AIRCURRENTS

THE PACIFIC CATASTROPHE RISK ASSESSMENT AND FINANCING INITIATIVE (PCRAFI)

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EDITOR'S NOTE: As part of a joint initiative led by the World Bank, AIR is developing new probabilistic models aimed at quantifying the natural disaster risk faced by island nations in the Pacific.

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INTRODUCTION

This year's Tohoku earthquake and ensuing tsunami in Japan is one of the most catastrophic events in recent history, devastating a widespread region and causing an estimated USD 300 billion in economic losses. While Japan's economy may be slow to recover, many analysts expect the earthquake's impact on the country's long-term prospects will be limited.

The island countries of the Pacific Ocean are not so resilient. In fact, Pacific Island Countries (PICs) are among the world's most vulnerable to natural disasters such as tropical cyclones, earthquakes, tsunamis and volcanic eruptions (Figure 1). In the past, these events have resulted in enormous losses with disastrous economic, human, and environmental consequences. For several PICs, the total monetary losses caused by natural disasters in the last 50 years are several times higher than their GDPs. Nevertheless, the recovery after major disasters has been historically left to the international donor community. Essentially, no ex ante risk mitigation strategies have been consistently implemented in any of these countries before.

The Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) aims to provide the Pacific Island Countries with risk modeling and assessment tools to enhance disaster risk reduction. It also aims to engage in a dialogue with the PICs on integrated financial solutions to reduce their vulnerability to natural disasters and climate change. The initiative is part of the broader agenda on disaster risk management and climate change adaptation in the Pacific region. PCRAFI is a joint initiative of the World Bank, the Asian Development Bank and the Pacific Islands Applied Geoscience Commission (SOPAC), with the financial support of the Government of Japan and the Global Facility for Disaster Reduction and Recovery (GFDRR), and technical support from GNS Science, Geoscience Australia, Pacific Disaster Center (PDC) and AIR Worldwide.

As part of this important initiative, AIR was selected by the World Bank to conduct detailed risk assessment studies that both quantify the exposure—as defined by the populations, the built environments and crops at risk—and explore the human and financial impacts of natural disasters on that exposure.

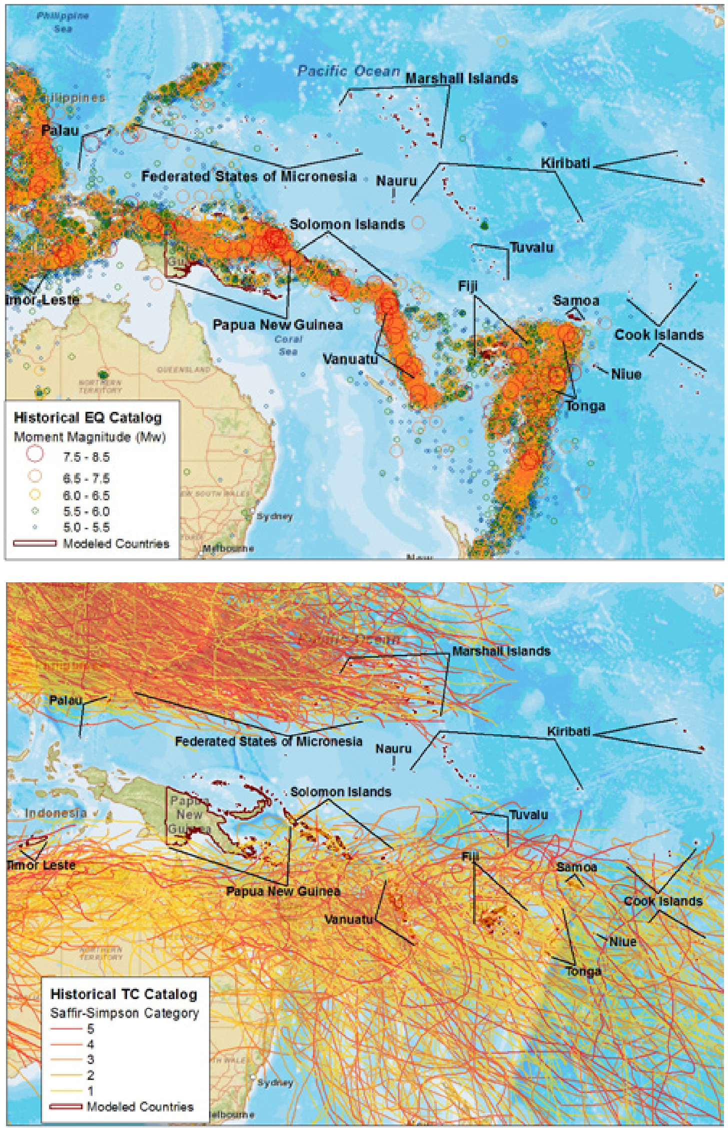

Figure 1: Epicenters of the 32,569 earthquakes with M≥5.0 that occurred from 1768 to 2009 (top); tracks of the more than 2,000 tropical cyclones occurred in the study region since 1948 (bottom) (Source: AIR).

A WEALTH OF NEW MODELS TARGETED FOR AN OFTEN NEGLECTED REGION

The ultimate goal of the PCRAFI initiative is to develop country-level risk profiles and, accordingly, to identify innovative, workable and effective insurance solutions for PICs, if favorable conditions arise. The first phase, which was completed in September 2008, consisted of a feasibility study focusing on eight island nations located in the South Pacific. The still ongoing second phase, which is scheduled for completion in the autumn of 2011, includes seven additional PICs, some of which are located in the Northern Hemisphere. The names and locations of all 15 countries under study are shown in Figure 2.

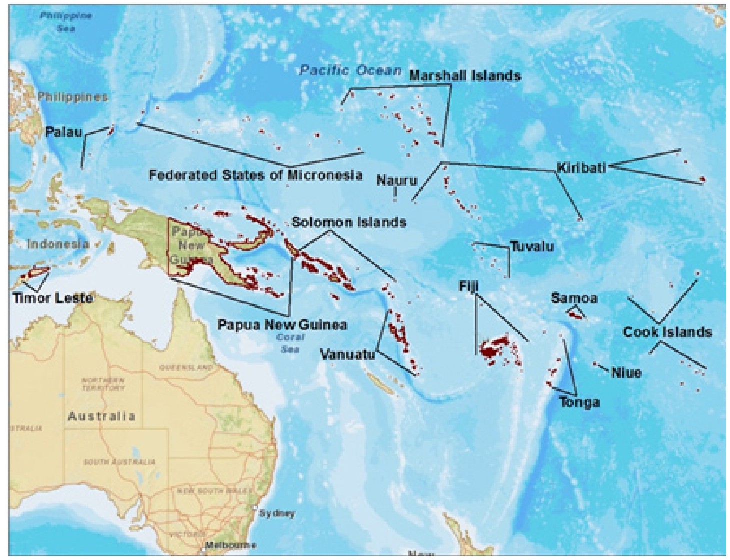

Figure 2: Fifteen countries considered in the PCRAFI study (Source: AIR).

AIR's contribution to the risk assessment study establishes the scientific and engineering basis of the initiative by developing a profusion of new probabilistic models aimed at quantifying the natural hazard risk faced by the people, the built environments (residential, commercial, public, industrial, and infrastructure assets) and major crops (e.g., sugar cane, coconut, banana, taro) of these countries.

The impact on population is measured by the number of people affected by each simulated event (in terms of number of fatalities, injuries, displacements, etc.). The impact on the built environment and crops is quantified by monetary losses. The threat posed by earthquakes considers both ground shaking intensity and—significantly— the effects of earthquake-generated tsunamis. These latter may be caused either by local events (such as the 29 September 2009 event that hit Western Samoa, American Samoa, and Tonga, see Figure 3) or by distant events along the entire Pacific Rim (so called tele-tsunamis). The effects of tropical cyclones include wind and flood caused both by precipitation and storm surge. The tropical cyclone and earthquake hazard models have been subjected to a comprehensive independent peer review conducted by researchers at Geoscience Australia, who found them to be "of a high standard, thorough and representative of best practice".

Modeling Tsunami Risk

The most common cause of a tsunami is the occurrence of a large offshore earthquake that raises the sea floor. Eighty percent of earthquakes occur on the sea floor, and most of them occur along plate boundaries, such as those in the South Pacific Region or around Japan.

For the PCRAFI study, AIR simulated tsunamis caused by large earthquakes in the stochastic catalogs of the AIR models that cover the Pacific Rim. Only large events with magnitude exceeding 8 are capable of generating enough slip along the fault to cause a widespread tsunami. For each such event in the catalogs, a fault slip map was estimated, which describes the amount and direction of slip that occurs on the subduction plate interface during the earthquake. Armed with the slip map, the orientation of the fault and the bathymetry of the seafloor in the region, the tsunami module produces wave height and velocity in the ocean and at the coastline.

The peak height and velocity of waves at the coastline, however, are not sufficient to predict the effect of the tsunami on structures and populations. Casualties and damage to structures are strongly related to the height and velocity of a tsunami wave not only at the shoreline but also as it moves inland. This concept becomes clear when looking at the figure below. Therefore, the tsunami module requires an additional component that uses topography data and wave height at the shoreline to compute inland penetration, as well as the peak height and velocity of the waves within the inundated area. These last two parameters are necessary to estimate damage and loss to exposures within the tsunami footprint.

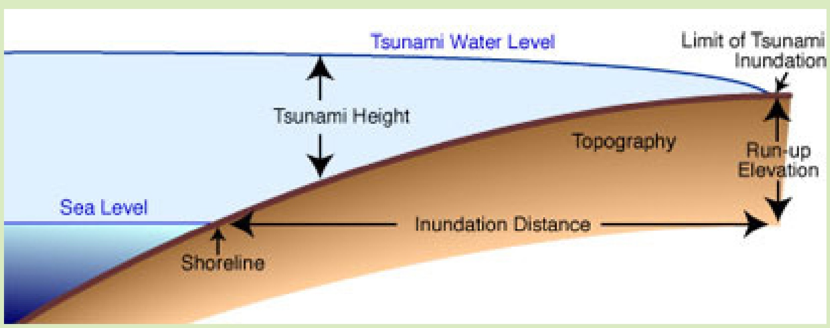

Figure3. Penetration of tsunami wave inland. (Courtesy of USGS)

DEVELOPING DETAILED EXPOSURE DATABASES THAT CAPTURE A HOLISTIC VIEW OF THE RISK

The breadth of this risk assessment study is unprecedented in the risk modeling industry, both in terms of the number of perils and sub-perils considered and of the effort being devoted to developing a consistent and accurate exposure database.

For example, the effects of tsunamis—which have proven to be devastating to these countries in the past—had never been accounted for before in a probabilistic risk assessment study of this magnitude. With respect to tropical cyclones, many models capture only the impact of damaging winds, yet in this region, most of the historical losses and fatalities are caused by flood.

In most risk models used in the private insurance and reinsurance industry, exposure databases are limited to insurable residential, commercial, and sometimes industrial assets. The PCRAFI effort considers a more holistic view of the impact of natural disasters and includes direct effects on population, on all built assets—including housing for the poor and even of squatters (which are never insured), as well as public and infrastructure assets (which are often not)—and on major crops (which are almost always neglected in risk assessment studies of all but the most important food-producing nations).

Figure 4. The Northern part of the Niuatoputapu island of the Kingdom of Tonga was completely leveled by the September 2009 tsunami that produced waves as high as 17m as measured by debris left on trees (Photo courtesy of Richard Kautoke of the Tongan Ministry of Lands, Survey and Natural Resources).

AIR has devoted considerable effort to developing accurate and detailed exposure databases. Existing and often obsolete country-specific population databases were made consistent across different levels of granularities and trended to current values using the most up-to-date projected growth estimates provided by the Secretariat of the Pacific Community.

Hundreds of satellite images were collected from different repositories for this project, which are used to help locate and characterize the crop, and building and infrastructures databases. Crop exposure was extracted from low- and moderate-resolution satellite imagery using an automated procedure, and validated using high resolution images and, where possible, ground truthing (visual inspection on the ground or of photos posted on Google Earth). This procedure yielded Land Use/Land Cover GIS maps (see Figure 5) for all the countries—maps that are expected to provide considerable value well beyond the scope of this study.

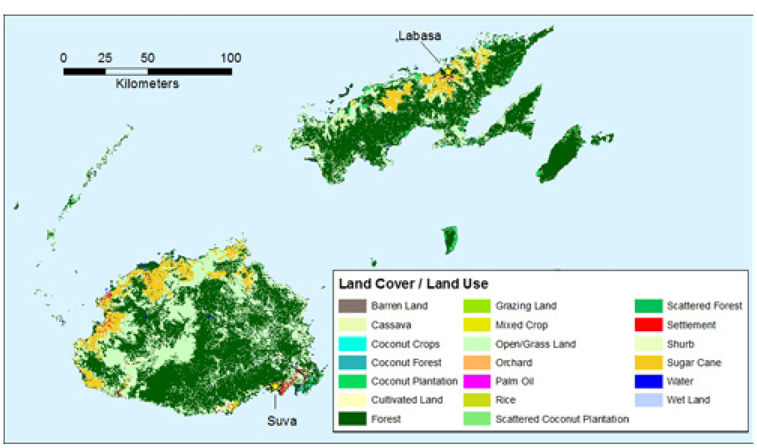

Figure 5: Land Use/ Land Cover Map developed for Fiji (Source: AIR)

By far the most meticulous work, however, went into developing an exposure database of buildings and infrastructure. More than 80,000 buildings and infrastructure assets (e.g., airports, ports, and bridges) were geo-referenced, visited and photographed. These field visits were conducted by trained personnel of SOPAC, GNS Science, and Pacific Disaster Center (PDC) under the auspices of both this World Bank funded project and of a sister project funded by the Asian Development Bank. An additional 400,000 buildings were digitized from high-resolution satellite imagery (see Figure 6), the vast majority of which were specifically acquired for this project. The locations of the remaining assets in the built inventory, numbering more than 1.5 million, were inferred using a mix of supervised classification and other techniques from optical satellite imagery. The resulting database is of a level of accuracy and detail that is seldom, if ever, achieved.

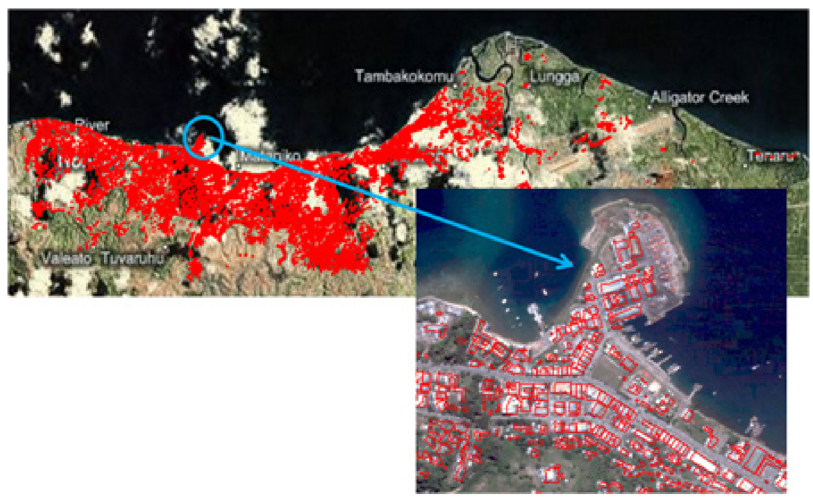

Figure 6: Example of buildings digitized in Samoa (Source: SOPAC)

DELIVERABLES DESIGNED TO ASSIST AT-RISK NATIONS

A key deliverable of this study will be consistently computed, probabilistic risk profiles for these 15 countries for all the perils considered, both separately and in combination. These risk profiles are of paramount importance for communicating risk to stakeholders and for devising optimal risk mitigation strategies that can lower the likelihood of future losses. For example, retrofitting hospitals to withstand the high shaking levels estimated in this study may save thousands of lives in the aftermath of the next catastrophe.

Indeed, a notable byproduct of this study is the generation of probabilistic seismic hazard and wind hazard maps, such as those shown in Figure 6. The large majority of these countries have never before had such maps computed, and they will have multiple applications beyond this study. They can be used, for example, to form the basis of seismic and wind design provisions for building codes that may be adopted in the future.

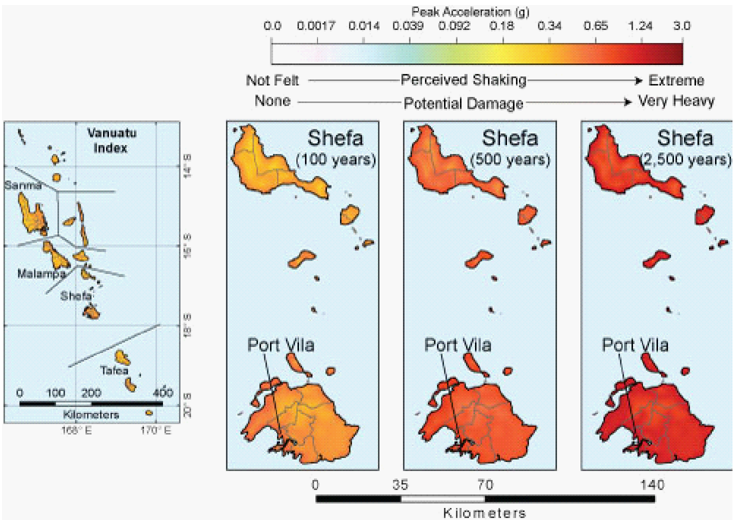

Figure 7: Probabilistic seismic hazard maps for Vanuatu's Shefa province, home to the capital Port Vila. The horizontal peak ground acceleration values shown are those that are expected to be exceeded on average every 100 years (top left), 500 years (top right), and 2,500 years (bottom left). (Source: AIR)

In addition to the country-specific risk profiles, the study will also explore the potential benefits that may arise from pooling catastrophe risk across multiple countries in the region, and will investigate the feasibility of selected reinsurance structures, estimate the potential cost of financing such structures in the reinsurance and capital markets, and look at potential trigger methodologies for the payout of such protection.

CONCLUSION

With the Pacific Catastrophe Risk Assessment and Financing Initiative, the natural disaster risk faced by Pacific Island Countries is being addressed for the first time. Only 10 million people live in these countries—fewer than the population of many mega-cities around the world—but their geographical location and the relatively small size of their economies make them particularly vulnerable to such events. It is hoped that this study will be the springboard for mitigating the risk in this region—and beyond.

ABOUT AIR WORLDWIDE

AIR Worldwide (AIR) is the scientific leader and most respected provider of risk modeling software and consulting services. AIR founded the catastrophe modeling industry in 1987 and today models the risk from natural catastrophes and terrorism in more than 50 countries. More than 400 insurance, reinsurance, financial, corporate and government clients rely on AIR software and services for catastrophe risk management, insurance-linked securities, site-specific seismic engineering analysis, and property replacement cost valuation. AIR is a member of the ISO family of companies and is headquartered in Boston with additional offices in North America, Europe and Asia. For more information, please visit www. air-worldwide.com.