CATDAT

Integrated Historical Global Catastrophe Database

Damaging Earthquakes Database 2010 – The Year in Review

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Author's Note

I hope that you enjoy the first edition of the CATDAT Annual Review of Damaging Earthquakes. I have been collecting earthquake, flood and other natural disaster loss data for quite a few years, with a more concerted effort in the past 2 to 3 years to build up the databases further. This report on 2010 only shows a small percentage of the data collected.

The purpose of this report is to present the damaging earthquakes of the year 2010 around the world that were entered into the CATDAT Damaging Earthquake Database in terms of their socio-economic effects. This 2010 report will also seek to introduce the CATDAT Damaging Earthquakes Database for those people who have not read or heard about it.

First of all a big thanks to my fiancée, Maren, for supporting me through the sporadic late nights (when earthquakes have occurred), as well as with SMS updates, translations, constant earthquake discussions and intellectual conversations. I would also like to thank my parents, Anne and Trevor, and also my sister, Katherine, for the numerous reports and papers I have sent them and they have checked and for the numerous updates as to potential natural disaster data.

A big thank you goes to the General Sir John Monash Foundation (supported by the Australian Government) who have been funding my PhD research at Karlsruhe at KIT/CEDIM and had allowed me to choose these from all worldwide institutions.

I would like to thank the University of Adelaide, Australia, Université Joseph Fourier, University of Pavia and Karlsruhe Institute of Technology for the background to undertake my study and to always promote learning outside the course environment.

Thank you also to the Center of Disaster Management and Risk Reduction Technology (CEDIM) for supporting me in my research in the natural disaster field. In addition, I would like to thank Friedemann Wenzel and Bijan Khazai for their interest, support and motivating me to publish my work. Thanks again, Bijan, for the countless translations from Farsi.

I have also been aided by a number of interested individuals for components of the database but with the amount of data around on historical damaging earthquakes, I am always interested in new reports, studies, questions, comments, improvements and collaboration.

I would also like to urge people's involvement with some great worldwide earthquake and natural disaster risk related initiatives out there – just to mention a few; earthquake-report.com, SOS Earthquakes, USGS-PAGER, EMSC-CSEM, GEO-CAN, WAPMERR, Global Earthquake Model (GEM) and Willis Research Network (WRN).

Many thanks,

James Daniell.

The data contained in this report is up to date as of 31 December 2010. The author takes no responsibility for errors that may be in the data and also misuse of the data provided. The EQLIPSE Building Inventory Database, CATDAT Natural Disaster Databases, OPAL Project, associated data and publications remain the intellectual property of James Daniell and are not to be reproduced in any form without permission.

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1 Introduction

2010 will be etched in many people's memories as the "year of the earthquake" – especially for those living in Haiti. 2010 started with a catastrophic earthquake for the country of Haiti. 240 years ago, after the major Haitian earthquake in 1770, it was decided that all buildings should be built of timber. Risk perception was at play, but through time there is a reduction in earthquake memory, earthquake-resistant building practices are lost, and the country reverts to the simplest building state. Of course, many other factors are at play which show the need for socio-economic vulnerability as part of any risk assessment. The 2010 earthquake hit one of the most undeveloped countries in the world, which had little to no seismic-resistant planning in place, and many underlying political, social and economic problems. Between 92000 and 225000 deaths occurred; the exact death toll will never be known but an estimate was used to create initial loss and aid estimates from developed nations.

Chile proved that their earthquake building practice for life safety is working, with less than 600 deaths recorded from a M8.8 earthquake. However, this earthquake did cause about 30 billion USD economic loss and was one of the highest insured losses of all time.

China, once again, has had a major disaster in the form of the Yushu earthquake in Qinghai province, with nearly 3000 deaths and between 3.472 billion and 4.81 billion USD.

New Zealand also had a major earthquake in the form of the Darfield (Christchurch) earthquake in September, causing another high insured loss, but no structural collapse related deaths.

It was also the year when the great Haiyuan earthquake of 1920 in China was depicted as the number 1 earthquake in terms of fatalities, with a new report from Zhang et al. (2010) showing the earthquake to have caused 273,400 deaths, a large proportion of these due to landslides.

2010 Damaging Earthquakes in Numbers

Number of CATDAT Damaging Earthquakes:	96+.
Number of Casualty-bearing Earthquakes:	61+ with at least 25 fatal.
Country with the most CATDAT Damaging Earthquakes:	China, 15.
Total Fatalities:	Between 95788 and 229185.
Total Injuries:	±337546.
Total Homeless:	±2.855 million
Total Economic Losses:	$45.52 billion - $55.15 billion US (Median = $51.16 billion US)
Total Insured Losses:	$11.21 billion - $18.52 billion US (Median = $14.32 billion US)

Please note that for the purposes of this report due to different meanings of billion and million worldwide:
1 billion = 1,000,000,000 or 10^9 1 million = 1,000,000 or 10^6

2 What is CATDAT?

CATDAT originated as a series of databases that have been collected by the author from many sources over the years (2003 onwards). It includes global data on floods, volcanoes and earthquakes (and associated effects). This report will focus on the damaging earthquakes in 2010, and a comparison as provided by the Damaging Earthquakes Database part of CATDAT. This database has been presented at the Australian Earthquake Engineering Society Conference in 2010 in Perth, Australia, in the form of 3 papers, and the data was also used to form an Asia-Pacific comparison of flood and earthquake socio-economic loss in the CECAR5 conference in Sydney, Australia, 2010.

As of February 2011 in CATDAT v5.01, over 17000 sources of information have been utilised to present data from over 12200 damaging earthquakes historically, with over 7000 earthquakes since 1900 examined and validated before insertion into the CATDAT damaging earthquakes database.

2.1 The development of the Damaging Earthquakes Database

The first step was a list of socio-economic details for various earthquakes that the author had collected online (OCHA ReliefWeb archives, NGOs, insurance companies), from news reports (global and historical), from earthquake-related books (Stein and Wysession 2003, Kramer 1996, Gutenberg and Richter 1948) and from papers (Ambraseys et al. 1982, 1991 etc., Samardzhieva and Badal 2002, BSSA 1911-2010) over a number of years due to the author's interest in natural disaster effects.

It was then realised that a detailed review and comparison was needed with other existing global databases. A review of existing global earthquake socio-economic effect databases was undertaken to see the completeness of these earthquake databases, as well as to source all the known lists of earthquake data worldwide. During this process, a report by Tschoegl et al. (2006) was very useful detailing information about existing Natural Disaster databases globally. It contains information on 6 international databases (EM-DAT, MunichRe NatCat, SwissRe Sigma, ADRC: GLIDE, University of Richmond: Disaster Database Project and BASICS) and a number of regional, national and sub-national databases. In addition, a comparison of 3 of these – EM-DAT, MunichRe, Sigma – revealed that there were major gaps in these databases (Guha-Sapir et al. 2002).

Also reviewed were many other global earthquake catalogues that have been created around the world, including the Utsu catalogue (2002), NGDC/NOAA (2010 searchable version), EM-DAT and a comparison of 8 of these databases for certain earthquakes through PAGER-CAT (2008). However, it was found that these earthquake databases lacked consistency and omitted or had erroneous earthquake details pre-1980. There were even many mythical earthquakes and untrue assumptions. Since the return period of most earthquake sources is much more than 30 years, increased knowledge of socio-economic effects pre-1980 was deemed to be required.

Thus, it was decided to expand the global CATDAT damaging earthquakes and secondary effects (tsunami, fire, landslides, liquefaction and fault rupture) database to validate, remove discrepancies and expand greatly upon the existing global databases; and to better understand the trends in vulnerability, exposure and possible future impacts of such historical earthquakes.

Four main databases (PAGER-CAT, NGDC, Utsu and MRNATHAN) were compared and checked earthquake by earthquake against the initial database. Although PAGER-CAT uses some Utsu and NGDC values, it was decided that a check was needed due to the possibilities of transmitting errors

and misprints from these databases. To delve further into the databases, where possible, the precursors to the databases were explored. In the case of the 2010 NGDC Significant Earthquakes Database, the precursor was the Dunbar et al. (1992) catalogue, which was based on the Ganse and Nelson (1981) catalogue. These two databases combined PDE and USGS data with famous databases such as Mallet (1852), Milne (1912), Sieberg (1932), Montandon (1953), Karnik (1969) and many regional databases such as precursor versions of Gu et al. (1989), Kondorskaya and Shebalin (1982), Coffman et al. (1982) etc.

NGDC is similar to the Utsu catalogue that reviewed the Dunbar et al. (1992) catalogue and added to the database using additional sources (CERESIS 1985, Papazachos et al. 1997, Gu et al. 1989 etc.). Utsu also noted the erroneous nature of figures and locations in the NGDC database. The Utsu database has a number of errors, and is limited to deaths, injuries, and a word description of damage and seismological information. However, it does have the largest number of damaging earthquakes out of all databases, including over 10000 up to 2002. Many of these were doubtful, repeated and erroneous and thus were not added to the CATDAT database. Each earthquake was audited with the original sources, or other sources where found. It was discovered through this study when going back to the original sources, that many errors in copying, values and assumptions had been made for many earthquakes worldwide.

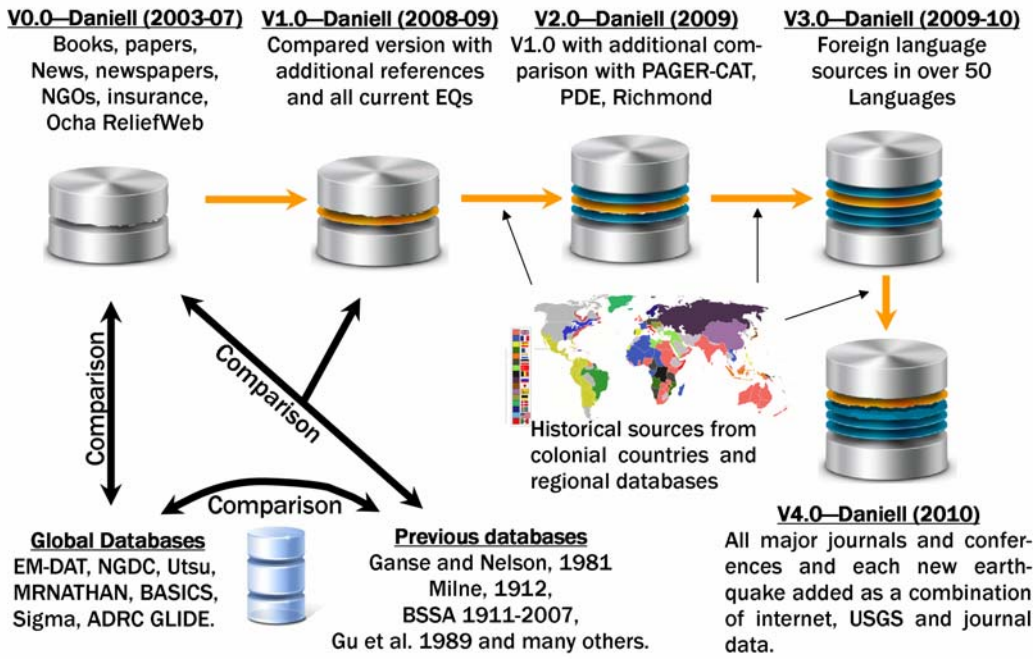

Figure 1 - The process used to create the CATDAT Damaging Earthquakes Database (Daniell, 2010a)

A good example of this is the Shemakha earthquake of 1902 in Azerbaijan in the NGDC, MunichRe NATHAN, Utsu, EM-DAT and PAGER-CAT databases. EM-DAT does not include this earthquake in its database, having only the El Salvador, Guatemala and Uzbekistan (Andizhan) earthquakes for 1902. Utsu includes 86 deaths and 60 injured as its main estimate but does have a note that it could have caused 10000/20000 deaths. PAGER-CAT uses the Utsu catalogue value of 86 deaths and 60 injured due to the algorithm that they use to choose between databases. NGDC also gives a value of 86 deaths and 60 injured. However, with CATDAT a large number of different sources are used, including the initial source in the database of Ganse and Nelson – Kondorskaya and Shebalin (1982); the description says that the value of 86 deaths comes about by only including deaths from villages around Shemakha and not the city itself. 20000 deaths is a probable exaggeration from newspapers

combining the number of homeless with deaths and people injured. Thus, 2000 deaths from many sources is the accepted death toll with a CATDAT accepted range of 2000 to 5000 deaths (Kondorskaya and Shebalin 1982, London Times 1902, New York Times 1902). Russian and Azerbaijani websites and records were also consulted.

This expert validation procedure has been undertaken for each earthquake and hence a range of social and economic losses is gained. It was also seen that regional and country based databases and reports need to be used, as only using English-speaking references reduces the volume and accuracy of the earthquake record collection. Thus, by using foreign sources i.e. Silgado 1968, 1978 (Spanish), Rothe 1965 etc. (French), Stuttgart 1933-1998 etc. (German), Postpischl et al. 1980 etc. (Italian), Gu et al. 1989 (Chinese), KOERI 2010 (Turkish) as well as Portuguese, Russian, Dutch (old Indonesian records), Farsi etc., the number of discovered earthquakes, social losses, economic loss values and building damage, as compared to other databases, was significantly increased. The colonisation through time was examined to determine in what language the old earthquake records of certain countries could be (Figure 2). Searches were made in both the language of colonisation as well as the official current languages of the respective countries. In this way, many old records were sourced.

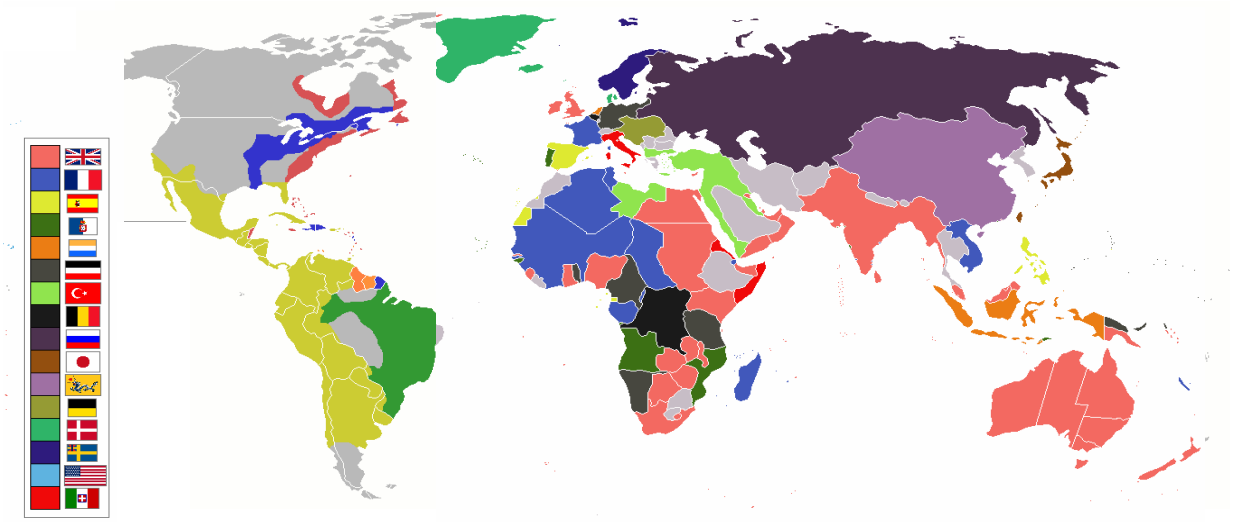

Figure 2 – The colonisation of countries used to determine languages required for searching for historic earthquake records (adapted from Wikipedia Commons 2010)

2.2 What is contained in the database?

Each validated earthquake includes the following parameters filled in to the best available detail:-

- Date (Day, Month, Year, Time (Local and UTC)).
- Seismological Information (EQ Hypocentre Latitude; Longitude; Depth (km); Intensity (MMI); Magnitude; Magnitude type)
- ISO3166-2 Country code, including Kosovo; ISO Country Name.
- Human Development Index of country; HDI Classification; Economic Classification; Social Classification; Urbanity Index; Population at time of event; Nominal GDP at time of event – split into developed or developing countries.
- CATDAT Preferred (Best Estimate) Deaths; Secondary Effect Deaths; Ground Shaking Deaths; CATDAT Upper and Lower Bound Death Estimates; Global Literature Source Upper and Lower Bound Death Estimates; Severe Injuries; Slight Injuries; CATDAT Upper and Lower

Bound Injury Estimates; Global Source Upper and Lower (U/L) Bound Injury Estimates; Homeless (and U/L Bound); Affected (and U/L Bound); Missing.

- Buildings destroyed; Buildings damaged; Buildings damaged – L4, L3, L2, L1; Infrastructure Damaged; Critical and Large Loss Facilities; Lifelines damaged.
- Secondary effects that occurred (Tsunami, Seiche, Landslide (mud, snow, rock, soil, quake lake), Fire, Liquefaction, Flooding, Fault Rupture); % of the social losses that were caused by each secondary effect; % of economic losses that were caused by each secondary effect; Tsunami Deaths; Landslide Deaths; Fire Deaths; Liquefaction Deaths.
- Disease and additional long-term problems.
- Full word description of various sources contributing to the data, including associated references.
- Country-based CPI at time of disaster; Country-based Wage Index at time of disaster; Country-based GDP Index; USA CPI for comparison; Hybrid Natural Disaster Economic Conversion Index.
- CATDAT Preferred (Best Estimate) Total Economic Loss; CATDAT U/L Bound of Economic Loss; Global Source U/L Bound of Economic Loss; Additional Economic Loss estimates from varying sources; CATDAT Economic Loss 2010 HNDECI-Adjusted; CATDAT Economic Loss 2010-country based CPI adjusted.
- Insured Loss; Insured Loss In 2010 dollars; Insured estimate source; Estimated Insurance Takeout (or approx. takeout) at time of event.
- Indirect and Intangible economic losses.
- Estimated life cost given social values, working wages etc. at the time.
- Total Economic Loss as a percentage of country's GDP; Social losses trended by population.
- CATDAT Earthquakes ranked via the Munich NatCat Service methodology.
- CATDAT Earthquakes ranked for the CATDAT Economic Disaster Ranking and CATDAT Social Disaster Ranking based on relative values and not absolute values. This will be explained further below.
- Link to ReliefWeb archive where available.
- Aid contribution; Aid delivered; Aid Source.
- Split country impacts (social and economic) where earthquake has affected more than 1 country.
- Various ratios between components for trends analysis.
- Normalisation strategies for current conditions. (Daniell et al. 2010b)
- Links to EQLIPSE, the author's global rapid loss estimation model (part of his PhD).

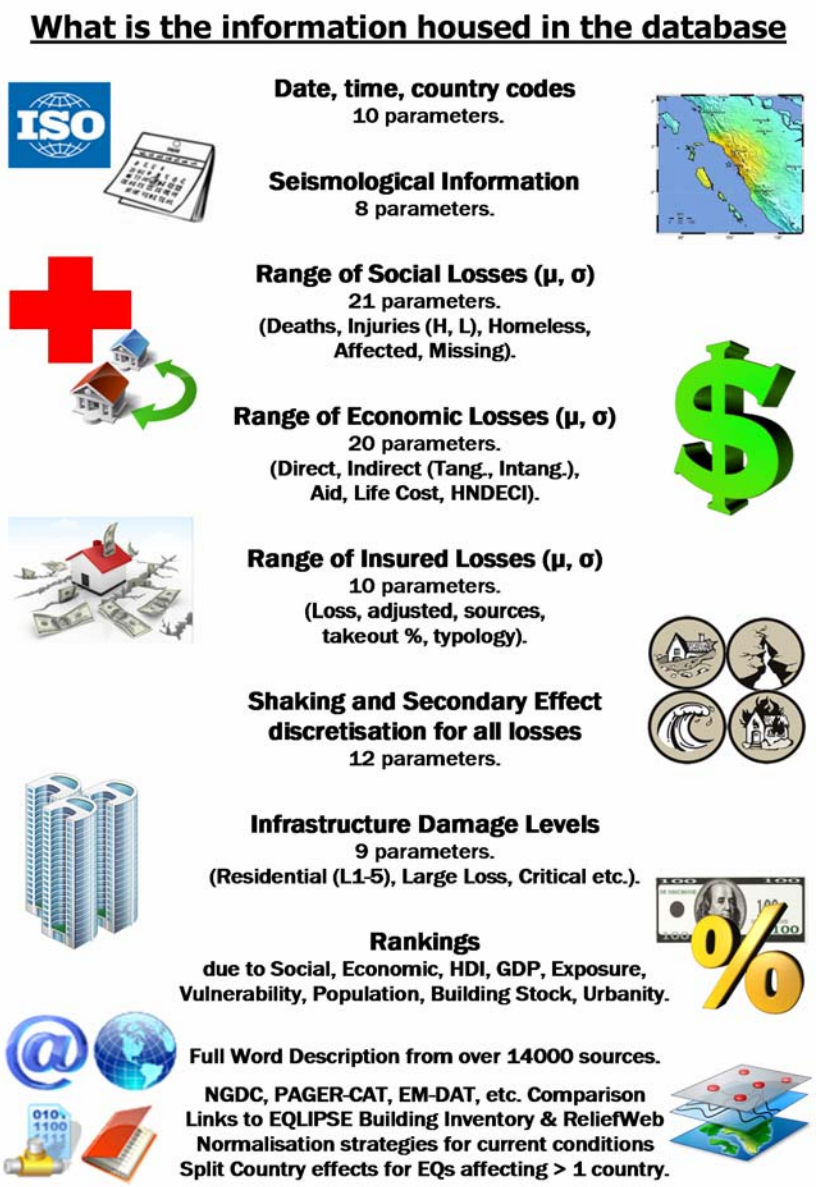

Figure 3 – The CATDAT Damaging Earthquakes Database parameters (Daniell, 2008-2010a)

This is contained in a Microsoft Excel framework with external links to other resources. It is also in SQL format.

2.3 Entry criteria

A damaging earthquake is entered into the CATDAT database by the following criteria in v. 5.01:-

- Any earthquake causing collapse of structural components.
- Any earthquake causing death, injury or homelessness.
- Any earthquake causing damage or flow-on effects exceeding $100,000 international dollars, Hybrid Natural Disaster Economic Conversion Index adjusted to 2010.
- Any earthquake causing disruption to a reasonable economic or social impact as deemed appropriate.
- A requirement of validation of the earthquake existence via 2 or more macroseismic recordings and/or seismological information recorded by stations and at least 1 of the 4 definitions above.
- Validation via external sources if Corruption Index < 2.7, subject to Polity ranking.

3 Damaging Earthquakes from 2010 in the CATDAT Damaging EQ Database

3.1 Where have the damaging earthquakes occurred?

There have been at least 96 damaging earthquakes in 2010. These have occurred in the following countries, as shown in the diagram below. There have been 15 damaging earthquakes in China that are classified under the CATDAT criteria, and 10 damaging earthquakes in Iran.

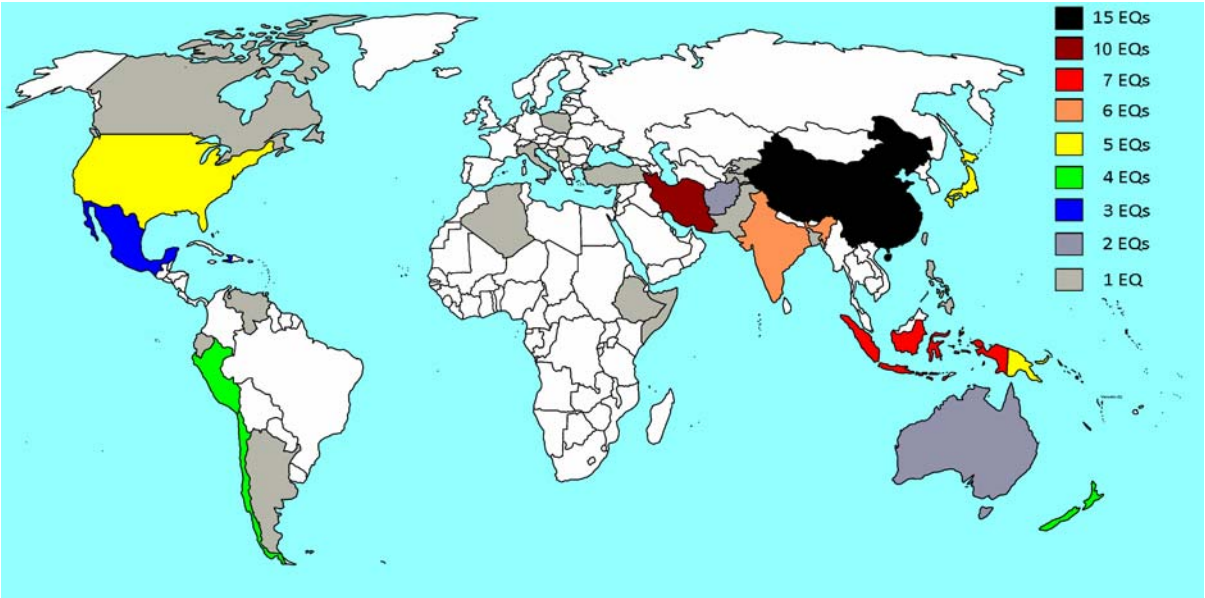

Figure 4 – The number of damaging earthquakes in various countries during 2010

This diagram has been updated since the 1st release of the report including the Aceh Tengah earthquake of 28.01.2010 has been classified as a CATDAT earthquake due to 2 houses damaged to a significant degree, and the 26.12.2010 aftershock from the New Zealand earthquake has occurred. Thus, Indonesia has 7 damaging earthquakes, and New Zealand, 4 damaging earthquakes for 2010. Poland also had a (in all probability) mining related earthquake of Mw4.5 on the 30.12.2010 which was added to this diagram.

3.2 Casualty-bearing 2010 earthquakes

There have been at least 26 fatal earthquakes in 2010. The most fatalities from an earthquake in2010 was that of Haiti which claimed somewhere between 92000 (Melissen, 2010) and 225000 (poss. Upper bound) deaths. The death toll from this earthquake has been discussed in Daniell et al. (2010d). CATDAT employs two different indices to check whether a sole government estimate can be taken for any natural disaster. The absolute index is made on the Corruption Perceptions Index from Transparency International. If a country has a value of less than 2.7, then a government estimate is treated with caution. The Polity IV Index is also used subjectively. A value of 162000 has been used in line with the work of Daniell et al. (2010d). The value presented by Melissen (2010) of 92000 deaths attempts to account for those buried in mass burials, those not buried, people dying of other means (suicide etc.), those cremated etc. The data shown by the government was unable to be verified by any other international source. Of course, recovery and reconstruction is the most important thing in Haiti at the moment; nevertheless, as the death toll was used to calculate initial funding as well as for use in any disaster analysis for future mitigation and disaster planning, it is very important that a reasonable validated estimate is made (Daniell et al., 2010d). In addition, 33

other injury-bearing earthquakes have occurred, making a total of 61 known casualty-bearing earthquakes for 2010.

The Yushu earthquake caused 2698 deaths and 270 missing people (counted as dead in CATDAT) in April. The Chile earthquake caused 523 deaths with 24 missing people and the Simeulue tsunami caused 454 deaths with 43 missing people.

Table 1 – List of casualty-bearing earthquakes in 2010

EQ Name	Cnt. ISO	Date	Best Estimate of Fatalities	Range of Fatalities	Heavy Injuries	Injuries or Slight Injuries	Pref. Source
Haiti	HT	12.01.2010	162000 (6-T)	(92000-225000)		310928	ReliefWeb, Melissen
Yushu	CN	13.04.2010	2968	(2698-2968)	1424	10701	ReliefWeb
Maule	CL	27.02.2010	547 (210-T)	(523-547)		12000	ReliefWeb
Mentawai	ID	25.10.2010	497 (T)	(454-528)	207	142	ReliefWeb
Elazig	TR	08.03.2010	42	(41-42)		137	ReliefWeb
Yapen	ID	16.06.2010	20 (13-L)	(17-22)	150		ID News, Govt.
Samangan	AF	18.04.2010	16	(16-16)		168	ReliefWeb
Guizhou	CN	17.01.2010	8 (L)	(8-8)	2	7	CN News, Govt
Fahraj	IR	20.12.2010	7	(5-11)	7	25	ILNA
Kraljevo	RS	03.11.2010	3 (1-HA)	(3-3)	2	100	EQ Report, ReliefWeb
Damghan	IR	27.08.2010	3	(3-3)		40	ILNA
Pichilemu	CL	11.03.2010	3 (2-HA)	(1-3)		Unk.	ReliefWeb
Rudna	PL	30.12.2010	3	(3-3)	2	10	EQ Report
Mexicali	MX, US	04.04.2010	2 (MX)	(2-4)		253 (MX=233, US=20)	ReliefWeb
Salta	AR	27.02.2010	2	(2-2)	4	100	News, Wiki
M'Sila	DZ	14.05.2010	2	(2-3)	23	20	Algerian News
North Mamuju	ID	16.06.2010	1 (L)	(1-1)	7	78	ID News, Govt.
Lamerd	IR	21.07.2010	1	(1-1)		70	IRNA, Oth. Press
Negar	IR	31.07.2010	1	(1-1)		30	IRNA, Oth. Press
Haripur	PK	11.10.2010	1	(1-1)	15		ASC India
Moxi	CN	30.01.2010	1	(1-1)	1	15	CN News, Govt.
Kazerun	IR	27.09.2010	1	(1-1)		7	IRNA, Oth. Press
Kimbe 2	PG	18.07.2010	1	(1-1)		3	NZ News
Garut	ID	10.01.2010	1 (HA)	(1-1)	2		ID News, Govt.
Oaxaca	MX	30.06.2010	1	(1-1)		0	News
Haiti AS 1	HT	12.01.2010	Additional	Unk.	Unk.	Unk.	ReliefWeb, USGS
Darfield	NZ	03.09.2010	0	(0-1) HA-link?	2	100	Govt.
Torbat	IR	30.07.2010	0	(0-0)	13	271	IRINN, Govt.
Dorud	IR	06.11.2010	0	(0-0)	26	93	Govt., Shasa
Kaohsiung	TW	04.03.2010	0	(0-0)		96	TWA fire, Govt.
Sinabang	ID	06.04.2010	0	(0-0)		62	Govt, ID News
Eureka	US	10.01.2010	0	(0-0)	0	30	Wiki, News.
Lufeng	CN	25.02.2010	0	(0-0)	3	32	CN News, Govt
Hossana	ET	19.12.2010	0	(0-0)		26	ENA, Govt.
Jianchuan	CN	01.01.2010	0	(0-0)		20	CN News, Govt
Qiaojia	CN	29.08.2010	0	(0-0)	3	14	CN News, Govt
Taikang	CN	24.10.2010	0	(0-0)	1	11	Govt.
Sucre	VE	15.01.2010	0	(0-0)		11	USGS, News
Tacna	PE	06.05.2010	0	(0-0)		11	News PE
Andaman Is.	IN	30.03.2010	0	(0-0)		10	ASC India

Lipari Is.	IT	16.08.2010	0	(0-0)	0	7	News IT
Solomon Is. 2	SB	03.01.2010	0	(0-0)	2	5	Press, Relief
Meulaboh	ID	09.05.2010	0	(0-0)		3	News ID
Ryukyu Is.	JP	26.02.2010	0	(0-0)	0	2	News JP
Fukushima	JP	13.03.2010	0	(0-0)	0	2	FDMA JP
Kalgoorlie	AU	20.04.2010	0	(0-0)	0	2	News AU
Norman	US	13.10.2010	0	(0-0)		2	News US
Yanjin	CN	17.10.2010	0	(0-0)		2	CN News, Govt
Vanj	TJ	02.01.2010	0	(0-0)	1		ReliefWeb
Guayaquil	EC	12.08.2010	0	(0-0)	1		News EC
Rajsamand	IN	09.11.2010	0	(0-0)	1		ASC India
Anjuman	AF	28.02.2010	0	(0-0)		1	ASC India
Honshu	JP	14.03.2010	0	(0-0)		1	News JP
Niigata	JP	01.05.2010	0	(0-0)		1	FDMA JP
Puerto Rico	US	16.05.2010	0	(0-0)		1	News US
Shidian County	CN	01.06.2010	0	(0-0)		1	Govt.
Port Blair	IN	12.06.2010	0	(0-0)		1	ASC India
Quebec	CA	23.06.2010	0	(0-0)		1	News CA
Iwate Pref.	JP	03.07.2010	0	(0-0)		1	FDMA JP
Kimbe 1	PG	18.07.2010	0	(0-0)		1	NZ News
Haiti AS2	HT	20.01.2010	Unk.	Unk.	Unk.	Unk.	
Total		**No. EQ**	**166132**	**(95788-229185)**	**At least 337546**		

3.3 2010 earthquakes with over 200 people homeless or requiring shelter

The earthquakes which impacted by far the most people were the Yushu earthquake in China, the Haiti earthquake and the Maule earthquake in Chile. Although generally linked to casualties, some major earthquakes have very few casualties yet high numbers of homeless. For earthquakes with smaller numbers of homeless people, estimates are not usually provided and need to be calculated by red tagged buildings, with a lowest estimate being those people living in destroyed buildings. A number of earthquakes in 2010 had unknown homeless levels.

The Haiti earthquake caused the most homeless in 2010 with somewhere between 1000000 and 2100000 people homeless, with the best estimate being 1200000 homeless sheltered around Port-au-Prince, 150000 moved overseas and 500000 living in other areas of Haiti. Although the casualty toll was not high in Chile, the number of homeless was about 800000. The Yushu earthquake in China also caused about 100000 homeless. Three other earthquakes caused major homeless tolls; the Mexicali earthquake had at least 25000 homeless, and the Samangan earthquake in Afghanistan and Simeulue Tsunami in Indonesia had about 15000 homeless each.

Although the overall damage was minor, due to the red tag level as the result of higher seismic standards in New Zealand than in many other countries, the Darfield, N.Z., earthquake will have a number of people displaced. Most have moved in with friends and family; however, they still count as displaced from their pre-earthquake state. The Mexicali earthquake also caused problems for over 300000 families who were without work due to the irrigation canal problems (over 300km being damaged) and the associated crop loss. The Kaohsiung earthquake caused about 545000 power outages, disrupting many people.

Table 2 – List of homeless-bearing earthquakes in 2010

EQ Name	Cnt. ISO	Date	Homeless Range	Affected Range	Pref. Source
Haiti	HT	12.01.2010	1850000 (1000000-2100000)	3200000 (3000000-4500000)	USAID, ReliefWeb

Maule	CL	27.02.2010	800000 (650000-950000)	2000000	USAID, PAHO
Yushu	CN	13.04.2010	-100000+	246842	ReliefWeb
Mexicali	MX, US	04.04.2010	25000+ (5000+ families)	1172400 (families – people out of business)	EERI, Govt., ReliefWeb
Samangan	AF	18.04.2010	15000 (1500-16000)	50000 (16000-260000)	ReliefWeb
Mentawai	ID	25.10.2010	14983 (3750-15000)	22000 direct (22000-65000)	OCHA, Govt.
Kraljevo	RS	03.11.2010	-8000+	100000 (70000-130000)	ReliefWeb
Moxi	CN	30.01.2010	4817	16976	CN Govt. Est
Yapen	ID	16.06.2010	4702	98000	News, Govt.
Lamerd	IR	21.07.2010	4000	Cplx: refer CATDAT	IRNA Est
Fahraj	IR	20.12.2010	4000 (2000-7200)	Up to 50000	IRNA Est
Darfield	NZ	03.09.2010	4000 (350-6000) – based on 1200 uninhabitable houses. 350 in shelter.	400000	NZ News, Est.
Elazig	TR	08.03.2010	-3477+	Cplx: refer CATDAT	Govt. Est
Lufeng	CN	25.02.2010	3000 (2000-8331) – 25600	164521 (40704 families)	CN Govt. Yn.
Damghan	IR	27.08.2010	2000-4000	6000	IRINN Est
M'Sila	DZ	14.05.2010	2000 (1231-3000)	Cplx: refer CATDAT.	DZ News
Khuzestan	IR	16.01.2010	2000	Cplx: refer CATDAT.	Est
Torbat	IR	30.07.2010	2000 (500-3000)	Cplx: refer CATDAT.	IR Govt. Est
Negar	IR	31.07.2010	1800 (500-3500)	Cplx: refer CATDAT.	IR Govt. Est
Qiaojia	CN	29.08.2010	1297 (878-4247)	34700 (34700-48000)	CN Govt. Est
Vanj	TJ	02.01.2010	1134 (768-1134)	6706	ReliefWeb
Sol Is. 1, 2, 3	SB	03.01.2010	1000 (750-1500)	8077 (4900-8077)	PacificWeb Sit. Reports
Haripur	PK	11.10.2010	848	Cplx: refer CATDAT.	Estimate
Shidian	CN	01.06.2010	315 (275-400)	Cplx: refer CATDAT.	CN Govt.
Jianchuan	CN	01.01.2010	-200+	19541	CN Govt.
Kaohsiung	TW	04.03.2010	No est.	Approx 1.7 million	Estimate

3.4 Economic Losses from earthquakes in 2010 over $5 million US

Economic losses from earthquakes in 2010 have been between $45.51 billion and $55.15 billion US, with the proportion of these coming from the Chilean earthquake of 27th February with approx. 30 billion dollars US damage. The median value has been **USD51.16 billion.**

The Haiti, Darfield, Yushu and Mexicali earthquakes also had significant economic losses of over USD1 billion.

The 13 damaging earthquakes of China were dominated by the economic losses of Yushu of somewhere between nearly USD3.47bn (226.5亿元) and USD4.81bn (316.5亿元). Although quoted earlier as a higher value of between USD8.944bn and USD12.00 bn economic loss (via AON Benfield), it has been decided that the reconstruction value of CNY31.65 billion (316.5亿元) will be used as the upper bound value. The direct economic losses quoted from the Chinese government were equal to CNY22.65 billion (226.5亿元) or USD3.47 billion. The previous values were assumed to account for indirect economic losses, however these have now been reduced.

This is much higher than the $500m USD quoted from MunichRe as the total cost. In terms of relief donations to Yushu via the Chinese Red Cross and other means from individuals this even outstripped the $500m USD with around CNY10.67 billion (USD1.62 billion) having been pledged as of August 2010.

However, six other Chinese earthquakes recorded losses in excess of $5m USD. In addition the Taiwanese earthquake had losses of $95m USD. The ten damaging Iranian earthquakes of 2010 had a combined loss total of between $124m and $151m USD. Three damaging earthquakes in Indonesia also recorded a combined loss total of about $126m USD. Total loss refers to indirect and direct loss combined.

Table 3 – List of economic losses in earthquakes in 2010 with over $5 million USD or other notable losses

Earthquake	Country	Date UTC	Total Loss Range (USD)	Pref. Source
Maule	Chile	27.02.2010	$30000m ($27500m-$32500m) Total	AIR, Ext.
Haiti	Haiti	12.01.2010	$7804m ($7500m-$8500m) Total	Govt., Ext.
Darfield	New Zealand	03.09.2010	$6500m ($5000m-$7876m) Total	Govt, Insurers
Yushu	China	13.04.2010	$4810m ($3350m-$4810m) Total	Govt., Ext.
Mexicali	Mexico, USA	04.04.2010	$1150m ($1091m-$1200m) Total	Reins, Govt.
Kraljevo	Serbia	03.11.2010	$150m ($139m-$150m) Total	ReliefWeb
Kaohsiung	Taiwan	04.03.2010	$95.24m ($80m-$95.50m) Total (Mostly Indirect)	AON, News
Yapen	Indonesia	16.06.2010	$85.20m Total	KOMPAS, Govt.
Pichilemu	Chile	11.03.2010	$75m ($31.60m-$109.80m) Direct	Est.
Moxi	China	30.01.2010	$66.56m Direct	Govt
Lufeng	China	25.02.2010	$51.94m Direct	Yunnan Govt
Dorud	Iran	06.11.2010	$45.10m ($18.80m-$45.10m) Direct	News, Govt.
Mentawai	Indonesia	25.10.2010	$35.27m Total	Govt. Indonesia
Lamerd	Iran	21.07.2010	$30.03m Direct	IRNA, Govt.
Eureka	USA	10.01.2010	$30m ($21.90m-$50m) Total	News
Quebec	Canada	23.06.2010	$30m ($16.30m-$30m) Total	CATDAT
Fahraj	Iran	20.12.2010	$19.26m+ Direct	IRNA, Govt
Datong	China	04.04.2010	$15.45m Direct (CNY108.94m)	CN Govt.
Torbat	Iran	30.07.2010	$15.02m Direct	IRNA, Govt.
Darfield AS3	New Zealand	25.12.2010	>$15m – waiting on EQC Total	Est.
Qiaojia	China	29.08.2010	$12.68m ($4.93m-$12.68m) Dir.	LSZ Govt.
Damghan	Iran	27.08.2010	$12.50m Direct	IRINN, Govt.
Negar	Iran	31.07.2010	$12.02m Direct	Shasa News, Govt
Khuzestan	Iran	16.01.2010	$8.60m (both quakes) Direct	Govt
Jianchuan	China	01.01.2010	$8.39m Direct	Govt
Yanjin	China	17.10.2010	$8.36m Direct	Govt
Kalgoorlie	Australia	20.04.2010	$7.50m ($4.47m-$15m) Total	Estimate, Govt
Shidian	China	01.06.2010	$6.20m Direct	Govt
Sinabang	Indonesia	06.04.2010	$5.65m Total	Govt., ID News
Elazig	Turkey	08.03.2010	$5.40m ($3.62m-$7.24m) Total	Estimate, TCIP
Samangan	Afghanistan	18.04.2010	$5.2m ($2.6m-$5.2m) Total	Est., ReliefWeb
Khonj	Iran	26.11.2010	$4.85m Direct	IRNA, Govt.
Kazerun	Iran	27.09.2010	$3.72m Direct	IRNA, Govt.
Wuqia	China	10.06.2010	$3.53m Direct (CNY24.08m)	CN Govt.
Rongchang	China	22.02.2010	$2.56m Direct (CNY18.09m)	CN Govt.
Taikang	China	24.10.2010	$2.12m Direct (CNY14.46m)	CN Govt.
M'Sila	Algeria	14.05.2010	$0.87m-$4.35m Direct	Est.
Vanj	Tajikistan	02.01.2010	$1.5m Direct	ReliefWeb
Taiyuan	China	05.06.2010	$0.627m Direct (CNY4.28m)	CN Govt.
Haiti AS1	Haiti	12.01.2010	Unable to split from main damage	
Haiti AS2	Haiti	20.01.2010	Unable to split from main damage	
Talca (AS)	Chile	02.05.2010	Unknown but >$5m	
Darfield AS1	New Zealand	18.10.2010	Unknown as yet – waiting on EQC	
Darfield AS2	New Zealand	14.11.2010	Unknown as yet – waiting on EQC	

It should also be seen that the Yunnan "2.25" earthquake in Lufeng did not cost $0.882m USD, as this was the Chinese government's initial relief effort which was subsequently increased. The total economic loss from the Lufeng earthquake was found to be CNY354.4 million (35440万元) or $51.94 million USD as per Yunnan Government releases.

Again with the Suining city "1.31" earthquake in Sichuan, the estimates of CNY30 million given by other company catastrophe reports, was an estimate 1 day after the disaster with little ground truthing. The final estimate of the government was CNY454.52 million (4.5452亿元) or USD66.56 million.

It should be noted that the cost of the Mentawai, Indonesia, earthquake was about IDR315 billion, which is equivalent to approx. $35.30 million USD. The value given in some major companies' Catastrophe Report is <u>not correct</u> as it contains the value for the Wasior floods (IDR280 billion) AND that of the Mentawai earthquake/tsunami in the value for just the Mentawai earthquake/tsunami.

The value in some Catastrophe reports for the Canadian earthquake also only consists of the damage done by the Gracefield bridge collapsing ($17 million CAD). Thus a more reasonable estimate is that of $30 million US.

In the Elazig earthquake, only TCIP (Turkish Catastrophe Insurance Pool) information was that 1305TL (850USD) per payout occurred to 222 claimants. This meant that based on the information of 3007 heavily or destroyed buildings (DR=1.04) that are demolished and reconstructed, 1561 moderately damaged buildings (DR=0.33) and 3854 slightly damaged buildings (DR=0.16) as per damage ratios in Bal et al. (2008), the approximate cost would be $3.62 million US from these houses. Of course, this is only including building damage, and no other infrastructure damage and other economic costs (direct and indirect) that make up a significant percentage of other damage estimates, but it gives a guide. A factor of 0.4 will be employed to attempt to factor in these losses. This makes the total $5.07 million. Looking at the reconstruction values available, the values are in excess of $8.3 million TL ($5.40 million USD).

3.5 Insured Losses from earthquakes in 2010

The losses in the reinsurance domain for 2010 have been the second largest cumulative annual loss in history. This will be seen in the following section. The table below shows the insured loss ranges for each damaging earthquake with insurance loss in 2010.

Table 4 – List of insured losses in earthquakes in 2010 over $1m

Earthquake	Country	Date	Insured Loss Range	Pref. Source
Maule	Chile	27.02.2010	$8500m ($7566m-$12000m)	Std & Poor's, PartnerRe
Darfield	New Zealand	03.09.2010	$3900m ($3040m-$5500m) NZEQC = $1150m then reinsurance	Catlin, PartnerRe
Mexicali	Mexico and USA	04.04.2010	$250m in Mexico, $150m in the USA (MunichRe)	AON, MunichRe
Yushu	China	13.04.2010	$165m ($80m-$222m)	ChinaLife, Est, AON
Haiti	Haiti	12.01.2010	$150m ($30m-$200m) CCRIF=$8m	MunichRe
Kaohsiung	Taiwan	04.03.2010	$76.12m ($76.12m-$80m)	AON
Eureka	USA	10.01.2010	$25m	MunichRe
Pichilemu	Chile	11.03.2010	$6.30m-$38.40m	Est.

The Maule, Chile earthquake represents the 2nd highest absolute insurance loss from an earthquake (unadjusted through time). A full comparison will be shown in section 4. Similarly the Darfield , N.Z., earthquake represents the 3rd highest absolute insurance loss from an earthquake going above the 1995 Kobe EQ. The Mexicali earthquake caused insured losses of $150m in the USA, and approx. $400m, including the $250m estimated insured losses from over 6000 claims in Mexico. The Haiti earthquake has differing ranges for insured loss, ranging from $30m from SwissRe, up to $200m by MunichRe. In this case, the $150-200m value is preferred. $100m was determined via AON.

For the Yushu, Qinghai earthquake, the insurance sector preliminary statistics in Yushu showed a total property insurance of 748 million yuan, motor vehicle insurance of 234 million yuan, personal accident insurance of 24 million yuan and 12.5 million yuan life insurance. The Sichuan earthquake showed an approximately 0.7% payout. Thus, based on $4.8 billion total loss in Qinghai, the assumed loss for insurance is approx. $80 million – a 1.7% payout. Using the AON Benfield estimate of $12 billion, an insured loss of $222m was shown. Using the Benfield estimated insurance takeout on a lower total loss of approx. $9 billion USD, a value of $165m is found. The Kaohsiung, Taiwan earthquake on 4th March 2010 also had some insurance penetration due to business interruption to silicon chip manufacturers and the loss to the textile factory and was approx. a $76m loss to insurers.

The Eureka earthquake on the 10th January 2010 had approximately $25 million USD in insurance losses according to MunichRe. In addition, the Kalgoorlie-Boulder earthquake of 20th April 2010 in Australia would have certain insured losses. However, as yet, a finalised value has not been ascertained. Many of the public buildings are insured and a $5 million AUD ($4.6 million USD in April 2010) heritage fund was put in place to restore some of the heritage buildings to bridge the gap between the insured loss and market value. In addition, there may have been business interruption cover for the goldmines in the region which has been determined to be millions of dollars lost. The Insurance Council of Australia has not published insured loss values, meaning that it should be less than $10 million AUD.

The Elazig earthquake in Turkey had approximately 222 claimants with a total of $200000 USD insured losses.

3.6 A quick comparison of the Haiti and Chile Earthquakes in Numbers

Parameter	Haiti	Chile
Magnitude (Mw)	7.0	8.8
Hyp. Depth (km)	13, onshore	35, offshore
Max. Intensity	X	IX
Tsunamigenic	Yes (local, landslide)	Yes (Pacific-wide)
Largest Aftershock (Mw)	5.9-6.0	6.7-6.9
Total damaged buildings	(PADB) 177000+-313000 (PDNA)	1500000 (IMIA)
Fatalities	92000-225000	521-577
Injuries	310000+	12000+
Homeless	±1850000	±800000
Total Economic Loss	$7.50-$8.50 billion US	$25-30 billion US
As a % of Nominal GDP (PPP)	70.8	11.7
As a % of Nom. GDP	120.6	15.27

GDP (PPP) per capita highest year, 1980 to 2008	1980	2008
Total Insured Loss	$30-$150 million US	$7566 - $12000 million US
Total Int. Aid Given/hr in the first 48 hours (World Vision US Aid)	$3.90 million in the first 48 hrs	$0.22 million in the first 48 hrs
Total Int. Aid (ReliefWeb)	$4542 million US	$74 million US
Corruption Index	146th, 2.2/10 (late 2010)	21st, 7.2/10 (late 2010)
Hours before pres. post-quake address	168	2
Total Population 2010	10.09 million	17.17 million
Urban Population	50%	89%
Rate of natural increase	1.9%	1.0%
Old Method HDI	0.532 (149th/182)	0.878 (44th/182)
New HDI	0.404 (145th/169)	0.783 (45th/169)
New Ineq. HDI	0.239 (124th/139)	0.634 (43rd/139)
Poverty (% below $2/day)	72.1	2.4

4 How does 2010 compare to the past 110 years of losses?

4.1 Damaging Earthquakes – 1900 to 2010

Figure 5 depicts a trend between the number of damaging earthquakes in countries of differing development levels. The author has developed the first complete Human Development Index for all 244 nations through time from 1900 to 2010 (Daniell, 2010c) as part of his work in his PhD. This meant the creation of life expectancy, GDP (PPP) per capita, literacy rate and enrolment rate tables for each country through time, in order to create this index. It also required the knowledge of wars, history of countries, and country border changes. Thus, with CATDAT, for the first time, a standardised look at natural disaster losses as a function of country status can be gleaned. It can be seen that a proportion of the earth is still developing, and that a large proportion of high seismic risk countries have an HDI which is still less than 0.8, as of 2010. Please note, that as of November 2010, a new method of calculating HDI has been formulated which will be incorporated into the 2011 version of the report when the author has formulated the indices for 1900-2010 (UNDP, 2010).

As can be observed in Figure 5 below, the number of damaging earthquakes is not outstanding. The year ranks approximately 10th in terms of historic earthquakes.

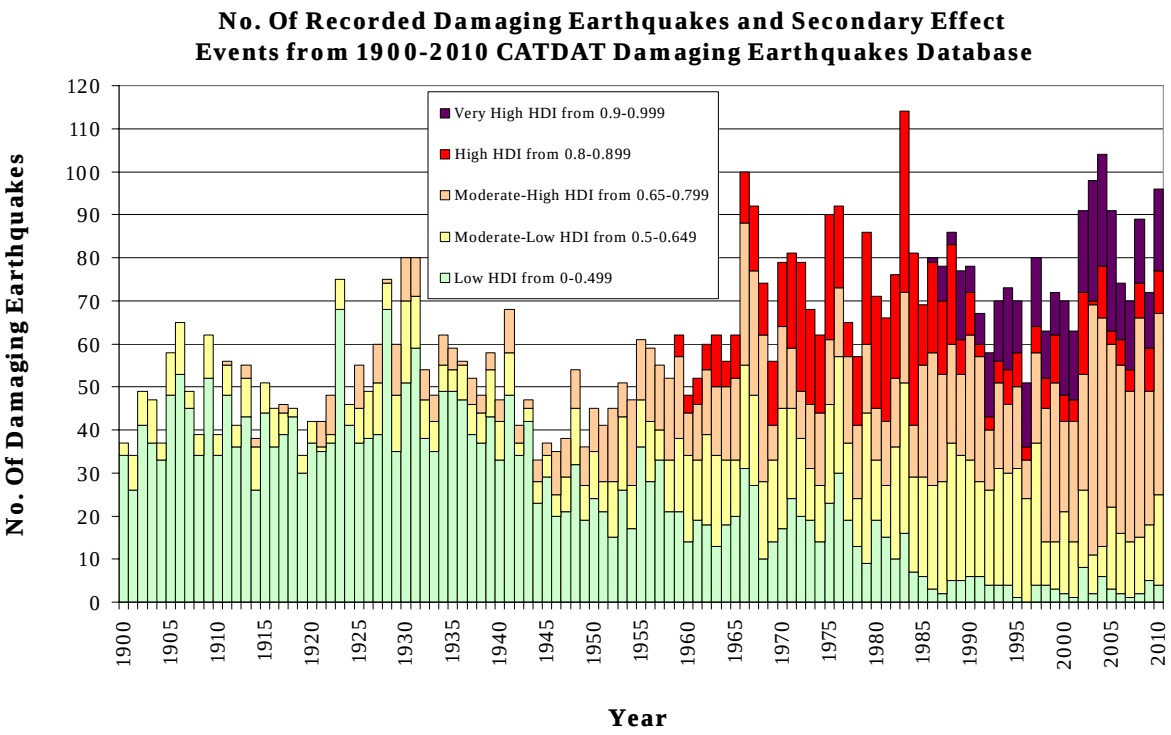

Figure 5 – Damaging earthquakes in the CATDAT damaging earthquakes database from 1900-2010 (Daniell, 2010a)

4.2 Social Losses from Earthquakes – 1900 to 2010

The number of deaths in all countries since 1900 has been found to be approximately 2.484 million (2.261-2.720 million). There have been approximately 3.8 million injuries recorded; yet the trended value of injured (accounting for where injury data is unavailable) is towards 10 million injured. Assuming 6 billion deaths worldwide from 1900-2010, earthquakes have caused approximately

0.041% of fatalities. There have been over 3000 casualty-bearing earthquakes globally since 1900, i.e. causing either death or injury, and a great number more have caused homelessness or affected the lives of the population.

The top 10 fatal earthquakes since 1900 will now be presented in order to lessen some of the discrepancies shown in other major databases like EM-DAT, MRNATHAN, NGDC etc. For more information, see Daniell, 2010a or Daniell, 2008-2010a. A common error is to include the 1927 Xining earthquake in the top 10, where this is often confused with the death toll of the 1920 Haiyuan earthquake. The Xining earthquake of 1927 caused about 40900 deaths (Gu et al., 1989), leaving it out of the top 10.

Rank	Earthquake	Main Country	Date	Median Fatalities	CATDAT Lower/Upper	Pref. Source
1	Haiyuan	China	16.12.1920	273400	235502-273400	Zhang et al., 2010
2	Tangshan	China	27.07.1976	242419	240000-255000	Yong et al., 1989
3	Indian Ocean	Indonesia etc	26.12.2004	228194	227640-230210	Indiv. Country Reports
4	Haiti*	Haiti*	12.01.2010	222500*	92000-225000	Melissen, Govt Haiti*
5	Great Kanto	Japan	01.09.1923	142831	142800-143000	Scawthorn et al. 2005
6	Aschgabad	Turkmenistan	05.10.1948	122000	110000-176000	CATDAT
7	Sichuan	China	12.05.2008	88287	87476-89000	Govt.
8	Kashmir	Pakistan etc	08.10.2005	87364	73338-87364	ReliefWeb
9	Messina	Italy	28.12.1908	85926	80000-90000	CATDAT
10	Ancash	Peru	31.05.1970	66794	52000-96794	CATDAT

*subject to further confirmation from a non-government source due to Corruption Perceptions Index value.

It can be seen from Figure 6 that approximately 8.48 million people have been recorded as having died from earthquakes through time. When compared to the global population, it can be observed that the fatality rate as a % of population is decreasing, considering the greatly increased population. Trends referring to 1900 onwards are shown in Daniell et al. (2010a). The exact number of deaths can never be exactly quantified post-disaster, due to quick burials, decomposition, inaccurate counting and other reasons; however, with careful analysis of all sources detailing effects relating to an earthquake, an educated judgement can be made as to a range of fatalities. The CATDAT upper and lower bounds show the most feasible range. For example, the Haiti earthquake most likely caused between 92000 and 225000 deaths. These form the lower and upper CATDAT bounds. The median value is at the moment 162000 deaths in CATDAT due to the evidence provided (Daniell et al. 2010d). This has been similarly undertaken for estimates of injured, homeless, affected, building damage, economic losses and other socio-economic consequences of earthquakes for each earthquake through time.

The global upper and lower bound refer to the upper and lower bounds found in literature (deleting obvious errors). This is not the range condoned by CATDAT.

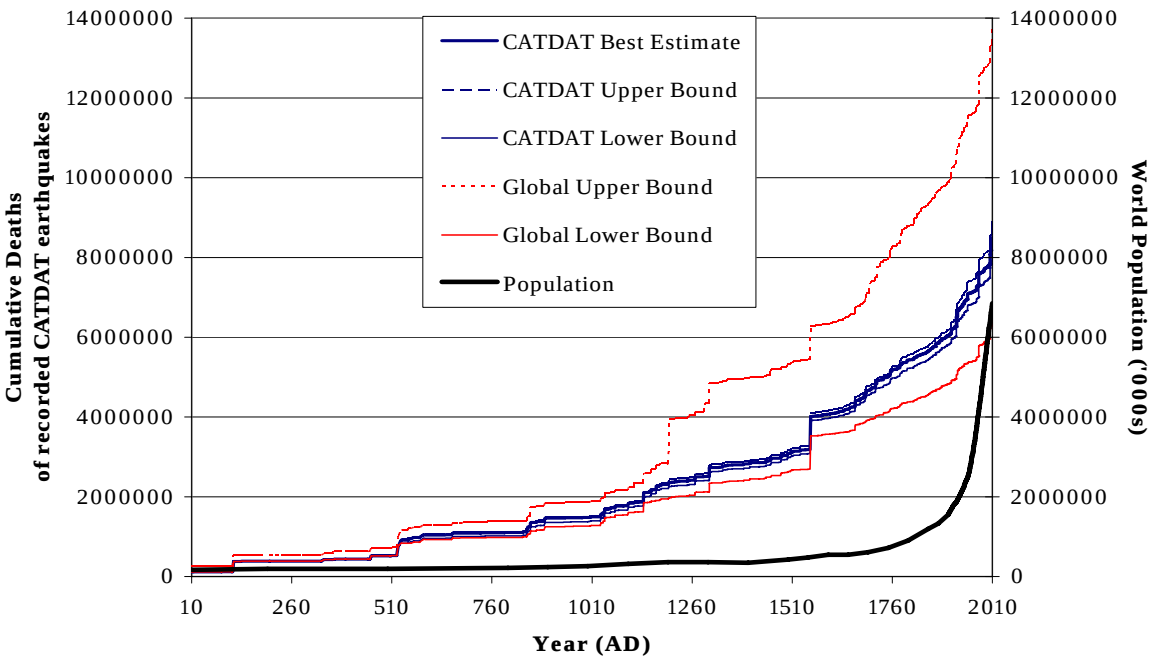

Figure 6 – The CATDAT estimates versus the smallest plausible and largest plausible fatalities from earthquakes from various literature sources. This is compared with the global population. (Daniell, 2010a)

It can be seen in the following Figure 7 that there is a very low value of deaths from 1900 onwards in developed countries when compared to developing countries. This is in part due to the increasing development of countries through the time period. In Figure 7, the annualised global fatalities are presented. The average deaths per year are approximately 22000. Trends as to affected, aid, homelessness and injuries are also included in the CATDAT database. It can be observed that there are virtually no deaths for earthquakes occurring in countries with HDI over 0.8. This is due to two reasons:- 1) as these countries develop, more attention is paid to disaster management, and 2) there are comparatively less damaging earthquakes that have occurred since 1900 in these nations (as seen in Figure 7) due to development status of countries. To counteract this discrepancy in number of damaging earthquakes it can be standardised to a deaths per damaging earthquake (Figure 8).

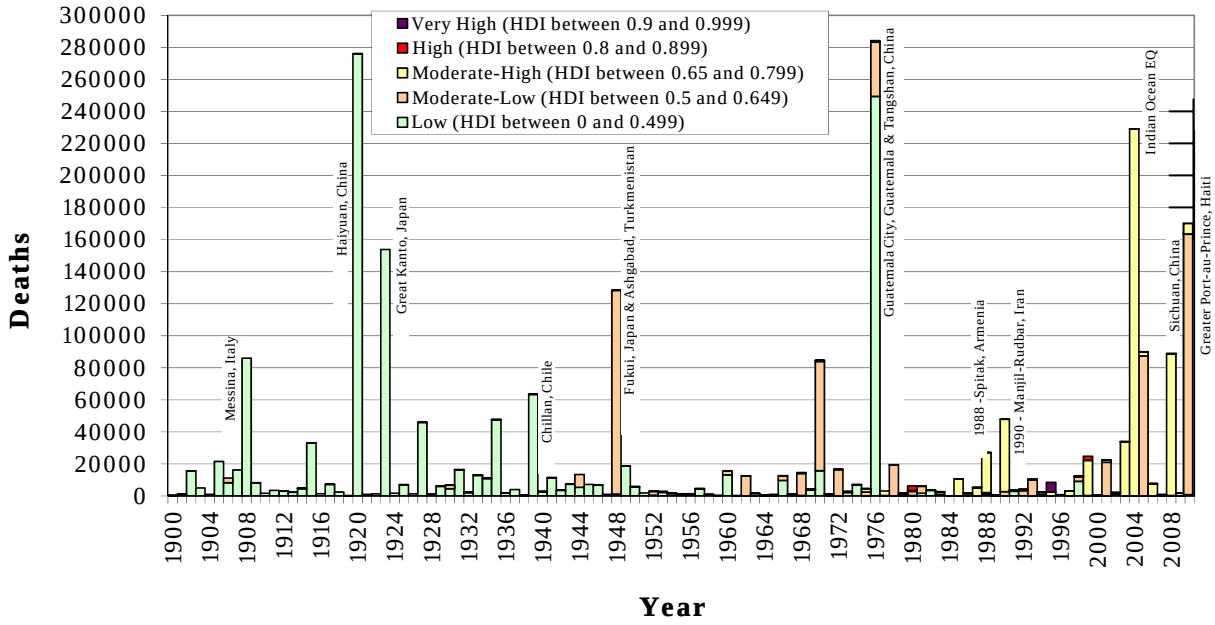

Figure 7 – CATDAT v4.79 Damaging Earthquakes – Best estimate of yearly deaths for events from 1900-2010

The following Figure 8 shows that as countries develop, generally better enforcement of building codes, research into earthquake hazard and effects, and also better earthquake building practice and risk reduction measures are present. This has been explored in Daniell, 2010c.

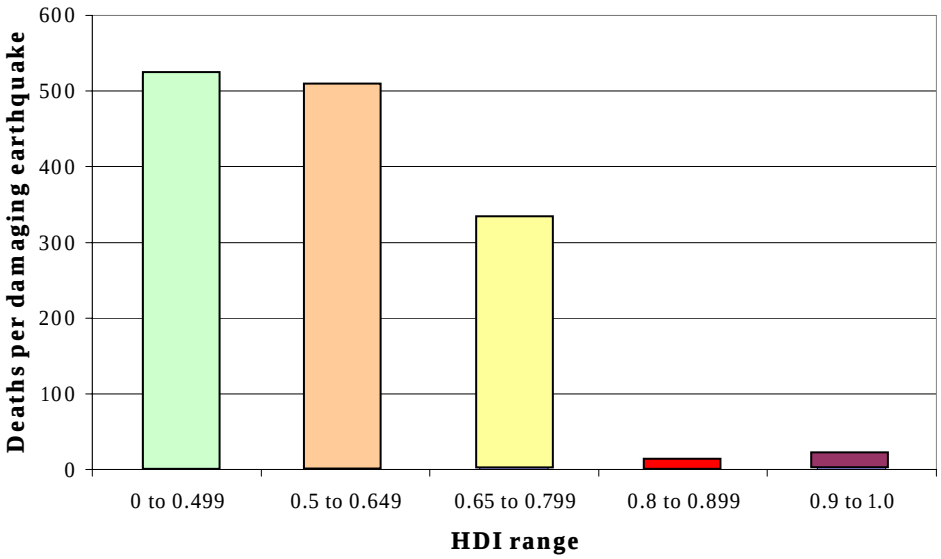

Figure 8 – Median deaths per CATDAT v4.79 damaging earthquake for a particular Human Development Index bracket (Daniell, 2010a, Daniell, 2010c)

Figure 9 is the number of deaths that have occurred due to earthquakes in each country divided by the population (in millions) at the time of disaster, integrated over the entire time period from 1900 to 2010. It can be seen that Turkmenistan and Armenia have the highest relative fatality rates globally. These have been caused primarily by the 1948 and 1988 earthquakes respectively. In absolute values, China, Haiti, Indonesia, Iran, Japan and Turkmenistan have had the highest death and injury counts since 1900. In terms of homelessness, China dominates the statistics due to the large building losses in Haiyuan 1920, Xining 1927, Tangshan 1976 and Sichuan 2008.

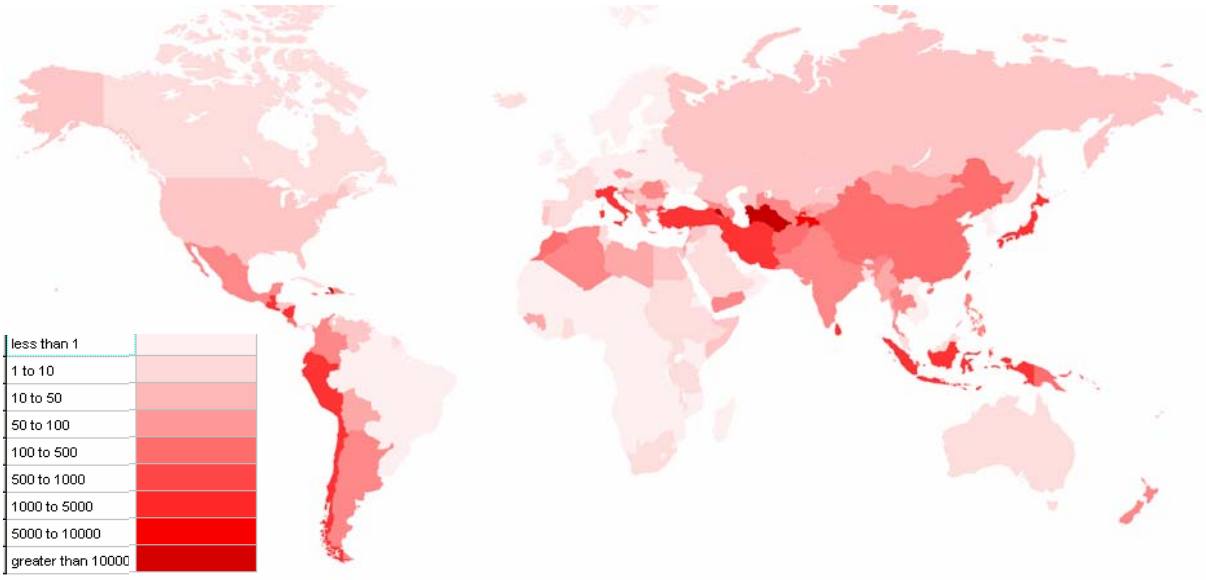

Figure 9 – Number of deaths for each country as a proportion of millions of population at the time of disaster integrated from 1900 to 2010. CATDAT v4.79, 2010.

4.3 Secondary Effect Losses from Earthquakes – 1900 to 2010

The secondary effects of 6500 earthquakes since 1900 were separated from the ground shaking effects. The economic losses, building damage and social losses have also been separated and will be presented in a future paper. The following diagram differs significantly from Bird and Bommer (2004) and is closer to Marano et al. (2010). It can be seen that the effects of fire (mostly 1923 Great Kanto), tsunami (mostly 2004 Sumatra) and landslides (1920 Haiyuan) dominate the fatalities (Daniell, 2010b). However, it is important to also take region into account. Through the following diagram, a higher percentage of secondary effect deaths has been seen in the Asia-Pacific region when compared to the entire world picture. Note that heart attack losses are still being calculated as part of v4.80 and are set to change. Economic losses have also been divided for all previous earthquakes using available data and assumptions. This year, about 5 earthquake heart attacks (not including Yushu, Maule and Haiti) have occurred and 659 tsunami-related deaths (median estimate), mostly from Mentawai and Maule.

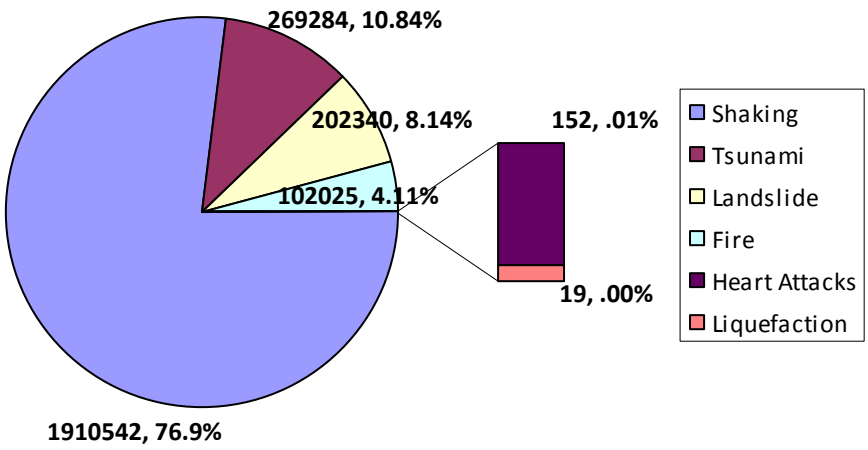

Figure 10 –Shaking and Secondary Effect Deaths Worldwide (Daniell et al. 2010c, Daniell 2010a)

4.4 Economic Losses from Earthquakes – 1900 to 2010

4.4.1 Total Economic Losses

As mentioned previously, a significantly increased database of economic losses from earthquakes has been created during this process. Much collection of building damage details and other infrastructure losses has occurred for the CATDAT entered earthquakes. In order to analyse and rank earthquakes due to economic criteria, an extensive global database of exchange rate, CPI and GDP (nominal and real) information was created in order to be able to adjust and compare foreign earthquake loss estimates (Daniell, 2010f). Global databases of wage rate and other parameters such as purchasing power parity (PPP) were also created as part of the study from sources such as Maddison (2003), World Bank GEM (Global Economic Monitor) and Indicators (2010), and IMF (2010), as these details are required to effectively convert loss estimates from around the world into present-day costs (Daniell, 2008-2010b).

For earthquakes in CATDAT where there is no estimate from a previously written source, separate analysis has been done to calculate an order of magnitude for the economic losses based on historical construction costs, wages as a proportion of building damage and then a reanalysis of losses. Using the economic status of a region, a reasonable estimate has been established. In some

cases, the range description developed by Ganse and Nelson (1981) in 1979 dollars, and Dunbar et al. (1992) based on 1990 dollars was used; however, in many cases it was found to be erroneous. Every one of the 6500+ earthquakes in the CATDAT database from 1900 onwards has an economic loss range associated with it. This is used to fill in the gaps in earthquake economic loss knowledge worldwide, to account for previously unquantified earthquakes.

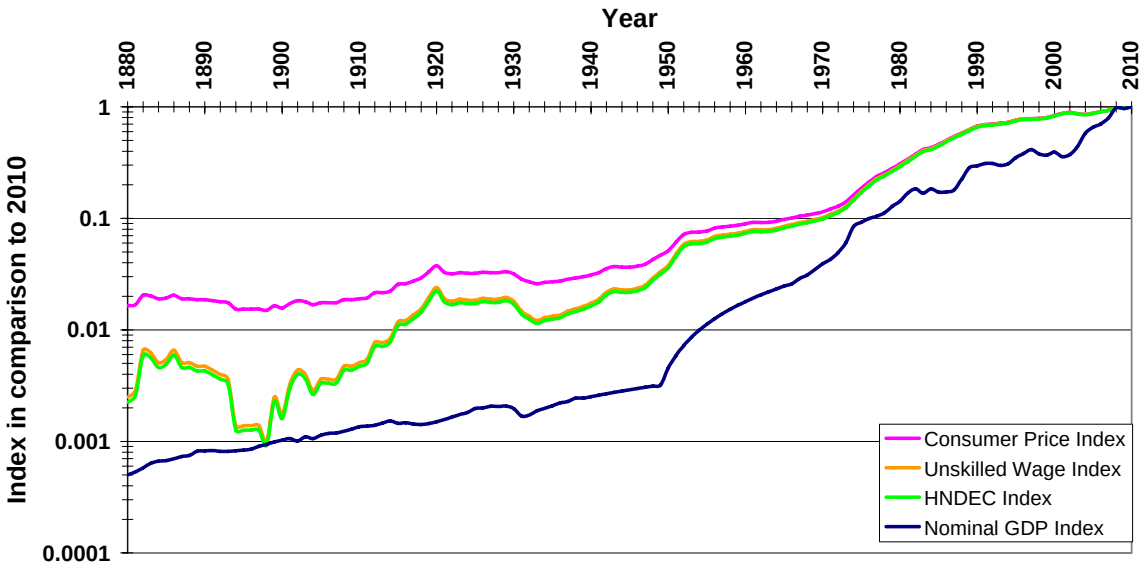

Figure 11 – Australian measuring worth indices including the HNDEC Index (Daniell et al., 2010b)

In the **Hybrid Natural Disaster Economic Index (HNDECI)** developed as part of the CATDAT database to compare earthquakes, components of the earthquake loss (direct and indirect) are assigned an inflation adjustment measure to bring it to present day value in much the same way as a project escalation index. In this way, the total earthquake loss will be defined to present day value, eliminating the error of CPI adjustment. Through the descriptions of major earthquake damage costs in CATDAT and through reconstruction costs it can be seen that 33% of the cost of an earthquake comes from reconstruction unskilled wages. Thus, the HNDECI is primarily based on unskilled wage and building material trends as well as relative utility trends, life costs and other inflation measurements to bring the value forward and needs to be calculated on a country-by-country basis. Refer to Daniell et al. (2010a) for more information as to the HNDECI. An example from Daniell et al. (2010b) is shown above in Figure 11.

Using the HNDECI for all worldwide earthquakes to adjust economic loss to 2010 dollars, Figure 12 shows the results of cumulative economic loss for each year. In this case, the 2010 Human Development Index is used to classify the country losses with developing countries (defined as a 2010 HDI<0.87 shown in orange) and developed countries (defined as a 2010 HDI>0.87 shown in blue). The black line shows the approximate trend of cumulative annual HNDECI economic loss.

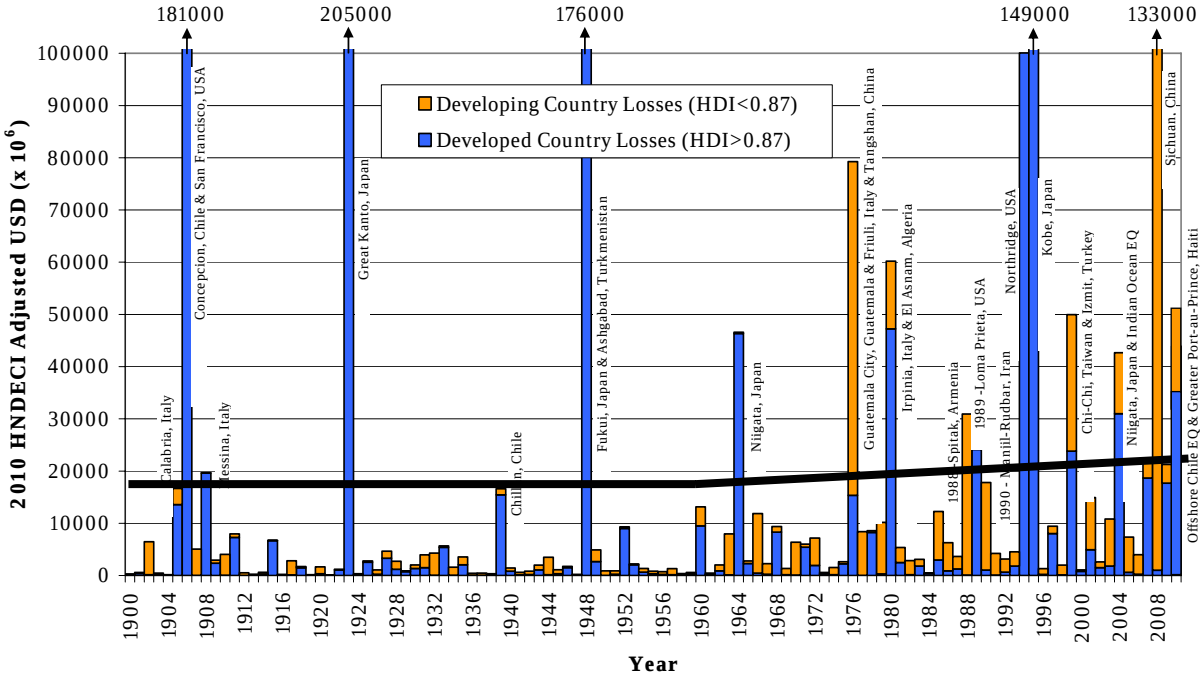

Figure 12 – CATDAT v4.79 Damaging Earthquakes – Economic Losses (2010 Hybrid Natural Disaster Economic Conversion Index adjusted) for 6500+ earthquakes from the year 1900-2010 worldwide

The economic losses in absolute values are reasonably consistent with previous estimates showing the most losses in the following countries; Japan ($683 billion 2010 HNDECI-adjusted dollars), United States ($271 billion), China ($210 billion), Italy ($132 billion) and Chile ($109 billion). However, it is important to take into account the changing GDP in countries and to determine the impact based on this. The relative values between nations based on a division of economic losses incurred at time of disaster as compared to GDP are shown in the following world map. This was then integrated over the time period from 1900 to 2010. Armenia, Turkmenistan, Haiti, Nicaragua, Wallis and Futuna, TFYR Macedonia and Chile have been seen to have the highest relative ratios, as shown in Figure 13.

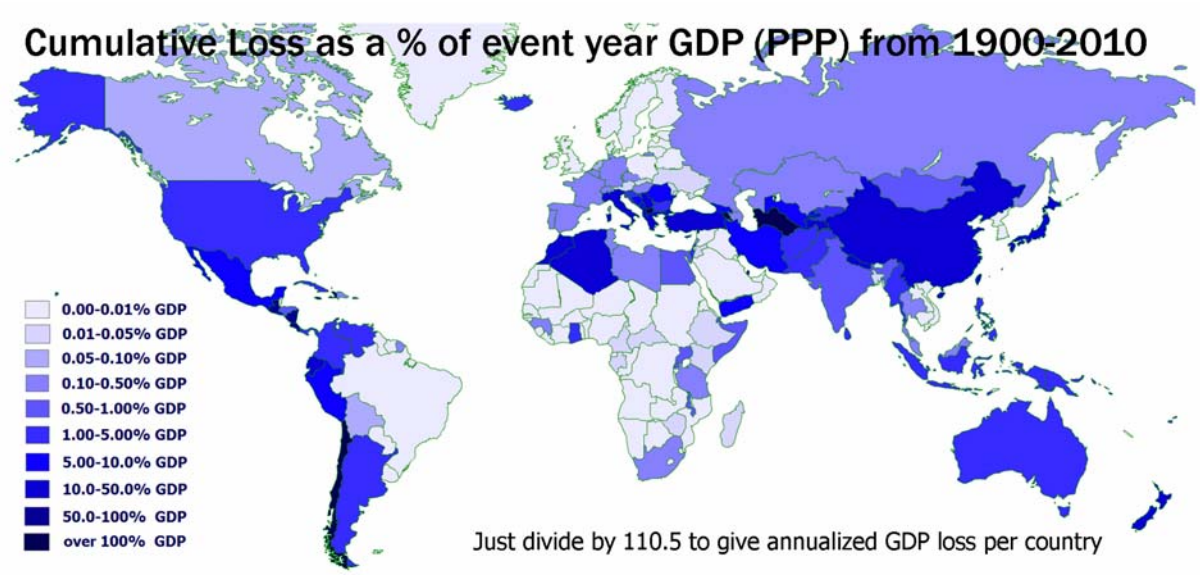

Figure 13 – Economic Losses for each country as a proportion of GDP (PPP) in at the time of disaster cumulative from 1900 to 2010. Daniell et al. (2010a), Daniell (2010f).

The following is a list from CATDAT of the greatest economic losses as a function of GDP (Nominal) and GDP (Nominal, PPP) to compare the total economic loss at the time of disaster to the economy of the time. The median cost shown in Table 5, presented in US dollars, is the most accepted value of total economic loss at the time of the earthquake as found from CATDAT through the literature. This is classified as the median cost of the event. In the full CATDAT database, there is a range of accepted loss estimates for each earthquake that is not included in this report. This was generally presented in US dollar values in the literature (converted from local currency using time-of-event exchange rate). For more detail refer to Daniell et al. (2010a).

Table 5 – The highest ranked earthquake losses since 1900 in terms of percentage of nominal GDP (both unadjusted and purchasing power parity) – CATDAT v4.79, Daniell et al., 2010a.

Rank	Earthquake	Date	Median cost at time of event in $US	% of Nominal GDP (PPP)	% of Nominal GDP
1	Spitak, Armenia*	07.12.1988	16.20 bn	92.3	358.9
2	**Port-au-Prince, Haiti**	**12.01.2010**	**7.804 bn**	**70.8**	**120.6**
3	Guatemala	04.02.1976	3.900 bn	44.6	98.0
4	Managua, Nicaragua	23.12.1972	0.845 bn	19.7 to 38.3	67.1 to 96.2
5	Cartago, Costa Rica	04.05.1910	0.025 bn	63.5	≈90.0
6	Maldives Tsunami**	26.12.2004	0.603 bn	50.1	77.7
7	Concepcion, Chile	17.08.1906	0.260 bn	47.8	55.0 to 82.9
8	Wallis and Futuna	12.03.1993	0.014 bn	51.9	54.0
9	Great Kanto, Japan	01.09.1923	3.840 bn	29.8	52.8
10	Nicaragua	31.03.1931	0.030 bn	26.5	51.0
11	Jamaica	14.01.1907	0.013 bn	23.9	45.9
12	El Salvador	10.10.1986	1.500 bn	12.8	39.8
13	Chillan, Chile	25.01.1939	0.361 bn	21.5	31.8
14	Racha, Georgia*	29.04.1991	1.700 bn	3.5 to 17.0 (5.4)	17.2 to 85.0 (26.8)
15	Samoa**	29.09.2009	0.147 bn	17.8	26.3
16	El Salvador	08.06.1917	0.025 bn	15.8	≈26.0
17	Romania	04.03.1977	4.513 bn	8.5	17.2
18	Skopje, TFYR Macedonia***	26.07.1963	1.100 bn	9.0	16.5
19	Quito, Ecuador	06.03.1987	1.500 bn	7.2	16.5
20	Fukui, Japan	28.06.1948	1.000 bn	3.6	15.6
21	**Maule, Chile**	**27.02.2010**	**30.00 bn**	**11.7**	**15.3**
22	Agadir, Morocco	29.02.1960	0.300 bn	9.3	14.7
23	Nepal**	29.07.1980	0.210 bn	3.7	12.6
24	Valdivia, Chile	22.05.1960	0.550 bn	6.5	12.5
25	El Asnam, Algeria	10.10.1980	5.200 bn	9.2	12.3
26	Ecuador	05.08.1949	0.053 bn	4.7	15.4
27	El Salvador	13.01.2001	1.604 bn	5.6	11.6
28	Guam	08.08.1993	0.300 bn	9.4	10.3
29	Peru	31.05.1970	0.550 bn	2.9	9.2
30	Valparaiso, Chile	03.03.1985	1.500 bn	3.9	9.1
31	Manjil, Iran	20.06.1990	8.000 bn	3.7	8.8
32	Izmit, Turkey	17.08.1999	20.000 bn	4.9	8.0
33	Bourmedes, Algeria	21.05.2003	5.000 bn	2.5	7.3
34	Tangshan, China	27.07.1976	11.000 bn	5.0	7.2
35	Limon, Costa Rica	22.04.1991	0.510 bn	2.8	7.1
	El Salvador	*06.05.1951*	*0.023 bn*	*2.6*	*6.1*

	Hawkes Bay, NZ	*02.02.1931*	*0.025 bn*	*3.4*	*5.7*
	Darfield, NZ	***03.09.2010***	***6.500 bn***	***5.6***	***4.8***
	Kobe, Japan	*16.01.1995*	*123.000 bn*	*4.2*	*2.3*

*Accounts for a partial Soviet Union response – doubling the 1990 Nominal GDP and GDP (PPP) of Armenia. In terms of the Georgian earthquake, hyperinflation made it very difficult to properly determine the GDP of the time; thus, a range has been given incorporating different sources from 1991-95 using an average value through this period consistent with the reconstruction payout.

** 1. Only Samoan loss counted – other affected countries include American Samoa, Tonga and French Polynesia. 2. Similarly for Maldives in the Indian Ocean Tsunami of 2004. 3. Only Nepalese loss counted. India also affected.

***If counted as only a proportion of TFYR Macedonia, the value would have been about 165% of the GDP of the Macedonian part of the former Yugoslav republic.

Other Assumptions

- 1902 Uzbekistan (7.715 million USD), 1902 Shemakha, 1907 Karatag (8 million USD), 1948 Turkmen SSR are classified as part of the Russian empire. Similarly many other earthquakes, such as 1905 Albania & 1906 Taiwan, fall into previous empires (Ottoman, Japan, Yugoslav etc.)
- 1902 Guatemala (up to 25 million USD, up to 35% GDP(PPP)); it is difficult to discern which losses are earthquake and which losses are volcano-related (Santa Maria).
- 1918 Puerto Rico (up to 29 million USD) was deemed to be part of the USA. If not, the output for the year was 36.8 million USD – translating into approximately 80% of output.
- 1917 El Salvador (25 million USD, 15.7% GDP(PPP)), 1928 Bulgaria (16 million USD, 3.85% of nominal GDP), 1931 Nicaragua (30 million USD, 26.5% GDP(PPP)), 1934 Bihar (25 million USD, 6.6% GDP(PPP)), 1935 Pakistan (25 million USD, deemed India), 1945 Pakistan (25 million USD, deemed India), 1982 Yemen (90-320 million USD, up to 10% GDP(PPP)) have not been included in the table above due to uncertainties in the nominal GDP data collected.

4.4.2 Total Insured Losses

Within the full database, a significant amount of information on insurance losses is included. Shown below in Table 6 are the top 10 from 1900 to 2010. It can be seen that two are from 2010! These values employ the use of many different methods encompassed in Daniell (2008-2010a,2008-2010b, 2010e) and Daniell et al. (2010a).

Table 6 – List of highest insured losses (1900-2010) in 2010 Country CPI adjusted $ international

Rank	Earthquake	Country	Date	Insured Loss Range	Pref. Source for Event Loss
1	Northridge	USA	17.01.1994	$22.92bn	RMS
2	Great Kanto	Japan	01.09.1923	$8.73bn-$15.06bn	Daniell (2010b)
3	**Maule**	**Chile**	**27.02.2010**	**$7.57bn-$12.00bn**	**Standard and Poor's**
4	Kobe	Japan	16.01.1995	$6.78bn	Horwich (2000), RMS
=5	San Francisco	USA	18.04.1906	$5.98bn	Daniell (2008-2010a)
=5	**Darfield**	**NZ**	**03.09.2010**	**$3.04bn-$5.50bn**	**PartnerRe, Catlin**
=5	Izmit	Turkey	17.08.1999	$3.38bn-$7.89bn	RMS (1999)
8	Sumatra	Many	26.12.2004	***$2.311bn-$4.11bn***	Average CPI used
9	Loma Prieta	USA	18.10.1989	$2.51bn	Amer. Ins. Serv. Group
10	Newcastle	Australia	27.12.1989	$2.05bn	Daniell (2010b)

5 Conclusion

2010 has indeed been a larger than average year for socio-economic losses from earthquakes. It has seen the Haiti earthquake with a range of 92000 to 225000 deaths, and over 100% of nominal GDP in losses, and two of the top 10 insured loss earthquakes of all time – the Chile earthquake with $30 billion USD and $7.5-12 billion USD insured losses, and the Darfield earthquake in NZ with about $3-5.5 billion in insured losses. There is also much potential observed through CATDAT earthquake data from the past 110 years for further insurance potential in lower HDI locations where rapid development is occurring, leading to increasing economic losses due to earthquakes.

The CATDAT Damaging Earthquake database contains much data suitable for use in many sectors from earthquake loss estimation, to risk mapping, for insurance purposes and simply as a validated dataset to reduce the erratic values of socio-economic losses quoted wrongly throughout a number of sources. It has been shown that the traditional view that social and economic losses are increasing exponentially should be treated with caution. The dataset contains many more earthquakes with socio-economic data than other earthquake databases on trend analysis and hopefully this has led to more populated trends. Large natural disaster losses are extremely difficult to quantify using a single number. Thus, CATDAT uses a lower bound, upper bound and best estimate value, using expert judgement; yet also presents all data to the user. It should also be noted that traditional databases making trends over multiple years based on year-of-event dollars or adjusting using a mass United States Consumer Price Index trend over earthquake losses worldwide are incorrect. Economic loss should be calculated on a country-by-country basis and then compared. This is the same for absolute versus relative loss.

Over 11600 earthquakes show over 8.47 million deaths since the beginning of earthquake records. Earthquakes in the 20th and 21st centuries have already caused approximately $1.8 trillion (2010 HNDECI-Adjusted int. dollars) damage. Collection of building damage for historic earthquakes demonstrates the vulnerability of traditional building stocks such as masonry, adobe and badly constructed reinforced concrete. However, given the population increase around the world, there has been a significant reduction in loss of life due to earthquakes compared to what should be expected. This has come through a combination of country development, implementation of better building practice to resist earthquake forces and a more stable world, allowing for earthquake insurance and protection of financial assets.

Many of the references for this paper are included in associated papers and over 16000 individual sources of information have been used to create the data in the CATDAT damaging earthquakes database.

Man sagt oft : Zahlen regieren die Welt.
Sicher ist nur: Zahlen zeigen wie sie regiert wird.

It is often said: Figures rule the world. The only sure thing is: Figures show how it is ruled.

J.W. Goethe (1749-1832)

6 Main References

Given the fact that over 16000 individual sources of information have been used in the CATDAT Damaging Earthquakes database, only the main references will be shown in this list. Please refer to the following papers for more information or email me to get more details.

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Appendix A: Summary pages of each 2010 damaging earthquake

The following section contains a summary of each 2010 damaging earthquake. More information is included in the full database; however, the section below provides a useful overview. It should be noted that much discrepancy is shown in values, and the author takes no responsibility for misuse. Most data is from other sources. Should the reader require more information, much more data on each earthquake is housed in the CATDAT Damaging Earthquakes database.

Attached are 3 examples of the 1 page summaries for each of the earthquakes. The full set can be sent out to any interested users. It uses the following references to determine the values:- Daniell (2008-2010a, 2008-2010b, 2008-2010c, 2009, 2010d, 2010e, 2010f).

Simply email me at j.e.daniell@gmail.com, or use the contact details on the back page in order to be sent the additional one page summaries. These will be sent from 31st January onwards, due to the potential for new information to come available and if a major earthquake occurs in the few hours before release on 31st December before 1st January 2011 00:00:00 UTC, this will then be included.

Again, I welcome any feedback, as there will no doubt be discrepancies, additions, possible other sources of information and unbeknown data to me. However, I have done my best to minimise errors.

CATDAT Damaging Earthquake Database Summary List - 2010

No.	Name	Date	Time (UTC)	LT	Lat	Long	h km	Mag.	Ctry	HDI	Corr.	Fatality Range	Injury Est.	Homeless Est.	Red Build	Yellow Build	Econ. Loss Range $USDm	Insured Loss $USDm	Aid Impact $USDm	2nd Effects
001	Jianchuan	01-01	02:08:20	+8	26.3	99.8	11	4.6Ml	CN	0.764	3.6	0-0	15	-200+	60	2655	8.39	na	Govt.	
002	Vanj	02-01	02:51:12	+5	38.233	71.5	47	5.3Ml	TJ	0.606	2.0	0-0	1	-1134	162	796	1.5+	na	1	
003	Sol. Is. 1	03-01	21:48:05	+11	-8.733	157.484	26	6.6Mw	SB	0.628	2.8	0-0	0	inc. 004	0	several	<0.5	na	inc 004	
004	Sol. Is. 2	03-01	22:36:28	+11	-8.799	157.36	25	7.1Mw	SB	0.628	2.8	0-0	1	-1000+	98	159	0.496-2.48	na	1-1.34	T
005	Sol. Is. 3	05-01	12:15:32	+11	-9.056	157.585	19	6.8Mw	SB	0.628	2.8	0-0	0	inc. 004	0	several	<0.5	na	inc 004	
006	Garut	10-01	00:25:00	+7	-7.907	107.879	65	5.1Mb	ID	0.705	2.8	1-1	2	0	0	1	<0.09	na	na	HA
007	Eureka	10-01	00:27:39	-8	40.652	-124.692	29	6.5Mw	US	0.950	7.5	0-0	30	-40+	11	453	21.9-50	25	na	
008	Haiti	12-01	21:53:10	-5	18.457	-72.532	22	7Mw	HT	0.515	1.8	92k-225k	311k	--1850000+	75549	98214	7500-8500	30-200	3400-4500	T, Lq, L
009	Haiti AS1	12-01	22:00:41	-5	18.386	-72.785	24	6Mw	HT	0.515	1.8	Unk.	Unk.	inc 008	additional		Unk.	na	inc 008	
010	Sucre	15-01	18:00:46	-4.5	10.424	-63.485	5	5.5Mw	VE	0.805	1.9	0-0	11	0	1	3	<1.05	na	na	
011	Khuzestan 1	16-01	20:23:37	+3.5	32.45	48.3	5	5Ml	IR	0.788	1.8	0-0	0	2000	2400 HU		8.6	na	Govt	
012	Khuzestan 2	16-01	21:26:20	+3.5	32.456	48.284	18	4.1Ml	IR	0.788	1.8	0-0	0		inc 011			na	Govt	
013	Guizhou	17-01	09:37:26	+8	25.558	105.804	27	4.4Ml	CN	0.764	3.6	6-8	9	0	0	0	<2.1	na	Govt	L
014	Haiti AS2	20-01	11:03:43	-5	18.425	-72.805	10	5.9Mw	HT	0.515	1.8	0-0	0	inc. 008	additional		Unk.	na	na	
015	Aceh Tengah	28-01	16:12:00	+7	4.82	96.78	10	5Ml	ID	0.705	2.8	0-0	0	0	0	2	0	na	na	
016	Moxi	30-01	21:37:00	+8	30.258	105.726	19	5.2Mw	CN	0.764	3.6	1-1	16	4817	118	16630	66.56	na	0.44i Govt.	
017	Mexico City	09-02	00:47:42	-6	16.145	-96.525	35	5.7Mw	MX	0.834	3.3	0-0	0	0	0	Minor	<1.15	na	na	
018	Rongchang	22-02	13:32:00	+8	29.4	105.5	10	4.2Ml	CN	0.764	3.6	0-0	0	0	0	6 or 7	2.65	na	na	
019	Lufeng	25-02	04:56:56	+8	25.536	101.919	39	5Ml	CN	0.764	3.6	0-0	35	-3000++	1446 rooms	58056 rooms	51.94	na	Govt.	
020	Ryukyu Is.	26-02	20:31:27	+9	25.903	128.417	22	7Mw	JP	0.968	7.7	0-0	2	0	0	? pipes	<2.17	na	na	
021	Maule	27-02	06:34:14	-3	-35.835	-72.753	58	8.8Mw	CL etc.	0.870	6.7	523-547	12000	-800000+	1500000		25000-30000	7566-12000	140 Tel/int	T (20), L
022	Salta	27-02	15:45:41	-3	-24.588	-65.432	38	6.3Mw	AR	0.841	2.9	2-2	104	<100	Slums, small bd.	Some	<0.53	Na	na	
023	Anjuman	28-02	23:21:13	+4.5	35.912	70.051	105	5.7Mw	AF	0.341	1.3	0-0	1	0	0	Bricks, cracks	<0.01	Na	na	
024	Kaohsiung	04-03	00:18:52	+8	22.91	120.82	5	6.4Mw	TW	0.938	5.6	0-0	96	0	0	1340	95.24	76.12	Ins, Govt.	545066 Power
025	Inner Mongolia	08-03	20:36:44	+8	40.51	111.48	6	Swarm	CN	0.764	3.6	0-0	0	0	0	47 minor	0.009	Na	Govt	
026	Elazig	08-03	02:32:45	+2	38.852	39.949	10	5.9Mw	TR	0.795	4.4	41-42	137	-3477+	3005 (O=2435)	5718 (O=3182)	3.62-7.24	0.2	3 Govt	
027	Pichilemu	11-03	14:39:44	-3	-34.259	-71.929	11	6.9Mw	CL	0.870	6.7	1-3	Unk.	Unk.	Some	many	31.6-109.8	6.3-38.4	inc. 021	HA
028	Fukushima	13-03	12:46:00	+9	37.6	141.5	80	5.7Mw	JP	0.968	7.7	0-0	2	0	0	0	<2.08	na	Na	
029	Honshu	14-03	08:08:05	+9	37.78	141.562	39	6.5Mw	JP	0.968	7.7	0-0	1	0	0	0	<1.81	Na	Na	

030	Andaman Is.	30-03	16:54:48	+5.5	13.616	92.958	45	6.6Mw	IN	0.622	3.4	0-0	10	0	0	Cracks, minor	<0.026	Na	Na	
031	Datong	04-04	13:46:00	+8	40.0	113.9	8	4.5Ml	CN	0.764	3.6	0-0	0				15.954	Na	na	
032	Mexicali	04-04	22:40:41	-7	32.128	-115.103	10	7.2Mw	MX,US	0.834	3.3	2-4	253	-25000+	10000		1091-1200	306	Govt. Ins.	
033	Sinabang	06-04	22:15:02	+7	2.36	97.132	31	7.7Mw	ID	0.705	2.8	0-0	62	0	few	1000	5.65	na	Govt.	T(loc), L
034	Yushu	13-04	23:49:42	+8	33.26	96.67	46.9	6.9Mw	CN	0.764	3.6	2698-2968	12125	-100000+	20000	130000	3472-4810	165-222	1500+, 4635	L
035	Mt. Barker	16-04	13:57:00	+9.5	-35.099	138.866	25	3.8Ml	AU	0.972	8.7	0-0	0	0	0	Minor cracks	<1	1000 claims?	Na	
036	Lae	17-04	23:15:24	+10	-6.683	147.307	70.7	6.2Mw	PG	0.568	2.1	0-0	0	0	0	some	<0.37	na	Na	
037	Samangan	18-04	20:28:50	+4.5	35.7	67.65	10	5.3Mw	AF	0.341	1.3	16-16	168	--15000+	2000-3000	unk.	2.6-5.2	na	2.937	
038	Kalgoorlie	20-04	00:17:08	+8	-30.798	121.485	10	5.0Ml	AU	0.970	8.7	0-0	2	0	0	100+	4.47-15	c. 5	Govt., Ins.	M?
039	Niigata	01-05	09:20:00	+9	37.6	139.2	10	4.9Mw	JP	0.968	7.7	0-0	1	0	0	0	<2.08	na	Na	
040	Talca AS	02-05	10:52:39	-4	-34.297	-70.072	35.9	5.9Mw	CL	0.870	6.7	0-0	0	0	0	0	Unk.	Na	Na	
041	Tacna	06-05	02:42:48	-5	-18.023	-70.508	37	6.2Mw	PE	0.783	3.7	0-0	11	0	0	some	<0.26	na	Na	L
042	Meulaboh	09-05	05:59:42	+7	3.775	96.055	45	7.2Mw	ID	0.705	2.8	0-0	3	0	3	20	<0.09	na	Na	
043	M'Sila	14-05	12:29:23	+1	35.998	4.162	10	5.2Mw	DZ	0.758	2.8	2-3	43	-2000+	400	670	0.87-4.35	na	Na	
044	Puerto Rico	16-05	05:16:10	-4	18.4	-67.07	113	5.4Mw	US	0.950	7.5	0-0	1	0	0	several	<1.8	na	Na	
045	Amazonas	18-05	04:15:44	-5	-5.019	-77.495	138	6Mw	PE	0.783	3.7	0-0	0	0	0	Tiles and walls	<0.26	na	Na	
046	Shidian	01-06	15:58:07	+8	24.15	99.033	1	4.5Ml	CN	0.764	3.6	0-0	1	-315+	105 rooms	24570 rooms	6.20	na	Govt.	
047	Taiyuan	05-06	12:58:00	+8	38.2	112.7	5	4.6Ml	CN	0.764	3.6	0-0	0	0	0	0	0.627	na	Govt.	
048	Wuqia County	10-06	06:38:00	+8	39.9	74.7	8	5.1Ml	CN	0.764	3.6	0-0	0	0	0	184	3.53	na	Na	
049	Port Blair	12-06	19:26:50	+5.5	7.848	91.919	35	7.5Mw	IN	0.622	3.4	0-0	1	0	0	None (hl cracks)	<0.026	na	Na	
050	South Cal. 1	15-06	04:26:58	-7	32.7	-115.921	5.4	5.8Mw	US	0.950	7.5	0-0	0	0	0	50+	<1.8	na	Na	
051	N. Mamuju	15-06	23:53:01	+8	-1.419	119.378	57	5.1Mw	ID	0.705	2.8	1-1	85	0	0	some	<0.09	na	Na	L
052	Yapen	16-06	03:16:27	+9	-2.171	136.549	18	7Mw	ID	0.705	2.8	17-22	-150	4702	3297-L3	1058-L1,2	85.20	na	0.17 Govt	L (75)
053	Quebec	23-06	17:41:41	-4	45.904	-75.497	16	5Mw	CA	0.969	8.7	0-0	1	0	0	some	16.3-30	unk.	Govt, Ins.	L
054	Dharchula 1	23-06	23:11:22	+5.5	29.914	80.504	0	5.1Mb	IN	0.622	3.4	0-0	0	0	0	7	<0.04	na	Na	
055	Oaxaca	30-06	07:22:28	-5	16.527	-97.76	20	6.2Mw	MX	0.834	3.3	1-1	0	0	1+	many	<0.5	na	Na	
056	Iwate Pref.	03-07	23:40:00	+9	39	140.9	10	5.2Mw	JP	0.968	7.7	0-0	1	0	0	0	<2.08	na	Na	
057	Dharchula 2	04-07	02:35:59	+5.5	29.874	80.387	0	4.7Mb	IN	0.622	3.4	0-0	0	6	1	Some	<0.026	na	na	
058	South. Calif. 2	07-07	23:53:33	-7	33.42	-116.489	14	5.4Mw	US	0.950	7.5	0-0	0	0	0	Minor	<1.8	na	na	L
059	Bio-Bio AS2	14-07	08:32:22	-4	-38.002	-73.282	28.4	6.5Mw	CL	0.870	6.7	0-0	0	0	0	Some	<0.75	na	na	
060	Kimbe 1	18-07	13:04:11	+10	-6	150.436	42	6.9Mw	PG	0.568	2.1	0-0	1	<100	Some	Some	<0.37	na	na	
061	Kimbe 2	18-07	13:34:59	+10	-5.939	150.572	35	7.3Mw	PG	0.568	2.1	1-1	3	<100	Some	Some	<0.37	na	na	
062	Lamerd	21-07	19:50:11	+4.5	27.054	53.81	10	5.1Mw	IR	0.788	1.8	1-1	70	0	2000		30.03	na	Govt.	

063	Torbat	30-07	13:50:14	+4.5	35.22	59.25	26.1	5.6Mn	IR	0.788	1.8	0-0	284	-2000+		5200	15.02	na	Govt.	
064	Negar	31-07	06:52:57	+4.5	29.7	56.82	4	5.8Mb	IR	0.788	1.8	1-1	30	-1800+	0	700	12.02	na	Govt.	
065	Kimbe 3	04-08	22:01:43	+10	-5.768	150.776	44	7Mw	PG	0.568	2.1	0-0	0	0	Some	Some	<0.01	na	na	
066	Vanuatu	10-08	05:23:46	+11	-17.561	168.028	35	7.3Mw	VU	0.712	3.2	0-0	0	0	0	Minor	<0.1	na	na	
067	Guayaquil	12-08	11:54:16	-5	-1.26	77.312	211	7.1Mw	EC	0.789	2.2	0-0	1	0	0	Slight	<0.28	na	na	
068	Lipari Is.	16-08	12:54:47	+2	38.32	14.98	10	4.3Mw	IT	0.960	4.3	0-0	7	0	0	Minor	0.2-2	na	na	L (100)
069	Damghan	27-08	19:23:48	+4.5	35.457	54.55	10	5.7Mw	IR	0.788	1.8	3-3	40	2000	1000-2000		12.50	na	Govt.	
070	Qiaojia	29-08	00:53:31	+8	27.1	102.9	10	5Mw	CN	0.764	3.6	0-0	14	-1297+	298 rooms	3811-L3, 16514-L1	12.68	na	Govt.	
071	Darfield	03-09	16:35:44	+12	-43.332	172.438	16	7Mw	NZ	0.936	9.4	0-1	102	-4000+	Still calc.	157701 claims	5000-7876	3.04-5.5k	Govt.	HA, L, Lq
072	Osh	07-09	15:41:41	+6	39.478	73.84	25	5.3Mw	KG	0.615	1.9	0-0	0	0	0	some	<0.023	na	na	
073	Luzhou	10-09	15:21:46	+8	29.4	105.5	7	4.7Ml	CN	0.764	3.6	0-0	0	0	4	20	<0.5	na	na	
074	Narayanganj	10-09	17:24:18	+6	23.422	90.695	14.1	4.8Mb	BD	0.582	2.4	0-0	0	0	0	4	<0.013	na	na	
075	Ica	22-09	08:00:14	-5	-13.364	-76.048	48.8	5.9Mw	PE	0.783	3.7	0-0	0	42	10		<0.26	na	na	
076	Kazerun	27-09	11:22:44	+3.5	29.651	51.69	18	5.5Mw	IR	0.788	1.8	1-1	7	0	4000 HU minor		3.72	na	Govt.	
077	Jalandhar	05-10	00:00:00	+5.5	23.4	70.3	0	4.9Swarm	IN	0.622	3.4	0-0	0	0	village		<0.026	na	na	
078	Haripur	11-10	21:44:26	+5	33.941	72.845	33	5.1Mb	PK	0.622	2.4	1-1	15	848+	100	Unk.	<0.23	na	na	
079	Norman	13-10	14:06:30	-5	35.191	-97.32	13	4.7mBLg	US	0.950	7.5	0-0	2	0	0	minor	<1.8	na	na	
080	Yanjin	17-10	21:59:00	+8	28.04	104.07	0	4.6Ml	CN	0.764	3.6	0-0	2	0	31	258-L3, 2625-L1	8.36	na	Govt.	
081	Darfield AS1	18-10	22:32:00	+13	-43.63	172.56	9	5Ml	NZ	0.936	9.4	0-0	0	0	unk.		Unk.	1778 claims		
082	Taikang	24-10	08:58:00	+8	34	114.6	8	4.7Ml	CN	0.764	3.6	0-0	12	0	24	Some	<1.0	na	na	
083	Mentawai	25-10	14:42:22	+7	-3.486	100.088	20	7.7Mw	ID	0.705	2.8	454-528	349	-14983+	545	14500	35.27	na	4.5 in prog	T (100)
084	Kraljevo	03-11	00:56:54	+1	43.74	20.69	2	5.4Mw	RS	0.795	3.5	3-3	102	-8000+	1094	5000/10000	139-150	na	28 RS	HA (33)
085	Dorud	06-11	03:52:20	+3.5	33.37	87.456	5	4.9mBLg	IR	0.788	1.8	0-0	119	0	9415 HU		18.8-45.1	na	45.1 Govt	
086	Rajsamand	09-11	22:46:33	+5.5	25.463	73.725	131	4.5Mb	IN	0.622	3.4	0-0	1	0	2	50+	<0.026	na	na	
087	Darfield AS2	14-11	06:21:05	+13	-43.599	172.413	9	4.8Ml	NZ	0.936	9.4	0-0	0	0	unk.		Unk.	1792 claims		
088	Borama	23-11	20:35:00	+3	9	23	0	4.5Unk	SO	0.284	1.1	0-0	0	0	Some minor damage		<0.1	na		
089	Velille	24-11	22:08:40	-5	-14.39	-71.41	61	4.9Ml	PE	0.783	3.7	0-0	0	0	0	3	<0.26	na	na	
090	Khonj	26-11	12:33:43	+3.5	28.09	52.51	10	5.6Mw	IR	0.788	1.8	0-0	0	0	470	many	4.85	na	Govt.	
091	N.Vizcaya	13-12	00:24:42	+8	16.463	121.305	51.9	4.7Mw	PH	0.700	2.4	0-0	0	0	0	0	<0.085	na	na	
092	Bougainville	13-12	01:14:43	+10	-6.6	155.6	146	6.2Mw	PG	0.568	2.1	0-0	0	0	0	minor	<0.01	na	na	
093	Hossana	19-12	12:14:24	+3	7.5746	37.7925	9.8	5.1Ml	ET	0.451	2.7	0-0	26	<100	0	100	<0.18	na	na	
094	Fahraj	20-12	18:41:59	+3.5	28.491	59.117	11.8	6.5Mw	IR	0.788	1.8	5-11	32+	-4000+	1000+ HU		19.26+	na	Govt.	L
095	Darfield AS3	25-12	21:30:00	+13	-43.55	172.66	12	4.9Mw	NZ	0.936	9.4	0-0	0	+	120	31.12.2010	>15	1800+ claims		
096	Rudna	30-12	08:56:42	+1	51.644	16.177	5	4.5Mw	PL	0.88	5.3	3-3	12	0	0	0	<0.75	Just human loss		M

Official Earthquake Name	Date	UTC	Local	CATDATEQ_ID
Jianchuan County EQ	**01-Jan-2010**	**02:08:20**	**+8**	**2010-001**

Preferred Seismological Information:

EQ_Latitude	EQ_Longitude	Magnitude	Hyp_Depth (km)	Fault Mech.	Source	Spectra
26.316	**99.767**	**4.6Ml**	**11**	**na**	**CSN**	

Location Information:

Country	ISO	District/State	Most Impact	BPF	HDI	Urbanity	Corruption
China	**CN**	**Yunnan**	**35 Villages**	**Refer – 2010d**	**0.7635**	**0.2**	**3.5/10**

Given corruption scale, estimates from Govt. sources are **NOT likely** to be manipulated or erroneous.

Preferred Intensity Information:

MSK-64	MMI	EMS-98	EQLIPSE Building Typologies
5.5			Brick URM building types prevalent with also tiled roofs contributing to damage. Refer to Daniell 2010e.
Intensities			
No information given – adjusted on the basis of damage in the region to 5.5. Peak intensity of 7.5 - MSK in areas where older masonry buildings became uninhabitable.			

Preferred Building Damage Information:

Description:	L1	L2	L3	L4
14 damaged schools, cultural relics, 60 buildings destroyed (wall collapses etc.), 2655 with light damage (tiles, cracking etc.), pipes.	2655			60
	Reports from Chinese officials re: Yunnan Seismological Bureau			

Secondary Effect Information: None.

Type	Impact	Damage %	Social %	Economic %

Preferred Social Impact Information:

Type	Median	Accepted Range	Description	Source
Deaths	0	n/a		Press
Injuries (Serious)	0	n/a		Press
Injuries	20	7-20	Mostly from falling tiles.	Press
Homeless	200	n/a	From the 60 uninhabitable buildings	Estimate
Affected	19541	n/a	4771 families	Press, Govt.
Indirect SE				

Preferred Economic Impact Information: $million int. event-day dollars

Type	Median	Accepted Range	Description	Source
Total Losses	$8.392m	$8.392m+	Direct economic loss CNY 5730万元	Govt.
Insured Losses	n/a	n/a		
Aid Impact	Govt.		Initial aid. Reconstruction via Govt.	Govt. Dept.

Abridged Description from full CATDAT description sources:

Magnitude 4.6 earthquake affecting 8 towns and 35 villages. Shaxi was most damaged, with between 7-20 injured. 2715 households had wall cracking and falling tiles. Water pipeline damage, 14 damaged schools, some historical relics damaged, power station and also power lines were damaged. There were power outages in the town.

CATDAT Economic Index Rank:	3: Minor	**CATDAT Social Index Rank:**	3: Minor

Official Earthquake Name	Date	UTC	Local	CATDATEQ_ID
Solomon Islands EQ 2nd Shock	**03-Jan-2010**	**22:36:28**	**+12**	**2010-004**

Preferred Seismological Information:

EQ_Latitude	EQ_Longitude	Magnitude	Hyp_Depth (km)	Fault Mech.	Source	Spectra
-8.799	**157.36**	**7.1Mw**	**25**	**Subduction**	**USGS**	

Location Information:

Country	ISO	District	Most Impact	BPF	HDI	Urbanity	Corruption
Solomon Is.	**SB**	**Rendova**	**Rendova**	**Refer 2010d**	**0.6283**	**0**	**2.8/10**

Given corruption scale, estimates from Govt. sources are **less likely** to be manipulated or erroneous.

Preferred Intensity Information:

MSK-64	MMI	EMS-98	EQLIPSE Building Typologies in damage area
	7.5		Island huts mainly with thatch roofs, metal or wood poles and sheeting as supporting structure.
Intensities			
(VII-VIII)Rendova, (VI) Gizo, (IV) Honiara			

Preferred Building Damage Information:

Description:	L1	L2	L3	L4
4 schools damaged in addition to 98 destroyed and 159 damaged houses.		159		98
	Pacific Web Situation Reports 1-10			

Secondary Effect Information:

Type	Impact	Damage %	Social %	Economic %
Tsunami	Destruction of Property – 2-3m	33	33	33
Landslide	Water sources damaged	Flow-on	Flow-on effects	Flow-on

Preferred Social Impact Information:

Type	Median	Accepted Range	Description	Source
Deaths	0	n/a		PacWeb
Injuries (Serious)	2	(2-2)	Broken Leg in Rano, 1 injury in Baniata	PacWeb SR3
Injuries (Slight)	5	(1-10)	Minor injuries on Tetepare	PacWeb SR3
Homeless	1000	(750-1500)		PacWeb
Affected	8077	(4900-8077)		PacWeb
Indirect SE			Flow-on change in life structure, food	PacWeb

Preferred Economic Impact Information: $million int. event-day dollars

Type	Median	Accepted Range	Description	Source
Total Losses	$1.5m	$0.5m-$2.48m		Est.
Insured Losses	na			
Aid Impact	$1m	$0.5m-$1.5m	$50k initial AUSAID	PacWeb

Abridged Description from full CATDAT description sources:

Somewhere between 1000 and 1140 homeless, 2 seriously injured and 5 slight injuries from a major earthquake affecting primarily the islands of Rendova and Tetepare in the Solomons. The building stock on these islands was not designed for earthquakes and is of local materials. 98 huts and structures were destroyed and 159 damaged. 4 schools were damaged in addition. Predicted economic loss less than $2.5m. Much aid was provided from Pacific nations.

CATDAT Economic Index Rank:	5: Medium-Low	**CATDAT Social Index Rank:**	6: Medium

Official Earthquake Name	Date	UTC	Local	CATDATEQ_ID
Haiti EQ	**12-Jan-2010**	**21:53:10**	**-5**	**2010-008**

Preferred Seismological Information:

EQ_Latitude	EQ_Longitude	Magnitude	Hyp_Depth (km)	Fault Mech.	Source	Spectra
18.443	**-72.571**	**7.0Mw**	**13**	**Left SS**	**USGS**	

Location Information:

Country	ISO	District	Most Impact	BPF	HDI	Urbanity	Corruption
Haiti	**HT**	**Southern**	**Port-au-Prince**	**20.2**	**0.5152**	**0.93**	**2.2/10**

Given corruption scale, estimates from Govt. sources are **very likely** to be manipulated or erroneous.

Preferred Intensity Information:

MSK-64	MMI	EMS-98	EQLIPSE Building Typologies
	10		60.6% UCB, 11.7% URM/M,9.4% W, 18.3% SS-INF, Refer to Daniell, 2010e for more info.
Intensities			
(IX-X) Petit Goave, Grand Goave, (VIII) Leogane, (VII-VIII) at Port-au-Prince and Petionville and (V) at Vieux Bourg d'Aquin and Port-de-Paix. Felt (V) at La Vega, Moca and San Cristobal; (IV) at Puerto Plata, Santiago, Santo Domingo and Sosua, Dominican Republic. Felt (III) at Oranjestad, Aruba; (IV) at Santiago de Cuba. Felt in parts of The Bahamas, Puerto Rico and the US Virgin Islands and as far as southern Florida, northern Colombia and NW Venezuela.			

All absolute values for this earthquake should be treated with caution and are estimates!

Preferred Building Damage Information:

Description:	L1	L2	L3	L4
Non-govt (PADB) less than govt. Estimates (105000 destroyed, 208000 damaged). Major infrastructure loss with 75549 red tagged, 98214 yellow tagged buildings from 382000. PADB.		98214		75549
	PADB, ReliefWeb and EERI reports			

Secondary Effect Information:

Type	Impact	Damage %	Social %	Economic %
Tsunami	Between 3-7 deaths (slide)	Minor	3-7 deaths	<.01%

Preferred Social Impact Information:

Type	Median	Accepted Range	Description	Source
Deaths	222500*	92000-225000**	Great variability in poss. death toll.	Melissen etc., Govt.
	**NB:CATDAT does not accept 316000 deaths by Bellerive in 2011 as poss.			
Injuries	310928	250000-310928	310928 injuries of all descriptions	Govt. Haiti
Homeless	1500000	(1m-2.1m)	66% in shelter, 34% left area.	ReliefWeb
Affected	3200000	(3m-4.5m)	Southern portion of Haiti.	ReliefWeb
Indirect SE	2591 deaths	63711 hospital	Cholera epidemic, flow-on effects	MSPP OCHA

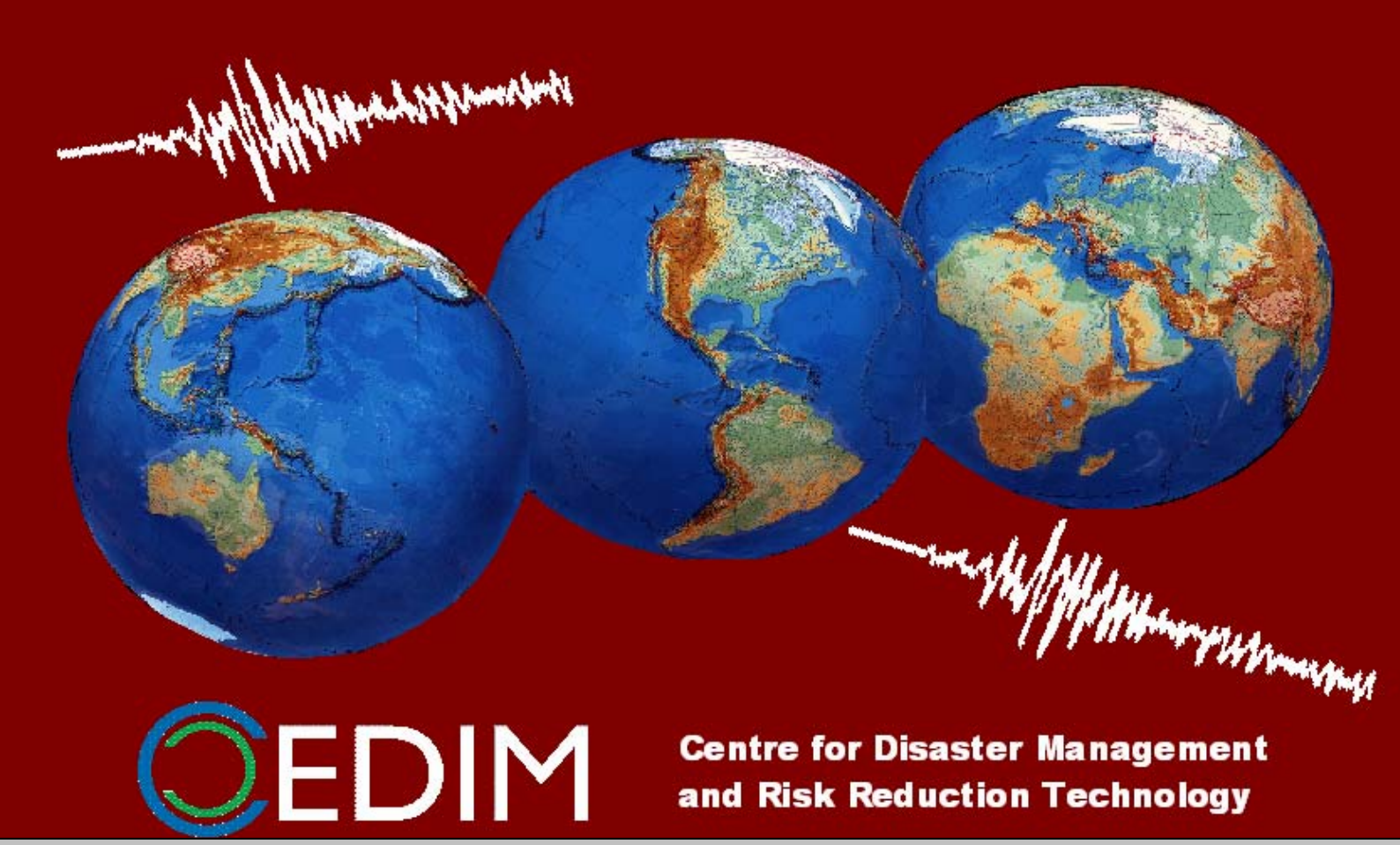
Preferred Economic Impact Information: $million int. event-day dollars

Type	Median	Accepted Range	Description	Source
Total Losses	$7804m	$7.5bn-$8.5bn	Total estimate	Haiti PDNA
Insured Losses	$150m	$30m-$150m	Minor insurance takeout	MunichRe
Aid Impact	$3504m	$3.5bn-$4.54bn	Promised much more than given so far	ReliefWeb

Abridged Description from full CATDAT description sources:

A catastrophic earthquake hit the densely populated southern part of Haiti. With little support, insufficient earthquake-resistant building practices, disaster management, corruption etc., the numbers have been exacerbated by the pre-earthquake state of the country. Over 100% nominal GDP economic loss, approx. $4bn aid promised, 92000+ deaths. Refer to full Daniell (2008-2010a) and a discussion in Daniell et al. (2010d).

CATDAT Economic Index Rank:	10: Catastrophic	**CATDAT Social Index Rank:**	10: Catastrophic



This report is also released as:
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