Pacific Damage and Loss (PDaLo) Information System

Loss Exceedance Curves

Samantha Cook

AUGUST 2013

SPC SOPAC PUBLISHED REPORT (PR188)

UNISDR
The United Nations Office for Disaster Risk Reduction

SPC
Secretariat of the Pacific Community

Our Mission

The mission of the SPC is “to help Pacific island people position themselves to respond effectively to the challenges they face and make informed decisions about their future and the future they wish to leave for the generations that follow.

Our Goal

The goal of the Applied Geoscience and Technology Division is to apply geoscience and technology to realise new opportunities for improving the livelihoods of Pacific communities.

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Important Notice

This report has been produced with the financial assistance of the European Union. The views expressed herein do not necessarily reflect the official opinion of the European Union.

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Background

In the past, costs associated with historic disaster events have been used to inform decisions on various strategies, policies and projects to better protect society, infrastructure and economic development against the impacts of future events. Analysis of historic costs can be useful to identify patterns and changes over time. Such patterns become important to develop future policies and procedures. For example, historic analysis of disaster costs has been used to inform urban planning and moving development away from risk prone areas through land zoning. In addition, historical cost analysis can be used to inform mitigation policies and even enable the identification of the minimum reserves required to finance emergency response budgets.

In recent years, work has been conducted to move from simple analysis to more complex regressions where historic cost information is modelled to predict the impacts of future events. Such analysis results in estimates of future costs which are of particular interest to governments when budgeting for a suitable cash level reserved for disaster response. This short paper considers one form of historic cost analysis – the Loss Exceedance Curve (LEC) – and how the information provided can be used to inform disaster risk management.

A definition

In simple terms, Loss Exceedance Curves (LEC) provide a graphical representation of the probability that a certain level of loss will be exceeded in a given time period.

Construction of the curve

An LEC is based on the analysis of four core components; hazard, exposure, vulnerability and financial loss. Historic data for each component is used to determine the probability that an event of a certain magnitude will occur within a future timeframe. The estimation of financial loss involves using the results of the analysis of the hazard, exposure and vulnerability to estimate average annual losses and the probability that this loss will be exceeded within a certain timeframe.

The LEC provides a graphical representation to demonstrate the annual frequency with which the determined economic loss will be exceeded, based on the analysis of the four components. The LEC can be calculated for a single major probable event in one year or for all possible events as a function of their return period. The Global Assessment Report for Disaster Risk Reduction (UNISDR, 2013) expresses a preference for the second approach as it allows for the occurrence of more than one catastrophic event per year.

An example

As part of the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI), AIR Worldwide conducted the aforementioned analysis and, for the first time, developed catastrophe risk models for tropical cyclones and earthquakes across the Pacific. The models enabled the generation of LECs for 15[1] Pacific Island Countries (PICs). The results of the AIR risk models were published in a series of country risk profiles. These profiles give an estimation of: (i) the average annual losses a country will experience from tropical cyclones and earthquakes/ tsunamis, based on previous experience; and (ii) the probability that losses will exceed events of a magnitude equivalent to a 1 in 50-year event, a 1 in 100-year event and a 1 in 250-year event.

For example, the Country Risk Profile produced for Niue states that:

'Niue is expected to incur, on average, US$0.9 million per year in losses due to earthquakes and tropical cyclones. In the next 50 years, Niue has a 50 per cent chance of experiencing a loss exceeding US $15 million … and a 10 per cent chance of experiencing a loss exceeding US $60 million[2]'.

This information was also translated into an LEC for Niue, as seen in Figure 1.

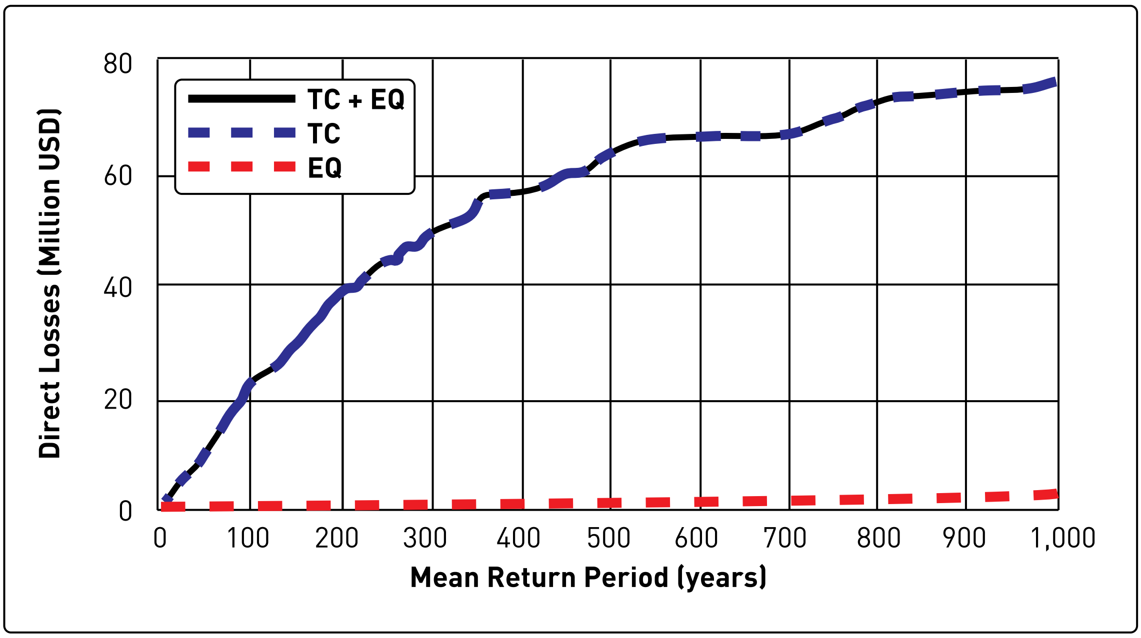
1 For the purposes of PCRAFI, Timor Leste was included as a PIC.

2 Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) – Country Risk Profile: Niue (2011).

How to read an LEC – Tropical Cyclone (TC)

Figure 1 shows that direct losses[3] are expressed on the vertical (Y) axis and the mean, or average, return period on the horizontal (X) axis. Simply pick the return period (or frequency) of interest from the X axis — say, 100 years — then read directly up until the blue chart line for Tropical Cyclone (TC) is met. It can be seen that an earthquake or tropical cyclone event with the frequency of 1 in 100 years in Niue has associated damage costs of US $22.4 million.

Figure 1: Direct Losses (in US$ millions) for Niue caused by either tropical storms or earthquakes that are expected to be exceeded, on average, once in the time period indicated.



Source: PCRAFI

Useful Tip

To envisage the type of event that would generate such losses, it is useful to relate loss estimates back to the damage costs reported in actual past events. In this case, the Niue disaster that most closely matches a 1 in 100-year event with US $22 million worth of costs is TC Heta, a category 5 cyclone that struck Niue in January 2004, causing approximately US $35 million[4] in damages.

LECs can also be used 'backwards' to estimate the likely return interval of a major event. Using, again, the TC Heta example, if you find US $35 million on the Y axis and read across, then down, this would indicate that an event such as TC Heta has an estimated return period of approximately 1 in 175 years.

How to read an LEC – Earthquake (EQ)

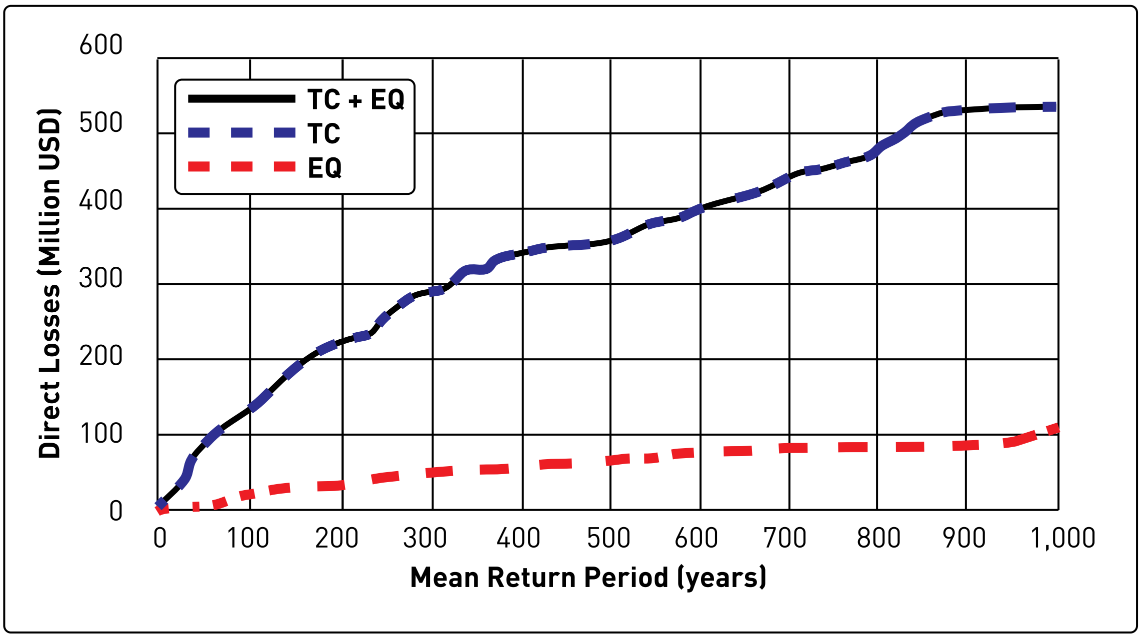
To demonstrate that the same principles apply for other perils — in this case earthquakes (which includes tsunamis as a sub hazard) — the example of the September 2009 magnitude 8.0 earthquake and subsequent tsunami that affected Samoa is presented.

[3] A loss, which is a direct consequence of a particular peril, in this case tropical cyclone or earthquake. Often known as damage.

[4] Government of Niue Recovery and Reconstruction plan.

The epicentre of the Earthquake (EQ) was 190 km south of the Samoan capital of Apia and was followed 20 minutes later by two tsunami waves that impacted American Samoa, the Independent State of Samoa, and the small northern island of Niuatoputapu in the Kingdom of Tonga. The total value of the disaster effects caused by the tsunami in Samoa is estimated at US $124.04 million, equivalent to 22 per cent of Samoa's GDP.

Figure 2: Direct Losses (in US$ millions) for Samoa caused by either tropical storms or earthquakes that are expected to be exceeded, on average, once in the time period indicated.



Source: PCRAFI

Using the LEC to work 'backwards' to establish the mean return period for an event with losses equivalent to those generated by the 2009 earthquake would be akin to that of an event with a frequency over 1000 years. That is, by using the value of US $124 million on the Y axis for direct losses, simply read across until the orange line for earthquakes is reached. On this occasion, the cross section is off the chart and indicates just how extraordinary this event was.

How to read an LEC – Demonstrating the different levels of risk faced by countries

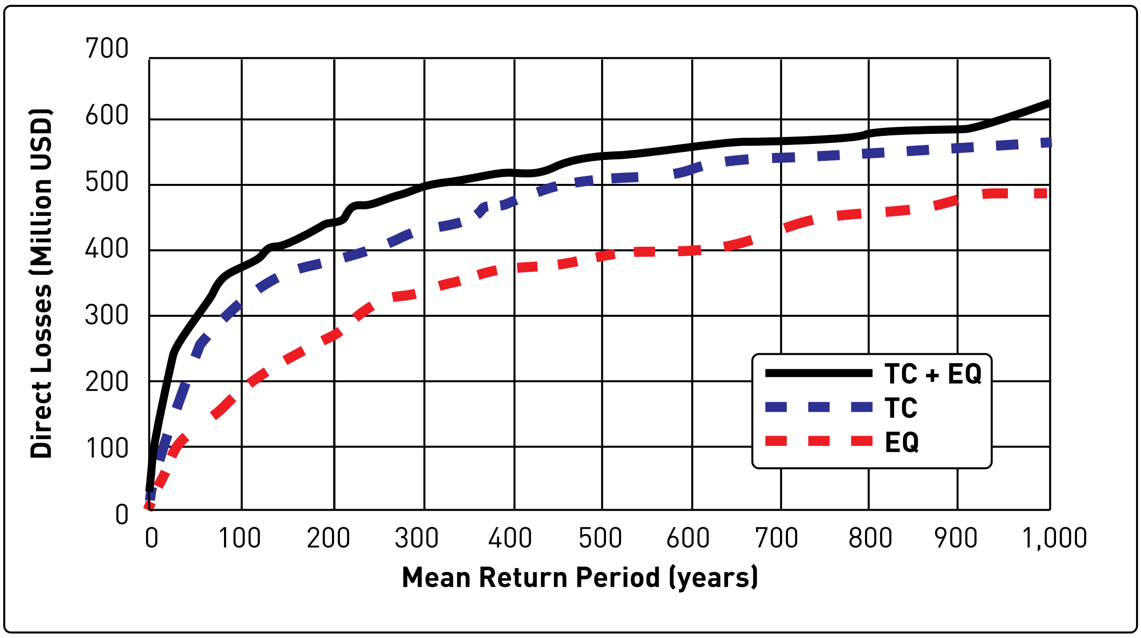
As mentioned earlier, AIR Worldwide developed catastrophe risk models for tropical cyclones and earthquakes for 15[5] PICs and their associated LECs. To demonstrate that at first glance the LECs can give an indication of a country's risk to the different perils, the last example presented is from Vanuatu.

Looking at Figure 3, the LEC for Vanuatu, it becomes apparent that Vanuatu faces a significant amount of risk from both tropical cyclones and earthquakes. In fact, they face almost the same level of risk for both perils. In comparison, Niue shown in Figure 1 faces minimal risk from earthquakes and the orange line for earthquakes remains close to zero. This indicates to the reader that Vanuatu has a higher level of risk from earthquakes as they occur more frequently and with higher levels of direct losses as indicated by the LEC.

5 For the purposes of PCRAFI Timor Leste was included as a PIC.

To work through one last example, the case of TC Uma which affected Vanuatu in 1987 is used. TC Uma was the most destructive cyclone to have affected Port Vila, the capital of Vanuatu. At its peak intensity, TC Uma is estimated to have attained mean wind speeds of 90 knots with gusts up to 120 knots. It passed within 30 miles of Port Vila and affected Efate with its storm and hurricane winds for about seven hours. The total damage to the country was estimated to be US $150 million (Vanuatu Meteorological Services, 1994).

Figure 3: Direct Losses (in US$ millions) for Vanuatu caused by either tropical storms or earthquakes that are expected to be exceeded, on average, once in the time period indicated.



Source: PCRAFI

Using the figure of US $150 million as a proxy for direct losses and reading up the Y axis and reading across to where this meets the blue line for TCs, this gives us an indication that TC Uma has a mean return period of 1 in 10 years.

There are two important points to take from this. First, risk comparisons across countries should not be made. Each country faces a different level of exposure to a given peril and this should be recognized in order to help countries best prepare for these perils.

Second, when using historic events such as TC Uma to try and establish return periods, the user should exert caution. The figure used for TC Uma is expressed in 1987 prices and the LEC shown was developed using 2010 prices. This will create a significant gap in valuation. This is known as the time value of money, which states that a US $1 today is worth more than a US $1 tomorrow[6]. Consequently, goods (or in this case losses) in 1987 will be worth more in 2010 values. Users can choose to use a deflator to adjust the numbers accordingly, however, this is beyond the scope of this note, or they can use past values as an indication of the frequency of this type of event, acknowledging that there may be some disparity in the numbers. The larger the time gap between the reported losses of an event and the values in the LEC curve, the less accurate a simple comparison will be. Each user should make an informed decision on this.

[6] This is because if the money is deposited in an account, it will earn interest, this gives a preference to receiving money today to deposit in to an account as opposed to waiting and receiving the US $1 tomorrow, which will be worth less as no interest has been received.

How to use this information

While analysis based around LECs may seem simple, it can be used to help countries make informed decisions about risk management. It can, for example, inform an appropriate level of catastrophe risk insurance coverage. Before choosing the level of insurance coverage, governments need to decide whether they would prefer to be covered for more frequent and less severe events, or be covered for more severe and less frequent events. Having access to an LEC can help make this decision.

Interestingly, the information from LECs is also used by the private sector insurance industry to develop catastrophe risk insurance (and reinsurance) products and catastrophe bonds.

LECs can also help countries to establish the minimum level of cash that they may wish to hold in reserve to facilitate disaster response as they will have an estimation of loss for events of different magnitudes and the probability of occurrence.

In its simplest form, the LEC serves to provide an assessment of catastrophe risk which is used to inform risk management decisions. As mentioned earlier, in order to develop an LEC, there are several pieces of analysis that must be conducted first. It is these preliminary analyses on hazard, exposure and vulnerability that can often be of most importance. These analyses can be used to inform national planning and the development of land zoning by the creation of hazard and exposure maps. These maps depict ground-up losses and are often used for looking at the most densely populated areas within a country. These maps can be invaluable tools when trying to reduce underlying risk and vulnerability of the population.

Limitations

It should be remembered that an LEC relies on the compilation and analysis of records of hazards, vulnerability, exposure and financial loss. The models and data upon which they are based need to be continuously updated over time to produce the best results. The weak information management due to the limited capacity and resources will impact on the quality of the LECs produced in the Pacific region. The quality of data and information including updates is essential to produce realistic and quality results. Given how quickly an urban landscape can change in a country, particularly developing countries like many Pacific Island Countries, due caution should be given to ensure that there is time, money and expertise in the region to ensure on-going maintenance of these products.

The need for on-going maintenance of these sophisticated models further emphasizes the need to strengthen existing post-disaster reporting. Post-disaster reporting is inconsistent across sectors and countries in the Pacific at the moment but it is hoped this improves with the implementation of a regional programme to standardize post-disaster assessments. Consistent reporting of damages will undoubtedly improve the results of the model and consequently lead to governments that are better informed and, as a result, in a stronger position to develop appropriate risk reduction strategies.

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