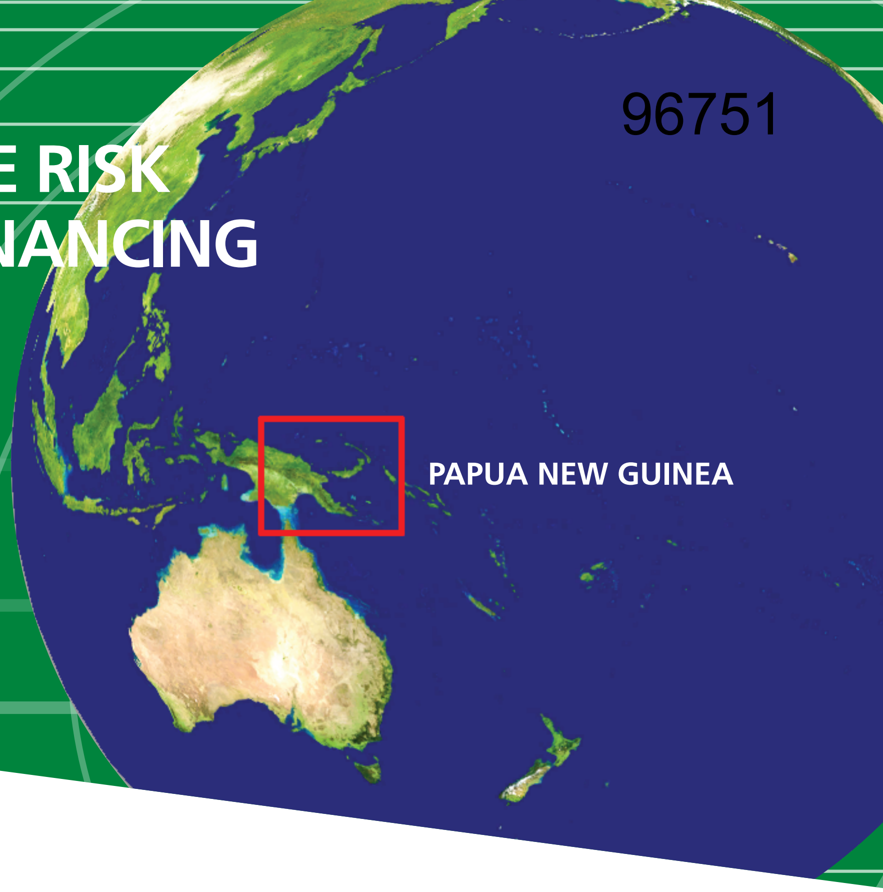
PACIFIC CATASTROPHE RISK ASSESSMENT AND FINANCING INITIATIVE



SEPTEMBER 2011

COUNTRY RISK PROFILE: PAPUA NEW GUINEA

Papua New Guinea is expected to incur, on average, 85 million USD per year in losses due to earthquakes and tropical cyclones. In the next 50 years, Papua New Guinea has a 50% chance of experiencing a loss exceeding 700 million USD and casualties larger than 4,900 people, and a 10% chance of experiencing a loss exceeding 1.4 billion USD and casualties larger than 11,500 people.

BETTER RISK INFORMATION FOR SMARTER INVESTMENTS

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, palm oil, taro, sugar cane and many others.

TABLE 1: Summary of Exposure in Papau New Guinea (2010)	
General Information:	
Total Population:	6,406,000
GDP Per Capita (USD):	1,480
Total GDP (million USD):	9,480.0
Asset Counts:	
Residential Buildings:	2,261,485
Public Buildings:	43,258
Commercial, Industrial, and Other Buildings:	88,536
All Buildings:	2,393,279
Hectares of Major Crops:	1,350,990
Cost of Replacing Assets (million USD):	
Buildings:	39,509
Infrastructure:	6,639
Crops:	3,061
Total:	49,209
Government Revenue and Expenditure:	
Total Government Revenue	
(Million USD):	2,217.9
(% GDP):	23.4%
Total Government Expenditure	
(Million USD):	2,817.7
(% GDP):	29.7%

[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 2000 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 Papua New Guinea. It is estimated that the ***replacement value of all the assets in Papua New Guinea is 49.2 billion USD*** of which about 80% represents buildings and 13% represents infrastructure.

Figures 1 and 2 illustrate the building exposure location and replacement cost distribution, respectively. The footprints of about 135,000 of the approximately 2.4 million buildings shown in Figure 1 were digitized from high-resolution satellite imagery. About 12,000 of such buildings located in Kokopo, Rabul, Lae, Madang and other locations, were also field surveyed and photographed by a team of inspectors

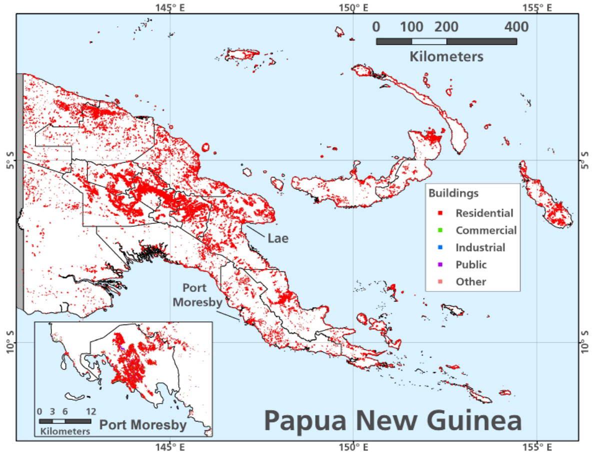


Figure 1: Building locations.

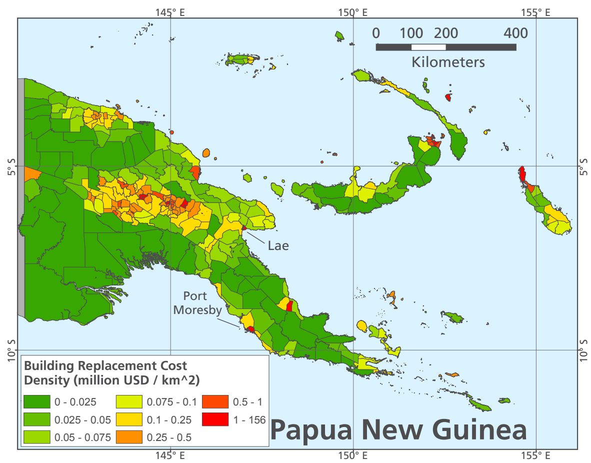


Figure 2: Building replacement cost density by district.

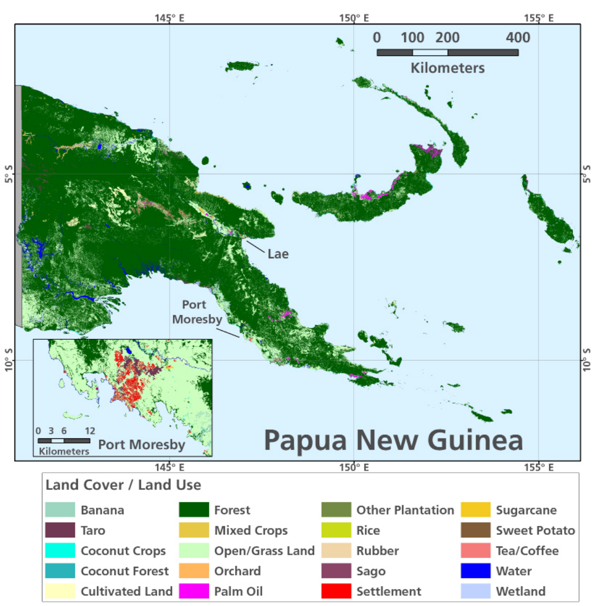


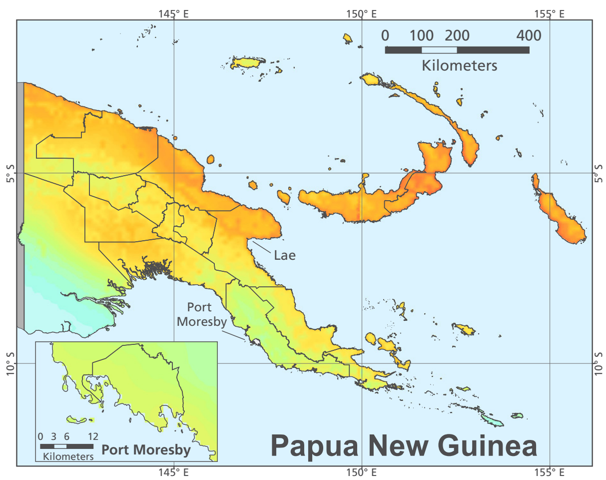
Figure 3: Land cover/land use map.

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 PAPUA NEW GUINEA

The Pacific islands region is prone to natural hazards. Papua New Guinea is situated along one segment of 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 earthquakes and, in some cases, major tsunamis that can travel great distances. Many earthquakes caused deaths and destruction in Papua New Guinea in the last decades. A recent and tragic example, is the 1998 magnitude 7.0 earthquake, which struck the north coast region near Aitape triggering a large undersea landslide that caused a devastating tsunami with almost 2,200 fatalities and 50 million USD in economic losses. Figure 4 shows that Papua New Guinea has a 40% chance in the next 50 years of experiencing, at least once, very strong to severe levels of ground shaking. These levels of shaking are expected to cause damage ranging from moderate to heavy to well-engineered buildings and even more severe damage to structures built with less stringent criteria.

Papua New Guinea is located south of the equator at the northern extremity of 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 each year. The northern part of the country is close to the equator where tropical storms are rarer. The southern part, however, was affected by severe cyclones multiple times in the last few decades. For example, tropical cyclones Justin and Guba, in 1997 and 2007, caused between 180 and 260 fatalities, brought torrential rains that produced widespread flooding and landslides, and damaged buildings, infrastructure and crops with about 300 to 500 million USD in losses combined. Figure 5 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 moderate to severe damage to buildings, infrastructure and crops with consequent significant economic losses.



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 4: 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 (100-year mean return period).

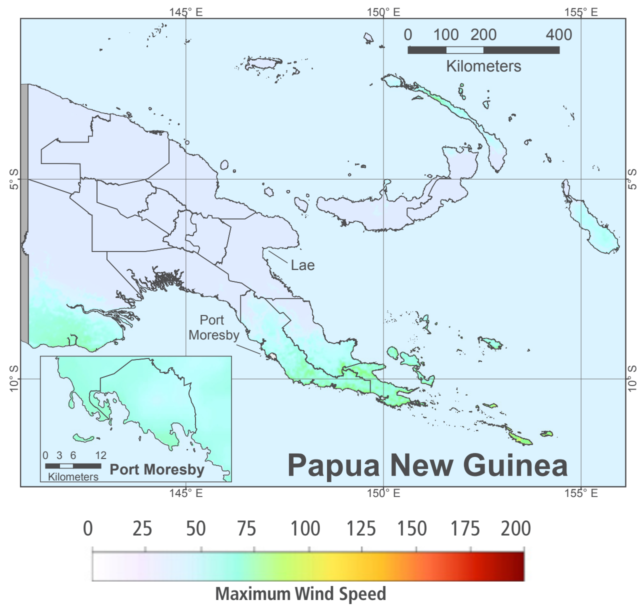


Figure 5: Maximum 1-minute sustained wind speed (in miles per hour) with a 40% chance to be exceeded at least once in the next 50 years (100-year mean return period).

RISK ANALYSIS RESULTS

To estimate the risk profile for Papua New Guinea 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 Papua New Guinea'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 include 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 for earthquakes they 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 Papua New Guinea, 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 local government levels are displayed in absolute terms in Figure 7 and normalized by the total asset values in each local government level in Figure 8. Figure 8 shows how the relative risk varies by local government level across the country.

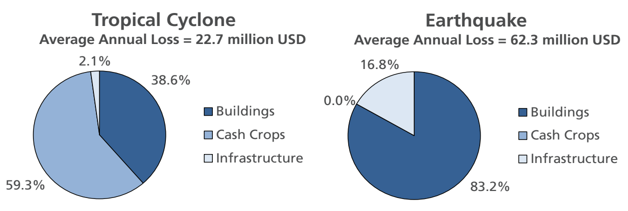


Figure 6: Average annual loss due to tropical cyclones and earthquakes (ground shaking and tsunami) and its contribution from the three types of assets.

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

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 Papua New Guinea 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 Papua New Guinean 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.

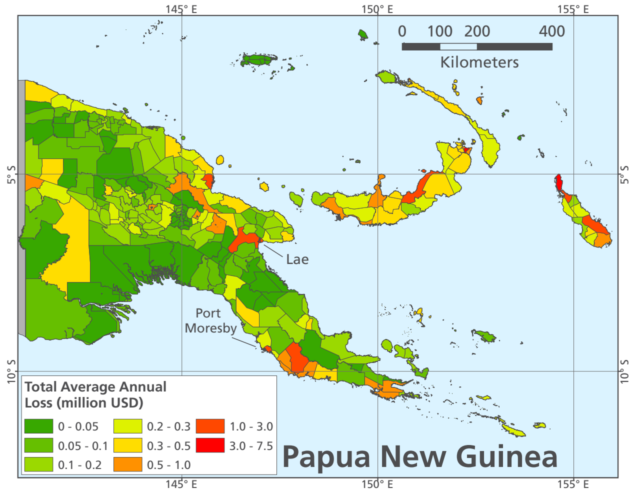


Figure 7: Contribution from the different districts to the average annual loss for tropical cyclone and earthquake (ground shaking and tsunami).

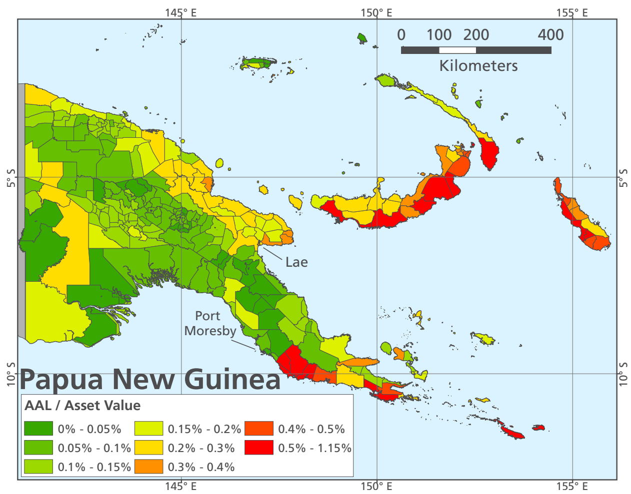


Figure 8: Contribution from the different districts to the tropical cyclone and earthquake (ground shaking and tsunami) average annual loss divided by the replacement cost of the assets in each district.

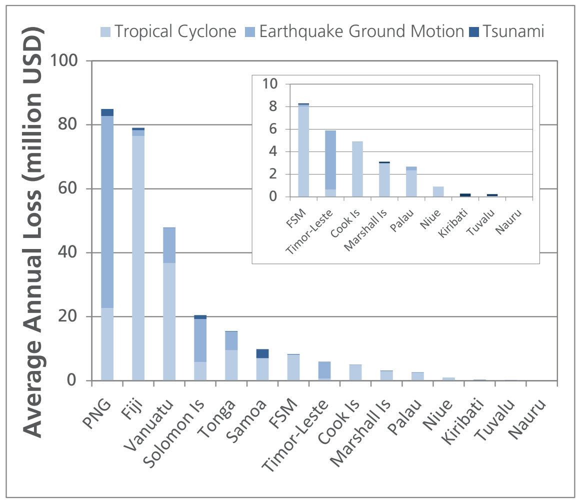
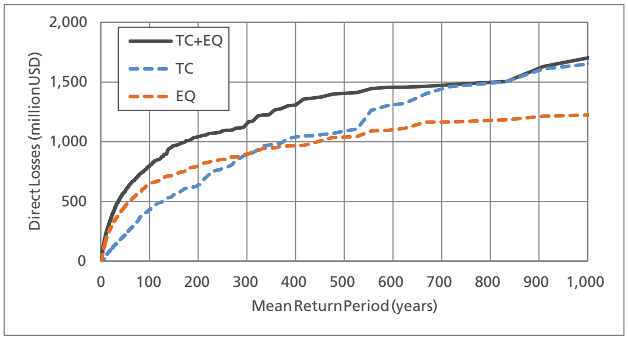


Figure 9: Average annual loss for all the 15 Pacific Island Countries considered in this study.

Table 2 includes the losses that are expected to be exceeded, on average, once every 50, 100, and 250 years. For example, ***an earthquake loss exceeding 645 million USD, which is equivalent to about 7% of Papua New Guinea's GDP, is to be expected, on average, once every 100 years***. In Papua New Guinea, earthquake losses are expected to be more frequent and severe than losses due to tropical cyclones. Rare and intense tropical cyclones, however, with a path hitting major inhabited areas are 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 5,800 people in Papua New Guinea***. Events causing 10,000 or more casualties are also possible but have much lower likelihood of occurring.



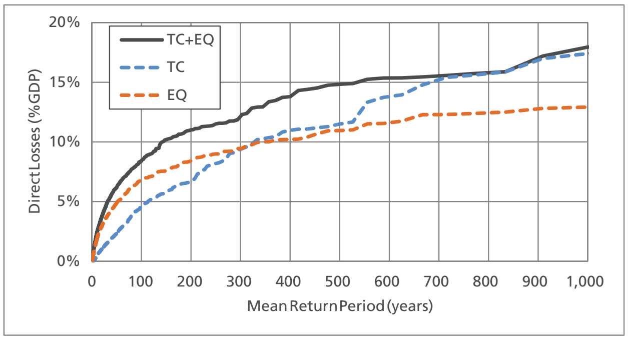


Figure 10: Direct losses (in absolute terms and normalized by GDP) caused by either tropical storms or earthquakes that are expected to be exceeded, on average, once in the time period indicated.

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)	22.7	218.8	432.0	776.6
(% GDP)	0.2%	2.3%	4.6%	8.2%
Emergency Losses				
(Million USD)	5.2	50.3	99.3	179.1
(% of total government expenditures)	0.2%	1.8%	3.5%	6.4%
Casualties	242	2,489	4,735	8,105
Risk Profile: Earthquake and Tsunami				
Direct Losses				
(Million USD)	62.3	460.1	645.5	851.9
(% GDP)	0.7%	4.9%	6.8%	9.0%
Emergency Losses				
(Million USD)	10.1	74.4	103.9	136.6
(% of total government expenditures)	0.4%	2.6%	3.7%	4.8%
Casualties	198	1,929	2,891	4,294
Risk Profile: Tropical Cyclone, Earthquake, and Tsunami				
Direct Losses				
(Million USD)	85.0	582.9	794.9	1,091.0
(% GDP)	0.9%	6.1%	8.4%	11.5%
Emergency Losses				
(Million USD)	15.3	107.6	145.2	221.5
(% of total government expenditures)	0.5%	3.8%	5.2%	7.9%
Casualties	440	3,734	5,864	9,243

[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 hazards 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 identify 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.***

SPC Secretariat of the Pacific Community
Applied Geoscience and Technology Division (SOPAC)

THE WORLD BANK

ADB

GFDRR
Global Facility for Disaster Reduction and Recovery

AIR WORLDWIDE

GNS SCIENCE TE PŪ AO

For information please visit
http://pacrisk.sopac.org/
or contact pcrafi@sopac.org