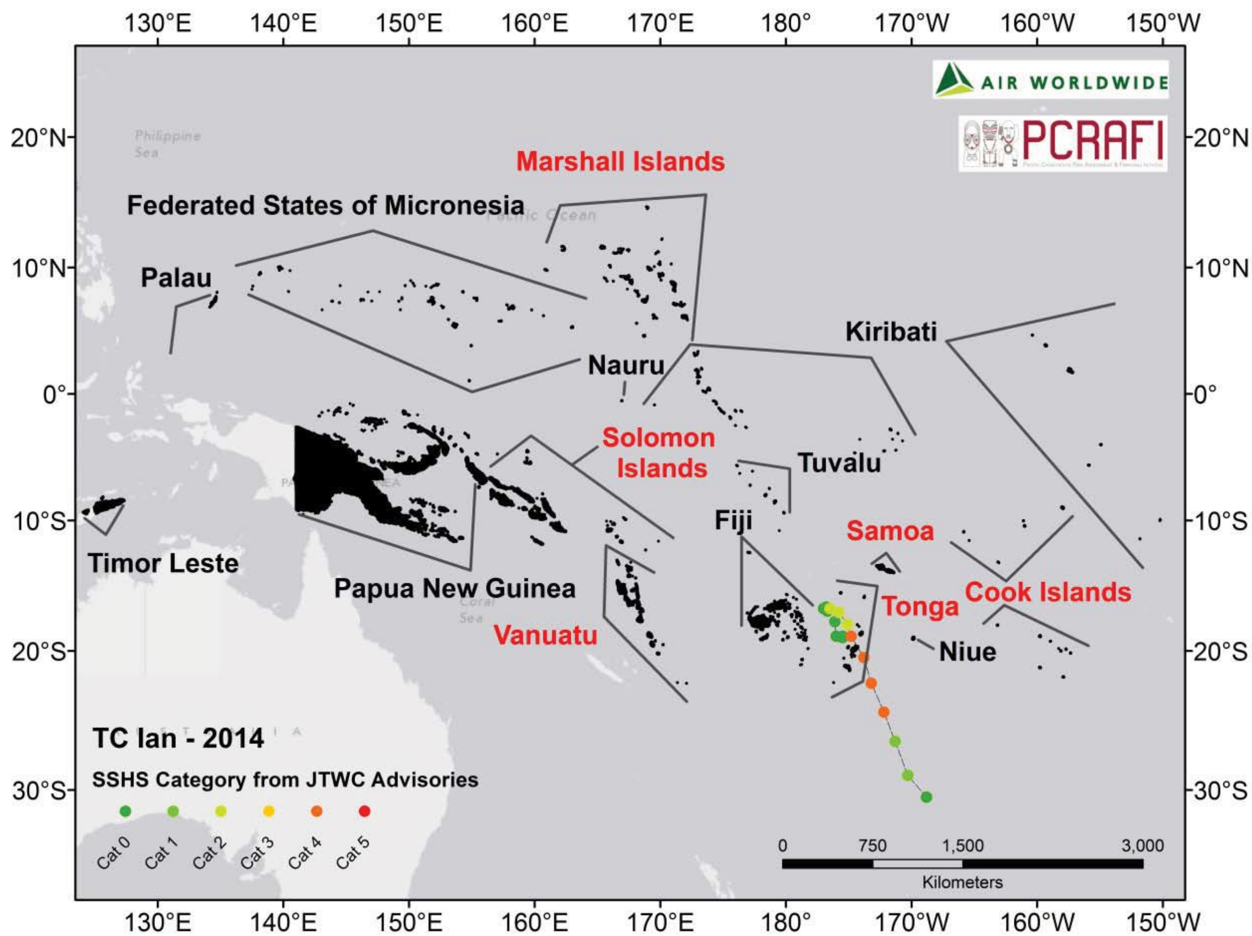


Figure 4– Damage to homes on Lifuka Island, Ha'apai, Tonga (Photo: New Zealand Air Force)

Affected Countries: Tonga

In the early hours of Saturday 11 January, TC Ian passed east of the Vava'u group (population approximately 15,000) before the eye passed directly over Ha'apai (population approximately 6,600) in the afternoon. The Prime Minister of Tonga declared a state of emergency for Vava'u and Ha'apai the same day. The Ha'apai group was worst hit by TC Ian's passage. As of January 23, current assessments4 indicate one confirmed death, 14 injuries, and 1,094 buildings in Ha'apai have been destroyed or damaged (e.g., see Figure 4). Approximately 2,335 people sought refuge in evacuation centers. There have been reports of significant damage to houses, infrastructure and agriculture across 18 villages in the islands of Ha'apai, including Uiha, Uoleva, Lifuka, Foa, Ha'ano and Mo'unga'one.

Reports from Vava'u also indicate significant damage to fruit-bearing trees. Other minor damages have been reported in Vava'u and Tongatapu.

Tonga's building stock consists mainly of masonry/concrete buildings and single story timber frame homes. Overall, the PELC estimates that TC Ian resulted in a loss cost (defined as the total modeled ground-up mean losses normalized by the associated exposure value of the assets) of approximately 2 percent for the entire country of Tonga. In Ha'apai specifically, the modeled damage was severe, with a loss cost of over 40 percent. In Appendix A, Table A1 summarizes the modeled assets for Tonga in the year 2010, while Table A2 illustrates the relative losses by district. Figure 5 below illustrates the modeled physical exposure of Tonga (in terms of value) and how it differs across the islands. For example, Nuku'alofa, Tonga's capital, is highlighted as a concentration of exposure. Figure 5 also shows the track of Tropical Cyclone Ian based on the JTWC Advisories. Note that damaging winds can extend many kilometers from the central track of the storm, thus affecting the assets in Tonga (see Appendix B for a modeled wind speed map). Other modeled perils that have an impact on the exposure are flooding from storm surge and flooding from tropical-cyclone induced precipitation (see Appendix B for a modeled accumulated precipitation map).

Figure 5– Modeled Physical Exposure of Tonga and Track Data for Tropical Cyclone Ian Taken from JTWC Advisories

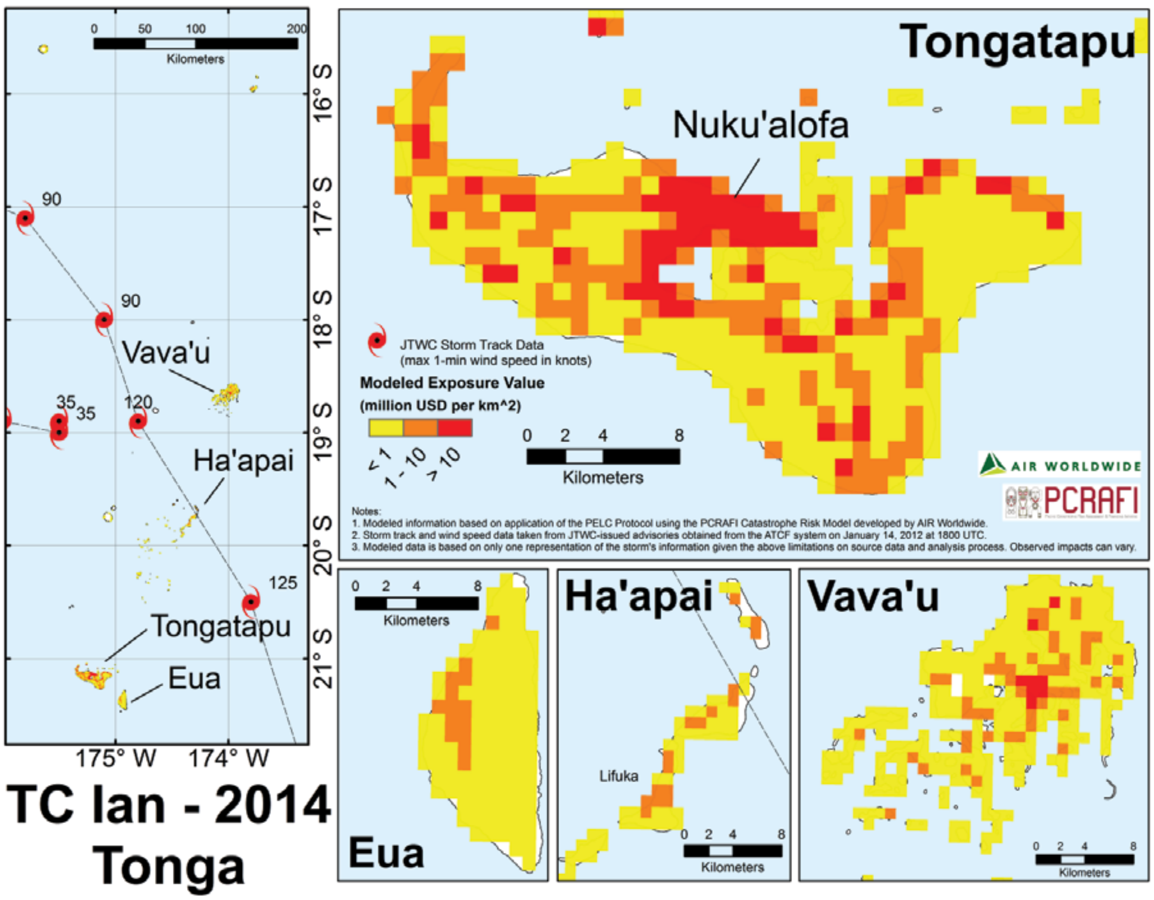


Figure 6 shows the modeled ground-up mean losses for Tonga resulting from TC Ian as well as the event track. It can be seen that the Pangai Division (Lifuka Island) sustained the highest value of ground-up mean losses, estimated at US$12 million. Losses have been calculated using the PELC methodology outlined above.

The highest level of modeled losses, accounting for 66 percent of the total modeled ground-up mean loss of USD 49.3 million, was attributable to residential buildings. This is followed by crop losses, which accounted for a further 20 percent of the total modeled ground-up mean loss. The classifications of "Public buildings and infrastructure" and "Commercial, industrial and other buildings" accounted for 9 percent and 5 percent, of the total ground-up mean losses respectively (see Figure 7). Most of modeled losses are due to tropical cyclone induced wind damage; losses due to flooding from precipitation and storm surge ranges from less than 1 percent to 13 percent on the district level, with most of the districts experiencing non-wind losses of less than 5 percent.

Figure 6– Total Modeled Ground-Up Mean Loss per Division of Tonga from Tropical Cyclone Ian and Track Data for Tropical Cyclone Ian Taken from JTWC Advisories.

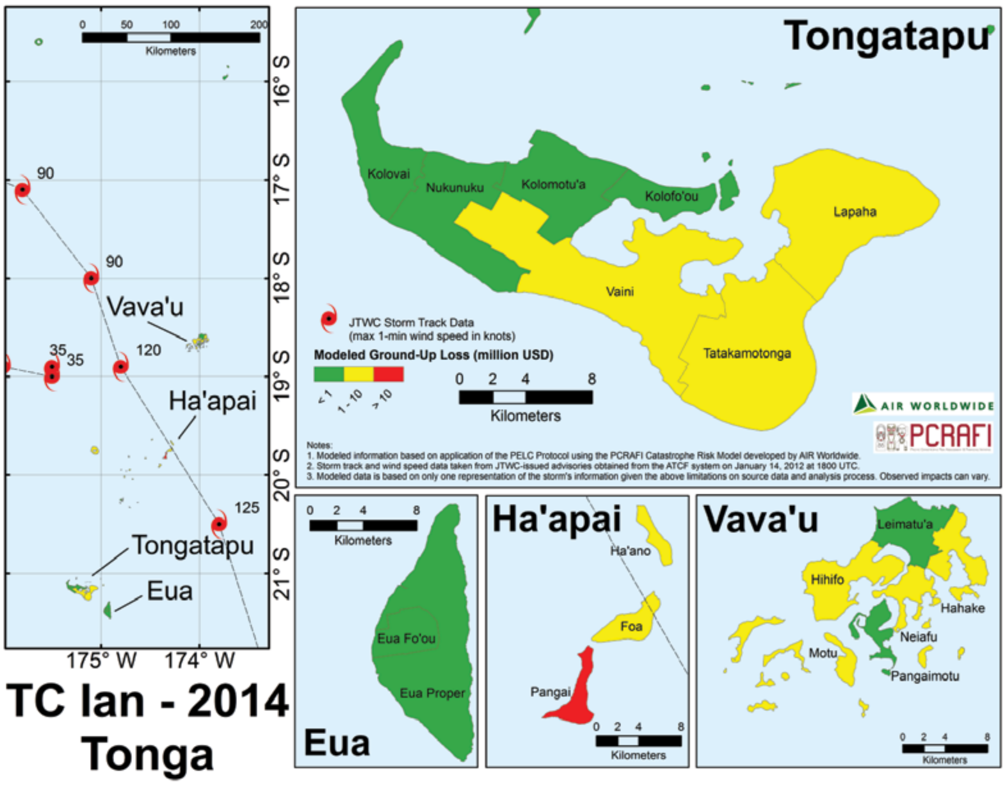
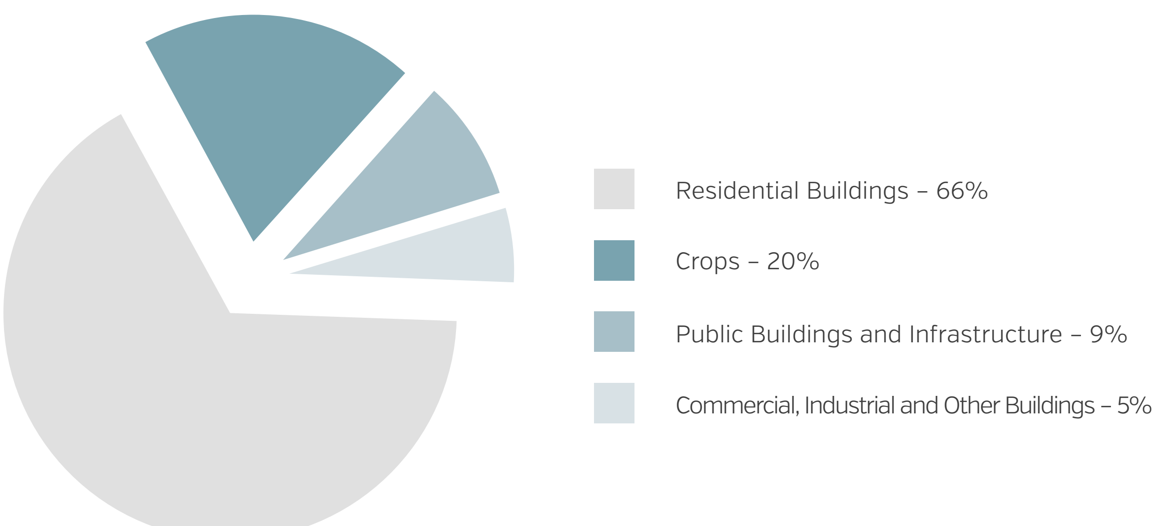


Figure 7– Breakdown of Total Modeled Ground-Up Mean Loss by Sector for TC Ian, Tonga



Appendix A

Table A.1– Summary of Modeled Exposure in Tonga (2010)

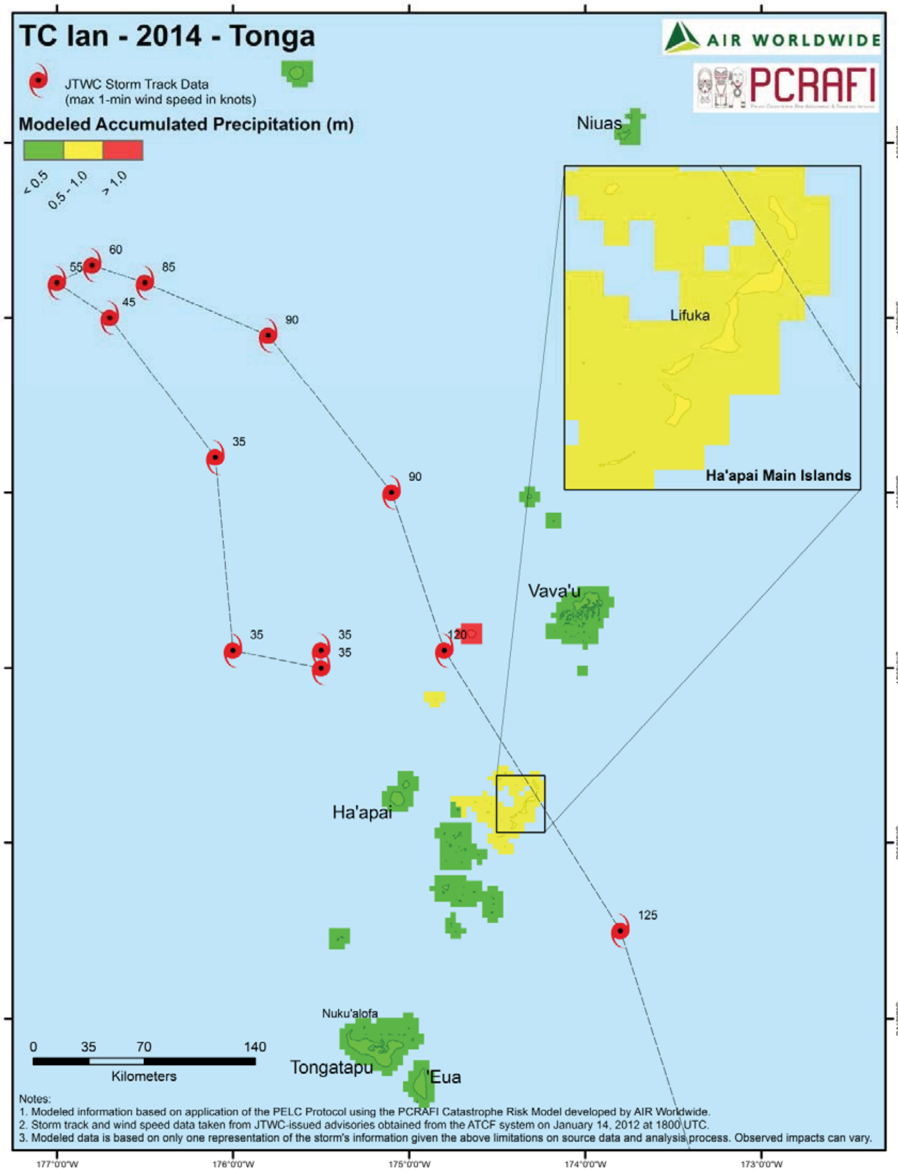
General Information:	
Total Population:	103,000
GDP Per Capita (USD):	3,470
Total GDP (million USD):	357.5
Asset Counts:	
Residential Buildings:	30,156
Public Buildings:	1,594
Commercial, Industrial, and Other Buildings:	3,001
All Buildings:	34,751
Hectares of Major Crops:	36,010
Cost of Replacing Assets (million USD):	
Buildings:	2,525
Infrastructure:	259
Crops:	32
Total:	2,816
Government Revenue and Expenditure:	
Total Government Revenue:	
(Million USD):	81.8
(% GDP):	22.90%
Total Government Expenditure:	
(Million USD):	99.2
(% GDP):	27.70%

Table A.2– Summary of Modeled Ground-up Mean Loss Estimates in Tonga from TC Ian

Division	District	Loss Cost (Modeled Loss Normalized by Exposure Value)
Uiha	Ha'apai	> 50%
Ha'ano	Ha'apai	> 50%
Foa	Ha'apai	25% - 50%
Pangai	Ha'apai	25% - 50%
Lulunga	Ha'apai	25% - 50%
Motu	Vava'u	10% - 25%
Mu'omu'a	Ha'apai	5% - 10%
Hihifo	Vava'u	1% - 5%
Pangaimotu	Vava'u	1% - 5%
Hahake	Vava'u	1% - 5%
Eua proper	Eua	1% - 5%
Neiafu	Vava'u	1% - 5%
Leimatu'a	Vava'u	1% - 5%
Niuafo'ou	Niuas	1% - 5%
Lapaha	Tongatapu	< 1%
Tatakamotonga	Tongatapu	< 1%
Nukunuku	Tongatapu	< 1%
Kolovai	Tongatapu	< 1%
Eua Fo'ou	Eua	< 1%
Vaini	Tongatapu	< 1%
Kolomotu'a	Tongatapu	< 1%
Niuatoputapu	Niuas	< 1%
Kolofo'ou	Tongatapu	< 1%

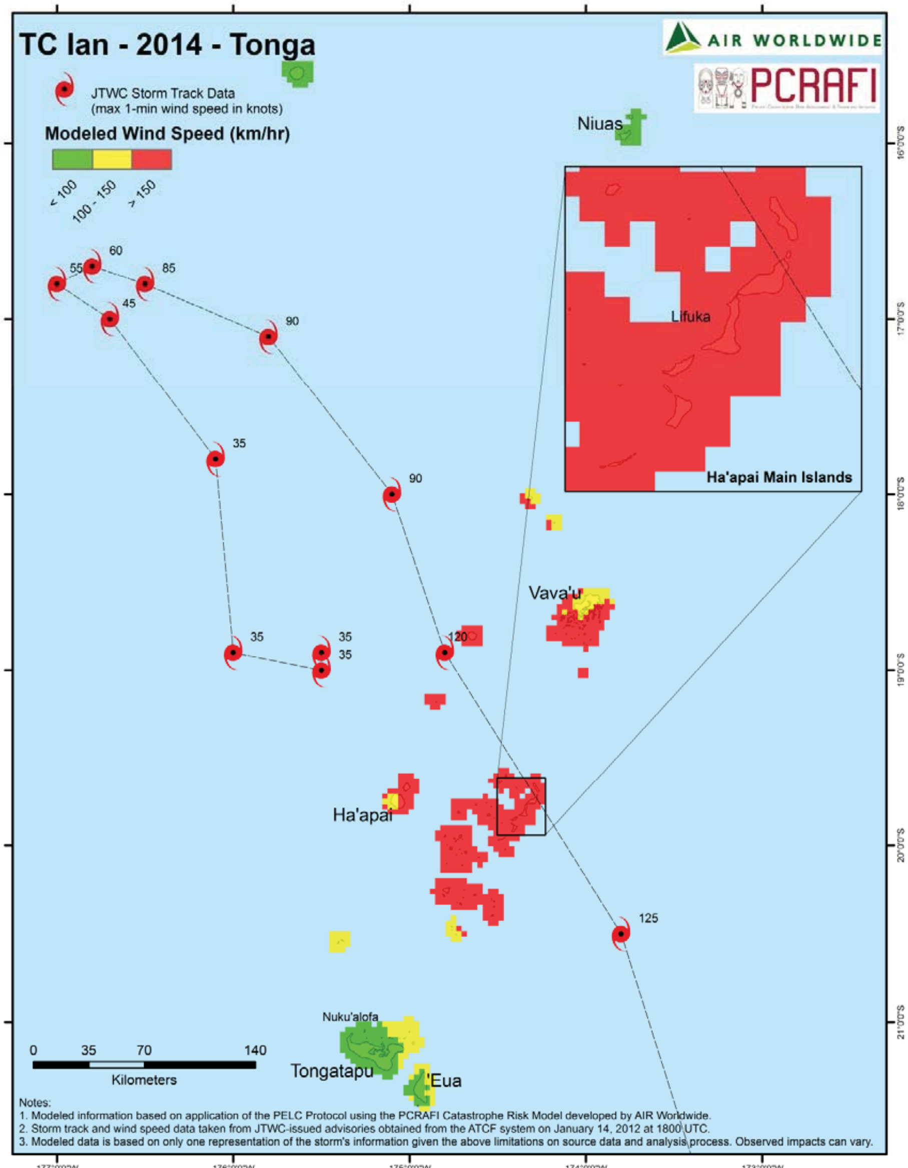
Appendix B: Modeled physical hazard from Tropical Cyclone Ian

Figure B.1– Modeled Accumulated Precipitation from Tropical Cyclone Ian over Tonga[5]



5 The JTWC issues wind speed data in knots, while the modeled wind speed is presented in km/hr. 1 knot = 1.852 km/hr

Figure B.2– Modeled Maximum Wind Speed from Tropical Cyclone Ian over Tonga[6]



6 The JTWC issues wind speed data in knots, while the modeled wind speed is presented in km/hr. 1 knot = 1.852 km/hr

Appendix C

Table C.1– Summary of TC Ian Storm Parameters Obtained from the JTWC

						One-Minute Maximum Sustained Surface Winds	
Year	Month	Day	Hour	Lat	Long	knots	km/hr
2014	1	5	18	-18.9	-175.5	35	64.82
2014	1	6	6	-19	-175.5	35	64.82
2014	1	6	18	-18.9	-176	35	64.82
2014	1	7	6	-17.8	-176.1	35	64.82
2014	1	7	18	-17	-176.7	45	83.34
2014	1	8	6	-16.8	-177	55	101.86
2014	1	8	18	-16.7	-176.8	60	111.12
2014	1	9	6	-16.8	-176.5	85	157.42
2014	1	9	18	-17.1	-175.8	90	166.68
2014	1	10	6	-18	-175.1	90	166.68
2014	1	10	18	-18.9	-174.8	120	222.24
2014	1	11	6	-20.5	-173.8	125	231.50
2014	1	11	18	-22.4	-173.2	125	231.50
2014	1	12	6	-24.5	-172.2	115	212.98
2014	1	12	18	-24.6	-171.3	80	148.16
2014	1	13	6	-29	-170.3	65	120.38
2014	1	13	18	-30.5	-168.8	50	92.60

PCRAFI

Pacific Catastrophe Risk Assessment & Financing Initiative

Annex 03:

Event Briefing

Earthquake and Tsunami in Solomon Islands

FEBRUARY 26, 2013 // COUNTRIES AFFECTED: SOLOMON ISLANDS

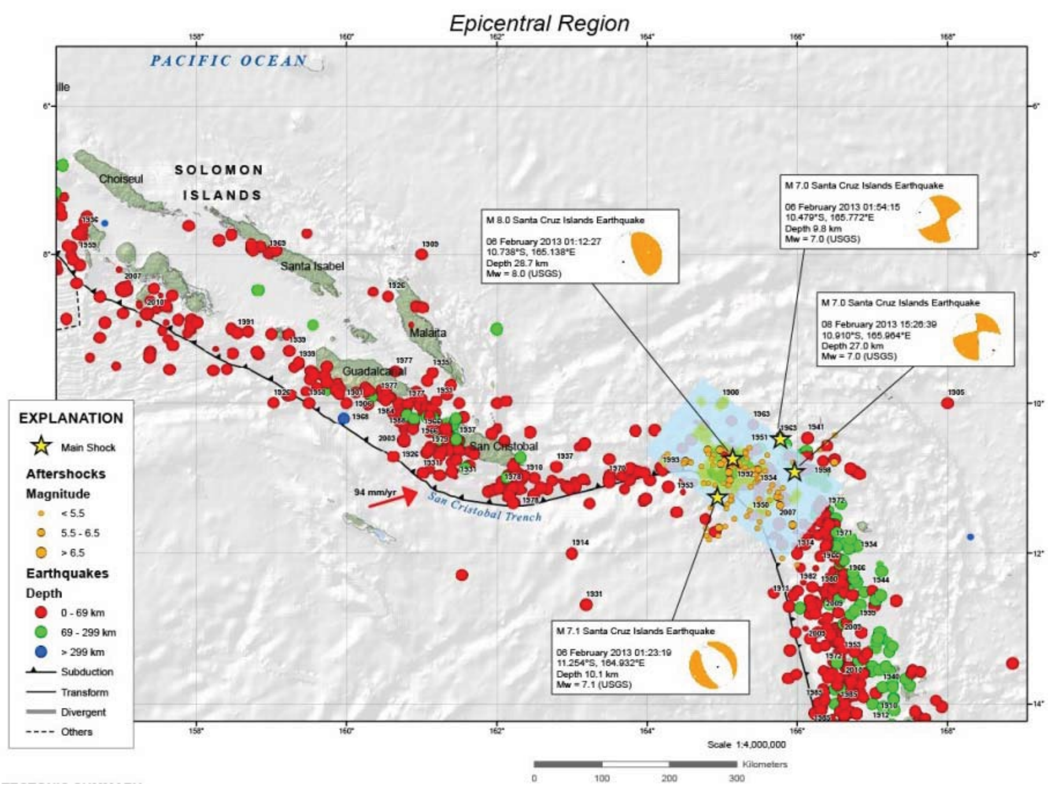
SPC Secretariat of the Pacific Community ADB GFDRR Global Facility for Disaster Reduction and Recovery WORLD BANK GROUP

Event Description

On 6 February 2013, at 12:12 local time (01:12 UTC) a 29 km deep M8.0 earthquake struck the Santa Cruz Island Group of the Solomon Islands, about 75 kilometers west of the town of Lata on Nendö Island, over 500 kilometers east-southeast of the Solomon Island capital of Honiara (see Figure 1). The earthquake occurred as a result of shallow thrust faulting around the plate boundary interface between the Australia and Pacific plates. In the region of this earthquake, the Australia plate converges with and subducts beneath the Pacific plate, moving towards the east-northeast at a rate of approximately 94 mm/yr. Over the month leading up to the February 6th earthquake, there have been dozens of earthquakes in the epicentral region – over 40 M4.5 or larger in the preceding seven days alone, seven of which were larger than M6. Several strong aftershocks were reported, including three with magnitudes of M7.0 or greater. (USGS, 2013)

Following the M8.0 earthquake, the Pacific Tsunami Warning Center (PTWC) issued a tsunami warning for the Solomon Islands, Papua New Guinea, Vanuatu, Fiji, and several other islands in the region; the agency also issued a tsunami watch for Tonga, Samoa, Marshall Islands, Australia, New Zealand, and other locations (PTWC, 2013). The earthquake produced a tsunami measuring about one meter in the Lata wharf in the Solomon Islands. Smaller tsunamis of 8 cm and 33 cm were reported in Honiara (the capital of Solomon Islands) and Vanuatu, respectively (NOAA, 2013). Further assessments indicated that the tsunami wave was closer to 3.5 meters high in some areas of Nendö Island (OCHA, 2013).

Figure 1– Map of the M8.0 event, foreshocks, aftershocks, and historical seismicity near the epicentral region (Source: USGS)



Source: JTWC

ANNEX 03

Post Event Loss Calculation Results

Under the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI), a post event loss calculation (PELC) protocol has been developed, which determines modeled mean loss estimates for impacted countries based on catastrophe risk models (earthquake, tsunami, and tropical cyclone) developed by AIR Worldwide Corporation for 15 Pacific Island Countries (PICs[1]). These modeled mean loss estimates are used for the Pacific Catastrophe Risk Insurance Pilot Program for five pilot countries (Samoa, Tonga, Marshall Islands, Vanuatu, and Solomon Islands). This program aims to increase the financial resilience of PICs against natural disasters. The modeled loss calculation is being conducted by AIR Worldwide Corporation.

Under this protocol, for an individual event, country-wide modeled ground-up mean losses (defined as the estimated cost to repair or replace damaged assets, including residential, commercial, industrial, and public buildings, cash crops, and major infrastructure) caused by earthquake ground shake and tsunami wave are calculated. In addition, estimates of emergency losses that national governments may sustain as a result of providing necessary relief and undertaking recovery efforts are calculated as a fraction of the ground-up losses. Earthquake parameters are obtained from the United States Geological Survey (USGS).

Based on a strict application of the PELC protocol, the modeled mean ground-up and emergency losses for the Solomon Islands are listed in Table 1.

It is emphasized that these estimated mean losses are only one view of the potential loss estimates; the estimated mean losses are for a single representation of the earthquake based on the USGS parameters and resulting calculated parameters as required by the PELC protocol. These losses represent averages which have uncertainty associated with them. The uncertainty (or range) around the mean loss value can be significant due to multiple sources of uncertainty, including but not limited to observation uncertainty (in hypocenter location and reported magnitude), uncertainty of the mean damage functions used to derive the modeled mean loss value, and the uncertainty in the hazard relationships used within the framework of the model. Additionally, it should be noted that the reported modeled mean loss values may differ from reported estimates. This is due to many factors including inconsistent definitions and methodologies used to derive the losses, exclusion of some sector losses from reported estimates, and limited completeness of the damage assessments conducted. Thus, any comparison between modeled mean loss estimates and reported estimates should be done with caution and with a full understanding of the limitations on the loss estimates.

Table 1– Modeled Mean Losses for the Solomon Islands from the Post Event Loss Calculation (PELC)[2]

Peril Type	Modeled Ground-up Losses (USD million)	Modeled Emergency Losses (USD million)
Ground Shaking	1.1	0.2
Tsunami Wave	2.6	0.6
Total	3.7	0.8

1 Cook Islands (CK), Federated States of Micronesia (FM), Fiji (FJ), Kiribati (KI), Republic of the Marshall Islands (MH), Nauru (NR), Niue (NU), Palau (PW), Papua New Guinea (PG), Samoa (WS), Solomon Islands (SB), Timor–Leste (TL), Tonga (TO), Tuvalu (TV), and Vanuatu (VU).

2 Note that these modeled loss estimates are based on USGS issued earthquake information obtained on February 8, 2013 at 18UTC (refer Appendix A). Estimated losses are rounded.

Event Impacts

Of the 15 PICs, the Solomon Islands is the only PIC that was materially impacted by the earthquake event (see Figure 2 that shows an overlay of the exposure value on the ground shaking intensity associated with the event). As shown in Figure 2, the impact of this large magnitude 8.0 earthquake was mitigated by the fact that it occurred at a significant distance from the principal concentrations of assets and population. The impacts of the earthquake were concentrated in the Temotu province which accounts for less than 5 percent of the population of the Solomon Islands, and less than 2 percent of total asset values as modeled in the PCRAFI exposure database (see Appendix B). Based on felt reports from the USGS's "Did you feel it?" system, the ground shaking intensity in Honiara was reported as an MMI of 2 (weak), corresponding to a PGA of about less than 0.02g. In general, other provinces outside Temotu province experienced similar low intensities. The impact on Solomon Islands is discussed in further detail below, with a summary assessment of the other PICs following.

Figure 2– Modeled physical exposure value for Solomon Islands overlaid on a footprint of peak ground acceleration estimates derived from the USGS Shakemap

Note that USGS data is provided only for a certain distance from the epicenter and the mean loss calculations under PCRAFI are based on a model generated event footprint that covers a much larger spatial extent)

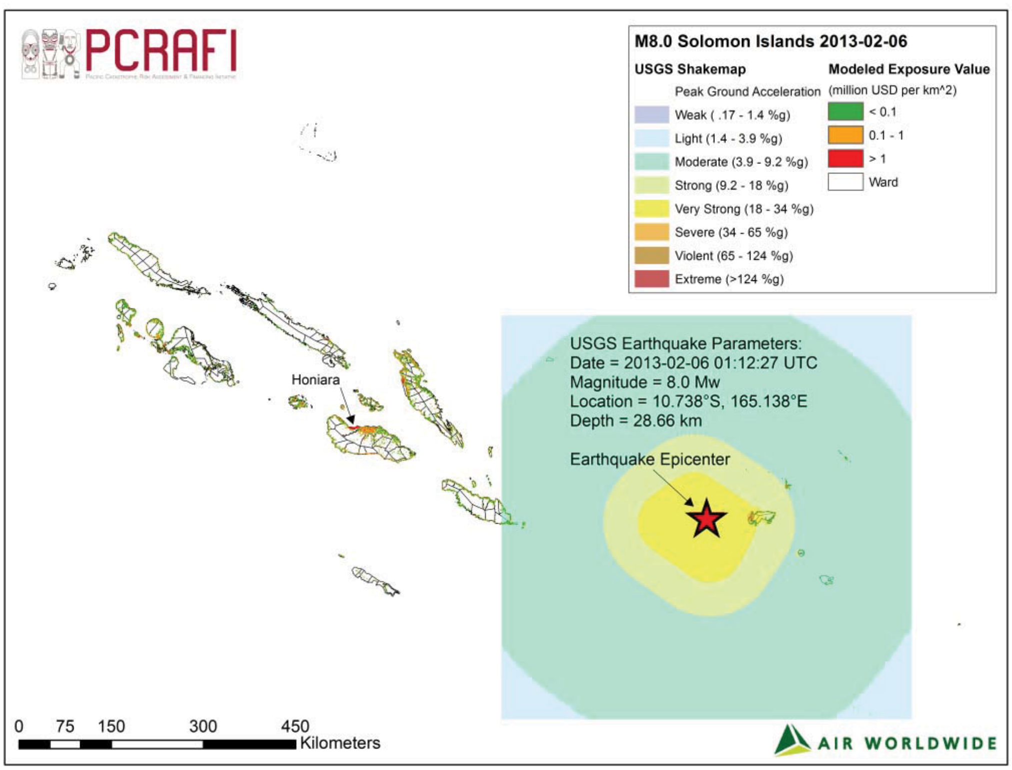


Figure 3– Damage in Venga Village, Nendö Island (Photo: Matt Anderson/DFAT/AusAID)

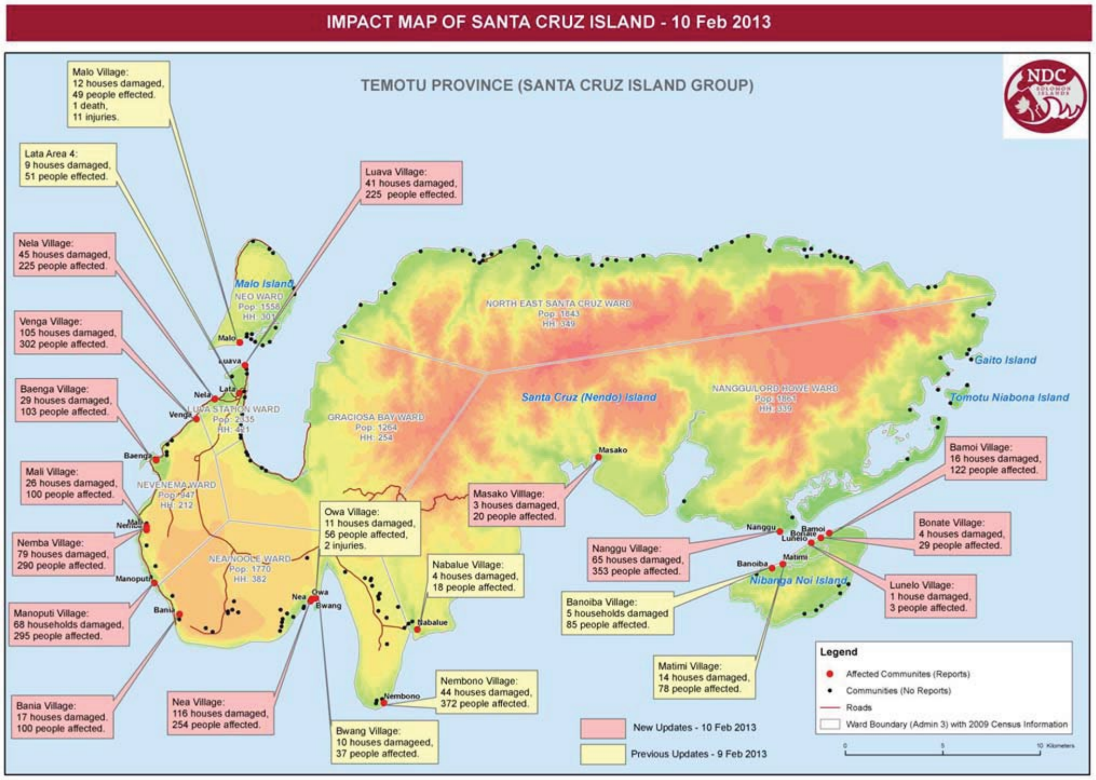
Affected Countries: Solomon Islands

The maximum ground shaking intensity, based on an average of three reported human observations at Lata on Nendö Island, i.e., the "felt" intensity, was MMI 8 (severe), according to the USGS "Did You Feel It?" system. According to the NOAA/WDC Tsunami Event Database, tsunami wave heights of 1.5 meters and 3.0 meters were observed (from eye-witness accounts) on Nendö Island. Based on current assessments3, a number of villages in the Solomon Islands' southeastern province of Temotu (approximate population of 20,000) have suffered extensive damage (e.g., see Figures 3 and 4). As of February 20th the Initial Damage Assessment from the Government of the Solomon Islands reported 581 houses destroyed, 479 houses partially damaged and 4486 people affected by the earthquake and tsunami. The National Disaster Management Office confirmed 10 fatalities following the disaster. The water supply infrastructure in Lata was significantly damaged, affecting the entire population. The Lata airport and wharf both sustained significant damages. Relevant hazard and exposure data are presented in Figure 5.

Government estimates of damage costs and losses are currently not available, although detailed sector assessments are underway. The NOAA/WDC Tsunami Event Database currently estimates the damage from the tsunami at approximately one to five million USD. The modeled mean ground-up loss estimate presented above from the PELC of $3.7 million is driven by damage in the residential sector which accounts for the majority of the total modeled loss. Damage to public assets is the second largest contributor, although this accounts for less than a quarter of the modeled total. Damage occurring through other sectors, including commercial buildings and infrastructure, accounts collectively for less than 10 percent of the modeled total.

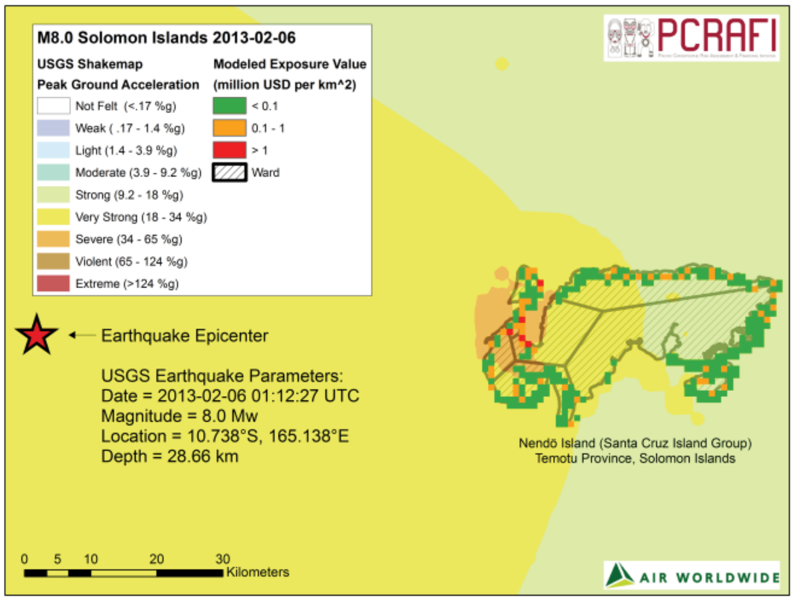
3 IFRC, Information Bulletin n° 2, TS-2013-000015-SLB, 19 February 2013 and OCHA, Solomon Islands: Earthquake and Tsunami, Situation Report No. 6 (as of 21 February 2013)

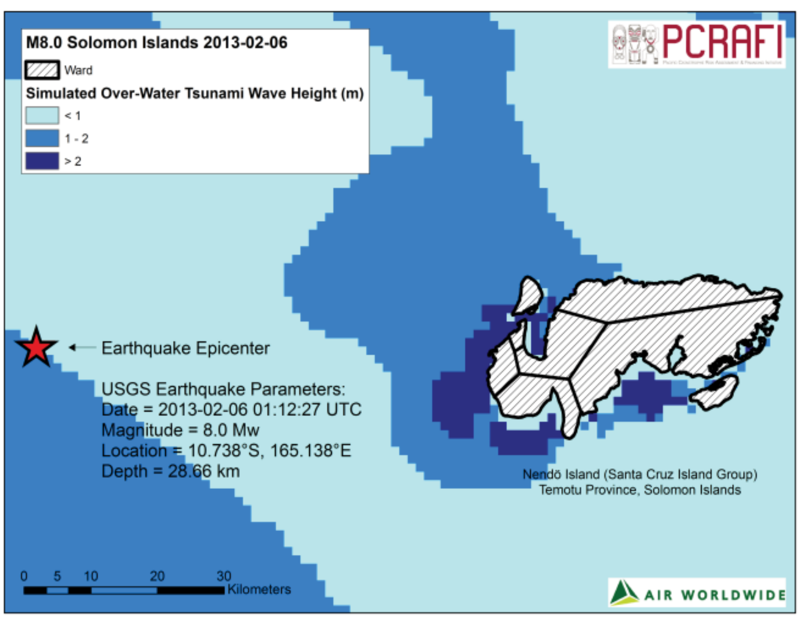
Figure 4– An impact map of Santa Cruz, showing affected villages as at February 10th 2013



(Source: Government of the Solomon Islands)

Figure 5– Modeled physical exposure value overlaid on peak ground acceleration estimates derived from the USGS Shakemap (top) and PELC simulated over-water (not run-up) tsunami wave heights (bottom)





Other Pacific Island Counties

Besides Solomon Islands, no other country was significantly impacted by the earthquake and tsunami. Due to the remoteness of the earthquake, damaging ground shaking is expected to have only occurred in the Temotu Province (e.g., the Santa Cruz Island Group) in the Solomon Islands. Table 2 shows the maximum observed tsunami run-ups in the other PICs as reported by the NOAA/WDC Tsunami Event Database.

Table 2– Summary of Modeled Exposure in To``nga (2010)

Country	Maximum Water Height (m)	Measurement Type
Vanuatu	0.33	Tide-gauge measurement
Papua New Guinea	0.17	Deep ocean gauge
Kiribati	0.12	Tide-gauge measurement
Samoa	0.07	Tide-gauge measurement
Fiji	0.06	Tide-gauge measurement
Tonga	0.04	Tide-gauge measurement
Federated States of Micronesia	0.02	Deep ocean gauge

Appendix A

Table A.1– Summary of Earthquake Parameters Obtained from the USGS

Pacific Earthquake Event Parameter	Value
Date	2013-02-06 01:12:27 UTC
Moment Magnitude	Mw 8.0
Centroid Location (latitude/ longitude)	10.7377° S, 165.1378° E
Centroid Depth	28.66 km
Strike Angle (Rupture Azimuth)	308.0 degrees
Dip Angle	18.0 degrees
Slip Angle (Rake)	64.491 degrees (rounded)
Rupture Length and Width	Not given[4]

Notes:

Parameters are obtained from the USGS-issued "Preliminary Finite Fault Results for the Feb 06, 2013 Mw 8.0 -10.7377,165.1378 Earthquake (Version 1)" with "Location and Magnitude contributed by: USGS, NEIC, Golden, Colorado (and predecessors)"

Page URL: http://earthquake.usgs.gov/earthquakes/eventpage/usc000f1s0 Page Last Modified: February 07, 2013 03:14:45 UTC

Page Accessed: February 08, 2013 18UTC

4 Rupture length and width are calculated from relationships outlined in the PELC protocol documentation.

Appendix B

Table B.1– Modeled Distribution of Assets and Population for the Solomon Islands

Province Name	Projected 2010 Population	Modeled Asset Value (2010 USD)
	Percentage of Country Total	*Percentage of Country Total*
Choiseul	4.90%	2.10%
Western	15.30%	16.60%
Isabel	5.00%	2.30%
Central	5.30%	3.80%
Rennell-Bellona	0.60%	0.40%
Guadalcanal	14.70%	19.60%
Malaita	30.00%	13.70%
Makira-Ulawa	7.60%	2.70%
Temotu	4.60%	1.30%
Honiara	12.00%	37.5

Source PCRAFI 2012

PCRAFI
Pacific Catastrophe Risk Assessment & Financing Initiative

Annex 04:

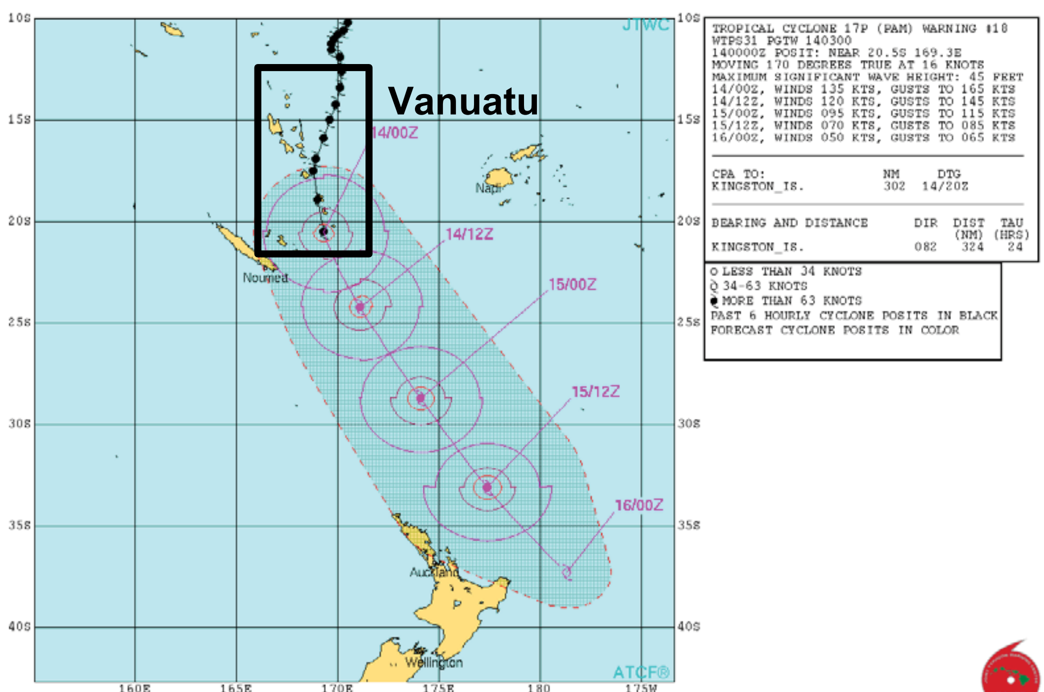
Event Briefing Tropical Cyclone Pam

APRIL 14, 2015 // COUNTRIES AFFECTED: VANUATU

Event Description

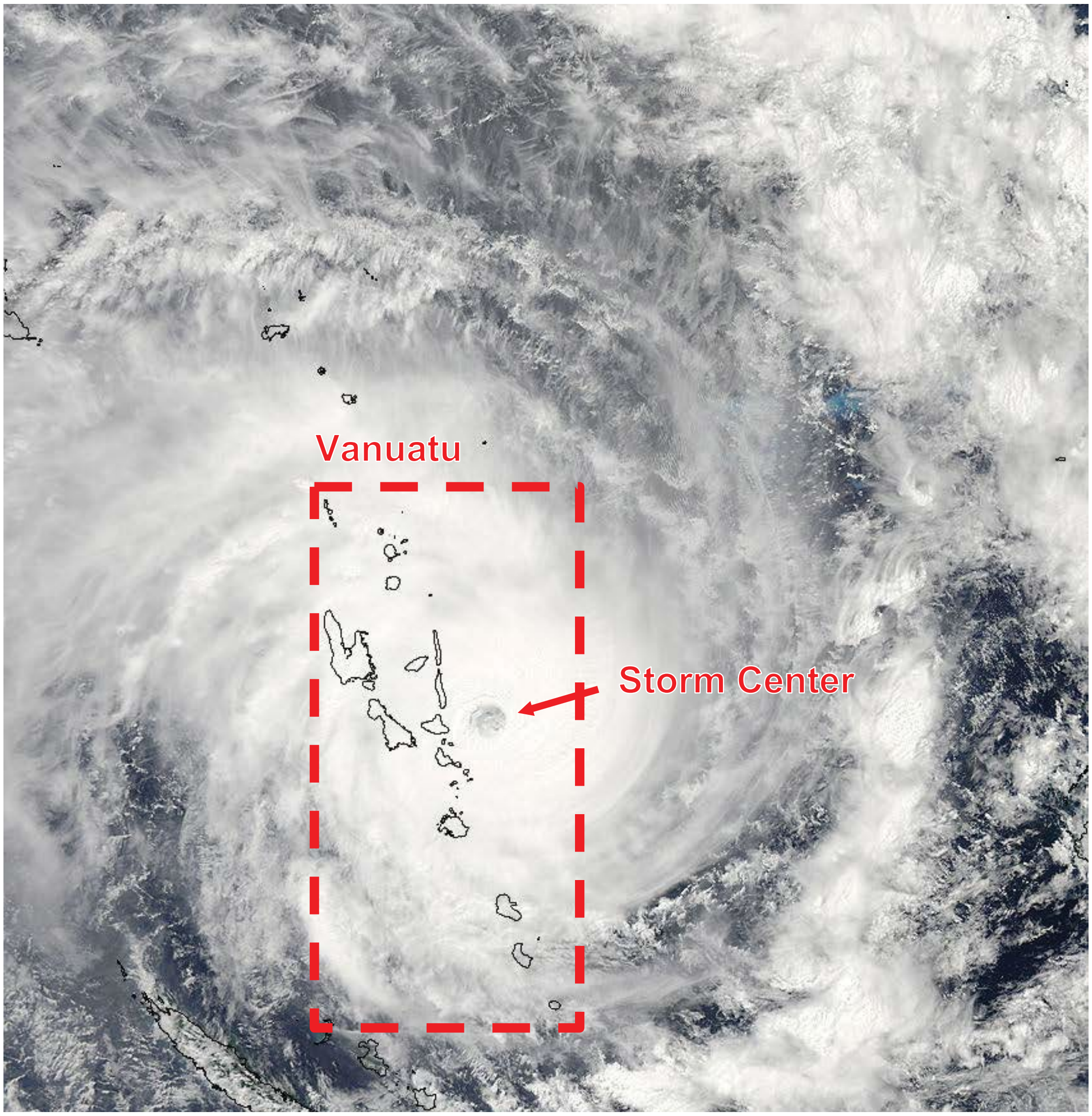
On March 6, 2015, the Fiji Meteorological Service's Regional Specialized Meteorological Centre in Nadi, Fiji (RSMC Nadi) reported that Tropical Disturbance 11F had developed about 1,140 km (710 mi) to the northwest of Nadi, Fiji. The system was located within an area of favorable environment for further development, which included low to moderate vertical wind shear and favorable sea surface temperatures. The disturbance slowly strengthened while foundering east of the Solomon Islands for two days before RSMC Nadi reported, on March 8, that the system had developed into a tropical depression. By the next day, the system further consolidated before the United States Joint Typhoon Warning Center (JTWC) initiated warnings and designated the depression as Tropical Cyclone 17P (Pam) later that day (see Figure 1 for an example warning advisory). Tropical Cyclone Pam continued south-southwest and rapidly intensified as it approached Vanuatu (see Figure 2 for a satellite image of Tropical Cyclone Pam on March 13 at 0220 UTC). On March 13 at 1200 UTC the storm reached its maximum intensity (with one minute maximum sustained surface winds of 145 knots) as the eye of the tropical cyclone passed by Vanuatu's capital approximately 45 km east of Port Vila. Based on the JTWC tropical cyclone warning advisories, the storm continued to track in the south-southeast direction, passing east of Efate and continuing in the southerly direction as its intensity weakened.

Figure 1– JTWC-Issued Warning Advisory for Tropical Cyclone Pam on 0000 UTC March 14, 2015



Source: JTWC

Figure 2– Satellite Image of Tropical Cyclone Pam on 0220 UTC March 13, 2015.



Source: NASA Goddard MODIS Rapid Response Team)

Post Event Loss Calculation Results

Under the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI), a post event loss calculation (PELC) protocol has been developed, which determines modeled mean loss estimates for impacted countries based on the catastrophe loss models (earthquake, tsunami, and tropical cyclone) developed by AIR Worldwide Corporation (AIR) for 15 Pacific Island Countries (PICs1). These modeled mean loss estimates are currently used for the Pacific Catastrophe Risk Insurance Pilot Program for five countries (Samoa, Tonga, Marshall Islands, Vanuatu, and Cook Islands). This program aims to increase the financial resilience of PICs against natural disasters. The modeled loss calculation was conducted by AIR.

Under this protocol2, for a tropical cyclone event, country-wide modeled ground-up mean losses (defined as the estimated cost to repair or replace damaged assets, including residential, commercial, industrial, and public buildings, major cash crops, and major infrastructure) caused by tropical cyclone induced wind, flood from storm surge, and flood from tropical cyclone induced precipitation are calculated. In addition, estimates of emergency loss that national governments may sustain as a result of providing necessary relief and undertaking recovery efforts are calculated as a fraction (23percent) of the ground-up mean loss estimates. Tropical cyclone parameters are obtained from JTWC-issued tropical cyclone warning data archived by the Automated Tropical Cyclone Forecasting (ATCFTM) System (see Appendix C for track parameters).

Based on a strict application of the PELC protocol, the modeled ground-up mean loss for Vanuatu is calculated to be US$183.5 million with an associated modeled emergency loss of US$42.2 million (see Table 1).

It must be emphasized that these estimated mean losses are only one view of the potential loss as the losses are generated using a single representation of the storm track and intensity based on the JTWC parameters as required by the PELC protocol. These losses represent averages which have uncertainty associated with them. The uncertainty (or range) around the mean value can be significant due to multiple sources of uncertainty, such as observation uncertainty (in track location and reported wind speed) and uncertainty around damage functions used to derive the modeled mean value, among other sources of uncertainty in the calculations.

Additionally, it should be noted that the reported modeled mean loss values can differ from reported government estimates. This is due to many factors including those discussed above as well as differing definitions, methodologies, and sectors covered in the assessments and vice-versa (see Figure 7 for breakdown of modeled losses by sector). Thus, any comparison between modeled mean loss estimates and reported government estimates should be done with caution and with a full understanding of the limitations on both sets of loss estimates. It should also be noted that any payout resulting from the Pacific Catastrophe Risk Assessment and Financing Initiative is based on the results of the PELC, not the government assessments.

Table 1– Modeled Mean Losses from Post Event Loss Calculation (PELC)[3]

Country	Modeled Ground-up Losses (USD million)	Modeled Emergency Losses (USD million)
Vanuatu	183.5	42.2

1 Cook Islands (CK), Federated States of Micronesia (FM), Fiji (FJ), Kiribati (KI), Republic of the Marshall Islands (MH), Nauru (NR), Niue (NU), Palau (PW), Papua New Guinea (PG), Samoa (WS), Solomon Islands (SB), Timor–Leste (TL), Tonga (TO), Tuvalu (TV), and Vanuatu (VU).

2 The Post Event Loss Calculation (PELC) Process specified in the Calculation Agency Agreement.

3 Note that these modeled loss estimates are based on JTWC-issued storm parameters obtained from the ATCF on March 15, 2015 at 1800 UTC (refer to Appendix C) from **http://www.nrlmry.navy.mil/atcf_web/docs/warnings/2015/**. Estimated losses shown are rounded.

Event Impacts

Of the 15 PICs, Vanuatu is the only PIC that exhibited significant modeled mean loss estimates and damage (e.g., see Figure 3 for the track of TC Pam relative to the PICs). Other PICs, namely Solomon Islands, Kiribati, and Tuvalu, reported impacts from this event, but these nations do not participate in the PCRAFI PELC process and thus do not have modeled loss estimates. As such, the impact of TC Pam on Vanuatu is discussed further in the next section.

Figure 3– Track Data for Tropical Cyclone Pam from JTWC Advisories Overlaid on the PIC Domain (Pilot Countries Labeled in Red)

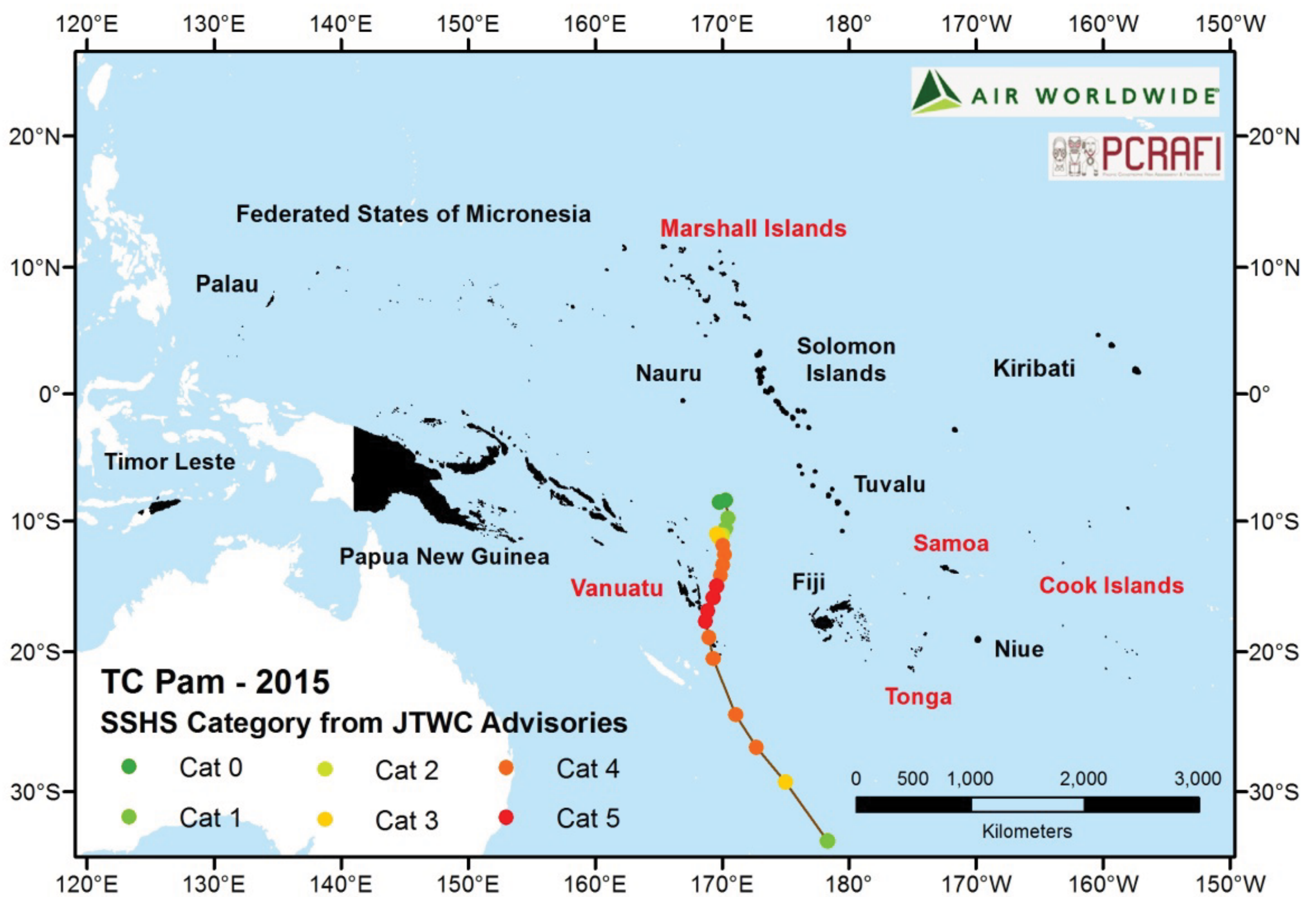


Figure 4– Homes destroyed by Tropical Cyclone Pam in Port Vila on March 16, 2015. [Photo: REUTERS/Dave Hunt/Pool]

Affected Countries: Vanuatu

On March 13, 2014, Tropical Cyclone Pam swept through the southern portion of Vanuatu's islands with reported maximum one-minute sustained wind speeds of 145 knots (equivalent to Category 5 strength on the Saffir-Simpson Hurricane Wind Scale), and tracked almost 15 km/hr in a south-southeast direction. At approximately 1200 UTC, the cyclone's western eyewall passed over the eastern side of Efate Island (population of approximately 66,000), which is home to the capital city of Port Vila. Port Vila is located on the southwest side of the island and was able to escape the strongest winds of the eyewall despite sustaining damage. Tropical Cyclone Pam continued in the southerly direction, passing just west of Erromango Island and Tanna Island by 1800 UTC March 13, with maximum one-minute sustained wind speed of 135 knots (equivalent to Category 4 strength on the Saffir-Simpson Hurricane Wind Scale). Note that the above information is based on reported parameters obtained from tropical cyclone warning advisories issued by the JTWC, which is a requirement of the PELC. Other agencies (e.g., Fiji Meteorological Service and Vanuatu Meteorological Service) may report different values for the parameters.

After the tropical cyclone passed Vanuatu, there were reports of damage (e.g., see Figure 4), and by March 25, there were 11 confirmed fatalities, 15,000 buildings damaged or destroyed, and an estimated 3,370 people in 48 evacuation centers. Reconnaissance flights by Australia and France found severe and widespread damage to the larger islands of Tanna, Erromango, and Efate, while less damage was assessed on the smaller islands of Aneityum, Aniwa, and Futuna in the southern region. Islands in Tafea Province and the outer islands of Shefa Province were deemed high priority areas for water, food, shelter, and health assistance. Root crops, which constitute approximately 80% of the local food source for the entire population, have been significantly damaged across all affected islands (Data collected primarily from OCHA Situation Report No. 3-11).

Countrywide, Vanuatu's building stock consists mainly of single story masonry/concrete buildings, traditional style dwellings (typically constructed of woven bamboo walls and thatch roofs), and single story timber frame homes. However, the distribution of construction types may vary between urban and rural communities across the islands (e.g. Port Vila has a higher percentage of masonry/concrete buildings and lower percentage of traditional-style dwellings when compared to the country-wide average). Overall, the PELC estimates that TC Pam resulted in a loss cost of 5.5% (which is defined as the total modeled damage normalized by the associated replacement value) for the entire country of Vanuatu. Table A (see Appendix A) summarizes the modeled assets for Vanuatu in the year 2010. Figure 5 illustrates the modeled physical exposure of Vanuatu (in terms of value) and how it differs across the islands. For example, Port Vila, Vanuatu's capital city, is highlighted as a concentration of exposure; however, there is also a large concentration center, Luganville, in the northern islands. Damaging effects from the storm (wind and flooding from precipitation and storm surge) are primarily concentrated in the southern part of the country, as these areas experienced the highest hazard intensities (see Appendix B for a modeled wind speed map and modeled accumulated precipitation map).

Figure 6 shows the modeled ground-up mean loss, by Area Council, resulting from TC Pam. It is estimated that Shefa Province sustained the highest value of ground-up mean losses, estimated to be US$98.9 million. Losses have been calculated using the PELC methodology outlined above. The highest level of modeled losses was attributable to residential buildings, which account for about 60% of the total modeled mean ground-up loss. This was followed by the classification of "Commercial, industrial, and other building" losses, which accounted for approximately 18% of the total modeled mean ground-up loss. The classification of "Public buildings and infrastructure" accounted for approximately 18% of the total mean ground-up losses. Crops constituted the smallest proportion of modeled losses at approximately 5% (see Figure 7).

While Tropical Cyclone Pam has caused substantial damage to Port Vila and the southern islands of Vanuatu, there are other plausible storm scenarios that have the potential to cause greater loss. Vanuatu's exposure value is dispersed throughout the island chain and is not exclusively concentrated in the capital of Port Vila. While 60% of the exposure value is located in the provinces of Shefa and Tafea, approximately 30% of the value is located in the provinces of Sanma and Malampa, where Pam is expected to have caused less damage. Figure 5 shows that Pam's track passes closely to the southern provinces of Shefa and Tafea, where most of the damage is being reported. The northern provinces – particularly Sanma and Malampa – are much further from the centerline of the track, and the maximum modeled wind speeds in these regions are much lower than those in the south (see Appendix B).

If Pam's path had significantly impacted the northern provinces of Sanma and Malampa or passed closer to the capital city of Port Vila, the damage and associated loss incurred by Vanuatu would have been much higher. It is possible for other tropical cyclones to have tracks that pass close enough to affect all the islands of Vanuatu, causing significant damage throughout the entire country.

The estimated return period of the tropical cyclone hazard at West Tanna, where tropical cyclone Pam imposed some of the highest wind speeds on populated areas, was greater than 500 years. However, the return period of the modeled loss is approximately 40 years and the wind speed hazard at Port Vila is approximately 50 years because the center of the storm remained offshore of the capital by approximately 45km. Should Pam's central path have passed closer to Port Vila, the damage and associated losses incurred would have been substantially greater than the modeled losses caused the by Pam's track, corresponding to a modelled loss return period of more than 150 years.

Figure 5– Modeled Physical Exposure of Vanuatu. Track Data for Tropical Cyclone Pam taken from JTWC Advisories

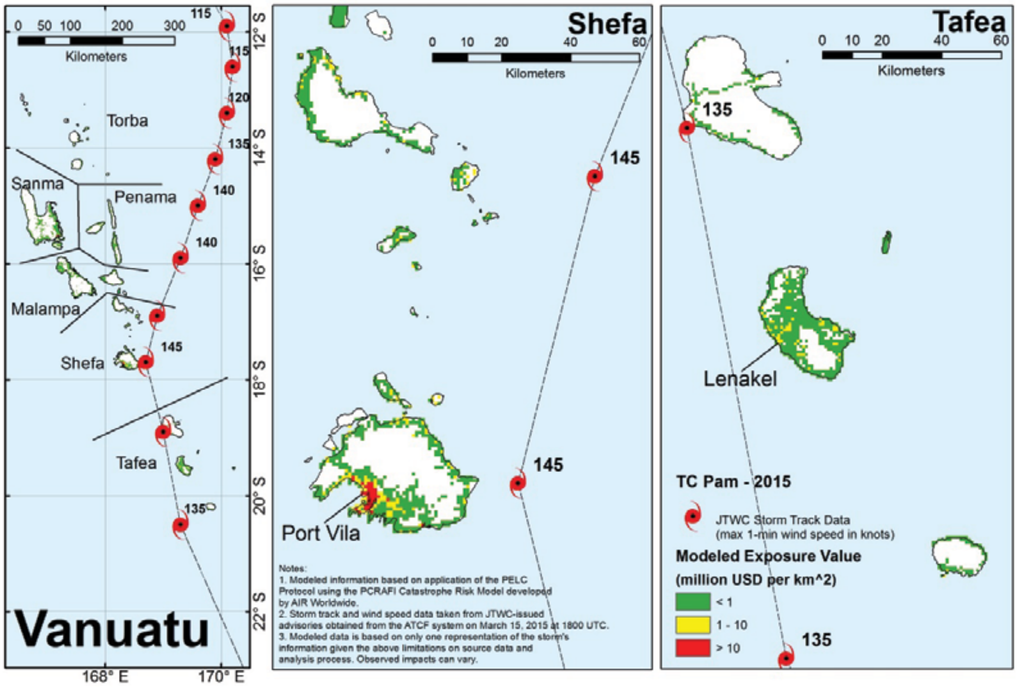


Figure 7– Breakdown of Total Modeled Ground-up Mean Loss by Sector for Tropical Cyclone Pam in Vanuatu

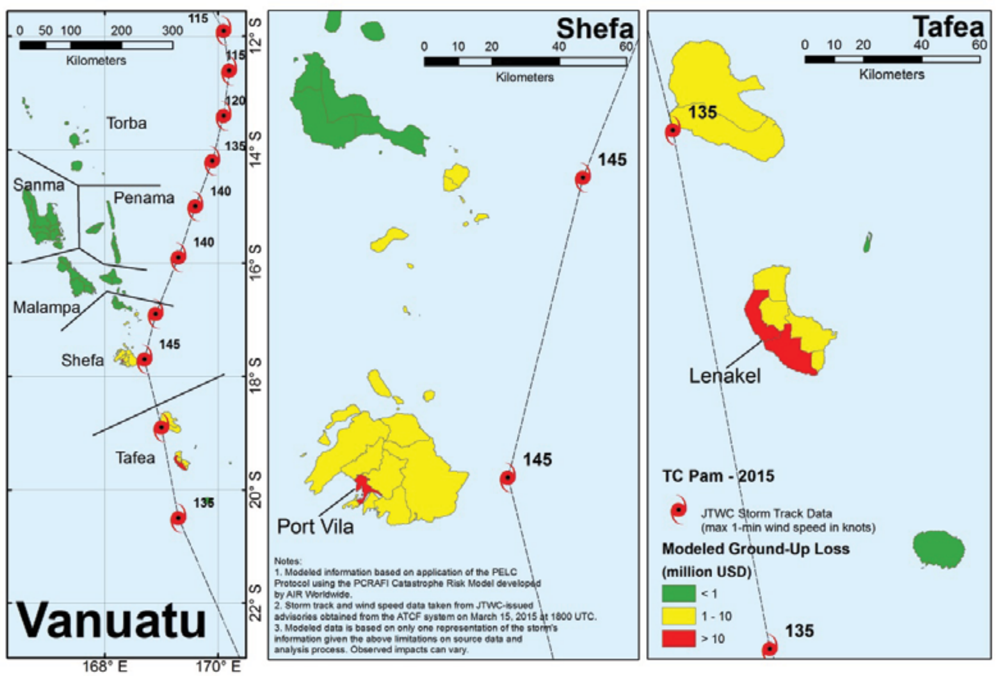
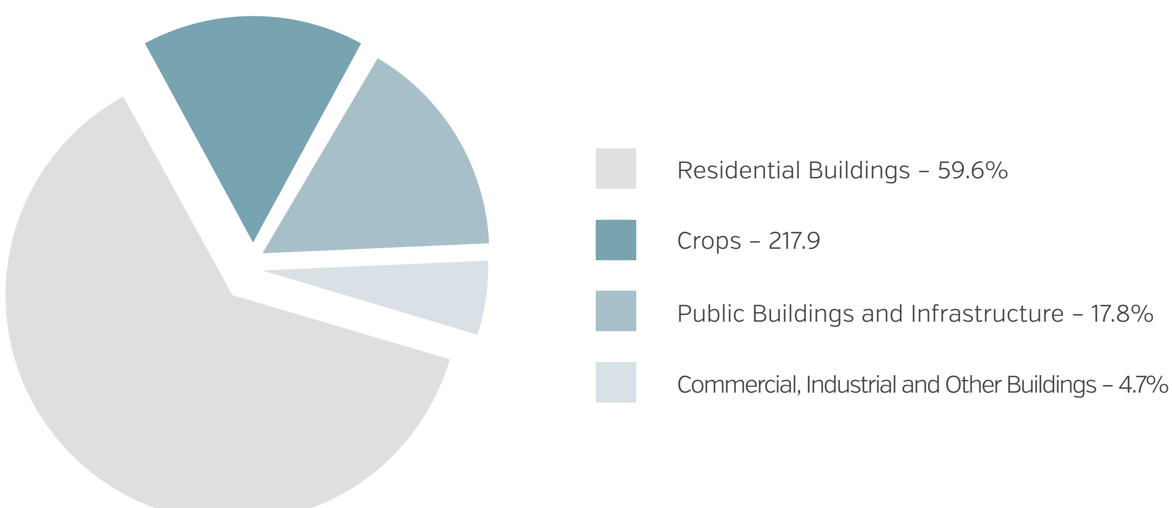


Figure 8– Breakdown of Total Modeled Ground-up Mean Loss by Sector for Tropical Cyclone Pam in Vanuatu



Appendix A

Table A.1– Summary of Modeled Exposure in Vanuatu (2010)

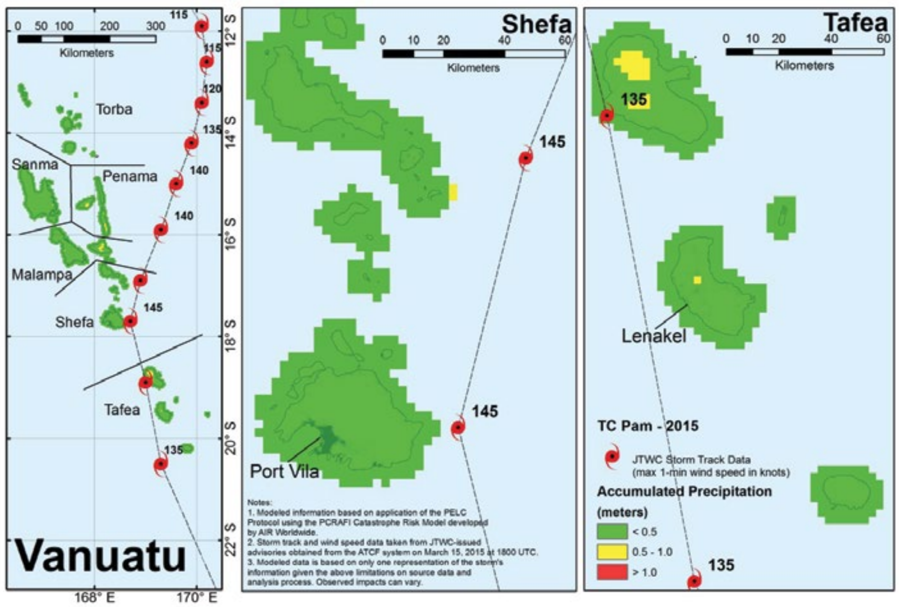
General Information:	
Total Population:	246,000
GDP Per Capita (USD):	2,960
Total GDP (million USD):	729.0
Asset Counts:	
Residential Buildings:	90,699
Public Buildings:	3,280
Commercial, Industrial, and Other Buildings:	6,767
All Buildings:	100,746
Hectares of Major Crops:	78,434
Cost of Replacing Assets (million USD):	
Buildings:	2,858
Infrastructure:	420
Crops:	56
Total:	3,334
Government Revenue and Expenditure:	
Total Government Revenue:	
(Million USD):	173.7
(% GDP):	23.80%
Total Government Expenditure:	
(Million USD):	178.8
(% GDP):	24.50%

Table A.2– Summary of Modeled Ground-up Mean Loss Estimates in Vanuatu from TC Pam

Area Council	*Province*	*Loss Cost (Modeled Loss Normalized by Exposure Value)*
Emau	Shefa	> 50%
South West Tanna	Tafea	25% - 50%
South Tanna	Tafea	25% - 50%
West Tanna	Tafea	25% - 50%
Tongariki	Shefa	25% - 50%
North Tanna	Tafea	25% - 50%
North Tongoa	Shefa	25% - 50%
Aniwa	Tafea	25% - 50%
Middle Bush Tanna	Tafea	25% - 50%
Whitesands	Tafea	10% - 25%
North Efate	Shefa	10% - 25%
Nguna	Shefa	10% - 25%
South Erromango	Tafea	10% - 25%
Eton	Shefa	10% - 25%
Makimae	Shefa	10% - 25%
North Erromango	Tafea	10% - 25%
All Others		< 1%

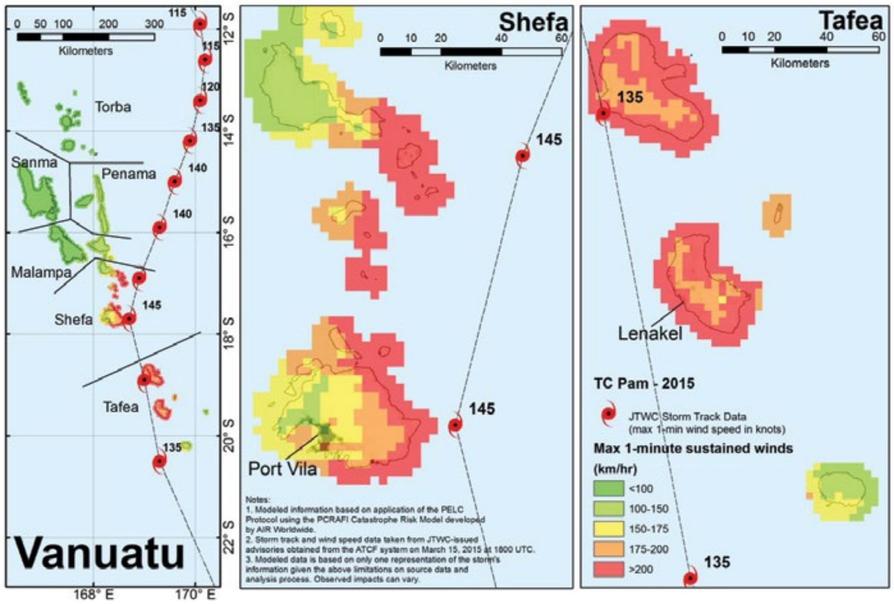
Appendix B: Modeled physical hazard from Tropical Cyclone Pam

Figure A.1– Modeled Accumulated Precipitation from Tropical Cyclone Pam over Vanuatu[4]



4 The JTWC issues wind speed data in knots, while the modeled wind speed is presented in km/hr. 1 knot = 1.852 km/hr

Figure A.2– Modeled Maximum Wind Speed from Tropical Cyclone Pam over Vanuatu[5]



5 The JTWC issues wind speed data in knots, while the modeled wind speed is presented in km/hr. 1 knot = 1.852 km/hr

Appendix C

Table C.1– Summary of TC Pam Storm Parameters Obtained from the JTWC

						One-Minute Maximum Sustained Surface Winds	
Year	Month	Day	Hour	Lat	Long	knots	km/hr
2015	3	9	6	-8.5	169.8	35	64.8
2015	3	9	12	-8.4	170.3	45	83.3
2015	3	10	0	-9.8	170.5	65	120.4
2015	3	10	12	-10.6	170.3	80	148.2
2015	3	10	18	-11.1	170.1	90	166.7
2015	3	11	0	-11	169.6	100	185.2
2015	3	11	6	-11.2	169.7	105	194.5
2015	3	11	18	-11.9	170.1	115	213
2015	3	12	0	-12.6	170.2	115	213
2015	3	12	6	-13.4	170.1	120	222.2
2015	3	12	12	-14.2	169.9	135	250
2015	3	12	18	-15	169.6	140	259.3
2015	3	13	0	-15.9	169.3	140	259.3
2015	3	13	6	-16.9	168.9	145	268.5
2015	3	13	12	-17.7	168.7	145	268.5
2015	3	13	18	-18.9	169	135	250
2015	3	14	0	-20.5	169.3	135	250
2015	3	14	12	-24.6	171.1	130	240.8
2015	3	14	18	-26.9	172.7	115	213
2015	3	15	0	-29.3	175	100	185.2
2015	3	15	12	-33.3	178.3	65	120.4

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