2010 EARTHQUAKES IN HAITI AND CHILE: A SYSTEMIC COMPARATIVE ANALYSIS

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ABSTRACT

Why did a relatively mild earthquake of 7.0 degrees on the Richter scale in Haiti cause more than 200,000 dead? And why did a very intense 8.8 Richter earthquake in Chile cause less than one thousand dead? In this paper, the socio-economic, demographic, legal, cultural, and natural causes of these differences are analyzed from a systemic standpoint. The objective of this paper is to contribute to the creation of a set of standards for Latin-American cities, to be better prepared in confronting the effects of disastrous events such as earthquakes.

Some of the preliminary conclusions of this paper are that the lack of high construction standards in Haiti, together with poverty and uncontrolled demographic growth in Port au Prince made the city very vulnerable. Chilean cities, on the other hand, with a better socio-economic and cultural level, and very strict construction standards, survived the earthquake and its sequels better than in Haiti.

Keywords: Earthquakes, Haiti, Chile, Systemic Analysis, Disaster Prevention

INTRODUCTION

Two large earthquakes happened in Latin America during the first two months of 2010. The Haiti´s earthquake caused 200,000 dead persons. The Chile´s earthquake caused less than one thousand dead persons. The facts of these two disasters are showed in Table 1.

Table 1. Haiti and Chile 2010 earthquakes characteristics.

Concept	**Haití**	**Chile**
Date	12-01-2010	27-02-2010
Local time	16:59 Hs	3:34 Hs
Day of the week	Tuesday	Saturday
Richter magnitude	7.0	8.8
Released energy (PJ, Petajoules)	2.0	1000
Deaths	200,000	800
Lethality rate % (deaths / national population)	2.3 (8.7 million)	0.005 (17 millions)

(Sources: http://es.wikipedia.org/wiki/Terremoto_de_Hait%C3%AD_de_2010, http://es.wikipedia.org/wiki/Terremoto_de_Chile_de_2010, http://es.wikipedia.org/wiki/Escala_sismol%C3%B3gica_de_Richter),http://www.prtchile.org/content/view/94/28/, http://es.wikipedia.org/wiki/Econom%C3%ADa_de_Hait%C3%AD, http://en.wikipedia.org/wiki/Richter_magnitude_scale)

Starting with these facts, we can make a quantitative and qualitative analysis to draw some conclusions and recommendations

QUANTITATIVE ANALYSIS

From the data in Table 1, we can analyze the relative differences in magnitude of both seismic energy released in each earthquake, and lethality rates in each country.

Relative rate of released energy (RRRE)

Equation 1 may help us to calculate the relationship among both earthquakes in terms of released energy:

RRRE = RE Chile / RE Haiti (1)

Where, RE Chile = Released energy in Chile´s earthquake, Petajoules
RE Haiti = Released energy in Haiti´s earthquake, PJ

With the values in table 1, and in annex 1, we obtain

RRRE = 1000 / 2.0 = 500

This means that the energy released in Chile´s Earthquake was 500 times bigger than in Haiti´s earthquake.

Relative rate of Lethality (RRL)

Equation 2 may help us to calculate the relationship among both earthquakes lethality.

RRL = L Chile / L Haiti (2)

Where L Chile = Lethality in Chile´s earthquake,
L Haiti = Lethality in Haiti´s earthquake

With the values in table 1 we obtain

RRL = 0.005 / 2.3 = 0.002

This means that the lethality in Chile´s earthquake was 500 times smaller than in Haiti´s earthquake. The opposite one could expect.

Relative rate of relative rates (RRRR)

Equation 3 may help to calculate the relationship among both rates, RRRE and RRL

RRRR = RRRE / RRL 3

With the calculated values we obtain

RRRR = 500 / 0.002 = 250.000

This means that the relative impact of the earthquake in Haiti was 250,000 greater than in Chile.

Given this great difference, one may ask: How could be that a relatively small tremor of 7.0 Richter provoked 200,000 death persons, while a 500 times stronger earthquake killed less than one thousand people?

The answer may be sought in the vulnerability of each community, rather than in the aggressiveness of the earthquakes.

Social Vulnerability

Equation 4 shows that the magnitude of a disaster is a function of two different but complementary aspects: 1- The social vulnerability of a population, and 2- The aggressiveness of the earthquake.

D = V * A 4

Where D = Disaster magnitude, measured by the number of deaths,
V = Vulnerability of the population,
A = Aggressiveness of the earthquake, measured in megatons (annex 1)

From equation 4, we can find the variable V, expressed by equation 5

V = D / A 5

With this equation 5, the vulnerability of Haiti and Chile may be determined.

Social vulnerability of Haiti

With the data of table 1 and with equation 5, we obtain

V = 200,000 deaths/ 2.0 PJ = 100,000 deaths / PJ

This means that the vulnerability in Haiti was 100,000 deaths / PJ

Social Vulnerability of Chile

Making the same calculations for the Chile´s earthquake

V = 800 deaths / 1,000 PJ = 0.8 deaths / PJ

This means that social vulnerability in Chile was 0.8 deaths / PJ

Relative rate of vulnerability (RRV)

Equation 6 may help us to calculate the Relative Rate of Vulnerability

RRV = V Haiti / V Chile **6**

With the values calculated, we obtain

RRV = V Haiti / V Chile = 100,000 /0.8 = 125,000

This means that the vulnerability in Haiti was 125,000 times bigger than in Chile.

But these data are just numbers. It is more important to find the qualitative causes of these disparities.

SYSTEMIC CAUSES OF VULNERABILITY

The most probable systemic causes of vulnerability in these cases are:

1- Legal regulations of construction and urbanization

2- Government capacity to handle emergencies

3- People´s education for coping with disasters

4- Poverty and shortage of resources to meet basic needs

5- Other factors, such as fatalism and religious beliefs.

2010 Earthquakes

1. Legal regulations

Chile has a long tradition of high standards for construction of dwellings and buildings, because it has frequently suffered earthquakes. As an example, the strongest earthquake recorded in modern times was in Chile, 9.5 Richter, (05/22/1960). By contrast, Haiti had not suffered earthquakes in more than 200 years, so building standards were much looser and Haitians were not prepared to deal with it.

2. Governmental capacity to face emergencies.

Haiti had a long tradition of dictators (Duvalier and his son), and lack of governance. In short, it was not prepared to provide protection to its inhabitants in case of emergency. By contrast, Chile has a democratic government, and one of the most successful economies in South America. The Chilean government had, in this case, the capacity to face the emergency. While Haiti, in this case, did not have the capacity to face the emergency, and then the Haitian president did let the U.S. government to control the air traffic and the humanitarian aid.

3. People´s education

Chile has a long tradition of good education, culture, awareness, training and social organizations to deal with risks of disasters caused by earthquakes, by the recurrence of such phenomena in their territory. By contrast, Haiti does not have this tradition, because there had been no cases of earthquakes in the past two centuries.

The level of social organization in Chile is high. Chile has high resilience, which means that it has a great capacity to recover by itself, and it is expected to get back to normality in a few months. By contrast, Haiti has low resilience, and it is estimated that it will take several years and a lot of external aid to arrive to an acceptable level of living.

4. Poverty, resource´s scarcity

Chile has 30% of people in poverty status, so we can say that most people can live in earthquake resistant dwellings. By contrast, Haiti is considered the poorest country of the American continent. Two thirds of the population are unemployed or under employed, ie more than half of the population is very poor, so they do not have resources to build an earthquake resistant dwelling.

5. Other factors, such as fatalism or religious beliefs

Most Haitians are fatalists. They believe that earthquakes and other natural extraordinary phenomena are a divine punishment, and that it does not make sense to try to prevent them. That is why they are not prepared for contingencies. By contrast, Chileans have a high level of education. They are not fatalists, and they know that if they are prepared, they can face the strongest earthquakes, and save lives.

CONCLUSIONS AND RECOMMENDATIONS

The comparative analysis of two Latin American nations, Haiti and Chile, which have suffered the ravages of earthquakes during the first two months of 2010, is illustrative of what should be done to reduce the disastrous impact of natural phenomena.

The earthquakes are inevitable, and it is not feasible, yet, to predict when and where it will be a strong one in the near future.

So to reduce the magnitude of disasters, the vulnerability of population must be reduced, and this may be done by the applications, among others, of the following recommendations.

1. Improve building standards for dwellings and other structures, capable of withstanding earthquakes expected on the basis of past experiences.
2. Improve urban development regulations, so that no human settlements will be located in risky terrains.
3. Improve governmental capacity to cope with emergencies and to prevent disasters.
4. Empower people to learn how to prevent and react in case of earthquakes.
5. Create teams of professionals who can help people trapped or who have lost their homes and/or belongings.
6. Reduce level of poverty in the population so that all people had the capacity of satisfying their basic needs.
7. Implement a sustainable development model, in which natural resources are kept, and social needs are fulfilled, to achieve high quality of life of present and future generations.

Applying these recommendations, there will be more chances to cope with the risk of disasters due to earthquakes.

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ANNEX 1

Table of magnitudes of earthquakes and their energy equivalent TNT

(Source: http://en.wikipedia.org/wiki/Richter_magnitude_scale)

Richter Approximate Magnitude	Approximate TNT for Seismic Energy Yield	Joule equivalent	Example
0.0		63 kJ	
0.5	0.07 kg (0.16 oz)	.35 MJ	Large hand grenade
1.0	0.43 kg (0.95 lb)	2.0 MJ	Construction site blast
1.5	2.42 kg (5.34 lb)	11.2 MJ	WWII conventional bombs
2.0	30 lb	63 MJ	Late WWII conventional bombs
2.5	168 lb	354 MJ	WWII blockbuster bomb
3.0	952 lb	2.0 GJ	Massive Ordnance Air Blast bomb
3.5	2.67 metric tons	11.2 GJ	Chernobyl nuclear disaster, 1986
4.0	15 metric tons	63 GJ	Small atomic bomb
4.5	84.2 metric tons	354 GJ	
5.0	476 metric tons	2.0 TJ	Seismic yield of Nagasaki atomic bomb (Total yield including air yield 21 kT, 88 TJ) Lincolnshire earthquake (UK), 2008
5.5	2.6 kilotons	11.2 TJ	Little Skull Mtn. earthquake (NV, USA), 1992 Alum Rock earthquake (CA, USA), 2007 2008 Chino Hills earthquake (Los Angeles, USA)
6.0	15 kilotons	63 TJ	Double Spring Flat earthquake (NV, USA), 1994
6.5	84 kilotons	354 TJ	Caracas (Venezuela), 1967 Rhodes (Greece), 2008 Eureka Earthquake (Humboldt County CA, USA), 2010 Southeast of Taiwan (270km), 2010
6.7	168 kilotons	707 TJ	Northridge earthquake (CA, USA), 1994
6.9	333 kilotons	1.4 PJ	San Francisco Bay Area earthquake (CA, USA), 1989
7.0	476 kilotons	2.0 PJ	Java earthquake (Indonesia), 2009 2010 Haiti Earthquake
7.1	666 kilotons	2.8 PJ	Energy released is equivalent to that of Tsar Bomba (50 megatons, 210 PJ), the largest thermonuclear weapon ever tested

			1944 San Juan earthquake
7.5	2.67 megatons	11.2 PJ	Kashmir earthquake (Pakistan), 2005 Antofagasta earthquake (Chile), 2007
7.8	7.5 megatons	31.6 PJ	Tangshan earthquake (China), 1976 Hawke's Bay earthquake (New Zealand), 1931) April 2010 Sumatra earthquake (Indonesia)
8.0	15 megatons	63 PJ	San Francisco earthquake (CA, USA), 1906 Queen Charlotte earthquake (BC, Canada), 1949 México City earthquake (Mexico), 1985 Gujarat earthquake (India), 2001 Chincha Alta earthquake (Peru), 2007 Sichuan earthquake (China), 2008 1894 San Juan earthquake
8.5	84.2 megatons	354 PJ	Toba eruption 75,000 years ago; the largest known volcanic event Sumatra earthquake (Indonesia), 2007
8.8	238 megatons	1.0 EJ	Chile earthquake, 2010
9.0	476 megatons	2.0 EJ	Lisbon Earthquake (Lisbon, Portugal), All Saints Day, 1755
9.2	947 megatons	3.98 EJ	Anchorage earthquake (AK, USA), 1964
9.3	1.3 gigatons	5.6 EJ	Indian Ocean earthquake, 2004
9.5	2.67 gigatons	11.22 EJ	Valdivia earthquake (Chile), 1960
10.0	15 gigatons	63 EJ	Never recorded by humans
13.0	476 teratons	2.0 YJ	Yucatán Peninsula impact (causing Chicxulub crater) 65 Ma ago (10^8 megatons = 100 teratons; almost $5x10^{30}$ ergs = 500 ZJ).