Evidence and Policy Lessons on the Links between Disaster Risk and Poverty in Latin America

Lopez-Calva, Luis Felipe and Ortiz-Juarez, Eduardo

UNDP Regional Bureau for Latin America and the Caribbean

20 January 2009

United Nations Development Programme
Regional Bureau for Latin America and the Caribbean

Research for Public Policy
MDGs and Poverty

MDG-01-2009

Evidence and Policy Lessons on the Links between Disaster Risk and Poverty in Latin America:

Methodology and Summary of Country Studies♦

Luis F. López-Calva*
Eduardo Ortiz Juárez*

Keywords: natural hazards, poverty, wellbeing
JEL Codes: I30, O10, O54, Q54

♦ Document prepared for the ISDR/RBLAC Research Project on Disaster Risk and Poverty. This document is part of the Latin American contribution to the Global Assessment Report on Disaster Risk Reduction, and the Regional Report on Disaster Risk and Poverty in Latin America. The terms *natural disaster* and *climate-related events* will be used interchangeably, understanding that socioeconomic conditions play a role to explain the intensity and consequences of such phenomena. Thus, no event is strictly or exclusively natural.

*Regional Bureau for Latin America and the Caribbean, UNDP

Please cite this document as: López-Calva, L. F. and E. Ortiz-Juárez (2009) "Evidence and Policy Lessons on the Links between Disaster Risk and Poverty in Latin America: Methodology and Summary of Country Studies", Research for Public Policy, MDGs and Poverty, MDG-01-2009, RBLAC-UNDP, New York

Evidence and Policy Lessons on the Links between Disaster Risk and Poverty in Latin America:

Methodology and Summary of Country Studies [1]

Luis F. López-Calva
Eduardo Ortiz Juárez
Regional Bureau for Latin America and the Caribbean
UNDP

1. The Issues

Extreme climate-related events have a direct impact on the welfare of households. The frequency and magnitude of those shocks appear to be closely linked to increasing vulnerability of households and communities in developing countries. The impact of such events could result in an immediate increase in poverty and deprivation, with permanent effects over time (Carter et al, 2007). Vulnerability of households to natural shocks is determined by several factors: the economic structure, the stage of local development, social and economic conditions, coping mechanisms available, exposure to risk and frequency and intensity of disasters, among other factors. The impact on poor households and regions is multiple and may have permanent effects.

Yet, the link between natural disasters and living standards is complex and causality is difficult to capture empirically. Among other reasons, there is a two-way relationship between the vulnerability to natural disasters and poverty, and disentangling the direction of the causal impacts is rather challenging, especially in terms of the intensity of the effects of the events and not only their incidence.

[1] Empirical research for the country cases was conducted by Fernando Ramírez (Bolivia, Colombia, Ecuador, Peru); Elisabeth Mansilla (Mexico, El Salvador); Ernesto Pérez de Rada and Daniel Paz Fernandez (Bolivia); Carla Calero, Rosario Maldonado and Andrea Molina (Ecuador); Javier Baez and Indhira Santos (El Salvador); Alejandro de la Fuente, Rodolfo de la Torre and Eduardo Rodriguez-Oreggia (Mexico); and Manuel Glave, Ricardo Fort and Cristina Rosemberg (Peru). The authors acknowledge Andrew Maskrey and Alejandro de la Fuente for their support and helpful comments. The document benefitted from discussions with all the authors involved in the project, and from conversations with the ISDR-GAR team during the meetings held in Geneva, Bangkok, Bogota and Mexico City.

The magnitude of the social and economic consequences of recent natural events in the world has reinforced the need to place hazard-related concerns at the top of the global poverty and development agenda. Lindell and Prater (2003), for example, persuasively outline the policy relevance of the issue. First, policy makers must understand the impacts of natural shocks on poor households so that the assistance becomes more effective. Moreover, specific population groups should be identified as more vulnerable to natural hazards, as a useful way for planning ex-ante responses to avoid long term consequences on welfare.

The geographical conditions of Latin America and the Caribbean make the region prone to the occurrence of high-intensity climate-related events. Yet, the large economic and human cost associated with these natural events is mainly the result of extreme vulnerability, which is explained by causes that are not purely exogenous (Charveriat, 2000).

The project on Disaster Risk and Poverty in Latin America and the Caribbean pursued two main goals. First, the empirical analysis estimated the relation between natural events and social indicators at the local level, establishing a causal link whenever possible. Second, analysis was carried out at the household level in order to determine the potential role played by coping mechanisms to influence long-term impacts on welfare.

As described below, the assets approach to poverty can be used as a reference framework to understand the nature and potential impact of shocks. Events can influence the stock of assets held by household members, the intensity in which such assets are used, and the prices paid for their use. Transfers can compensate short term impacts and may, in principle, be used to avoid long term consequences of shocks. Specific examples will be provided.

In terms of the policy implications, emphasis will be made on two “biases” that are present in disaster-related policies. First, physical infrastructure tends to be prioritized and, in many cases, assumed to be the only realm of public action and damage accounting. That is incorrect given the important economic losses implied by the

destruction of "intangibles" with long run effects: school attendance of children, health related impacts, systematic reduction of employment opportunities, and lower returns to assets. The second bias relates to the importance given to ex-post interventions, while ex-ante mechanisms could be put in place to shield households from losses, especially in human capital. Conditional cash transfers programs (CCT), for example, could incorporate shock-related responses. De Janvry, et al. (2006) shows that pre-existing conditional cash transfer schemes do function as a safety net for those exposed to natural events, and that such role could be strengthened.

2. A general methodology proposed

As we noted above, the links between natural events and living standards are difficult to capture empirically. As discussed in De la Fuente, et al. (2008), one important challenge in the analysis of disaster risk and poverty is the existence of a double causality. Thus, we can state the hypothesis of the interaction in two directions (see Figure 1):

i) Poverty –or socioeconomic conditions—do affect the incidence (in specific kinds of phenomena) and the intensity (in almost all cases) of hazards. We shall call this hypothesis i.
ii) The occurrence of natural hazards affects poverty. This will be called hypothesis ii.

Figure 1

The analysis summarized in this section focuses on both hypothesis above, though the econometric strategy aims at providing evidence on hypothesis ii. A summary of variables analyzed, data used and empirical strategies is shown in Annex 1. Following the empirical methodology outlined in De la Fuente, et al. (2008) the purpose of the

analysis is to determine the impact of natural events on poverty at the local – geographic-- and household levels, with causal implications whenever possible.

In terms of hypothesis ii) above, the first step is to look at the impact at the regional and/or local level. The question is whether it is possible to separate the effect of a shock on local social indicators. As stated in López-Calva and Rodríguez-Oreggia (2008), we can treat the natural event as an exogenous shock and calculate the effect of such event as a fixed effects specification given by:

$$Y_{it} = d_i + \alpha D_{it-1} + \alpha \mathbf{X}_{it} + \varepsilon_{it}$$

where Y_{it} is the social indicator chosen, d_i is a geographical unit fixed effect, D_{it-1} is a dummy taking the value of 1 if the unit suffered a shock in the previous period, and **X** is a set of characteristics. Other option is given by the estimation of a difference in difference specification as:

$$Y_{it} = \alpha_0 + \alpha_1 D_1 + \alpha_2 D_t + \alpha_3 D_1 D_t + \alpha_4 \mathbf{X}_{it} + \varepsilon_{it}$$

Here, D_1 is a dummy for areas considered treatment, D_t is a dummy taking the value of 1 after the event occurs and the term α_3 measures the impact of the event on Y_{it}.

For the analysis at the household level it can be followed the methodology used by Baez and Santos (2007), whenever feasible, again using a natural event as a natural experiment as follows:

$$C_{it} = \alpha + \pi_i + \beta_1 \mathbf{X}_{it} + \beta_2 \tau_t + \beta_3 treat + \beta_4 (\tau_t \cdot treat) + \beta_5 (\tau_t \cdot treat + \mathbf{Z}_{it})$$

where C_{it} is the outcome variable for household before and after the impact, π_i denotes household fixed effects, **X** is a set of pre-shock variables which are observable, τ_t denotes fixed year effects, *treat* is a dummy taking the value of 1 if household lives in an area that was hit by a natural event, β_4 captures the change in C_{it} between year and specific to the natural event shock, and β_5 controls for heterogeneity among households as **Z** is a subset of **X** for household demographics and composition.

3. The evidence

3.1. Mexico

According to National Center for Disaster Prevention (CENAPRED) between 1980 and 2006 there have been 75 major natural events that have produced more than 10 thousand deaths and a damage of about 9,600 million dollars. In the same period there were 17,172 natural events of medium and small scale with important negative effects (see table 1). These events also had particular impact on agriculture: during 1980-2006 more than 52.6 millions of crops hectares were lost, representing a loss of nearly 32 billion dollars.

More than half (54.5%) of the events are associated to climatic phenomena, while the anthropic and technological events represent less than a quarter of total. Regarding the first ones, floods are the event with higher recurrence, representing 22.1% of the total events.

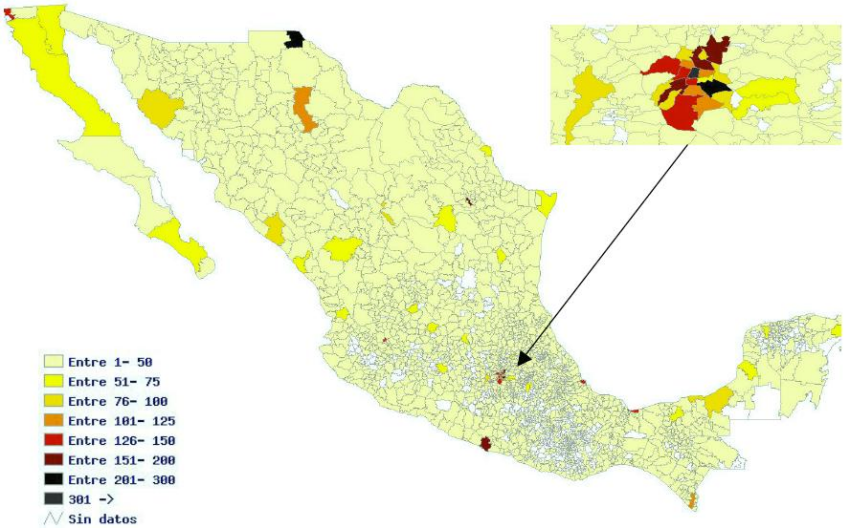
Table 1
Summary of damages
(Events of medium and small scale)

Total of events	**17,172**
Deaths	32,288
Missing people	9,076
Injured and sick	45,099,806
Victims	12,328,326
Dwellings affected	1,992,372
Dwellings destroyed	347,931

Source: Mansilla (2008a) on the basis of *Desinventar*.

According to their territorial distribution, over 40% of the events are located in five states: Distrito Federal, Veracruz, Estado de Mexico, Chihuahua and Chiapas. As can be viewed in map 1, at municipal level, only 22 of the 2,445 municipalities (0.9%) capture 3,401 events (around 20% of total events). Cuauhtemoc, in the Distrito Federal, has the highest incidence with 357 events, followed by Juarez, Chihuahua with 248 and by Iztapalapa, also in the Distrito Federal, with 228 events.

Map 1
Risk geography at the municipal level in Mexico, 1980-2006



Source: Mansilla (2008a) on the basis of *Desinventar*.

These 22 municipalities are characterized by having a high economic development degree. However, most of the metropolitan areas they belong to, have high marginalization levels in its urban population. Except Monterrey, Chihuahua, Guadalajara and the Mexico City Valley, the rest have high and very high marginalization degrees in more than 25% of its population. In cities like Juarez, Acapulco, Coatzacoalcos and Tapachula these marginalization degrees fall between 45% and 55% of the whole population. With this, we may infer that high risk levels would be associated with the growth of irregular human settlements and some urbanization forms in cities with these characteristics.

The analysis of the impacts of natural events on social indicators follows the next empirical questions: Is there an effect of the incidence of natural events on long term indicators such as those included in the Human Development Index? Are those events affecting the levels of poverty in such areas? Do public responses for localities affected reduce the impact of such events? Using information from *Desinventar* database and other publicly available data, the analysis for Mexico by Rodríguez-Oreggia, et al. (2008) tackles those questions. Specifically, the analysis focuses on how natural events may affect local social indexes at the municipal level, such as the Human Development Index (HDI), and poverty levels, between years 2000 and 2005.

Results show that there is a reduction of .006 on average in the HDI as result of the incidence of any type of natural events at the municipal level for the period 2000-2005, which represents on average 0.8% of the HDI. Also, there is an increase of about 3.6 percentage points in the incidence of food-poverty, three percentage points in capabilities-poverty, and 1.5 percentage points in assets-poverty.[2] Disaggregating by type of event, we find that droughts reduces the HDI on 0.009, representing about 1.2 per cent of the HDI on average, while heavy rains is significant for some of the specifications, representing a decrease of about 0.8 per cent of the HDI.

Disaggregating by type of event, floods have an incidence on the increase of food poverty of 3.5 percentage points, while droughts increase it by 4.1 percentage points. Also, floods and droughts increase capacities poverty in 2.9 and 3.7 percentage points respectively. Finally, floods and droughts also increase assets poverty by 1.9 and 2.5 percentage points.

3.2. El Salvador

El Salvador is a country that has been subjected to a large variety of natural hazards in the recent past: the San Salvador earthquake in 1986; "El Niño" phenomenon 1997-98; the hurricane Mitch (1998); the 2001 earthquakes and the drought in the same year; the pneumonia epidemic of 2003 which caused 304 deaths; and the tropical storm Stan in 2005. The impact of these events has resulted in considerable losses. In particular, the effects of two major earthquakes and a number of smaller follow-ups on rural household income and poverty in early 2001. According to ECLAC[3], these earthquakes and related landslides produced a death toll of more than 1,200 people, affected nearly 300,000 dwellings (about 32% of the existing housing stock) and caused US$1.6 billion in direct and indirect damages (12% of GDP in 2000).

In addition to these events, between 1970 and 2007, a total of 3,386 events of medium and small scale have occurred in the country. These events caused more than 2,000

[2] Food-poverty considers households with income that is insufficient to cover the minimum food requirements; capabilities-poverty refers to those households with income insufficient to cover food requirements and a minimum expenditure on education and health; and finally, assets-poverty includes households having insufficient income to cover food, education, health, clothing, public transport and housing requirements.

[3] Economic Commission for Latin America and the Caribbean (CEPAL, 2001a, 2001b)

deaths and more than 12,000 dwelling have been damaged or destroyed (see table 2). Floods and slides are the major events: 23% and 19% of total events, respectively.

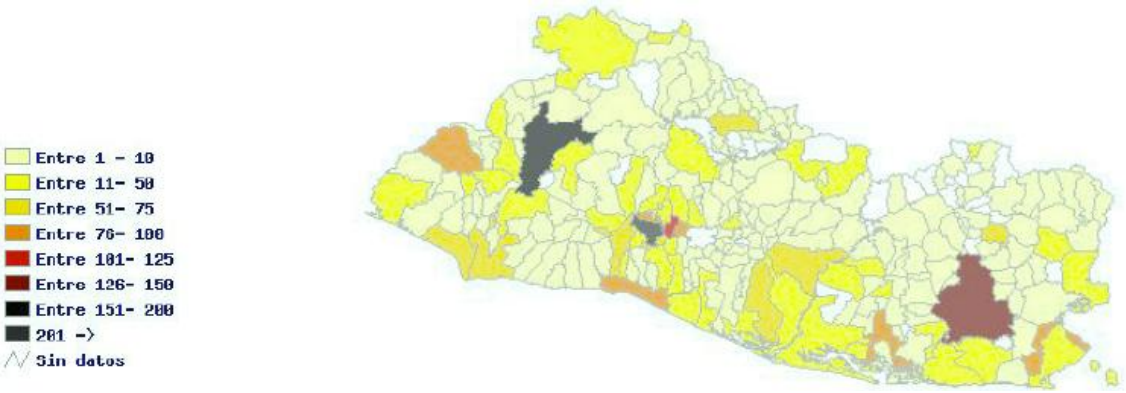
Table 2
Summary of damages, 1970-2007

Total	**3,386**
Deaths	2,120
Missing people	605,143
Victims	120,115
Dwellings affected	10,130
Dwellings destroyed	2,026

Source: Mansilla (2008b) on the basis of Desinventar.

The geographical distribution of these events shows a high concentration in San Salvador department, where has occurred the largest number of events during the analyzed period (31.2% of total). Similarly, at municipal level the largest number of events occurred in the Metropolitan Area of San Salvador, with 1,094 events (32.3% of total). In general, there is a large risk concentration in a small part of the territory: 48.6% of the total events occurred only in 20 of the 262 municipalities (see map 2).

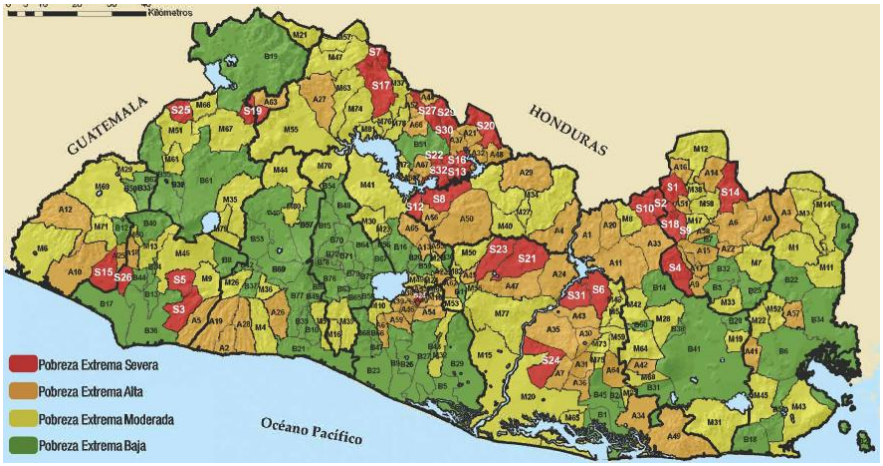
Map 2
Territorial distribution of the natural events, 1970-2007



Source: Mansilla (2008b) on the basis of Desinventar.

By comparing maps 2 and 3 it seems that there is not a direct relationship between risk and poverty since the total of municipalities with middle and high incidence remains with low levels of extreme and moderate poverty.

Map 3
National extreme poverty map in El Salvador



Source: FISDL, Government of El Salvador.

The empirical analysis exploits microeconomic evidence at the household level together with variation in the intensity of the geological shocks in a quasi-experimental way (Baez and Santos, 2008). Using longitudinal data collected in rural areas before and after the shock (approximately 700 households), the analysis specifically tests whether the 2001 earthquakes have an effect on household income, as well as on other indicators that can identify coping responses to the shock.

Results show that 2001 earthquakes are associated with a reduction of $1,760 *colones* in household income per capita (a reduction of 15%) or one third of the pre-shock average, in turn affecting poverty levels as well, though this change in poverty is not significant in a statistical sense. Yet, other indicators that measure the intensity of poverty such as the poverty gap show a relative worsening in highly affected areas. Some basic indicators suggest that alternative sources of income and consumption only played a limited role in coping with the effects of the shocks.

These findings highlight that while natural events can have a pervasive impact on wellbeing in the short term, the most dangerous effects are those that reveal themselves only in the medium to long term through reductions in human and physical capital. Results show that children in households highly exposed to the 2001 earthquakes in rural El Salvador became differentially less likely to attend school as the probability of enrollment decreased by 5.3 percentage points. “High-intensity” treated households also exhibit relatively higher losses of assets such as housing, land, livestock, farm

machinery and other physical capital. Overall, these impacts are expected to reduce the future earning capacity of the most affected households.

3.3. Peru

Peru is globally considered among the countries where "El Niño Southern Oscillation" (ENSO) strikes harder. The Peruvian ocean is the scenario of the encounter of warm waters from the Equator with the colder front coming from the extreme Southern Pacific. At the peak years along the ENSO cycles, popularly known as "El Niño years", the classic pattern of events is a combination of floods in the northern coast with extreme droughts in the southern Andean highlands. The most recent "El Niño years" have been 1972, 1983, and 1997-98 although the ENSO cycle is a dynamic climatological process and in the recent years the media tend to grade every year having a more or less strong ENSO effect.

The following analysis provides an overview of natural hazards in Peru since 1970. The events are classified using two criteria: extensive–intensive events depending of the number of deaths and dwellings destroyed (risk typology), and the division between geological and hydro-meteorological events (event typology).

Table 3 shows that the hydro–meteorological events are the most frequent, representing more than 90% of the total events reported in the period 1970-2006. The number of deaths caused by these events represents 62.5% of the total number of deaths reported. This table also shows that the geological disasters, despite its low frequency, cause the most number of dwellings destroyed, 66.4%, and an important percentage of the total number of deaths.

Table 3
Number of events, deaths and dwellings destroyed by event type (percentages)
1970-2006

Event type	Frequency	Deaths	Dwellings destroyed
Hydro-met	91.4	62.5	33.6
Geological	8.6	37.5	66.4
Total	**100.0**	**100.0**	**100.0**

Source: Glave, et al. (2008) on the basis of *Desinventar*.

Table 4 shows that natural hazards classified as extensive represents almost the total (99.5%) number of events registered in the period. However, given the definition of intensive events (with more than 50 deaths or 500 dwellings destroyed), although they represent only 0.5% of the total events reported, they cause 87.6% of the deaths and 74.8% of dwellings destroyed.

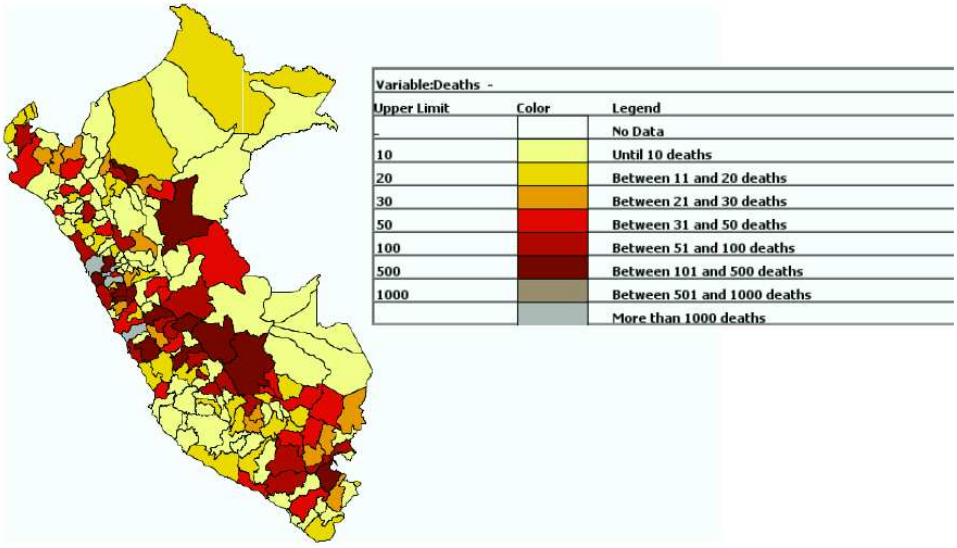
Table 4
Number of events, deaths and dwellings destroyed by risk type (percentages)
1970-2006

Risk type	Frequency	Deaths	Dwellings destroyed
Extensive	99.5	12.4	25.2
Intensive	0.5	87.6	74.8
Total	**100.0**	**100.0**	**100.0**

Source: Glave, et al. (2008) on the basis of *Desinventar*.

The territorial distribution of deaths caused by different events shows that there is an important concentration in the Huaraz department. This is explained by the 1970 earthquake, which epicenter was exactly in that area (see map 4).

Map 4
Territorial distribution of deaths



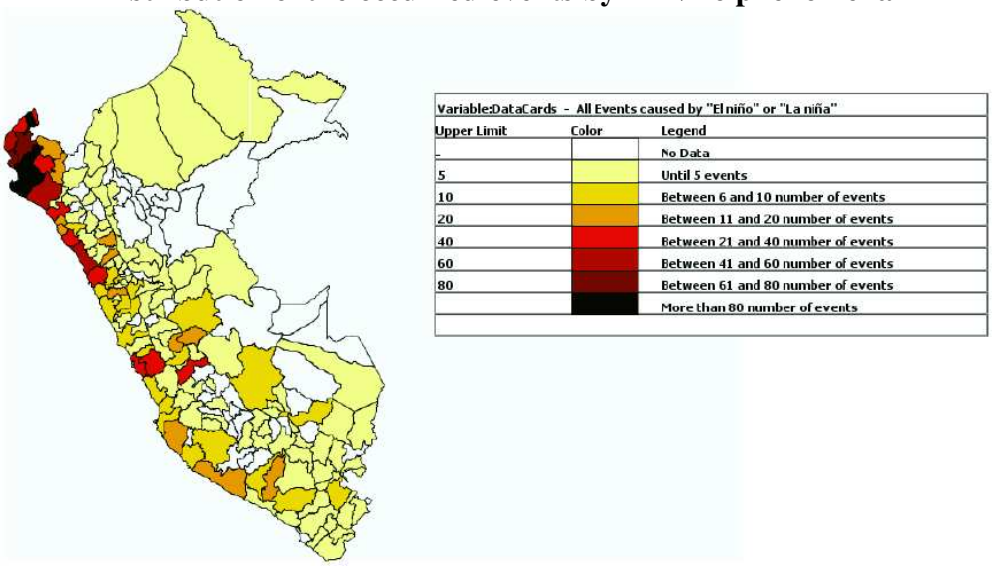
Source: Glave, et al. (2008) on the basis of *Desinventar*.

In terms of the number of dwellings destroyed, the 1970 earthquake is, again, the most significant event. However, there was an important amount of dwellings destroyed in 1983 and 2001. This is explained by the effects of El Niño in 1983 and by the

earthquake in 2001 in the south of the country. Huaraz is the most affected department, followed by the north zone, where El Niño typically causes great losses.

Floods and storms are the main events linked to the phenomenon of El Niño and therefore, are natural events that negatively affect the areas in which this phenomenon occurs. Map 5 shows that the coast provinces, especially in the north, are those that register the largest number of events. In these areas the material losses have been very important.

Map 5
Distribution of the occurred events by El Niño phenomena



Source: Glave, et al. (2008) on the basis of *Desinventar*.

In the case of Peru, as well as in other countries, there seems to be a strong bias in the information on natural hazards in the *Desinventar* database. First, more isolated districts do not count with any report on natural hazards in the past 36 years. Second, districts of higher rank or importance in terms of geo-political classification systematically present a higher number of reported events than the rest, even when compared to their neighbor districts. Given that the main scope of the analysis for Peru is to assess the relationship between natural hazards and welfare indicators, the fact that districts with better socio-economic conditions (like provincial capitals) tend to have a higher number of reported events in the *Desinventar* database due to its method for data collection, will seriously limit the possibility of using this information in the empirical analysis.

The bias in the *Desinventar* database deters the option of doing a clear analysis of the relationship at the District level. Thus, the analysis for Peru is based on the national household survey ENAHO, conducted by the National Institute of Statistics (INEI). It has been possible to ensemble a five-wave unbalanced panel database for the period 2002-2006 with information for 2,091 households at rural level. However, the balanced panel database just includes 831 households. ENAHO is used to calculate and monitor poverty in the country. Consequently it allows the calculation of household's consumption levels as well as income. Furthermore, it includes valuable information regarding durable and productive assets and access to public services. The survey also includes a question about the experience of a negative shock in the last 12 months (death of an income's provider, unemployment, natural hazard), and asks also about the consequences of that shock and the strategies undertaken (depletion of assets, borrow money, etc.)

An initial characterization of households (2002) by occurrence of natural events shows that households reporting disasters have on average less access to public services, are less integrated to the market, and have a higher proportion of agricultural income. As this difference could be signaling some bias in the report or occurrence of disasters towards this type of households, it is important to control for these characteristics in the regression analysis.

As showed in Glave, et al. (2008), a first approach to estimate the impact of hazards over poverty is to use the categories obtained from the analysis consumption-poverty transitions as dependent variable (never poor, one episode, several episodes, always poor). Two different specifications of the multinomial regressions show that households are between 2.3 and 4.8 times more likely to be "Always Poor" than to be "Never Poor" given that they have experienced a natural event. The analysis also shows that an increase in livestock holdings slightly reduces the probability of being always poor, what could be signaling the importance of this asset as a buffer stock. These results only hold if consumption, rather than assets, is used to measure poverty. Apparently, natural events affect these households through its negative impact on the agriculture activity, affecting the level and stability of their income, but do not have a sizeable effect on their possessions of durable goods.

Even though a dynamic analysis of changes in per capita consumption remains to be done, the analysis for Peru found the occurrence of natural events in the period 2002-2006 (average or total number) to have a profound impact on household´s monthly per capita consumption in 2006. Moreover, this impact seems to be stronger for households located at the bottom of the income distribution (quintile regression results). For instance, increasing the average occurrence of shocks in one unit reduces monthly per capita consumption by 2% for households in the lower quartile of the distribution, while it only reduces consumption by 1.2% for households in the richer quartile.

3.4. Bolivia

Between 1970 and 2007 a total of 1,406 events have been reported in Bolivia at level of Provinces. Only five of these events are risk-intensive: earthquake in 1998, slide in 1992, two flash floods in 1983 and 2002, and a flood in 2003 (see table 5). These events were reported in La Paz (2), Cochabamba (2) and Santa Cruz (1).

Table 5
Intensive and extensive events, by associated losses, 1970-2007

	Intensive	%	Extensive	%	Total
Events reported	5	0.3	1,401	99.7	**1,406**
Deaths	354	43.0	467	57.0	**821**
Dwellings destroyed	1,800	43.0	2,378	57.0	**4,178**
Dwellings affected	0	0	2,090	100.0	**2,090**

Source: Ramírez (2008) on the basis of *Desinventar*.

The extensive risk represents almost 60% of deaths and destroyed dwellings and the total of affected ones. In these manifestations, the climatic events represent 87% of the total of reports and deaths, and more than 90% of dwellings destroyed or damaged (see table 6).

The highest climatic events incidence (2006 and 2007) is associated to the two major rain waves that affected the east departments of the country, especially Beni, Pando and Santa Cruz. In terms of deaths, however, the greatest number was reported in 2004 when there was a drought in the providence of Cordillera, in Santa Cruz department.

Table 6
Extensive events and associated losses, 1970-2007

Extensive events	Events reported	%	Deaths (%)	Dwellings	
				Destroyed (%)	Affected (%)
Climatic	**1,228**	87.7	87.0	92.1	95.0
Geological	**16**	1.1	0.0	0.3	0.0
Technological	**118**	8.4	12.8	7.3	5.0
Total	**1,401**	**100.0**	**100.0**	**100.0**	**100.0**

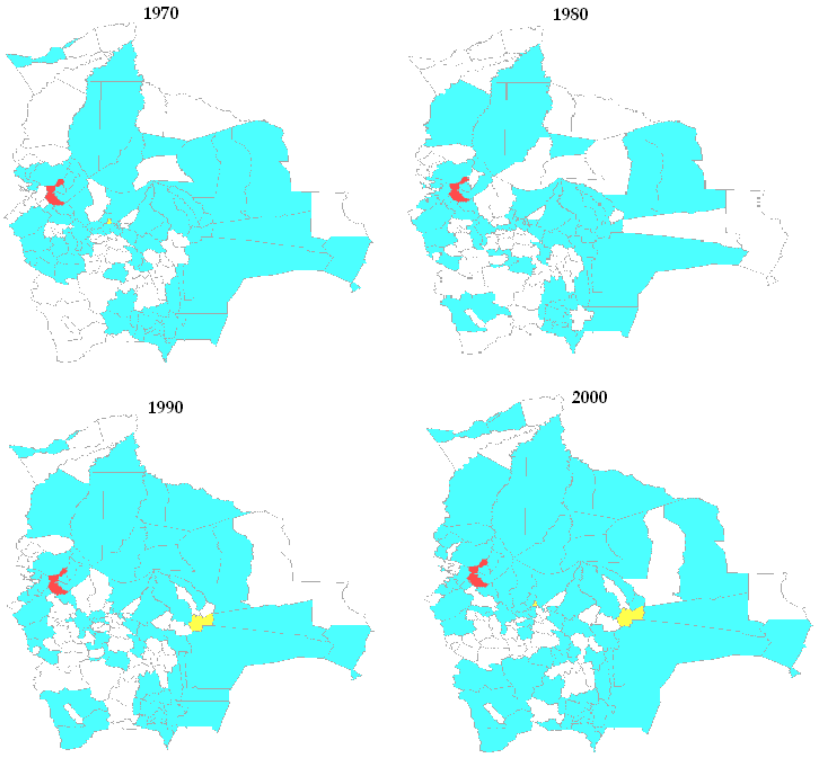
Note: 39 events are associated to fire.
Source: Ramírez (2008) on the basis of *Desinventar*.

Regarding the territorial distribution, a total of 94 provinces reported effects by any extensive risk manifestation. There is a middle or high occurrence in 13 of these provinces, and they concentrate 65% of the total reports, 47% of deaths, 56% of destroyed dwellings and 81% of affected ones. These provinces are: 4 in the Cochabamba department (Cercado, Chapare, Quillacollo and Carrasco), 2 in La Paz department (Murillo and Larecaja) and one in each of the other 7 departments of the country.

Map 6 shows how the affectation of provinces has changed during last decades. We can observe a territorial expansion of the extensive risk manifestations, highlighting the case of La Paz, which appears in all the decades; Cochabamba, especially affected in the eighties; and the case of Santa Cruz, with an important reports concentration in the last two decades. In the current century we observe a larger number of affected provinces, expanding significantly the extensive risk territory.

In general, Bolivia shows few risk manifestations during the last 38 years. The biggest damage is concentrated toward the end of the period. It is important to note that in this country there is no information at municipal level, which can lead to overestimate the extensive risk territory. Moreover, the extensive risk reports present a larger number of destroyed dwellings than affected ones. This may be a sign of an information sub-report on partial damage, or an extensive risk more destructive than in other countries, but without being "intensive".

Map 6
Extensive risk by decades, 1970-2007



Source: Ramírez (2008) on the basis of *Desinventar*.

The lack of information on natural hazards in Bolivia is the main limitation to carry out an empirical analysis of the relationship between poverty and natural hazards. Furthermore, the lack of statistically representative data and panel information of household surveys prevents the estimation of models that capture sharply the effect of natural hazards over wellbeing at household level, as well as estimation of the changes over time in poverty incidence due to natural events.

Considering the above limitations, the methodology applied for the Bolivian case analysis can be described as follows:

(i) Estimation of model of change in poverty incidence between census (1992-2001) at a municipal level as a function of risk index among other determinants. The risk index was constructed only with information of climate and geological events weighted by exposed population, since information of damages is not available;

(ii) Estimation of changes in poverty and inequality indexes as well as repeated cross section estimations of income functions in Trinidad – the city which was largely affected by floods in 2006-2007 by the phenomenon of "El Niño" – taking into account the effect of district of residence as a proxy of exposure to the natural event.

Among the results at municipal level the analysis for poverty incidence by Pérez de Rada and Paz (2008) shows, first, that the average schooling level in the municipality has an increasing contribution over the reduction of poverty incidence. Moreover, an initial greater incidence of poverty in the municipality (1992 incidence) has a positive effect on its change. However, this result can be interpreted as the effect of being in a disadvantageous initial situation more than as a symptom of convergence. Second, the negative change in the Rate of Child Mortality (interpreted as an improvement in living conditions) as well as positive rates of migration (immigration) impact positively over the change of poverty incidence. Despite that the sign in both variables changes in the simultaneous model and two stages least squares, the significance also falls. In the case of the change in Unmet Basic Needs (UBN, interpreted as non monetary poverty) results show a positive effect over monetary poverty.

Regarding the variable risk, it shows the results predicted by theory: as the risk is larger at the municipality level, smaller is the improvement in monetary poverty. The coefficient displays negative and statistically significant values in five estimations, although in the case of two stages least squares and simultaneous equations methods, the magnitude of the effect is lower in about 50% compared with the rest of the estimators obtained (4% and 3% respectively).

The interpretation of the variable risk must be taken with caution since this index may capture not only the vulnerability of municipalities in terms of natural events, but also other effects like productive capacity, agro-industrial potential or other kind of shock occurred in the municipality in nine years of inter-census period. Even when the variable is instrumented by exogenous variables (such altitude, temperature or slope) the coefficient may capture problems associated to agricultural efficiency, lack of roads and communication or other limitations derived from geography that are not always manifested as a natural event. The results are qualitatively consistent in different

estimations, emphasizing the fact that the index of risks has a negative incidence in the improvement of wellbeing in municipalities in all cases. Finally, statistical significance of education and risk variables are inalterable in all estimations.

The analysis for Trinidad City shows that the levels of poverty incidence in 2007 increased of almost twelve points compared with information of 2006. This increment occurred after the flood, is more than five times the increment observed at a national level. A similar situation is observed in the case of the poverty gap, whose interannual increase was more than six points. Finally, the severity of poverty, expressed by the FGT (2) index had also a substantial increase between the analyzed years.

Not only levels of poverty had a dramatic increase, but also inequality. In fact, Gini coefficient rose from 0.37 to 0.43 between 2006 and 2007. These results reveal the enormous impact in wellbeing conditions in the city of Trinidad, derived from the effects of the natural event. In this context, one of the major concerns is to isolate the effect of the flood on wellbeing conditions (measured by household income) through econometric estimations.

The results of the income regressions indicate that, first, every year of education is associated with an increase in income of 8.7% and 6.6% in 2006 and 2007 respectively. Note that the return of education is significantly smaller in 2007. Such situation could be due to the fact that the disaster shock might affect economic context of the city, which in turn, is translated into a lower return of education on income. A similar situation is observed in the case of male-female controls, given that for both years men have received an income-premium compared to women.

Additionally, this premium has increased between the 2006 and the 2007, which implies that the changes in socioeconomic context in Trinidad in this period (including the event of the flood) had more evident negative effects on the female population. Second, in the case of labor experience, the variable has a positive return over income, but with a decreasing rate. The changes between both years are not statistically different. Finally living in a protected zone from flood risks (smaller exposure to risk) implies a return on income. Although nothing can be concluded about the mechanisms that produce such

extraordinary return, we can observe that this return increased between 2006 and 2007 from 5% to 7%.

A vast literature about economic returns of residence (location) concludes that such approximation has endogeneity problems since place of residence is not a random decision in the household. If this is correct, we must expect that our proxy variable for exposition to natural hazard is upward biased. In any case, we can establish that at least one part of this effect can be attributable to the natural event occurred in Trinidad.

A final exercise accomplished for the case of Trinidad, was the decomposition of inequality Gini index. Among other results we can observe that schooling (education) has the largest contribution in explaining inequality of income in Trinidad. This variable explains between 75% and 77% of the inequality. This value is nine times greater than the other factors, including the residence district. Nevertheless, it is interesting to note changes registered in other factors between the 2006 and the 2007. In first place, we can observe that in 2006 the second factor in importance to explain the inequality is the labor experience, since its contribution to inequality is 7.9%. The district of residence and sex respectively are the third and fourth place in importance that year with a contribution to the inequality of 7.4% and 7.3%.

The magnitudes of the factors for 2007 registered an important change. Although the education is still the most important explanatory factor of the inequality, the factor district of residence is the second factor in importance now with a contribution of 9.6% over inequality. These results allow inferring that at least one part of the increase in the contribution of inequality by residence district is due to the impact of the natural event in the city of Trinidad. Additionally, the increase in the contribution of variable sex reveals that conditions for women not only are worse than those for men in absolute terms (smaller return). It also shows (at least in part) that women were more affected by natural events taking into account the changes in contribution of sex to inequality after the flood disaster in Trinidad.

3.5. Ecuador

Between 1970 and 2007, 3,596 natural events have been reported, of which only 6 are risk-intensive: two earthquakes (1987 and 1996), two slides (1983 and 1993), one flood (1987) and one flash flood (1993), while the rest are extensive (see table 7).

Table 7
Intensive and extensive events, by associated losses, 1970-2007

	Intensive	%	Extensive	%	Total
Events reported	6	0.2	3,590	99.8	**3,596**
Deaths	877	29.0	2,138	71.0	**3,015**
Dwellings destroyed	2,253	19.6	9,240	80.4	**11,493**
Dwellings affected	178	0.4	40,596	99.6	**40,774**

Source: Ramírez (2008) on the basis of *Desinventar*.

The low incidence of the first ones contrasts with the potential risk of the volcanic and seismic activity in the country. At least four active volcanoes have had eruptive episodes since 1999 (Reventador, Pichincha, Cotopaxi and Tungurahua), threatening large population areas including the capital.

In terms of extensive risk, the weather events represent not only the largest proportion (67.7% of total) but also, they are associated with nearly 80% of the total number of deaths and dwellings destroyed in the period, and almost 90% of affected ones (see table 8). This table shows that the extensive risk dynamics, in terms of the occurrence, deaths and dwellings destroyed and affected is characterized by climatic events, whose high incidence (especially in 1997 and 1998) seems to be associated with El Niño effects in those years, which left losses for more than 700 million dollars.

Table 8
Extensive events and associated losses, 1970-2007

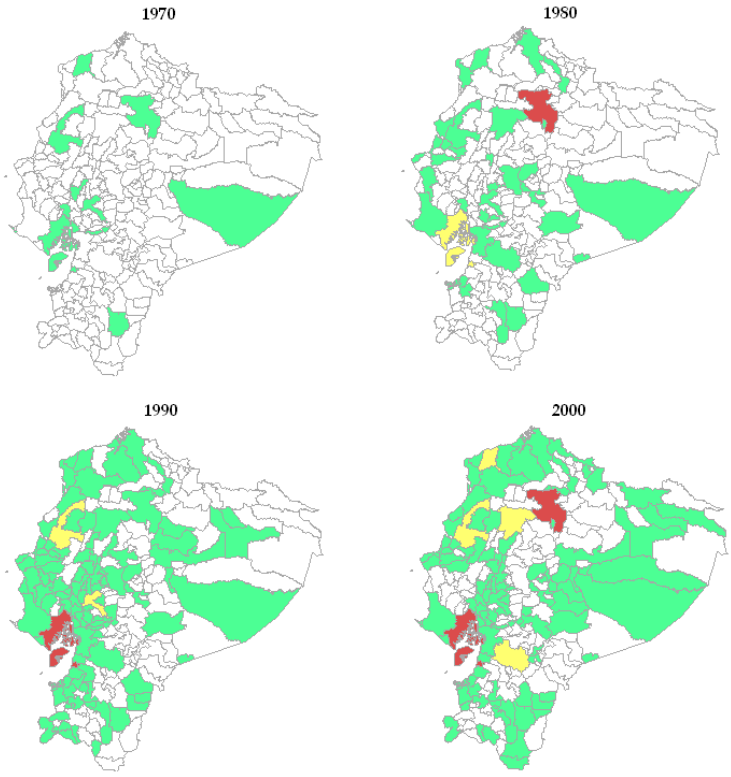
Extensive events	Events reported	%	Deaths (%)	Dwellings	
				Destroyed (%)	Affected (%)
Climatic	**2,431**	67.7	78.0	78.0	89.0
Geological	**124**	3.5	2.0	5.0	9.0
Technological	**934**	26.0	20.0	17.0	1.9
Total	**3,590**	**100.0**	**100.0**	**100.0**	**100.0**

Note: 101 evens are associated to fire.
Source: Ramírez (2008) on the basis of *Desinventar*.

Regarding the territorial distribution of the events, we observe that of the 194 affected *cantons*, the greatest damages appear in only 27 of them (14 of these located in the Region Costa). In these occurred 70% of the total deaths, 71% of the dwellings destroyed and 66% of the total number of affected ones. It is important to note that cantons such as Quito and Guayaquil concentrate together 30% of deaths and 23% of the dwellings affected, although only 4% of the destroyed ones.

Regarding climatic events, floods cause the larger volumes of dwellings destroyed and affected (66% in the first case and almost 93% in the second), and slides cause the largest number of deaths (55%). Map 7 shows the evolution of flood manifestation in the country. We can observe that during the seventies few cantons are affected by these events, but appear to be more intense in the next decade, especially in Quito, Guayaquil and the Coastal Zone. During the nineties, we observe a large number of affected cantons and therefore a significant risk expansion associated with flooding. Finally, in the current decade the risk increased in the Amazon region and decreased in the Sierra region. Quito and Guayaquil are still very affected.

Map 7
Extensive risk associated to floods, 1970-2007



Source: Ramírez (2008) on the basis of *Desinventar*.

In general, in Ecuador there is an association between the occurrence of El Niño and extensive events, given that between 1997 and 1998 there were the largest number of affected cantons.

In order to examine the relationship between natural hazards and poverty the analysis for Ecuador employs several specifications, corresponding to varying set of controls. For each specification the analysis take into account distinct natural hazards such as seismic events, earthquakes, landslides, droughts, and floods (Calero, et al., 2008).

Interestingly, only seismic events and droughts seem to have an effect on the changes in *canton* poverty incidence. Exposure to seismic events increases the changes in poverty incidence along all specifications. Further, instead of using the change in poverty incidence the change in poverty gap and severity is used; however, seismic events do not seem to have any effect on these measures. Similar patterns are observed for droughts, albeit with slightly higher marginal effects. Droughts are associated with increased changes in poverty incidence. For instance, in the complete specification exposure to droughts increases the changes in poverty incidence by 2 percentage point on average.

Although the findings are suggestive and lies on correlation analysis, understanding the link between poverty and natural hazards constitute a key element to design poverty alleviation strategies. Taking into account that natural hazards have important consequences on the welfare of households and particularly of vulnerable and poor ones, it is important to move from policies that respond to emergencies and disasters to policies that incorporates actively reducing natural hazard. Protecting vulnerable population and improving coping mechanisms (i.e. insurance, access to financial markets, among others) are critical for fighting against short and long term poverty.

4. Policy Lessons

The evidence indicates that sufficiently large or persistent natural events are likely to have both a short term and a potential long term and inter-generational impact on poverty, unless public policy plays both a prevention and mitigation role. How should policy address the issue?

First, in the short run, interventions aimed at protecting households from large and aggregate shocks have to address the most immediate humanitarian needs and damages in infrastructure, as well as instantaneous loss of income. Second, disaster-aid policies have to be combined with programs that emphasize the prevention of losses of productive human and physical capital. The design of preventive and ex-post safety nets targeting children and ensuring that they stay in school and healthy is a case in point to reduce the impacts on next generations.

Furthermore, the immediate response and transfers made could be designed on an ex ante basis to be triggered in a way to introduce the incentives for changes in behavior needed to achieve more efficient ex-ante risk management and ex-post coping strategies in the short-term. Optimal income diversification, improvements in the use of savings and less reliance on adverse coping strategies (e.g. reductions in consumption, child labor, sell of physical assets) are in principle more effective means to make rural income and human welfare more resilient to natural hazards such as earthquakes and other extreme events, even before they strike. CCT programs could be an instrument of this type (De Janvry, et al., 2008).

Finally, since policies can't be implemented in isolation, it is crucial that policy makers have a clear understanding of the interactions between poverty and institutional/social structures and how they matter for managing natural events in the local context. Policy implications of the study include public investments for the strengthening of information data sets on natural hazards by territorial units, for example. This implies capacity building activities at different levels of government (national, regional, local). Regarding the policy debates on coping mechanisms, the study seems to suggest that livestock holdings could be functioning as a buffer stock in the presence of natural hazards in rural areas, suggesting potential ex-ante public policies to also improve the management of strategic assets of the rural poor.

References

Baez, J. and I. Santos. 2008. "On *Shaky* Ground: The Effects of Earthquakes on Household Income and Poverty", Background paper of the ISDR/RBLAC-UNDP Project on Disaster Risk and Poverty in Latin America.

Baez, J. and I. Santos. 2007. "Children's Vulnerability to Weather Shocks: A Natural Disaster as Natural Experiment, Paper presented at LACEA 2006.

Carter, M., P. Little and T. Mogues. 2007. "Poverty Traps and Natural Disasters in Ethiopia and Honduras." *World Development*, 35(5), 835-856.

CEPAL. 2001a. "El Terremoto del 13 de Enero de 2001 en El Salvador. Impacto Socio-Económico y Ambiental".

CEPAL. 2001b. "El Salvador: Evaluación del Terremoto del Martes 13 de Febrero de 2001".

Charvériat, C. 2000. "Natural Disasters in Latin America and the Caribbean: An Overview of Risk." Working Paper No. 434, Research Department, Inter-American Development Bank, Washington.

De Janvry, A., E. Sadoulet, P. Salomón, and R. Vakis. 2006. "Uninsured Risk and Asset Protection: Can Conditional Cash Transfer Programs Serve as Safety Nets?" SP Discussion Paper No. 0604, World Bank, Washington.

De la Fuente, A., L. F. López-Calva and A. Revi. 2008. "Assessing the Relationship between Natural Hazards and Poverty: A Conceptual and Methodological Proposal", RBLAC-UNDP, mimeo.

Elliot, J. R. and J. Pais. 2006. "Race, Class, and Hurricane Katrina: Social Differences in Human Response to Disasters." *Social Science Research*, 35, 295-321.

Glave, M., R. Fort and C. Rosemberg. 2008. "Disaster Risk and Poverty in Latin America: The Peruvian Case Study", Background paper of the ISDR/RBLAC-UNDP Project on Disaster Risk and Poverty in Latin America, mimeo.

Lindell, M. K. and Prater, C. S. 2003. "Assessing Community Impacts of Natural Disasters." *Natural Hazards Review*, 4(4), 176-185.

López-Calva, Luis F. and E. Rodríguez-Oreggia. 2008. "Methodological Note for the Analysis of the Links between Natural Disasters and Poverty." RBLAC-UNDP, mimeo.

Calero, C., R. Maldonado and A. Molina. 2008. "Disaster Risk and Poverty in Latin America: The Case of Ecuador", Background paper of the ISDR/RBLAC-UNDP Project on Disaster Risk and Poverty in Latin America.

Mansilla, E. 2008a. "Marco general de riesgo en El Salvador", Background paper of the ISDR/RBLAC-UNDP Project on Disaster Risk and Poverty in Latin America, mimeo.

Mansilla, E. 2008b. "Marco general de riesgo en México", Background paper of the ISDR/RBLAC-UNDP Project on Disaster Risk and Poverty in Latin America.

Rodríguez-Oreggia, E., A. de la Fuente and R. de la Torre. 2008. "The Impact of Natural Disasters on Human Development and Poverty at the Municipal Level in Mexico", Background paper of the ISDR/RBLAC-UNDP Project on Disaster Risk and Poverty in Latin America.

Peacock, W. G. and C. Girard. 1997. "Ethnic and Racial Inequalities in Hurricane Damage and Insurance Settlements." In Peacock, W.G., B.H. Morrow and H. Gladwin (eds). Hurricane Andrew: Ethnicity, Gender, and the Sociology of Disasters. Routledge, London.

Pérez de Rada, E. and D. Paz. 2008. "Analysis on Relation between Natural Disaster Risks and Living Conditions: The Case of Bolivia", Background paper of the ISDR/RBLAC-UNDP Project on Disaster Risk and Poverty in Latin America.

Ramírez, F. 2008. "Patrones de manifestaciones de riesgo extensivo en la región Andina: Los casos de Colombia, Ecuador y Bolivia", Background paper of the ISDR/RBLAC-UNDP Project on Disaster Risk and Poverty in Latin America.

Table A1
Summary of empirical analysis from the country case studies

Country	Unit of observation	Impact	Intervention	Natural events	Data	Method
Bolivia	Municipalities	Change in poverty incidence between census (1992-2001)	Risk index	Drought, flood and snow	Cross section	Ordinary Least Squares
	Households	Changes in poverty and inequality between (2006-2007)	Exposure to floods	Floods in Trinidad (2006-2007)	Cross section	Ordinary Least Squares
El Salvador	Households	Changes in households' income	Risk index	Earthquakes (2001)	Panel	Quasi experimental
Peru	Households	Consumption-poverty transitions between (2002-2006)	Natural risk incidence	Natural events incidence	Five-wave balanced panel	Multinomial regression
Ecuador	Municipalities	Changes in poverty incidence between (1990-2001)	Natural events	Landslides, earthquakes, droughts and floods	Geographical panel	Multivariate regression
Mexico	Municipalities	Changes in poverty levels and HDI	Natural events	Hydrological, meteorological and geological	Geographical panel	Adjusted difference in difference

Source: Own elaboration on the basis of the country case studies.

Table A2
Main findings of the empirical analysis from the country case studies

Country	Unit of observation	Results
Bolivia	Municipalities	Schooling contributes on the reduction of poverty incidence. Immigration impact positively on the change of poverty incidence. As the risk is larger, smaller is the improvement in poverty.
	Households	After the flood, poverty in 2007 increased 12 pp compared with 2006 Gini coefficient rose from 0.37 to 0.43 between 2006 and 2007. *Isolating the effect of the flood on wellbeing:* -Schooling is associated with an increase in income of 8.7% (2006) and 6.6% (2007). -Smaller exposure to risk implies a return on income: 5% in 2006 and 7% in 2007. -By the decomposition of Gini index schooling explains inequality on around 77% -District of residence has a contribution on inequality of 9.6% in 2007 (7.4% in 2006).
El Salvador	Households	Before and after the shock there are no differential effects on poverty incidence. However, the earthquakes are associated with a reduction of $1,760 *colones*. Most dangerous effects are related to reductions in human and physical capital. In households exposed the probability of school enrollment decreased by 6 pp. "High-intensity" treated households exhibit relatively higher losses of assets.
Peru	Households	*Given that households have experienced a natural event:* -Households are 2.3-4.8 times more likely to be *always poor* than to be *never poor*. -Increase in livestock holdings reduces the probability of being *always poor*. -Results only hold if consumption, rather than assets, is used to measure poverty. *Occurrence of shocks (increase in one unit the average) reduces consumption*: -For households in the lower quartile of the distribution (2%). -For households in the richer quartile (1.2%).
Ecuador	Municipalities	Seism and droughts seem to have an effect on the changes poverty incidence. Exposure to droughts increases the change in poverty by 2 pp on average. There is no effect on the change in poverty gap and severity.
Mexico	Municipalities	Reduction of .006 on average in the HDI. Increase in the level of poverty: food (3.6 pp), capacities (3 pp) and assets (1.5 pp). *Disaggregating by type of event:* -Droughts reduce the HDI on 0.009 and rains about 0.8 per cent of the HDI. -Floods and droughts increase food poverty in 3.5 and 4.1 pp respectively. -Floods and droughts increase capacities poverty in 2.9 and 3.7 pp respectively. -Floods and droughts increase assets poverty by 1.9 and 2.5 pp respectively.

pp: Percentage points.

Source: Own elaboration on the basis of the country case studies.