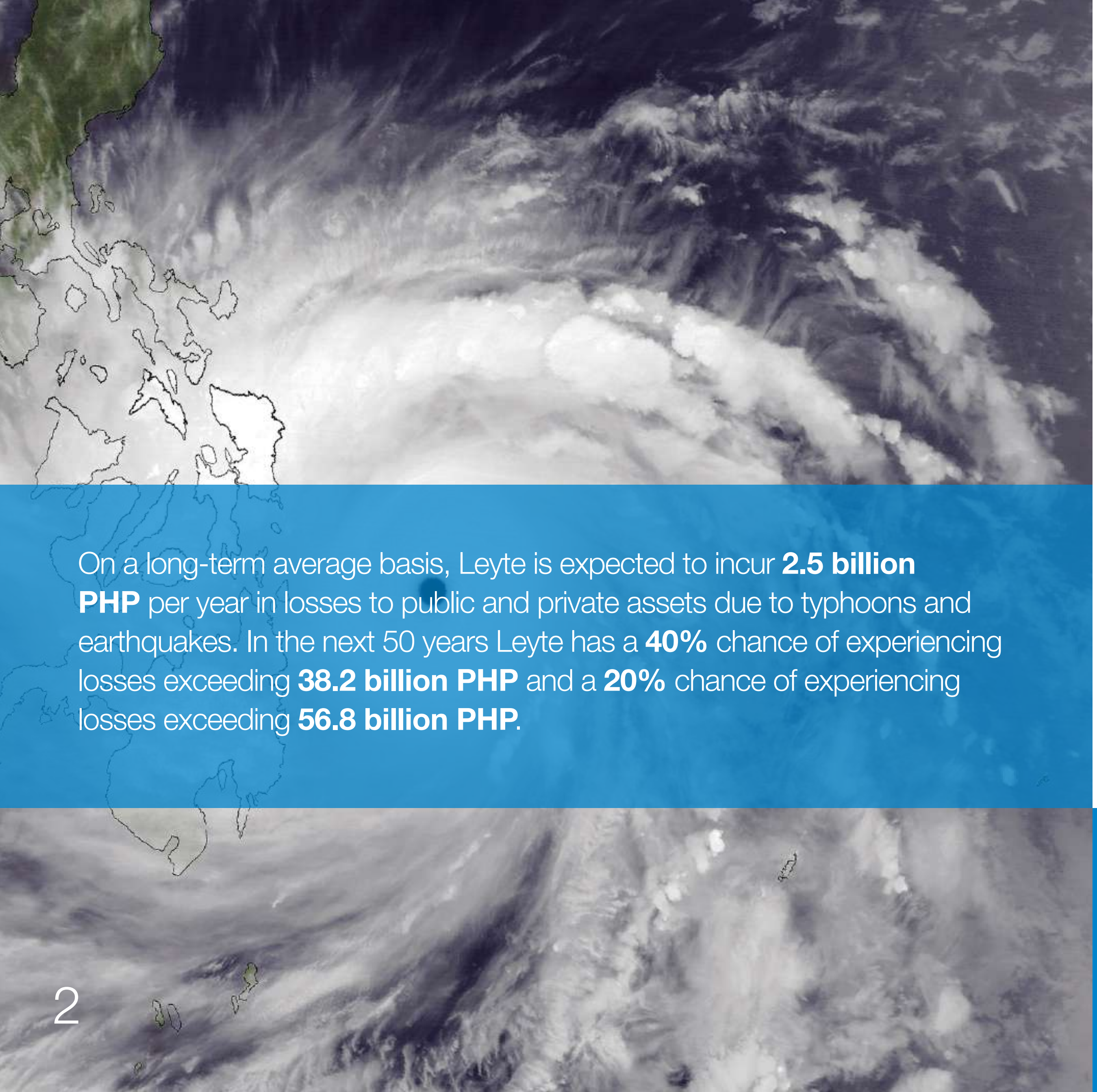
Province Risk Profile: Leyte

Philippines Catastrophe Risk Assessment and Modeling

January 2018



On a long-term average basis, Leyte is expected to incur **2.5 billion PHP** per year in losses to public and private assets due to typhoons and earthquakes. In the next 50 years Leyte has a **40%** chance of experiencing losses exceeding **38.2 billion PHP** and a **20%** chance of experiencing losses exceeding **56.8 billion PHP**.

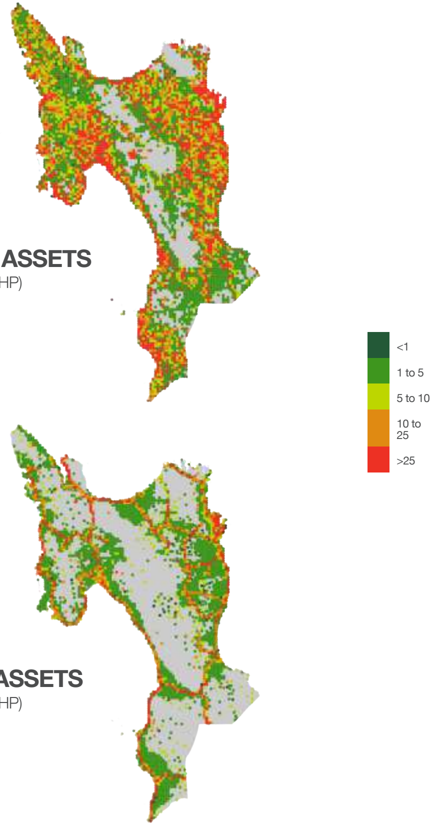
Leyte Asset Replacement Value (ARV)

A detailed asset exposure database in Leyte includes an inventory of public and private property assets at risk. Private assets include residential, commercial, and industrial buildings. Public assets include airports, ports, hospitals, clinics, power plants, prisons, public administration buildings, public schools & universities, rail tracks & stations, bridges, and roads. The database was assembled using a variety of information from official agencies in the Philippines, including the National Statistics Office, Department of Public Works and Highways, Department of Education, and numerous publicly available sources.

A summary of the total assets in Leyte (as of 2015) in terms of the replacement value is presented here. The replacement value includes replacement costs of both structure and contents, when applicable.

PRIVATE ASSETS
ARV (Millions PHP)

PUBLIC ASSETS
ARV (Millions PHP)



81% Private Assets
433 billion PHP

19% Pubilc Assets
101 billion PHP

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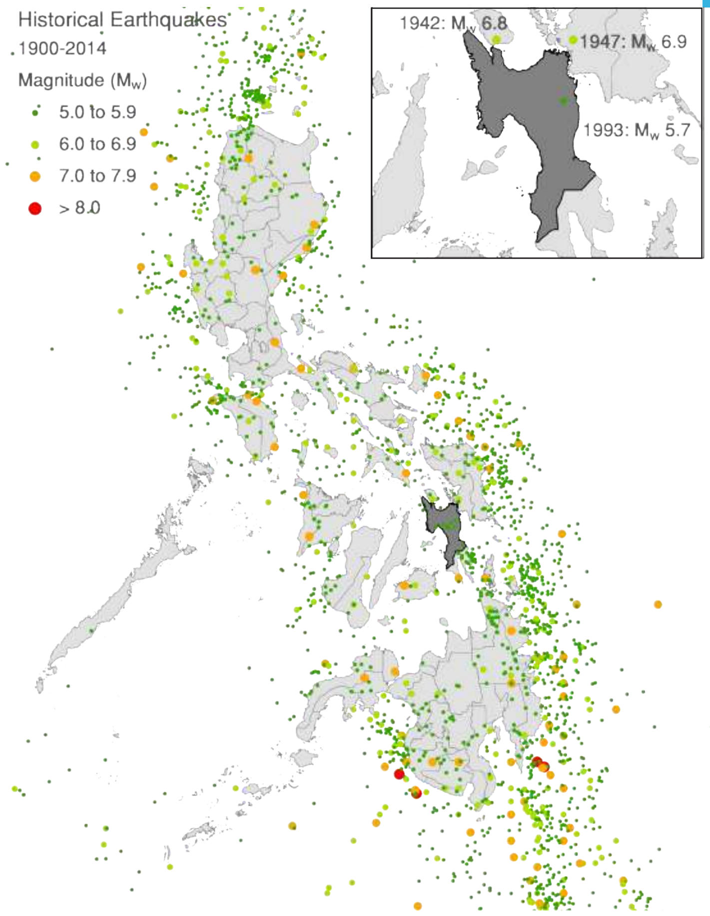

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EARTHQUAKE RISK

The Philippines is situated along the Pacific “Ring of Fire,” which aligns with the boundaries of major tectonic plates. These boundaries contain active seismic zones, capable of generating powerful earthquakes.

AIR’s model is developed using data from more than 80,000 historical earthquakes that have occurred within the model domain between 1600 and 2014.

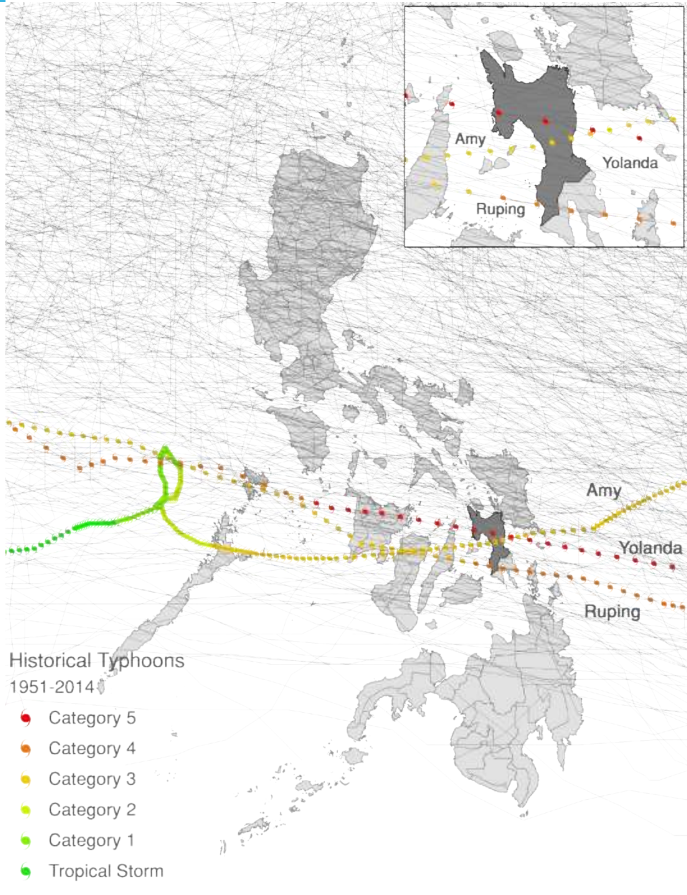
The map to the left depicts historical earthquake activity in the Philippines over the past century. For Leyte, three significant earthquakes by magnitude are highlighted.

TYPHOON RISK

The Philippines is one of the most natural hazard–prone countries in the world, due to its location in the Northwest Pacific Basin— known for its high frequency of typhoons and accompanying damaging winds, rain, and storm surge.

According to the JTWC, since 1959, an average of 26.6 typhoons and tropical cyclones have occurred in the Northwest Pacific Basin each year.[1] Typhoon activity in the basin peaks between July and November.

The map to the right depicts the historical record for typhoons in the Philippines between 1951 and 2014. For Leyte, three destructive historical typhoons are highlighted.



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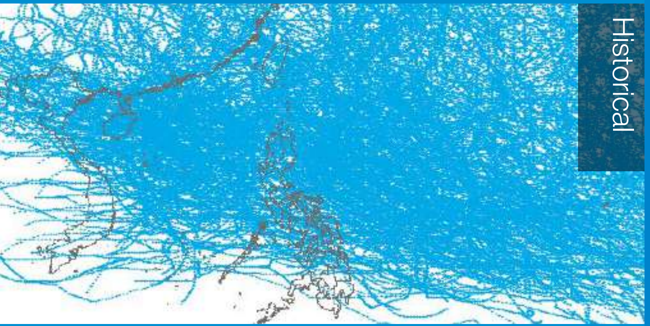
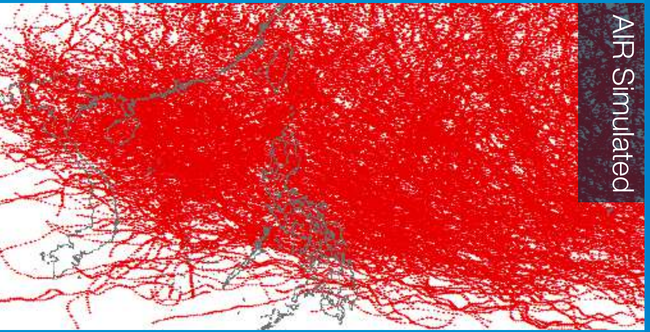
[1]JTWC Annual Tropical Cyclone Report 2016: https://metoc.ndbc.noaa.gov/ProductFeeds-portlet/img/jtwc/atcr/2016atcr.pdf

Event Simulation

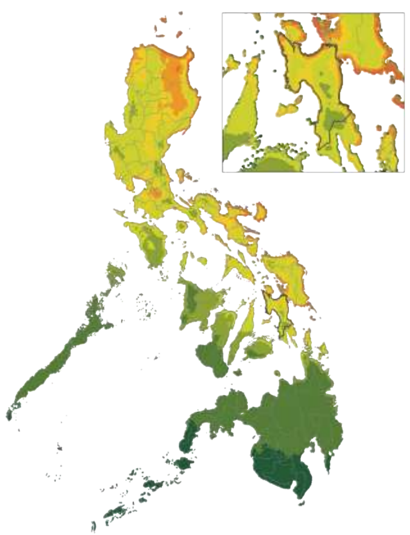




Using the historical catalogs of typhoons and earthquakes, AIR's researchers construct stochastic catalogs containing years of simulated activity that best reflect the scientific understanding of potential future events. For example, the illustration to the left compares the historical catalog of typhoons (blue) to the AIR simulated catalog (red). The typhoon and earthquake catalogs each contain 10,000 simulations of next year's event activity.

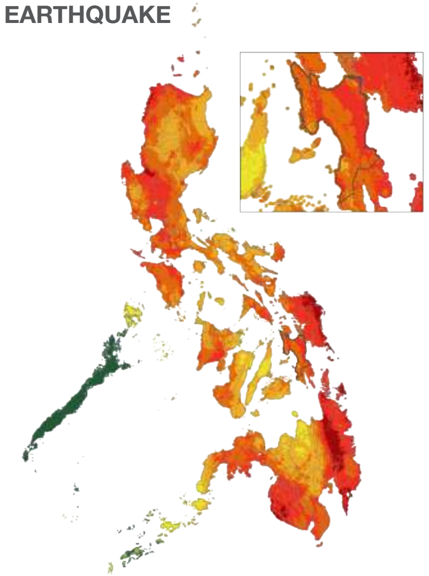
The simulated events are used to calculate the geographic distribution of hazard intensity associated with typhoons and earthquakes, such as wind speed and ground shaking, respectively. These intensity measures are directly related to the destructive potential of each event.

TYPHOON



Category	Tropical Storm		1		2		3		4		5	
Sustained Winds (km/h)	< 59	59 – 119	119 – 136	136 – 154	154 – 166	166 – 178	178 – 194	194 – 209	209 – 231	231 – 252	252 – 276	> 276
Potential Damage	Light		Moderate		Extreme		Devastating		Catastrophic		Catastrophic	

EARTHQUAKE



Instrumental Intensity	I	II-III	IV	V	VI		VII		VIII		IX		X+
Peak Acc. (%g)	< 0.17	0.17 – 1.4	1.4 – 4	4 – 9	9 – 13	13 – 17	17 – 24	24 – 32	32 – 45	45 – 61	61– 85	85 – 114	> 114
Potential Damage	None	None	None	Very Light	Light		Moderate		Moderate/ Heavy		Heavy		Very Heavy
Perceived Shaking	Not Felt	Weak	Light	Moderate	Strong		Very Strong		Severe		Violent		Extreme

The figures above depict the AIR simulated wind speed from typhoons (left) and ground shaking acceleration from earthquakes (right) that have a **1% probability** of being exceeded each year (i.e. 100-year mean return period). These levels of intensity can cause severe damage to buildings and infrastructure that can lead to large economic losses and casualties.

PROVINCE RISK PROFILE: LEYTE

Loss Estimates

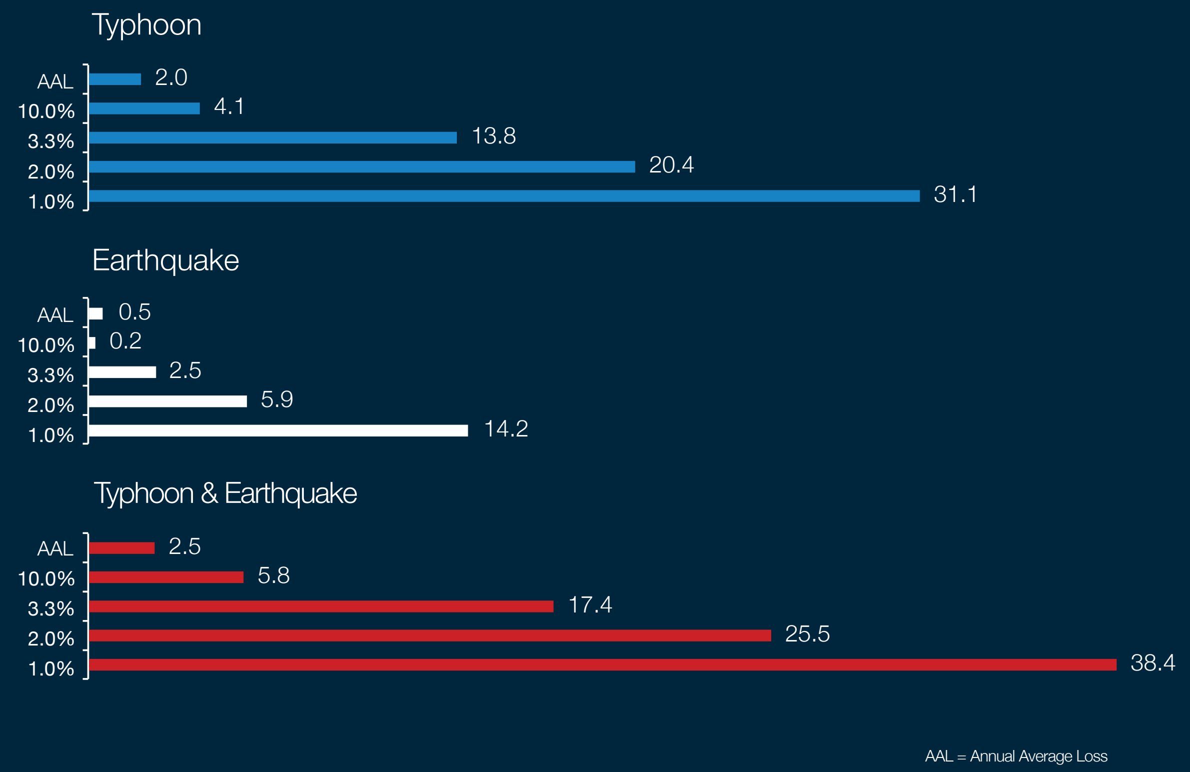
AIR's simulated event catalogs provide a measure of the likelihood of incurring a loss. These results can be used to calculate a probabilistic loss distribution, which is typically expressed as a loss exceedance probability (EP) curve. The EP curve represents the probability that a loss will be met or exceeded in any given year. The mean of this distribution is the average annual loss (AAL), or the expected loss per year, which represents the average loss a province is expected to incur each year.

In each simulated year, loss values are expressed as either the summation of all event losses (aggregate) or the maximum event loss (occurrence). Aggregate losses, or the total losses in a simulated year, are presented herein.

Calculating the Probability of Exceeding Loss Levels

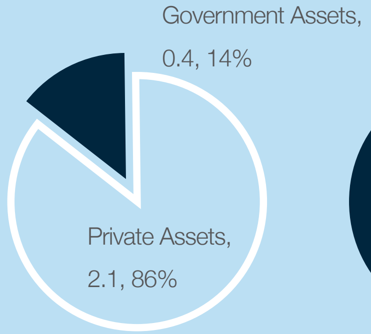
To generate AIR modeled losses, first the catalog of simulated events is run against the public and private asset database discussed on page 3. Next, the loss for each event in each of the 10,000 simulated years is calculated. Each simulated year's losses are summed and the years are ranked from largest to smallest by the amount of loss experienced during that year. The largest year's loss in the catalog is met only 1 time in 10,000 simulated years, which corresponds to an EP of 1/10,000, or a 0.01% chance of being met or exceeded in a given year. The graph to the right depicts the relationship between exceedance probability and loss. The chart on page 10 displays the modeled loss totals for Leyte from typhoons and earthquakes at different frequencies of occurrence. A 10% exceedance probability implies that Leyte has a 10% chance of meeting or exceeding that loss amount next year.

Modeled Loss in PHP (billions)

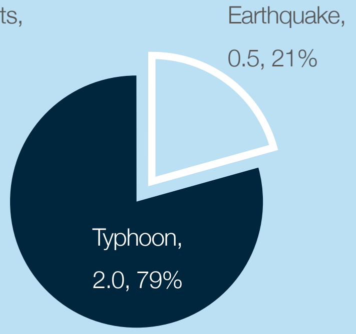


Average Annual Loss (AAL) Distribution

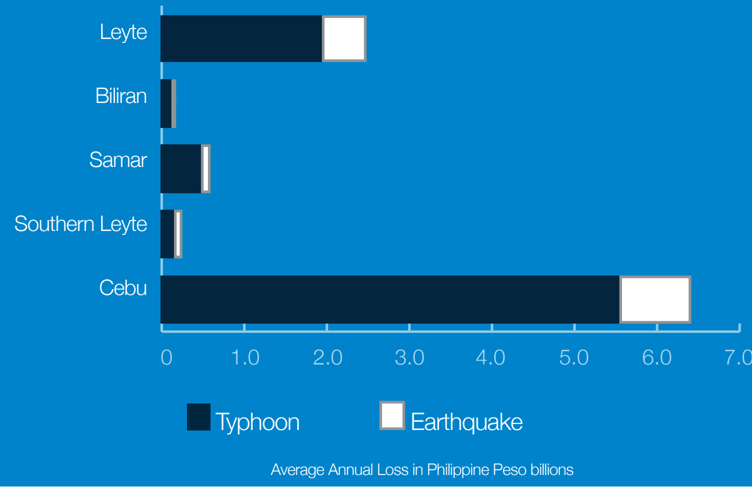
Leyte is likely to incur, on average, 2.5 billion PHP per year in direct loss to modelled private and public assets due to typhoons and earthquakes, of which 14% is related to public assets. Of this annual average loss typhoons contribute 79% and earthquakes 21%.



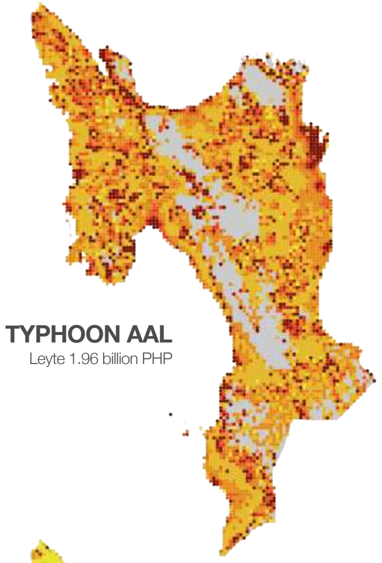
ALL PERIL AAL DISTRIBUTION BY ASSET TYPE (PHP BILLIONS, % TOTAL)



ALL ASSETS AAL DISTRIBUTION BY PERIL (PHP BILLIONS, % TOTAL)

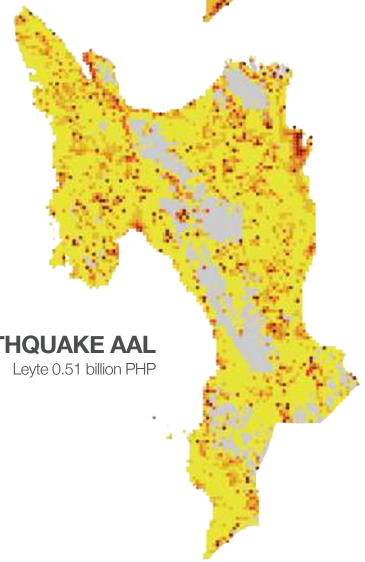


The chart depicts the loss contribution by peril for Leyte relative to neighboring provinces.



TYPHOON AAL

Leyte 1.96 billion PHP



EARTHQUAKE AAL

Leyte 0.51 billion PHP

Based on modeled results, Leyte is expected to incur, on average, 2.0 billion PHP per year in direct loss to modeled private and public assets due to typhoons—4 times greater than the average annual loss from earthquakes.

The loss maps to the left illustrate the AAL for Leyte from typhoons and earthquakes on a consistent loss scale enabling direct comparison between the two modeled perils.

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Annual Exceedance Probability of Occurrence	AAL	10.0%	3.3%	2.0%	1.0%
Mean Return Period (years)	AAL	10	30	50	100
Risk Profile: Typhoon					
Direct Losses (billions PHP)	2.0	4.1	13.8	20.4	31.1
(% Asset Replacement Value)	0.4%	0.8%	2.6%	3.8%	5.8%
Emergency Loss (billions PHP)	0.3	0.6	2.1	3.2	5.1
Risk Profile: Earthquake					
Direct Losses (billions PHP)	0.5	0.2	2.5	5.9	14.2
(% Asset Replacement Value)	0.1%	0.0%	0.5%	1.1%	2.7%
Emergency Loss (billions PHP)	0.1	0.0	0.3	0.7	1.7
Risk Profile: Typhoon & Earthquake					
Direct Losses (billions PHP)	2.5	5.8	17.4	25.5	38.4
(% Asset Replacement Value)	0.5%	1.1%	3.3%	4.8%	7.2%
Emergency Loss (billions PHP)	0.4	0.9	2.7	3.9	5.6

The table above details the modeled loss totals in addition to the proportion of the loss to the asset replacement value for Leyte from typhoons and earthquakes at different frequencies of occurrence. The emergency loss represents an estimate of the loss that the national government may sustain as a result of providing necesssary relief and undertaking recovery efforts. This is calculated as a proportion of the direct loss.

Glossary

Abbreviations:

AAL – Average annual loss
ARV – Asset replacement value
EP – Exceedance probability

Aggregate Loss – The sum of all event losses within each year in AIR's catalog of events (see Stochastic Catalog).

AIR Model – AIR develops catastrophe models, or computer programs that mathematically represent the physical characteristics of natural catastrophes, terrorism, pandemics, and cyber attacks. The results from the models help private and public sector entities understand and manage their risk. These models help answer questions such as: Where are future events likely to occur? How large, or severe, are they likely to be? How frequently are they likely to occur? What is the wind speed or ground shaking associated with each potential event? What is the property damage and loss associated with each potential event? The AIR Typhoon and Earthquake Models for Southeast Asia utilized for this project, and referred to in this brochure, were released in June 2016.

Asset Replacement Value – The cost to rebuild an entire structure/asset; the replacement value excludes land value and usually refers to part or all of the fixed components of a building or other asset or to its contents.

Average Annual Loss – The expected loss per year, averaged over the length of the catalog of events being considered (typically 10,000 simulated years). For example, if the total loss for 10,000 years is 10,000,000 PHP, then the average annual loss would be 1,000 PHP, or 10,000,000 PHP/10,000 years.

Event Intensity – The destructive potential of an event. The intensity metric varies by peril and includes ground shaking for earthquakes, wind speed for hurricanes, and the depth of the storm surge or precipitation-based flooding.

Exceedance Probability – The probability that any given level of loss will be met or surpassed within a given time period—for example, in the coming year. Loss probabilities can be provided at any geographic resolution—for an entire country's exposure, for a particular subset of buildings, or for an individual property. For example, if a historical typhoon has a 1% exceedance probability for the Philippines, that means that there is a 1% chance that another typhoon will cause losses equal to or greater than that in the Philippines next year.

Exposure Database – A collection of data containing counts of properties and their respective replacement values, along with information about occupancy (residential, commercial, industrial, etc.) and the physical characteristics of the structures, such as construction type (wood, steel, concrete, etc.), year built, and height classifications (1, 2, 3 stories, etc.).

Historical Catalog – A data set containing events that have previously occurred in the region. For typhoons, this includes meteorological and track information from the Japan Meteorological Agency (JMA) and the Shanghai Typhoon Institute (STI) for more than 1,800 storms that occurred in the Northwest Pacific Basin dating back to 1951. Precipitation data from the Tropical Rainfall Measurement Mission (TRMM) as well as satellite imagery from Digital Typhoon were primarily used to specify precipitation characteristics for the data set.

Mean – An average; the value obtained by dividing the sum of several quantities by their number.

Occurrence Loss – The largest event loss within each year in AIR's catalog of events (see Stochastic Catalog).

Peril – A natural or man-made hazard, i.e., typhoon, earthquake, flood, terrorism, pandemic, cyber attack, etc.

Probabilistic Model – A statistical model designed to simulate actual events based on probability theory or the fact that randomness plays a role in determining future events. AIR generates catalogs of potential future events (described under Stochastic Catalog), which form the basis for drawing conclusions such as the likelihood that a peril will strike, where it will strike, its intensity, and the range of potential losses it may incur.

Probability Distribution – A statistical function that describes all the possible values and likelihoods that a random variable can take within a given range between the minimum and maximum statistically possible values. These distributions are used to calculate the likelihood that a given amount of loss will occur based on a spread of possible losses.

Return Period – The time period over which you should expect, on average, to see a loss of the same or greater magnitude. Return Periods are an alternative way to express exceedance probabilities. For example, the loss associated with a return period of 20 years has only a 5% chance of being equaled or exceeded this year, or in one year out of 20, on average. Return Period = 1 / Exceedance Probability.

Simulated Activity/Events – AIR's models contain hypothetical years of typhoon/earthquake events, which are stored in event catalogs. These catalogs of computer-simulated catastrophes represent the broad spectrum of plausible events, with modeled years containing different numbers of events. The process of generating these events is described under Stochastic Catalog.

Stochastic Catalog – Catastrophe models simulate many years of natural disaster activity to capture a range of potential losses. These simulated events are contained in a stochastic catalog, with each year in the catalog representing one realization of what can happen in an upcoming year. To create a typhoon catalog, AIR first collects information on historical events (location, wind speed, central pressure, etc.) and subsequently develops probability distributions around these key variables. Once AIR creates the distributions for each of the variables, AIR samples from there to develop full catalogs based on their understanding of typhoons. For example, AIR starts by sampling from the annual frequency distribution, as this will determine the number of storms in any given year. Location frequency will determine where on the coast a typhoon will make landfall. The central pressure distribution will assign intensity to each event. The radius of maximum winds will tell AIR about the size of the typhoon. Forward speed can indicate the amount of damage that is likely to occur as slower storms frequently cause more damage. Finally, landfall angle plays a key role in understanding the potential impact of storm surge, or the rise of water above typical tidal levels resulting from a storm. This process allows AIR to account for events that are possible but may not have been recorded historically.

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