PACIFIC CATASTROPHE RISK ASSESSMENT AND FINANCING INITIATIVE

SEPTEMBER 2011

COUNTRY RISK PROFILE: SAMOA

Samoa is expected to incur, on average, 10 million USD per year in losses due to earthquakes and tropical cyclones. In the next 50 years, Samoa has a 50% chance of experiencing a loss exceeding 130 million USD and casualties larger than 325 people, and a 10% chance of experiencing a loss exceeding 350 million USD and casualties larger than 560 people.

POPULATION, BUILDINGS, INFRASTRUCTURE AND CROPS EXPOSED TO NATURAL PERILS

An extensive study has been conducted to assemble a comprehensive inventory of population and properties at risk. Properties include residential, commercial, public and industrial buildings; infrastructure assets such as major ports, airports, power plants, bridges, and roads; and major crops, such as coconut, banana, taro, sugarcane, papaya and many others.

TABLE 1:
Summary of Exposure in Samoa (2010)

General Information:	
Total Population:	183,000
GDP Per Capita (USD):	3,090
Total GDP (million USD):	565.2
Asset Counts:	
Residential Buildings:	41,960
Public Buildings:	1,720
Commercial, Industrial, and Other Buildings:	5,151
All Buildings:	48,831
Hectares of Major Crops:	35,553
Cost of Replacing Assets (million USD):	
Buildings:	2,148
Infrastructure:	465
Crops:	25
Total:	2,638
Government Revenue and Expenditure:	
Total Government Revenue	
(Million USD):	170.8
(% GDP):	30.2%
Total Government Expenditure	
(Million USD):	224.4
(% GDP):	39.7%

[1] Data assembled from various references including WB, ADB, IMF and The Secretariat of the Pacific Community (SPC).
[2] The projected 2010 population was trended from the 2006 census using estimated growth rates provided by SPC.

Table 1 summarizes population and the inventory of buildings, infrastructure assets, and major crops (or "exposure") at risk as well as key economic values for Samoa. It is estimated that the ***replacement value of all the assets in Samoa is 2.6 billion USD*** of which about 81% represents buildings and 18% represents infrastructure.

Figures 1 and 2 illustrate the building exposure location and replacement cost distribution, respectively. The footprints of all the approximately 49,000 buildings shown in Figure 1 were digitized from high-resolution satellite imagery. More than

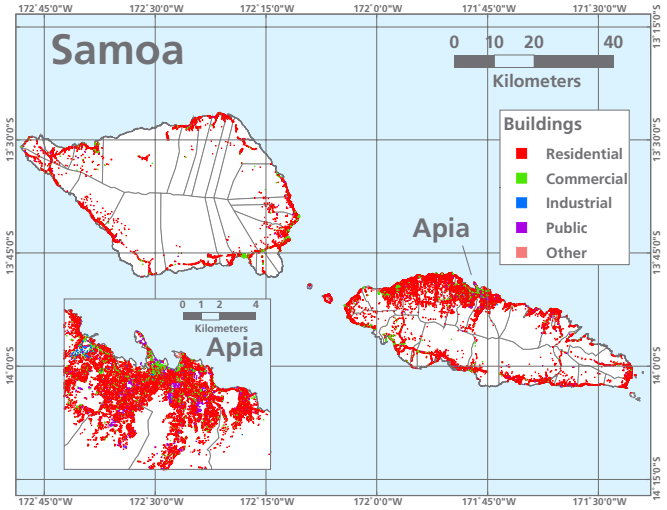


Figure 1: Building locations.

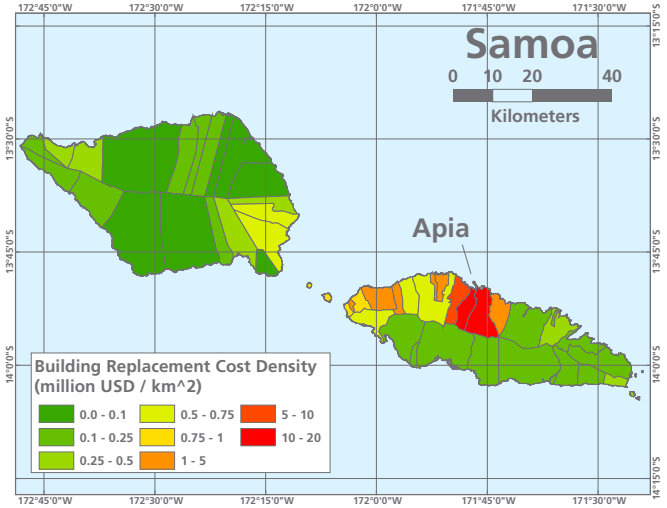


Figure 2: Building replacement cost density by district.

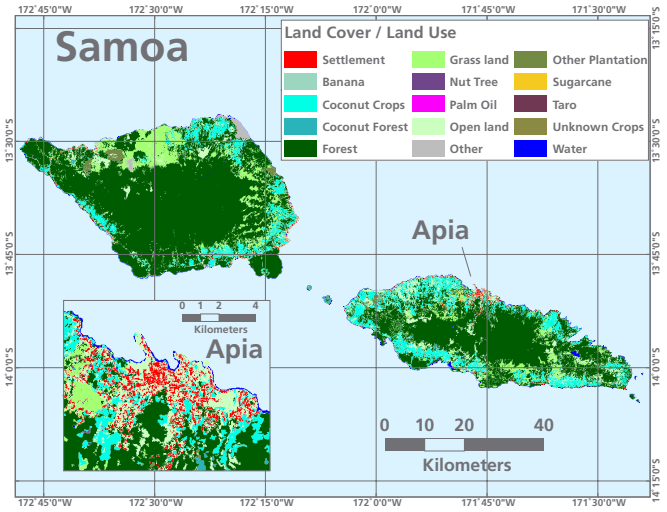


Figure 3: Land cover/land use map.

6,500 of such buildings, most of them in Apia, were also field surveyed and photographed by a team of inspectors deployed for this purpose. Figure 3 displays the land cover/land use map that includes the location of major crops. The data utilized for these exhibits was assembled, organized and, when unavailable, produced in this study.

TROPICAL CYCLONE AND EARTHQUAKE HAZARDS IN SAMOA

The Pacific islands region is prone to natural hazards. Samoa is located south of the equator in an area known for the frequent occurrence of tropical cyclones with damaging winds, rains and storm surge between the months of October and May. In the South Pacific region from the equator to New Zealand in latitude and from Indonesia to east of Hawaii in longitude almost 1,000 tropical cyclones with hurricane-force winds spawned in the last 60 years, with an average of about 16 tropical storms per year. Samoa was affected by devastating cyclones multiple times in the last few decades. For example, tropical cyclones Ofa and Val, in 1990 and 1991, caused 21 fatalities and widespread destruction with total economic losses between 300 and 500 million USD that crippled the local economy. Figure 4 shows the levels of wind speed due to tropical cyclones that have about a 40% chance to be exceeded at least once in the next 50 years (100-year mean return period). These wind speeds, if they were to occur, are capable of generating severe damage to buildings, infrastructure and crops with consequent large economic losses.

Samoa is situated in a relatively quiet seismic area but is surrounded by the Pacific "ring of fire," which aligns with the boundaries of the tectonic plates. These boundaries are extremely active seismic zones capable of generating large

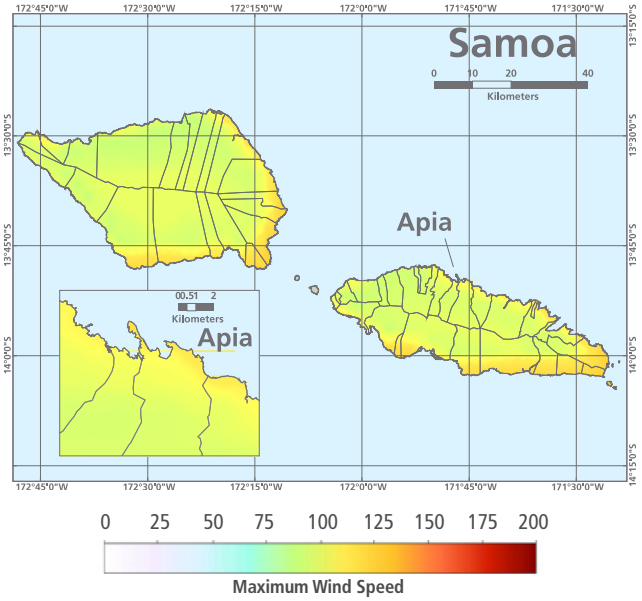
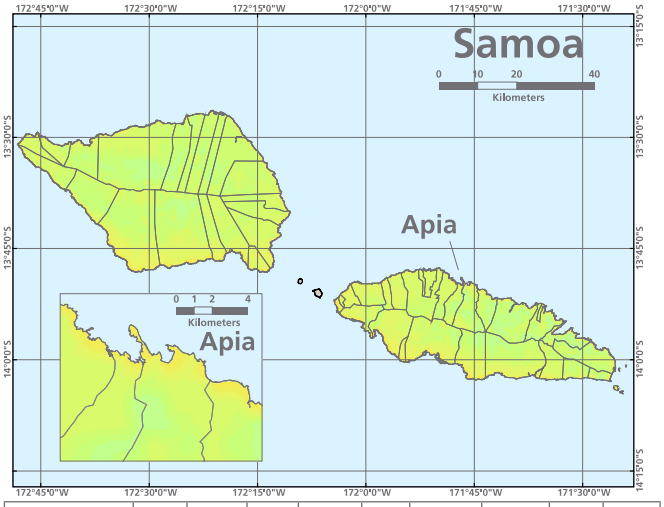


Figure 4: Maximum 1-minute sustained wind speed (in miles per hour) with a 40% chance to be exceeded at least once in the next 50 years.

earthquakes and, in some cases, major tsunamis that can travel great distances. The 2009 magnitude 8.1 earthquake, which generated a devastating tsunami destroying many villages on the island of Upolu, is a recent and tragic example. Figure 5 shows that Samoa has a 40% chance in the next 50 years of experiencing, at least once, moderate to very strong levels of ground shaking. These levels of shaking are expected to cause damage, ranging from light to moderate, to well-engineered buildings and even more severe damage to structures built with less stringent criteria.



Perceived Shaking	Not Felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
Potential Damage	none	none	none	Very light	light	Moderate	Moderate/ Heavy	Heavy	Very Heavy
Peak ACC. (%g)	<0.17	0.17-1.4	1.4-4.0	4.0-9	9-17	17-32	32-61	61-114	>114
Peak Vel. (cm/s)	<0.12	0.12-1.1	1.1-3.4	3.4-8	8-16	16-31	31-59	59-115	>115
Instrumental Intensity	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Wald. et al: 1999

Figure 5: Peak horizontal acceleration of the ground (Note: 1g is equal to the acceleration of gravity) that has about a 40% chance to be exceeded at least once in the next 50 years.

RISK ANALYSIS RESULTS

To estimate the risk profile for Samoa posed by tropical cyclones and earthquakes, a simulation model of potential storms and earthquakes that may affect the country in the future was constructed. This model, based on historical data, simulates more than 400,000 tropical cyclones and about 7.6 million earthquakes, grouped in 10,000 potential realizations of the next year's activity in the entire Pacific Basin. The catalog of simulated earthquakes also includes large magnitude events in South and North America, Japan and the Philippines, which could generate tsunamis that may affect Samoa's shores.

The country's earthquake and tropical cyclone risk profiles are derived from an estimation of the direct losses to buildings infrastructure assets and major crops caused by all the simulated potential future events. The direct losses comprise the cost of repairing or replacing the damaged assets but do

not include other losses such as contents losses, business interruption losses and losses to primary industries other than agriculture. The direct losses for tropical cyclones are caused by wind and flooding due to rain and storm surge, while losses for earthquakes are caused by ground shaking and tsunami inundation. After assessing the cost of repairing or rebuilding the damaged assets due to the impact of all the simulated potential future events, it is possible to estimate in a probabilistic sense the severity of losses for future catastrophes.

The simulations of possible next-year tropical cyclone and earthquake activity show that some years will see no storms or earthquakes affecting Samoa, while other years may see one or more events affecting the islands, similar to what has happened historically. The annual losses averaged over the many realizations of next-year activity are shown in Figure 6 separately for tropical cyclone and for earthquake and tsunami, while the contributions to the average annual loss from the different districts are displayed in absolute terms in Figure 7 and normalized by the total asset values in each district in Figure 8. Figure 8 shows how the relative risk varies by district across the country.

The same risk assessment carried out for Samoa was also performed for the 14 other Pacific Island Countries. The values of the average annual loss of Samoa and of the other 14 countries are compared in Figure 9.

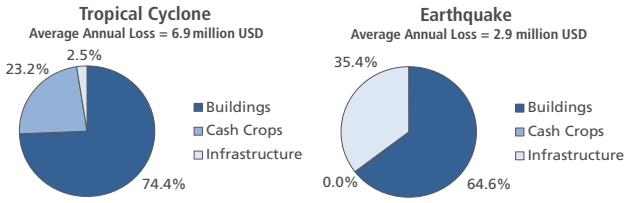


Figure 6: Average annual loss due to tropical cyclones and earthquakes (ground shaking and tsunami) and its contribution from the three types of assets.

In addition to estimating average risk per calendar year, another way of assessing risk is to examine large and rather infrequent but possible future tropical cyclone and earthquake losses. Table 2 summarizes the risk profile for Samoa in terms of both direct losses and emergency losses. The former are the expenditures needed to repair or replace the damaged assets while the latter are the expenditures that the Samoan government may need to incur in the aftermath of a natural catastrophe to provide necessary relief and conduct activities such as debris removal, setting up shelters for homeless or supplying medicine and food. The emergency losses are estimated as a percentage of the direct losses.

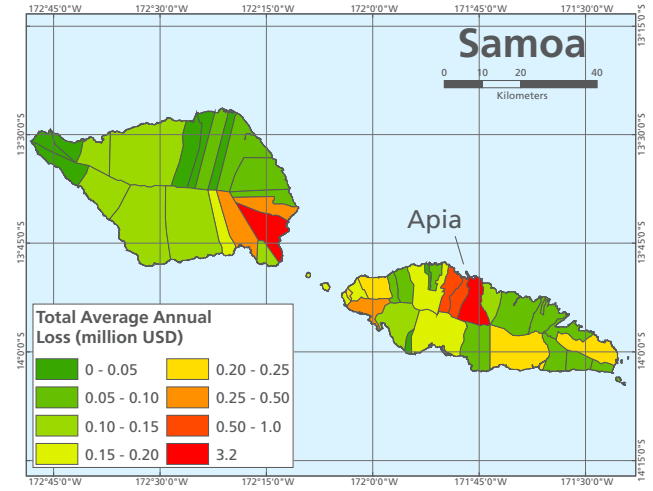


Figure 7: Contribution from the different districts to the average annual loss for tropical cyclone and earthquake (ground shaking and tsunami).

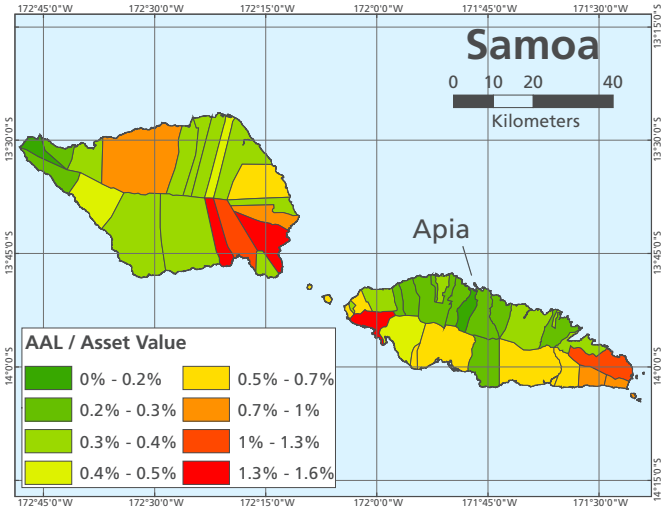


Figure 8: Contribution from the different districts to the tropical cyclone and earthquake (ground shaking and tsunami) average annual loss divided by the replacement cost of the assets in each district.

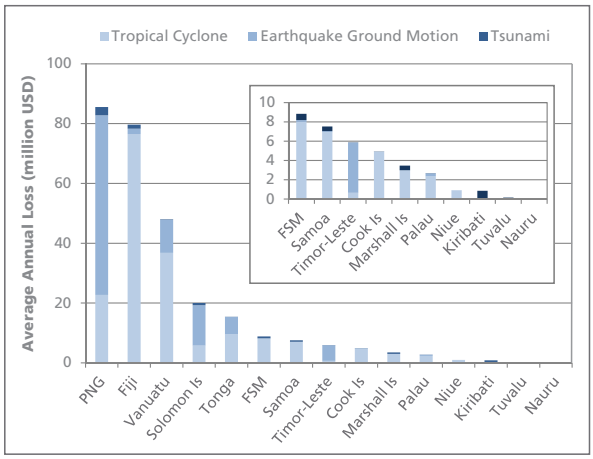


Figure 9: Average annual loss for all the 15 Pacific Island Countries considered in this study.

Table 2 includes the losses that are expected to be exceeded, on average, once every 50, 100, and 250 years. For example, ***a tropical cyclone loss exceeding 134 million USD, which is equivalent to about 24% of Samoa's GDP, is to be expected on average once every 100 years***. In Samoa, tropical cyclone losses are expected to be substantially more frequent and severe than losses due to earthquake ground shaking and tsunami. The latter, however, remain potentially catastrophic events.

A more complete picture of the risk can be found in Figure 10, which shows the mean return period of direct losses in million USD generated by earthquake, tsunami and tropical cyclones combined. The 50, 100, and 250 year mean return period losses in Table 2 can also be determined from the curves in this figure. The direct losses are expressed both in absolute terms and as a percent of the national GDP.

In addition to causing damage and losses to the built environment and crops, future earthquakes and tropical cyclones will also have an impact on population. The same probabilistic procedure described above for losses has been adopted to estimate the likelihood that different levels of casualties (i.e., fatalities and injuries) may result from the future occurrence of these events. As shown in Table 2, our model estimates, for example, that there is a ***40% chance in the next fifty years (100 year mean return period) that one or more events in a calendar year will cause casualties exceeding 370 people in Samoa.*** Events causing approximately 1,000 casualties are also possible but have much lower likelihood of occurring.

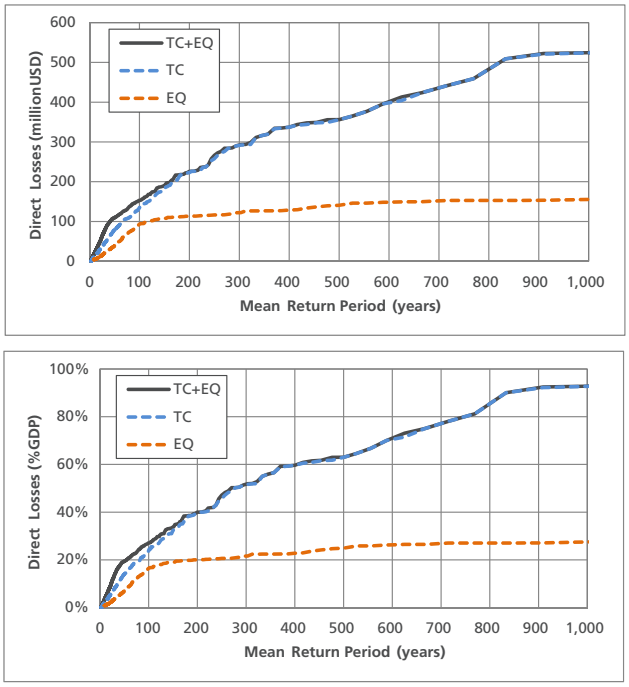


Figure 10: Direct losses (in absolute terms and normalized by GDP) caused by either tropical storms or earthquakes that are expected to be exceeded, on average, once in the time period indicated.

TABLE 2: Estimated Losses and Casualties Caused by Natural Perils				
Mean Return Period (years)	AAL	50	100	250
Risk Profile: Tropical Cyclone				
Direct Losses				
(Million USD)	6.9	78.6	134.1	257.8
(% GDP)	1.2%	13.9%	23.7%	45.6%
Emergency Losses				
(Million USD)	1.6	18.1	30.9	59.2
(% of total government expenditures)	0.7%	8.1%	13.7%	26.4%
Casualties	11	131	212	383
Risk Profile: Earthquake and Tsunami				
Direct Losses				
(Million USD)	2.9	39.1	93.1	116.3
(% GDP)	0.5%	6.9%	16.5%	20.6%
Emergency Losses				
(Million USD)	0.0	8.9	21.4	26.6
(% of total government expenditures)	0.0%	3.9%	9.5%	11.9%
Casualties	8	145	302	410
Risk Profile: Tropical Cyclone, Earthquake, and Tsunami				
Direct Losses				
(Million USD)	9.9	109.8	152.9	266.1
(% GDP)	1.7%	19.4%	27.0%	47.1%
Emergency Losses				
(Million USD)	2.3	25.2	35.1	61.2
(% of total government expenditures)	1.0%	11.2%	15.7%	27.3%
Casualties	19	254	374	469

[1]Casualties include fatalities and injuries.

APPLICATIONS

The country risk profiles can support multiple applications that benefit both public and private stakeholders. In ***urban and development planning,*** planners can use the risk profile information to identify the best location of new development areas, evaluate how natural hazard may shape their development, and to assess whether the benefits of reducing the risk of natural events justify the costs of implementing the risk mitigating measures. In addition, the risk profiles can inform the development of ***disaster risk financing and insurance solutions*** and ***ex ante budget planning*** options to increase the financial resilience of the countries against natural disasters while maintaining their fiscal balance. The earthquake and tropical cyclone hazard models also provide critical information for building codes in terms of country-specific seismic and wind loads that buildings should be designed for to ensure adequate shelter to the population. The risk information can also help identifying existing vulnerable areas and communities located in or adjacent to these areas. This information can assist in supporting more targeted intervention in ***community-based disaster risk management and climate change adaptation*** actions. In the occurrence of a natural disaster the database also provides extremely useful baseline data and information for conducting timely and effective ***post-disaster damage assessments***.

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