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## Comparing the Direct Human Impact of Natural Disasters for Two (Surprisingly Similar) Cases - the Christchurch Earthquake and Bangkok Flood of 2011

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**Abstract:** The standard way in which disaster damages are measured involves examining separately the number of fatalities, of injuries, of people otherwise affected, and the financial damage that natural disasters cause. Here, we implement a novel way to aggregate these separate measures of disaster impact and apply it to two recent catastrophic events: the Christchurch (New Zealand) earthquakes and the Greater Bangkok (Thailand) floods of 2011. This new measure, which is similar to the World Health Organization's calculation of Disability Adjusted Life Years (DALYs) lost from the burden of diseases and injuries, is described in detail in Noy (2014). It allows us to conclude that New Zealand lost 180 thousand lifeyears as a result of the 2011 events, and Thailand lost 2,644 thousand years. In per capita terms, the loss is similar, with both countries losing about 15 days per person due to the 2011 catastrophic events in these two countries. We also compare these events to other potentially similar events.

Data used for this paper is available at:

<https://sites.google.com/site/noyeconomics/research/natural-disasters>

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## 1. *Introduction*

The standard way in which disaster damages are measured involves examining separately the number of fatalities, of injuries (if that data is available), of people otherwise affected, and the financial damage that natural disasters, such as earthquakes or floods, cause. This classification dates back to a 1970s UN-sponsored project, at the Economic Commission for Latin America and the Caribbean (ECLAC, 2003). It was further developed and refined, and is now referred to as the Damage and Loss Assessment Methodology (Guha-Sapir and Hoyois, 2012).

Noy (2014) proposes a novel way to aggregate measures of disaster impact that overcomes some of the methodological difficulties inherent in any attempt to generalize anything from these separate measures. This measure is similar, in some ways, to the calculation of Disability Adjusted Life Years (DALYs) that is frequently used when comparing the efficacy of health interventions. The World Health Organization (WHO) uses this methodology to calculate the DALYs that are lost from the burden of diseases and injuries (WHO, 2014). As in the WHO's calculations of DALYs, the unit of measurement in the index used here is also life-years. However, the one conceptual difference between the WHO's approach measuring the 'burden of disease' and our approach is that the DALYs measure the impact of diseases exclusively on health, while our measurement is aimed at accounting for the impact of disasters on human welfare more generally, by also accounting for the impact of financial losses on human well-being.

## 2. *The Lifyears Index*

The basic premise is that the value of human life should ethically be considered as equal everywhere, while the value of monetary damages is not. Indeed, a dollar lost in a high-income country such as New Zealand imposes a less adverse impact on society than a dollar lost in a lower-income country like Thailand – income per capita in 2011 USD in the two countries was 5,192 and 37,192, respectively. The index we use here converts all damage indicators — including mortality, morbidity, other impacts on human lives (e.g. displacement), and damage to infrastructure and housing — into an aggregate measure of lifeyears lost, not of less easily interpretable currency/monetary units.

The index proposed here, based on a modified version of Noy (2014), consists of the following:

$$Lifeyears = L(M, A^{death}, A^{exp}) + I(N) + DAM(Y, INC)$$

where  $L(M, A^{death}, A^{exp})$  is the number of years lost due to event mortality, calculated as the difference between the age at death and life expectancy.

$L(M, A^{death}, A^{exp})$  requires not only information on the number of people who died ( $M$ ), but also the vectors of their age profile ( $A^{death}$ ), and the projected life expectancy for each individual ( $A^{exp}$ ). For life expectancy, we follow the WHO's approach in measuring DALYs. The WHO uses a uniform life expectancy of 92 years ( $A_m^{exp} = 92$  for all  $m$ ). This number originates from projections made by the United Nations regarding the likely average life expectancy at birth in the year 2050 (WHO, 2013, p. 5). The rationale for using this value for life expectancy, and one that is uniform across countries, is that the number represents a viable estimate of the

possible frontier of human longevity in the foreseeable future.<sup>1</sup> This assumption also removes another a potential difference in our measure between the Thailand and New Zealand disasters, as actual life expectancy in New Zealand is somewhat higher. Thus, our measure for the number of lifeyears lost due to disaster mortality is

$$L = \sum_{m=1}^M (92 - A_m^{death})$$

$\mathbb{I}(N)$  is the cost function associated with the people who were injured, or otherwise affected by the disaster. In principle, this should includes serious injuries, and the cost of their care, time spent in hospital and later rehabilitation, impact on people's mental health, impact on those whose houses were destroyed or livelihoods were adversely affected, impact on those who were displaced (temporarily or permanently), and any other direct human impact.  $N$ , in this framework, is all the information available for each disaster that allows us to calculate, as closely as is possible, this component of the overall index. The complete information set is never available, however. For global measures, one can typically only find information about the number of people injured and otherwise affected, though this count includes a wide range of syndromes and impacts. The EMDAT dataset, the most frequently used global dataset, includes only information on the number of people affected, but not on the nature of this impact. Desinventar, an alternative global dataset maintained by UNISDR, includes separately data on injuries, and people

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<sup>1</sup> It could be argued that a theoretically more attractive option is to use the life expectancy at the time of death. There is a practical challenge here, as the life expectancy at different ages varies significantly and information on the age profile of the dead is often not available. There is also an ethical challenge, since this implies placing more weight on disasters occurring in wealthier regions, where life expectancy is higher. We note, however, that life expectancy at the median age is significantly higher than life expectancy at birth, so that this choice of 92 does not exaggerate the impact of mortality to a very significant extent.

affected, but without further distinctions. In the cases we investigate here, we have additional information, which we use as well. Following the WHO methodology in calculating DALYs, we assume that the impact function is defined as  $I(N) = eTN$ .

The coefficient,  $e$ , is the ‘welfare-reduction weight’ that is associated with being exposed to a disaster. There is no precedent to determining the magnitude of this weight, and there is much debate about the appropriate methodology to determine such weights (see the discussion about the ‘disability weights’ in determining DALYs; WHO, 2013, p. 11). We adopt the WHO’s weight for disability associated with “generic uncomplicated disease: anxiety about diagnosis” ( $e=0.054$ ).<sup>2</sup>  $T$  is the time it takes an affected person to return back to normality, or for the impact of the disaster to disappear; while  $N$  is the number of affected people. Our benchmark calculations are based on a two- or three-year horizon for return to normality ( $T=3$  for Christchurch and  $T=2$  for Bangkok, given their very different experiences in the post-disaster period, and the more rapid recovery in Thailand).

The last component of the index,  $DAM(Y, INC, d, \delta)$ , attempts to account for the number of human years lost as a result of the damage to capital assets and infrastructure — including residential and commercial buildings, public buildings, and other types of infrastructure such as roads and water systems. In principle, we aim to measure the opportunity cost of spending resources (especially human effort) on the reconstruction of these destroyed assets.  $Y$ , the amount of financial damages, should therefore only include the value of the destroyed or damaged capital, rather

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<sup>2</sup> See, WHO (2013, p. 80) for the list of disability weights used in calculating DALYs.

than the cost of replacement.<sup>3</sup> *INC* is the monetary amount obtained in a full year of human effort. We use income per capita as an indicator of the cost of human effort, but discount this measure by 75% (*d*) in our benchmark calculations to account for the observation that much of our time is spent not in work-related activities. Thus,  $DAM(Y, INC, d, \delta) = (1 - d)\delta Y * INC^{-1}$ .

Given the assumptions detailed above, our benchmark index is calculated as:

$$Lifeyears = \sum_{m=1}^M (92 - A_m^{death}) + eTN + (1 - d)\delta Y * INC^{-1}.$$

The data on the relevant measures for the Canterbury and Bangkok events are taken from Thai and New Zealand national sources, at the most detailed level we could obtain. Data on per capita GDP are taken from the World Bank's *World Development Indicators*. The detailed data and all the calculations are available for download at:

### 3. Canterbury Earthquakes

We obtain the age of death for all the 182 people whose death is associated with the 22 of February, 2011 event. The total number of lifeyears lost due to mortality is thus  $L = \sum_1^{182} (92 - A^{death}) = 9,593$ .

The injuries to the 308 people who were hospitalized after the quake, and for whom we have hospital records, resulted in 2,930 days of hospitalization (8 lifeyears), and total cost of care of NZD 3.2 million. We use the NZ income per capita NZD 44,739 (for year ending March 2011) and the 75% discounting, to calculate the total cost as valued at 18 years. Further, there were 6,863 people who had reported injuries but

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<sup>3</sup> In cases where the only data available is the cost of replacement, we further discount the data by using a measure that accounts for the age of the physical assets destroyed ( $\delta$ ).



had not been hospitalized (or hospital record were unavailable). We assume each of these cases resulted in a loss of 1 week. Aggregated, that amount to a loss of 132 years. The total loss due to direct morbidity, therefore, is 158 years.

EMDAT lists that 300,000 people were affected. As mentioned earlier, we assume a DALY coefficient of 0.054, and duration of impact of three years given the slow recovery in Christchurch. These assumptions imply a total of 48,600 lifeyears lost as a direct result of the disaster's impact.

The most current estimate for the cost of replacement of all the damaged capital, which we were able to construct, is NZD 32,875 million (see appendix table for details). However, the replacement value is not identical to the damage, given the age of the capital that was destroyed. We assume that the damaged capital was one third through its life cycle, so the actual damage was around NZD 21,917 million. We further discount the amount by 75%, as explained above, and use the per capita income in New Zealand in 2011 of NZD 44,739 to obtain a total of 122,470 years lost due to damaged assets and capital.

**Thus, the estimated total number of lifeyears lost because of the 2011 Canterbury earthquakes is 180,821 years.**

#### *4. Bangkok Floods*

Data on the age at death of each mortality associated with the flooding is not available, but we were able to obtain the distribution of mortality by decadal cohort. We use the mid-point of each cohort and the other assumptions details above to conclude that 39,282 lifeyears were directly lost due to mortality.

The Thai government reported that 1,825,486 people experienced some injuries but the vast majority has not been hospitalized (hospital records associated with the floods are not available). Since it is reported that the top three causes for injuries are very minor, we assume that each of these cases only resulted in a loss of 2 days. Aggregated, that amount to a loss of 10,003 years.

The EMDAT database reports 9,500,000 being affected by the riverine flood in Thailand in 2011. As detailed earlier, we assume a DALY coefficient of 0.054, and a shorter duration of two years, given the faster recovery, to obtain the aggregate number of lifeyears lost as 1,026,000.

The available estimate for the cost of replacement of all the damaged capital is THB 1,490,458 Million. However, the replacement value is not identical to the damage, given the age of the capital and the reduced quality of infrastructure that was destroyed (relative to what will be reconstructed). As for the Canterbury event, we assume that the damaged capital was one-third through its life-cycle. Per capita income in Thailand in 2011 was THB 158,317. Together with our assumption of a 75% discounting, the total number of lifeyears lost due to the direct damage to capital and assets is 1,569,065 lifeyears.

**Thus, the estimated total number of years lost because of the Bangkok floods of 2011 is 2,644,350 years.**

##### *5. Some comparisons and final discussion*

Disaster losses worldwide are dominated by low-probability high-impact events (a small subset of the whole range of natural hazards affecting most countries

adversely on a regular basis. The disasters reported here were unusually catastrophic for both New Zealand and Thailand, but comparing them to a few other recent disasters might be instructive. For example, the loss experienced by Sri Lanka in the 2004 Boxing Day tsunami was significantly bigger in per capita terms (53 days), while the Haiti (Port-au-Prince) earthquake of 2010 was both much larger in absolute terms (20.9 million lifeyears lost) and in per capita terms (771 days) – more than 2 years lost per every single person living in country.

The approach proposed here has several attractive features, including: (1) emphasis on the loss of human potential associated with mortality; (2) emphasis on the tangible impact on people who were affected by disasters (but were not directly injured); (3) a full-information index, for specific disaster events, allows one to place a higher emphasis on the death of children and with higher life expectancy<sup>4</sup>; (4) a greater emphasis on the financial costs of disasters in lower income countries such as Thailand; and (5) perhaps most importantly, the fact that any of these assumptions can easily be modified, depending on the ultimate aim of the data analysis. In order to facilitate this, the data, including the calculations used to produce the table and figures, are posted at:

<https://sites.google.com/site/noyeconomics/research/natural-disasters>.

The measure proposed here focuses exclusively on the direct impact of disasters.

There are significant socioeconomic impacts that are indirect in nature. Such indirect impacts can also be potentially long lasting (more discussion of this typology is

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<sup>4</sup> Observing the public consternation with the high death toll among school age children in the Wenchuan Earthquake of 2008 suggests that the public, broadly speaking, shares this emphasis.

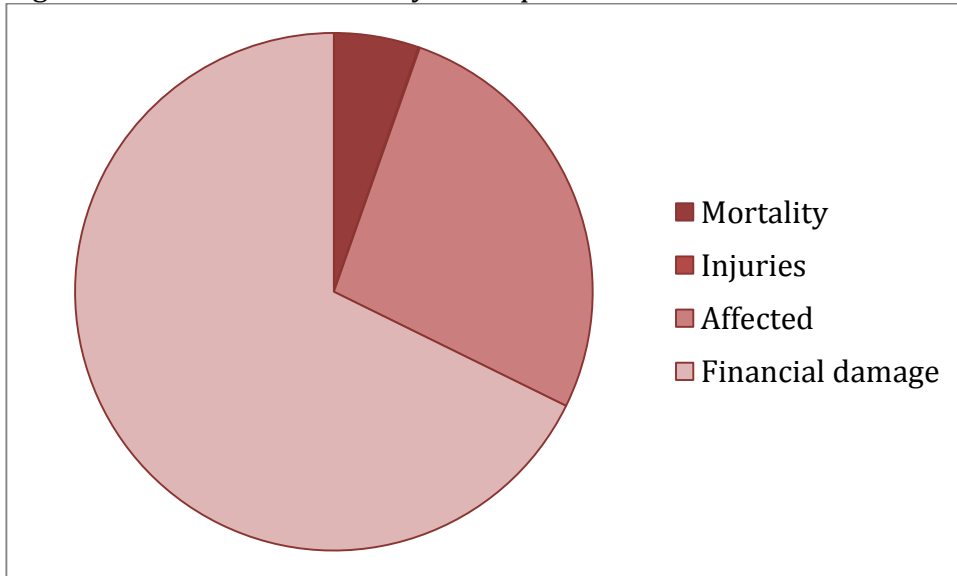
available in Cavallo and Noy, 2011 and Meyer et al., 2013). Current knowledge appears to indicate that these impacts can indeed be long lasting (Cavallo et al., 2013), most adverse for the geographical areas directly impacted (e.g. Hornbeck, 2012), and that the magnitude of indirect impacts may be a significant multiple of the direct adverse impact.

Furthermore, all existing attempts to measure disaster impacts, including the one described here, do not account for the direct impacts that are more difficult to quantify, especially the effect on natural capital (e.g. on the natural environment and the ecosystem services it provides us). For all these reasons, our quantification here should be viewed as significantly underestimating the overall impact of the Canterbury earthquakes and the Greater Bangkok floods on human activity.

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**Figure 1: The 2011 Canterbury Earthquakes**



**Figure 2: The 2011 Thailand Floods**

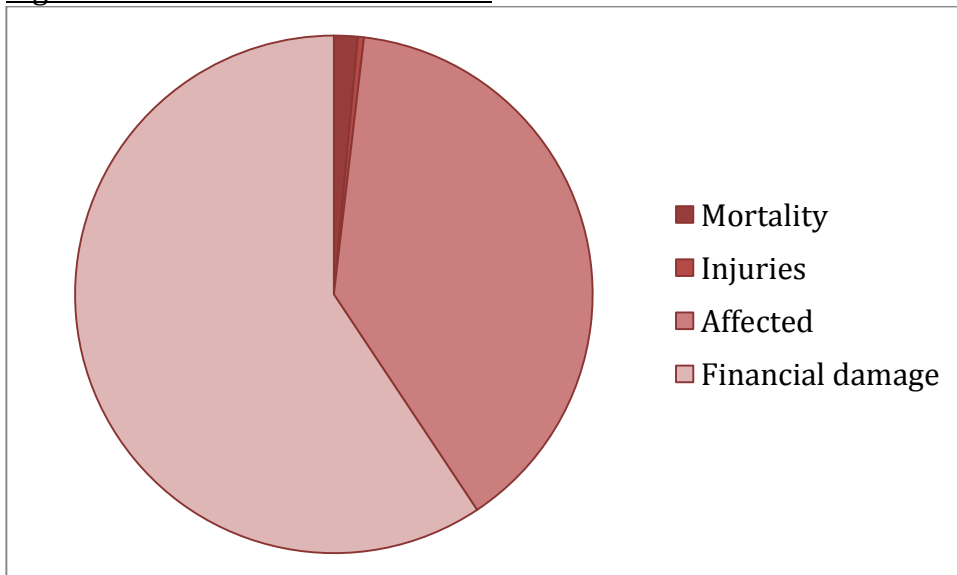


Table 1: The Events in Detail

	New Zealand		Thailand	
	Raw data	Lifeyears	Raw data	Lifeyears
Mortality	182 <sup>1</sup>	9,593	899 <sup>6</sup>	39,282
Morbidity (Total)				
Hospitalized days	2930 <sup>2</sup>	8		
Hospitalization costs	NZD 3,271,385 <sup>2</sup>	18		
Injuries (no hospital)	6,863 <sup>3</sup>	132	1,825,486 <sup>7</sup>	10,003
Affected	300,000 <sup>4</sup>	48,600	9,500,000 <sup>8</sup>	1,026,000
Damage (in million)	NZD 32,875 <sup>5</sup>	122,470	THB 1,490,458 <sup>9</sup>	1,569,065
<b>TOTAL</b>		<b>180,821</b>		<b>2,644,350</b>
<b>Per capita (days per person)</b>		<b>15.0</b>		<b>14.5</b>

1. Christchurch Earthquake : List of the deceased persons – <http://earthquake-report.com/2011/03/08/christchurch-earthquake-list-of-the-deceased-persons/>.
2. Personal correspondence from the Ministry of Health, Government of New Zealand.
3. Source: Johnston et al. (2014); we subtracted the 308 people for which we have hospital records.
4. EMDAT
5. See appendix table for sources for this observation.
6. Source: "Epidemiology of Drowning Death Identified from Flood - Related Surveillance during the Worst Flood in Thailand, August 2011 - January 2012." Bureau of Epidemiology, Department of Disease Control, Ministry of Public Health, Thailand. Volume 45 Number 19 : May 23, 2014
7. The total number of injured persons we report is the sum of persons experiencing physical injuries, from the Bureau of Information, Office of the Permanent Secretary (as at 13 November 2011), and the number of people reported to need mental health treatment, from the Department of Mental Health, Ministry of Public Health, Public Health, 2011.
8. The stated figure is from EMDAT. A Thai government source lists a higher number (12,860,946), but given the ambiguity in the definition of being affected, we prefer to use a consistent source for the two events. The government source: "Statistical report of natural disasters in 2011", September 2012, Department of Disaster Prevention and Mitigation (DDPM), Ministry of Interior, Thailand.
9. Source: World Bank (2012). *Thai Floods 2011: Rapid Assessment for Resilient Recovery and Reconstruction Planning*. GFDRR Paper.