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The Impact of Natural Disasters on Human Development and Poverty at the Municipal Level in Mexico♦

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Key words: natural disasters, impact, poverty, human development, geography
JEL classification: C52, I31, 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.

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THE IMPACT OF NATURAL DISASTERS ON HUMAN DEVELOPMENT AND POVERTY AT THE MUNICIPAL LEVEL IN MEXICO

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ABSTRACT

This paper seeks to analyze the impact of natural events on social indicators at the municipal level in Mexico. We focus on the impact of such events on indicators such as the human development index and different poverty levels. We control for a set of geographical and natural characteristics of location which may make more prone for occurrence of these events. We also control for a set of precondition institutional, economic and demographic characteristics to control for heterogeneity. Using an adjusted difference-in-difference regression with data for 2000 and 2005, results show a significant decrease of social indicators for general events, and especially for flood and droughts.

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1. Introduction

During the last years, there has been an increase in the reports of natural disasters. In addition to the global warming discussion which has sparked a stream of literature analyzing what the effects may be, the reality is that we are experiencing an increasing number of natural disasters, and this is also an area still to develop. This issue leads to ask some questions such as: Is there any effect from natural disasters that affect long term indicators such as the Human Development Index? Are those events affecting the levels of poverty in such areas?

To explore these issues, this paper examines data from a database of natural disasters in Mexico (DESINVENTAR) which register all natural events at the local level in Mexico, and using data from other public sources, we aim to shed some light on the natural disasters literature, while focusing on the local development impact. Specifically, we will focus on how natural disasters may affect local social indexes at the municipal level, such as the Human Development Index, and poverty levels, between years 2000 and 2005. Using the natural disaster event as exogenous shock we use a Difference-in-Difference methodology to isolate the impact. In addition, as we are using a variety of municipalities, we control for the heterogeneity of them, and control for variables in natural and geographical aspects, as well as for institutional and local capacity, socioeconomic, and some coping mechanism for localities, to implement a Regression Adjusted Difference-in-Difference.

The paper is structured as follows. Section develops a framework for the analysis of natural disaster in localities and factors that may be taken into account. Section 3 presents the methodology to use, data and model to apply. Section 4 presents the different results. Finally section 5 outlines the conclusions.

2. How natural disasters affect local development?

Natural disasters are a increasingly phenomena that we all clearly perceive and know that may have a direct impact on the welfare of a regions where it hits and also on specific households indicators in such areas. Depending of where we live, hurricanes, earthquakes, floods, droughts, etc, are threats to lives, properties, productive assets, and also can have an impact on social indicators.

The growing incidence of natural disasters is highly correlated to the increasing vulnerability of households and communities in developing countries, as previous socioeconomic vulnerabilities may exacerbate the impact of a natural disaster, making more difficult the process of recovery (Vatsa and Krimgold, 2000). Thus, the impact of such events could result in an immediate increase in poverty and deprivation (Carter et al, 2007). The literature has been even contradictory to some extent. For example Benson and Clay (2003) have argued that the long term impact on growth of natural disasters is negative, while Skidmore and Toya (2002) argue that such disaster may positive impact growth in the long run as there is a reduction to returns o physical capital but an increase in human capital, leading to higher growth. Strobl (2008) for the US coastal regions finds that hurricanes decrease county's growth initially by 0.8 per cent, while recovering after in 0.2 per cent. This author also finds for Central America and the Caribbean that the impact from a destructive hurricane is a reduction of 0.8 percent of growth (Strobl, 2008a).

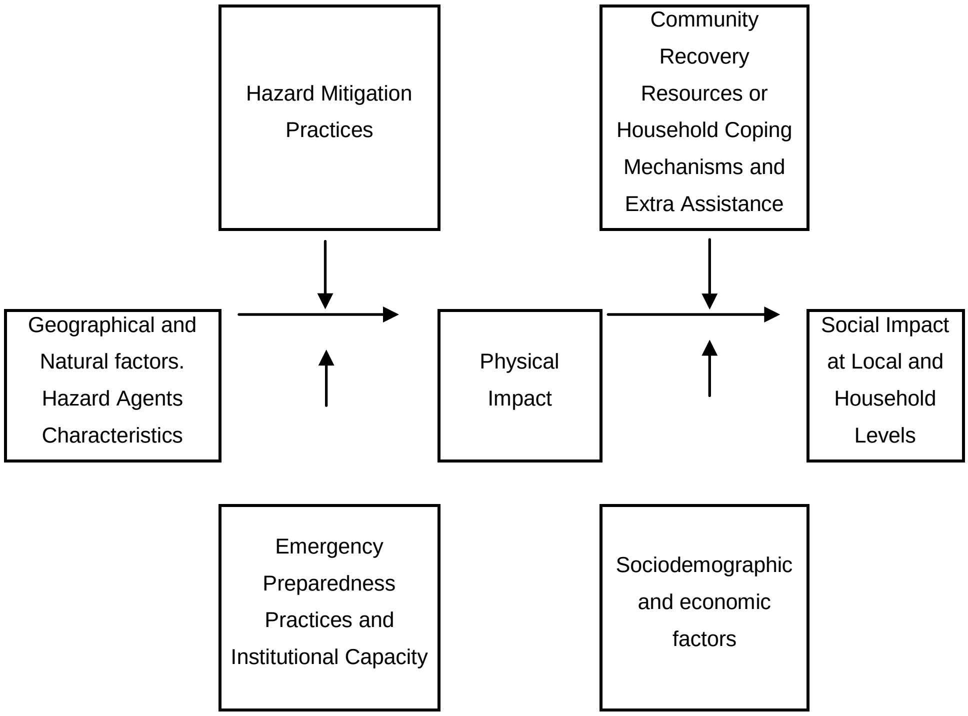
The impact of a natural disaster may also cause inequalities. The poor, who suffer from income fluctuations, and also have limited access to financial services, in the aftermath of a disaster may be more prone to reduce consumption and have a decreasing shock in other household indicators as a consequence. In addition, there are a number of non poor, or close to be, who are not insured against from those risks, and then may fall into poverty as consequence of decapitalizing when coping with the shock, depending the impact and likelihood of falling into poverty of the initial stock assets and coping mechanisms.

Moreover, vulnerability to natural disasters is a complex issue, as it is determined by the economic structure, the stage of development, prevailing of social and economic conditions, coping mechanism, risk assessment, frequency and intensity of disasters, etc. The impact on the poor could be losing access to some basic services, reversals in accumulation of physical and human capital, and perhaps an increase in child labor and criminal activities.

Lindell and Prater (2003) outline the importance of determining the impact and the affected agents in natural disasters. First, that information is useful for policy makers, as they can know the need for external assistance and which may be more effective; second, specific segments of affected can be identified, e.g. how low income household are affected, etc); and third, it may be also useful for planning assistance for natural disasters and the potential consequences.

One of the main questions regarding the impact of natural disaster on households or localities is how random they may be. Lindell and Prater (2003) also outline how the impact of natural disasters should take into account other mechanisms, such as mitigation practices emergency preparedness, assistance, etc, to determine the real impact. In addition, Donner (2007), analyzed the effects of tornadoes in the US and found that the effect are not random, because some factors such as environmental, organization, demographic, and technological, have an incidence on the impact of such events.

Figure 1. Model of Disaster Impact



Source: Adapted from Lindell and Prater (2003)

How authorities have specific practices regarding natural disasters and how they organize help in the aftermath can also be determinant of the impact. For example, Peacok and Girard (1997) document how the recovery process after hurricane Andrew in Florida was determined more by organizational impediments rather than lack of resources. Also, class and racial issues may be determinant on the impact of the disaster and the recovery process, as shown by Elliot and Pais (2006) for hurricane Katrina.

The availability of some mechanisms that can be used for coping when natural disasters occurs may make a difference on the magnitude of the impact on social indicators at local and household levels. For example, De Janvry et al (2006) shows that conditional cash transfers availability previous to a disaster serve as a safety net for those exposed to the disaster, while those uninsured and vulnerable non extremely poor use as coping mechanism an increase in child labor, and savings in nutrition and school costs. Alpizar (2007) also finds that access to formal financial services mitigates the negatives effects from natural disaster shocks for farmers in El Salvador, as it leads to more efficient production. Even Kahn (2005) and Toya and Skidmore (2007) find that institutions, higher education and trade openness, as well as strong financial sector and smaller governments are important determining the impact that natural disasters have on development at the international level.

Latin America is a region prone to natural disasters and the consequences are still to be understood given that new databases are emerging. For example, Auffret (2003) found that the impact of natural disaster on Latin America and the Caribbean is very significant, especially for the Caribbean the volatility of consumption is higher than in other regions of the world, where inadequate risk-management mechanisms have been available in the region. The geographical conditions of the continent make it more prone to natural events of severe intensity, but also part of the impact derives from the vulnerability derived from levels of socioeconomic development and the inadequate risk management (Charveriat, 2000). Thus, in addition to the fact that the region has been constantly hit by several natural disasters, as hurricanes, drought, floods and earthquakes,[1] which together with the fact that poverty and inequality are recurrent make of this area an interesting field for the analysis of welfare related issues to natural disaster shocks.

Mexico is not an exception. During the last years it has been constantly damaged by a sequence of natural disasters, especially by hurricanes, heavy rains and floods, droughts and frosts, all around the country. A list of some of the hard hit natural disasters occurred in the last years can be found in FCCT (2007). However, there are not many studies focusing on the impact on social indicators, besides the mentioned study by De Janvry et al (2004) on the poor and their public transfers. Next section presents the methodology and used data.

3. Methodology, Data and Variables

Methodology

We have about 2454 municipalities, from which several have occurrence of a natural disaster, while others do not. This allows for comparisons between different treatment groups and control groups, assuming that disasters introduce an exogenous shock to social indicators at the local level.

Few studies have analyzed the impact at the local level caused by natural disasters, and mostly they focus on villages effects with impact at the household level (see for example Dercon, 2004 and 2005). The idea here in this paper is to separate the effects that a shock introduced by the natural disaster may have on local social indicators such as the Human Development Index, and poverty levels.

Taking advantage of the natural disaster as a shock, we will use a Difference in Difference specification, in the following way:

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[1] For example Charveriat (2000) reports an average of 32.4 disasters per year in Latin America and the Caribbean for the decade of nineties.

$$(1)\quad Y_{jt}=\alpha_0+\alpha_1 T_i+\alpha_2 D_t+\alpha_3 T_i D_t+\alpha_4 X_{jt}+u_{jt}$$

Where Y denotes the indicator for a social variable (HDI or poverty level) in municipality i at time t. T denotes a dummy for areas considered treatment, i.e. municipalities with an incidence of a natural disaster; D_t is a dummy variable taking the value of 1 after the natural disaster occurs, X is a set of characteristics of the area. The term α_3 measures the impact of a natural disaster on the outcome variable Y. Treatment (T) can be defined as those areas that will suffer from a natural disaster in the period covered by the data.

However, this specification assumes that municipalities under treatment and control are similar in every way except in that control suffer from a natural disaster. As we are taking the whole municipalities, this assumption may be difficult to hold. To the extent that there is a different trend in time for treatment and control groups, failing for the trend parallel assumption, and thus causing the DiD estimation to be biased.

Following Hotz, Imbens and Klerman (2000 and 2006), we use the heterogeneity in the sample, exploiting the experimental data on the control group, and therefore they show this is a more reliable non-experimental estimator of the differential effects of municipalities with treatment and those who are under control. Adjustment trough pre-shock variables allows the data for the control group to empirically adjust for across-shocks differences in population and treatment component assigned mechanisms, helping in this way to isolate a consistent estimate of α_3. These authors show that this is a more conservative method for estimating than in other method which derive in similar results such as those non parametric versions of the same equation based on matching methods. The equation then becomes:

$$(2)\quad Y_{jt}=\alpha_0+\alpha_1 T_i+\alpha_2 D_t+\alpha_3 T_i D_t+\alpha_4 X_{jt}+\alpha_5 T_i X_{jt}+u_{jt}$$

We will include in X different sets of variables for which municipalities may be more heterogeneous in their response to a shocks from a natural disaster and also for responding to the levels of social indicators of interest, or making the municipality more prone to natural disasters. Thus in the next subsection we present the sets of variables, their sources, and basic statistics.

Data and Variables

We are using data from different sources. We are interested in dependent variables such as the Human Development Index (HDI), as published by the UNDP at the municipal level for years 2000 and 2005, and also the poverty levels in three definitions (food, capacities, assets) as published by CONEVAL also for 2000 and 2005 at the municipal level.

Data for natural disaster are gathered and classified from DESINVENTAR database, which has gathered a number of natural events in municipalities following reports in all media. A description of this database is in the annexes.

A potential drawback is that we have to use all disasters together. Thus, in a first step we will include a dummy variable for disasters in general, where the comparisons are those municipalities without any natural event. In a second stage we divide the events in categories, where the comparisons again are municipalities without disasters. And finally we will restrict the sample to those municipalities with disasters, where the comparison groups are municipalities with other categories of disasters.

The geographical distribution of natural disasters is shown in the Maps in the Annexes. Where we can see that some patterns can be seen but they do not seem to be too strong in some cases. For example, floods events seems to be distributes all around the country, droughts seem to be more concentrated to some extent in the north areas of the country, while frosts also seem to be concentrated in the north, finally rains seem to be concentrated in northern and southern areas mostly in coastal zones.

Dependent variables are categorized following the framework outlined in Figure 1 above. In this way we have natural hazard characteristics of localities under the classification of Geography and Nature, where we include latitude, altitude, length, arid and semiarid areas, deforestation rates, maximum and minimum temperatures and rain. Data is for years previous to 2000. In this way, we control for similar characteristics regarding natural factors that may affect the development of a natural disaster.

We also consider the hazard mitigation practices, as well as the emergency preparedness under the category of Institutional /Local Capacity. Here we include a set of variables that may affect the response capacity of local governments to respond to natural events, or that may affect the impact of an event, such as municipal regulations and plan regarding contingencies, and also if they have a hazard map, if they receive consultancy from NGOs or other national or international organizations, and the share of own local financial resources.

In addition we also control for initial conditions of factors that may affect the vulnerability of population to natural disasters. Here we include variable such as rurality, economic dependence rate in the locality, population with social security, the share of indigenous population, the gini index, and employees at different economic sectors. The last columns in each table include also dummies for state level effects.

All basic statistics are presented in the next Table.

Table 1

Descriptive statistics	Mean	Std. Dev.	Min	Max
Dependent				
HDI *	0.7079	0.0758	0.3915	0.9165
Food poverty incidence*	0.4438	0.2423	0.0160	0.9680
Capacities poverty incidence*	0.5141	0.2427	0.0280	0.9810
Assets poverty incidence*	0.6828	0.2119	0.0920	0.9950
Natural Disasters Occurrence				
Any event /2	0.4234	0.4942	0	1
Flood /2	0.2326	0.4226	0	1
Frost /2	0.0835	0.2768	0	1
Drought /2	0.0831	0.2761	0	1
Rains /2	0.0811	0.2730	0	1
Landslide /2	0.0590	0.2356	0	1
Others /2	0.1716	0.3771	0	1
Geography and Nature				
Altitude *	1304	819	2	2924
Latitude *	198388	33461	143827	322993
Length *	985658	43623	865878	1166813
Arid surface *	6.49	17.04	0.00	97.50
Semiarid surface*	16.38	20.22	0.00	72.50
Deforestation rate *	-18.27	17.89	-62.57	-0.56
Minimum temperature *	7.25	5.74	0.00	24.00
Maximum temperature *	27.46	2.90	16.00	30.00
Minimum rain*	15.76	10.17	1.50	57.40
Maximum rain *	175.78	51.93	8.00	315.50
Socioeconomic				
Rural municipalities **	0.8350	0.3713	0.0000	1.0000
Economic dependency rate *	0.8333	0.1693	0.3945	2.3700
Population with social security **	0.2148	0.1824	0.0000	0.8055
Population living in the same state 5 years before **	0.9677	0.0252	0.6714	1.0000
Indigenous population **	0.0379	0.0993	0.0000	0.7682
Gini coefficient*	0.4044	0.0556	0.1955	0.5978
Employed at primary sector ** /1	0.1284	0.0781	0.0005	0.5533
Employed at secondary sector ** /1	0.0705	0.0458	0.0000	0.3461
Employed at tertiary sector ** /1	0.0968	0.0618	0.0023	0.4098
Coping Funds and Covariates				
With CENAPRED resources 2000-2005 **	0.8014	0.3990	0.0000	1.0000
Same political party at municipal and state level when hazard occur	0.0348	0.1833	0	1
Same political party at municipal and federal level when hazard occur	0.0168	0.1285	0	1
Institutional/Local Capacity				
NGO for consultation or courses	0.2645	0.4412	0	1
Seminar attendance	0.1716	0.3771	0	1
No NGO	0.3014	0.4590	0	1
Associated services	0.2158	0.4115	0	1
Municipal regulations	0.2121	0.4089	0	1
Municipal development plan	0.7211	0.4485	0	1
Civil defense unit	0.5733	0.4947	0	1
Civil defense program	0.4607	0.4986	0	1
Natural contingency in tne 1990s	0.5909	0.4918	0	1
Hazard map	0.3055	0.4607	0	1
Tax resources **	6.4960	8.1633	0	90
Federal resources **	40.9682	19.8749	0	100

Notes: *average ** proportion. /1 Relative to total population. / 2 between 2000-2005. Data for year 2000 exceptt coping
Sources: UNDP (2008), CONEVAL (2008), CONTEO 2005 (ITER), CENSO 2000. CNA (2007). INEGI (2008), CENAPRED (2008). Data on deforestation came from FAO indicators in Davis, R. (2007).

4. Results

We apply equation 2 in order to calculate the impact of natural disasters on the Human Development Index, and the three levels of poverty all at the municipal level. The sample consists of 2418 municipalities with HDI and 2443 municipalities with poverty levels. In the next tables we present the results for the Difference-in-Difference coefficients. In addition, we have run different specifications using different sets of controls. All specifications have dummy variables at the state level in the last two runs.

Table 2 displays results for aggregated natural disasters events, which comprises any type of natural event in the period 2000-2005 in the locality. In general, controlling for different sets of variables, and their interactions with the treatment variable, has little effect on the impact coefficient, which is about -0.0069 on average of the Human Development Index. That is, in localities where a given natural disaster occurred in that period, there is a decrease of 0.006, which represents about 0.8 percent of the average Human Development Index.

Table 2

Results of Impact of Aggregated Natural Disasters on Municipal Indicators

General impact of natural hazards

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
IDH	-0.00691*	-0.00691*	-0.00691*	-0.00692***	-0.00694***	-0.00691**	-0.00691**	-0.00689***	-0.00689***
	(0.00406)	(0.00357)	(0.00353)	(0.00176)	(0.00175)	(0.00329)	(0.00327)	(0.00174)	(0.00174)
Adjusted R-squared	0.134	0.331	0.344	0.837	0.839	0.432	0.438	0.841	0.842
FGT0 PL1	0.0369***	0.0369***	0.0369***	0.0366***	0.0367***	0.0369***	0.0369***	0.0367***	0.0367***
	(0.0124)	(0.0102)	(0.0100)	(0.00585)	(0.00580)	(0.00953)	(0.00951)	(0.00571)	(0.00570)
Adjusted R-squared	0.094	0.392	0.404	0.798	0.802	0.464	0.467	0.808	0.808
FGT0 PL2	0.0304**	0.0304***	0.0304***	0.0299***	0.0301***	0.0304***	0.0304***	0.0300***	0.0300***
	(0.0127)	(0.0102)	(0.0101)	(0.00580)	(0.00575)	(0.00958)	(0.00956)	(0.00564)	(0.00564)
Adjusted R-squared	0.079	0.399	0.411	0.807	0.810	0.472	0.475	0.817	0.817
FGT0 PL3	0.0161	0.0161*	0.0161*	0.0153***	0.0154***	0.0161*	0.0161*	0.0154***	0.0154***
	(0.0113)	(0.00898)	(0.00889)	(0.00522)	(0.00520)	(0.00843)	(0.00842)	(0.00504)	(0.00503)
Adjusted R-squared	0.042	0.400	0.412	0.797	0.799	0.471	0.473	0.811	0.811
Natural Disasters Occurrence	yes	yes	yes	yes	yes	yes	yes	yes	yes
Geography and Nature		yes	yes	yes	yes	yes	yes	yes	yes
Socioeconomic				yes	yes	yes	yes	yes	yes
Coping Funds and Covariates						yes	yes	yes	yes
Institutional/Local Capacity								yes	yes

***** p<0.01, ** p<0.05, * p<0.1**
Standard errors in parentheses

In the lower panels of Table 2, we can find results for the impact of aggregated natural events on the different measures of the poverty levels. For the food poverty levels, there is an increase of about 3.6 percentage points, which means on average for municipalities with a disasters they experience an increase of about eight per cent in their food poverty level during the period due to the natural events.

The impact on capacities poverty is of an increase of about 3 percentage points, which represents about 5.8 percent increase on average or municipalities with natural events. Regarding the impact on the assets poverty level, we find that natural events in general increase this indicator by about 1.6 percentage points, which is about a 2.3 per cent increase in that level.

Table 3 shows results for the impact disaggregating for different types of events. Results shows that from the variety of natural events, droughts reduce HDI in about 0.0096, representing on average 1.3 per cent of the index. The impact of rain is not constant though the different specifications, although in some is significant but positive. Other disasters[2] have also a significant decrease of 0.008 of the HDI, representing about 1 per cent of decrease for such index.

Table 3

Results of Impact of Specific Natural Disasters on Municipal Indicators, HDI

Impacts on HDI by type of natural hazard

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Flood	-0.00282	-0.00282	-0.00282	-0.00283	-0.00285	-0.00282	-0.00282	-0.00282	-0.00281
	(0.00488)	(0.00432)	(0.00424)	(0.00221)	(0.00219)	(0.00403)	(0.00402)	(0.00218)	(0.00218)
Frost	-0.00503	-0.00503	-0.00503	-0.00503	-0.00503	-0.00503	-0.00503	-0.00503	-0.00503
	(0.00731)	(0.00647)	(0.00635)	(0.00330)	(0.00329)	(0.00603)	(0.00601)	(0.00326)	(0.00326)
Drought	-0.00969	-0.00969	-0.00969	-0.00970***	-0.00971***	-0.00969	-0.00969	-0.00967***	-0.00967***
	(0.00730)	(0.00647)	(0.00635)	(0.00330)	(0.00328)	(0.00602)	(0.00601)	(0.00326)	(0.00326)
Rains	0.00646	0.00646	0.00646	0.00646*	0.00646**	0.00646	0.00646	0.00645**	0.00645**
	(0.00732)	(0.00648)	(0.00636)	(0.00331)	(0.00329)	(0.00604)	(0.00602)	(0.00327)	(0.00326)
Landslide	0.00452	0.00452	0.00452	0.00452	0.00452	0.00452	0.00452	0.00451	0.00451
	(0.00832)	(0.00737)	(0.00723)	(0.00376)	(0.00374)	(0.00686)	(0.00684)	(0.00371)	(0.00371)
Others	-0.00806	-0.00806*	-0.00806*	-0.00806***	-0.00808***	-0.00806*	-0.00806*	-0.00805***	-0.00805***
	(0.00549)	(0.00486)	(0.00477)	(0.00248)	(0.00247)	(0.00453)	(0.00452)	(0.00245)	(0.00245)
Adjusted R-squared	0.208	0.379	0.402	0.838	0.840	0.461	0.465	0.842	0.843
Geography and Nature		yes	yes	yes	yes	yes	yes	yes	yes
Socioeconomic				yes	yes	yes	yes	yes	yes
Coping Funds and Covariates						yes	yes	yes	yes
Institutional/Local Capacity								yes	yes

***** p<0.01, ** p<0.05, * p<0.1**
Standard errors in parentheses. N=4836

Regarding the impact on poverty levels, we find in Table 4 the impact for the severe poverty, or PL1, where the incidence of floods increase severe poverty, or food poverty, in 0.035 percentage points. The incidence of droughts increase food poverty in 0.042 percentage points, while other disasters are significant and represents an increase of

[2] Avalanche, eruption, hailstorm, surge, snowstorm, earthquake, electric storm, tornado, strong winds.

about 0.03 percentage points in the food poverty. The other types of disasters are not significant.

Table 4

Results of Impact of Specific Natural Disasters on Municipal Indicators, PL1

Impacts on FGT PL 1 by type of natural hazard

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Flood	0.0354**	0.0354***	0.0354***	0.0351***	0.0352***	0.0354***	0.0354***	0.0351***	0.0351***
	(0.0150)	(0.0124)	(0.0122)	(0.00728)	(0.00724)	(0.0117)	(0.0117)	(0.00713)	(0.00712)
Frost	-0.0107	-0.0107	-0.0107	-0.0105	-0.0105	-0.0107	-0.0107	-0.0105	-0.0105
	(0.0226)	(0.0186)	(0.0183)	(0.0109)	(0.0109)	(0.0176)	(0.0175)	(0.0107)	(0.0107)
Drought	0.0424*	0.0424**	0.0424**	0.0417***	0.0418***	0.0424**	0.0424**	0.0417***	0.0417***
	(0.0225)	(0.0186)	(0.0183)	(0.0109)	(0.0108)	(0.0176)	(0.0175)	(0.0107)	(0.0107)
Rains	-0.00198	-0.00198	-0.00198	-0.00151	-0.00154	-0.00198	-0.00198	-0.00152	-0.00152
	(0.0225)	(0.0186)	(0.0183)	(0.0109)	(0.0108)	(0.0175)	(0.0175)	(0.0107)	(0.0107)
Landslide	-0.0123	-0.0123	-0.0123	-0.0117	-0.0117	-0.0123	-0.0123	-0.0117	-0.0117
	(0.0257)	(0.0212)	(0.0209)	(0.0124)	(0.0124)	(0.0200)	(0.0200)	(0.0122)	(0.0122)
Others	0.0341**	0.0341**	0.0341**	0.0337***	0.0338***	0.0341***	0.0341***	0.0338***	0.0338***
	(0.0169)	(0.0140)	(0.0138)	(0.00819)	(0.00814)	(0.0132)	(0.0132)	(0.00802)	(0.00801)
Adjusted R-squared	0.160	0.427	0.445	0.803	0.806	0.490	0.492	0.811	0.812
Geography and Nature		yes	yes	yes	yes	yes	yes	yes	yes
Socioeconomic				yes	yes	yes	yes	yes	yes
Coping Funds and Covariates						yes	yes	yes	yes
Institutional/Local Capacity								yes	yes

***** p<0.01, ** p<0.05, * p<0.1**

Standard errors in parentheses. N=4886

In Table 5 we can find results for the impact on the medium poverty level, or capacity poverty. Again, the relevant disasters are flood, droughts and others. The incidence of floods produces an increase of about 0.029 percentage points, while drought increase about 0.037 percentage points, and others disasters about 0.029 this poverty line.

Table 5

Results of Impact of Specific Natural Disasters on Municipal Indicators, PL2

Impacts on FGT PL 2 by type of natural hazard

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Flood	0.0297*	0.0297**	0.0297**	0.0292***	0.0293***	0.0297**	0.0297**	0.0293***	0.0293***
	(0.0154)	(0.0125)	(0.0123)	(0.00723)	(0.00720)	(0.0118)	(0.0118)	(0.00706)	(0.00705)
Frost	-0.00832	-0.00832	-0.00832	-0.00802	-0.00801	-0.00832	-0.00832	-0.00801	-0.00801
	(0.0231)	(0.0188)	(0.0185)	(0.0108)	(0.0108)	(0.0177)	(0.0177)	(0.0106)	(0.0106)
Drought	0.0385*	0.0385**	0.0385**	0.0376***	0.0377***	0.0385**	0.0385**	0.0376***	0.0376***
	(0.0230)	(0.0188)	(0.0185)	(0.0108)	(0.0108)	(0.0177)	(0.0176)	(0.0106)	(0.0106)
Rains	-0.00705	-0.00705	-0.00705	-0.00644	-0.00646	-0.00705	-0.00705	-0.00645	-0.00645
	(0.0230)	(0.0188)	(0.0185)	(0.0108)	(0.0108)	(0.0177)	(0.0176)	(0.0106)	(0.0106)
Landslide	-0.0105	-0.0105	-0.0105	-0.00970	-0.00974	-0.0105	-0.0105	-0.00972	-0.00972
	(0.0262)	(0.0214)	(0.0210)	(0.0123)	(0.0123)	(0.0201)	(0.0201)	(0.0121)	(0.0120)
Others	0.0292*	0.0292**	0.0292**	0.0287***	0.0287***	0.0292**	0.0292**	0.0287***	0.0287***
	(0.0173)	(0.0141)	(0.0139)	(0.00813)	(0.00809)	(0.0133)	(0.0132)	(0.00794)	(0.00793)
Adjusted R-squared	0.145	0.431	0.450	0.811	0.812	0.496	0.498	0.819	0.820
Geography and Nature		yes	yes	yes	yes	yes	yes	yes	yes
Socioeconomic				yes	yes	yes	yes	yes	yes
Coping Funds and Covariates						yes	yes	yes	yes
Institutional/Local Capacity								yes	yes

***** p<0.01, ** p<0.05, * p<0.1**

Standard errors in parentheses. N=4886

Table 6 shows results regarding the impact on the assets poverty, which comprises also the previous two poverty measures. In a consistent manner, floods, droughts and others also are significantly increasing the assets poverty line. The incidence of floods increases assets poverty in 0.019 percentage points, while droughts increase that poors in about 0025, and others is not significant in all specifications but is about 0.013 when significant.

Table 6

Results of Impact of Specific Natural Disasters on Municipal Indicators, PL3

Impacts on FGT PL 3 by type of natural hazard	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Flood	0.0196	0.0196*	0.0196*	0.0189***	0.0189***	0.0196*	0.0196*	0.0189***	0.0189***
	(0.0138)	(0.0111)	(0.0109)	(0.00655)	(0.00653)	(0.0105)	(0.0104)	(0.00633)	(0.00632)
Frost	-0.000652	-0.000652	-0.000652	-0.000221	-0.000209	-0.000652	-0.000652	-0.000212	-0.000212
	(0.0208)	(0.0166)	(0.0163)	(0.00982)	(0.00979)	(0.0157)	(0.0157)	(0.00949)	(0.00948)
Drought	0.0271	0.0271	0.0271*	0.0256***	0.0257***	0.0271*	0.0271*	0.0256***	0.0256***
	(0.0207)	(0.0166)	(0.0163)	(0.00981)	(0.00978)	(0.0157)	(0.0156)	(0.00948)	(0.00947)
Rains	-0.0143	-0.0143	-0.0143	-0.0134	-0.0135	-0.0143	-0.0143	-0.0135	-0.0134
	(0.0207)	(0.0166)	(0.0163)	(0.00981)	(0.00978)	(0.0156)	(0.0156)	(0.00947)	(0.00946)
Landslide	-0.0138	-0.0138	-0.0138	-0.0126	-0.0126	-0.0138	-0.0138	-0.0126	-0.0126
	(0.0236)	(0.0189)	(0.0186)	(0.0112)	(0.0111)	(0.0178)	(0.0178)	(0.0108)	(0.0108)
Others	0.0143	0.0143	0.0143	0.0135*	0.0136*	0.0143	0.0143	0.0136*	0.0136*
	(0.0156)	(0.0125)	(0.0123)	(0.00737)	(0.00734)	(0.0118)	(0.0117)	(0.00711)	(0.00711)
Adjusted R-squared	0.102	0.425	0.444	0.799	0.800	0.488	0.490	0.812	0.813
Geography and Nature		yes	yes	yes	yes	yes	yes	yes	yes
Socioeconomic				yes	yes	yes	yes	yes	yes
Coping Funds and Covariates						yes	yes	yes	yes
Institutional/Local Capacity								yes	yes

***** p<0.01, ** p<0.05, * p<0.1**
Standard errors in parentheses. N=4886

Even though the methodology described above reduces the heterogeneity among municipalities, we are also trying to test the robustness of the impacts obtained above and restricting the sample to obtain calculations only for municipalities with an event of a natural disaster. This reduces the sample to 1031 municipalities with HDI, and to 1034 with poverty levels. In this way, we get a more compact sample for comparison, and the comparison group is the dummy for other disasters, and applying the same specifications than before.

Table 7

Results of Impact of Specific Natural Disasters on Municipal Indicators. Only Municipalities with Disasters.

Impacts on HDI by type of hazard (alternative specifications)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Flood	-0.000537	-0.000537	-0.000537	-0.000540	-0.000540	-0.000537	-0.000537	-0.000533	-0.000533
	(0.00592)	(0.00543)	(0.00543)	(0.00249)	(0.00249)	(0.00493)	(0.00493)	(0.00244)	(0.00243)
Frost	-0.00453	-0.00453	-0.00453	-0.00453	-0.00453	-0.00453	-0.00453	-0.00454	-0.00454
	(0.00747)	(0.00685)	(0.00685)	(0.00314)	(0.00314)	(0.00622)	(0.00622)	(0.00307)	(0.00307)
Drought	-0.00883	-0.00883	-0.00883	-0.00885***	-0.00885***	-0.00883	-0.00883	-0.00882***	-0.00882***
	(0.00745)	(0.00684)	(0.00684)	(0.00314)	(0.00314)	(0.00621)	(0.00621)	(0.00307)	(0.00306)
Rains	0.00722	0.00722	0.00722	0.00723**	0.00723**	0.00722	0.00722	0.00721**	0.00721**
	(0.00741)	(0.00680)	(0.00680)	(0.00312)	(0.00312)	(0.00617)	(0.00617)	(0.00305)	(0.00304)
Landslide	0.00518	0.00518	0.00518	0.00520	0.00520	0.00518	0.00518	0.00517	0.00517
	(0.00842)	(0.00773)	(0.00773)	(0.00354)	(0.00354)	(0.00702)	(0.00702)	(0.00347)	(0.00346)
Adjusted R-squared	0.218	0.341	0.341	0.861	0.861	0.457	0.457	0.867	0.868
Geography and Nature		yes	yes	yes	yes	yes	yes	yes	yes
Socioeconomic				yes	yes	yes	yes	yes	yes
Coping Funds and Covariates						yes	yes	yes	yes
Institutional/Local Capacity								yes	yes

***** p<0.01, ** p<0.05, * p<0.1**

Standard errors in parentheses. N=2062

Impacts on FGT PL 1 by type of hazard (alternative specifications)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Flood	0.0412***	0.0326**	0.0326**	0.0324***	0.0324***	0.0326**	0.0326**	0.0324***	0.0324***
	(0.0149)	(0.0150)	(0.0150)	(0.00820)	(0.00820)	(0.0139)	(0.0139)	(0.00812)	(0.00810)
Frost	-0.00313	-0.00851	-0.00851	-0.00827	-0.00827	-0.00851	-0.00851	-0.00825	-0.00824
	(0.0224)	(0.0190)	(0.0190)	(0.0104)	(0.0104)	(0.0176)	(0.0176)	(0.0103)	(0.0102)
Drought	0.0474**	0.0426**	0.0426**	0.0420***	0.0420***	0.0426**	0.0426**	0.0420***	0.0420***
	(0.0226)	(0.0189)	(0.0189)	(0.0103)	(0.0103)	(0.0175)	(0.0175)	(0.0102)	(0.0102)
Rains	0.00224	-0.00193	-0.00193	-0.00147	-0.00147	-0.00193	-0.00193	-0.00143	-0.00143
	(0.0226)	(0.0188)	(0.0188)	(0.0103)	(0.0103)	(0.0174)	(0.0174)	(0.0101)	(0.0101)
Landslide	-0.00624	-0.0111	-0.0111	-0.0105	-0.0105	-0.0111	-0.0111	-0.0105	-0.0105
	(0.0257)	(0.0214)	(0.0214)	(0.0117)	(0.0117)	(0.0198)	(0.0198)	(0.0116)	(0.0115)
Adjusted R-squared	0.149	0.405	0.405	0.823	0.823	0.491	0.491	0.826	0.827
Geography and Nature		yes	yes	yes	yes	yes	yes	yes	yes
Socioeconomic				yes	yes	yes	yes	yes	yes
Coping Funds and Covariates						yes	yes	yes	yes
Institutional/Local Capacity								yes	yes

***** p<0.01, ** p<0.05, * p<0.1**

Standard errors in parentheses. N=2068

Impacts on FGT PL 2 by type of hazard (alternative specifications)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Flood	0.0279	0.0279*	0.0279*	0.0277***	0.0277***	0.0279**	0.0279**	0.0277***	0.0277***
	(0.0182)	(0.0153)	(0.0153)	(0.00833)	(0.00833)	(0.0141)	(0.0141)	(0.00817)	(0.00816)
Frost	-0.00601	-0.00601	-0.00601	-0.00568	-0.00568	-0.00601	-0.00601	-0.00567	-0.00567
	(0.0229)	(0.0193)	(0.0193)	(0.0105)	(0.0105)	(0.0178)	(0.0178)	(0.0103)	(0.0103)
Drought	0.0391*	0.0391**	0.0391**	0.0383***	0.0383***	0.0391**	0.0391**	0.0382***	0.0382***
	(0.0229)	(0.0193)	(0.0193)	(0.0105)	(0.0105)	(0.0178)	(0.0178)	(0.0103)	(0.0103)
Rains	-0.00670	-0.00670	-0.00670	-0.00608	-0.00608	-0.00670	-0.00670	-0.00605	-0.00604
	(0.0227)	(0.0191)	(0.0191)	(0.0104)	(0.0104)	(0.0176)	(0.0176)	(0.0102)	(0.0102)
Landslide	-0.00918	-0.00918	-0.00918	-0.00836	-0.00836	-0.00918	-0.00918	-0.00832	-0.00832
	(0.0259)	(0.0218)	(0.0218)	(0.0119)	(0.0119)	(0.0201)	(0.0201)	(0.0116)	(0.0116)
Adjusted R-squared	0.169	0.412	0.412	0.825	0.825	0.499	0.499	0.832	0.832
Geography and Nature		yes	yes	yes	yes	yes	yes	yes	yes
Socioeconomic				yes	yes	yes	yes	yes	yes
Coping Funds and Covariates						yes	yes	yes	yes
Institutional/Local Capacity								yes	yes

***** p<0.01, ** p<0.05, * p<0.1**

Standard errors in parentheses. N=2068

Impacts on FGT PL 3 by type of hazard (alternative specifications)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Flood	0.0195	0.0195	0.0195	0.0191**	0.0191**	0.0195	0.0195	0.0191**	0.0191**
	(0.0167)	(0.0137)	(0.0137)	(0.00814)	(0.00814)	(0.0128)	(0.0128)	(0.00778)	(0.00777)
Frost	0.000982	0.000982	0.000982	0.00150	0.00150	0.000982	0.000982	0.00151	0.00151
	(0.0211)	(0.0174)	(0.0174)	(0.0103)	(0.0103)	(0.0161)	(0.0161)	(0.00982)	(0.00982)
Drought	0.0278	0.0278	0.0278	0.0265***	0.0265***	0.0278*	0.0278*	0.0265***	0.0265***
	(0.0211)	(0.0173)	(0.0173)	(0.0103)	(0.0103)	(0.0161)	(0.0161)	(0.00980)	(0.00979)
Rains	-0.0138	-0.0138	-0.0138	-0.0128	-0.0128	-0.0138	-0.0138	-0.0128	-0.0128
	(0.0209)	(0.0172)	(0.0172)	(0.0102)	(0.0102)	(0.0160)	(0.0160)	(0.00972)	(0.00972)
Landslide	-0.0127	-0.0127	-0.0127	-0.0114	-0.0114	-0.0127	-0.0127	-0.0114	-0.0114
	(0.0238)	(0.0196)	(0.0196)	(0.0116)	(0.0116)	(0.0182)	(0.0182)	(0.0111)	(0.0111)
Adjusted R-squared	0.123	0.407	0.407	0.792	0.792	0.489	0.489	0.810	0.811
Geography and Nature		yes	yes	yes	yes	yes	yes	yes	yes
Socioeconomic				yes	yes	yes	yes	yes	yes
Coping Funds and Covariates						yes	yes	yes	yes
Institutional/Local Capacity								yes	yes

***** p<0.01, ** p<0.05, * p<0.1**

Standard errors in parentheses. N=2068

Here, for the HDI impact we only get a significant coefficient of 0-.0088, compared to municipalities with other disasters. Although this coefficient is compared to the average municipality with a disaster, instead of the average municipality as in Table 3, the coefficients are very similar in magnitud. The impact on the poverty measures shed that floods increase about 0.032 the food poverty, 0.027 the capacities poverty and 0.019 the assets poverty, compared to average municipalities with other type of disasters. Consistently, also droughts have a significant impact on increasing poverty which is about 0.042 for food poverty, 0.038 for capacities, ad 0.026 for assets poverty measures, being also similar to the coefficients obtained with the whole sample.

In addition, we want to know the extent to which the impact are different regarding how different are in the distribution of the social indicators of interest (Koenker and Basset, 1978). For that reason, we also implemented equation 2 using quantile regression, which provides with different coefficients according to different points in the conditional distribution.

Table 8 displays results for the differential impact at the different quantile levels, and the presented results are those using the full model as explained above. In general results show that for the HDI, disaggregating at quartiles of the HDI shows that for the lower quartile the impact is the average for the general impact shown in Table 2 above, and as expected, the higher the level of the HDI, the lower the impact on decreasing such indicator. Thus, it seems that the impact of natural disasters is higher for those with lower social indicators. This is to some extent similar to evidence at the international level, where developing countries experience a higher shock from a natural disaster in macro indicators, compare to developed countries (Noy, 2009).

Table 8

General impacts on human development and poverty by quartile

	HDI	PL 1	PL 2	PL 3
q 20	-.0060769**	.04743***	.04368***	.025294***
	(.0025232)	(.008180)	(.008458)	(.008047)
	[0.6456]	[0.5481]	[0.5746]	[0.6065]
q 40	-.0049387**	.04063***	.032889***	.019517
	(.0020223)	(.007260)	(.007399)	(.312334)
	[0.6413]	[0.5923]	[0.6087]	[0.6158]
q 60	-.0031631*	.03762***	.028734***	.011451**
	(.0017112)	(.006932)	(.007397)	(.005618)
	[0.6377]	[0.6214]	[0.6293]	[0.6143]
q 90	-.0000746	.04800***	.036652***	.013336**
	(.002127)	(.009782)	(.009122)	(.0065494)
	[0.6371]	[0.6323]	[0.6257]	[0.5641]
Number of observations	4860	4884	4884	4884
Geography and Nature	yes	yes	yes	yes
Socioeconomic	yes	yes	yes	yes
Coping Funds and Covariates	yes	yes	yes	yes
Institutional/Local Capacity	yes	yes	yes	yes

***** p<0.01, ** p<0.05, * p<0.1**
Bootstrap Standard errors in parentheses. Pseudo R2 in brackets.
State level fixed effects included.

For poverty levels, the interpretation is a bit different, as the lower quartile indicates localities with lower levels of poverty, i.e. more developed areas. For severe of food poverty (PL1), the higher effects are in the two ends of the distribution, as localities with lower food poverty experience an increase of about 0.047 percentage points, while those localities with more food poverty experience an increase of about 0.048 percentage points. For the other poverty levels, the impact is also not distributed according to the level of poverty. In all cases, the pattern seems to take the form of an u. This may be understandable if we suppose that in localities with higher poverty have a more widespread effect, and localities with lower poverty levels may have an impact more focused on those under the poverty line.

5. Conclusion

Natural disasters have become common events in recent years, especially in Latin America and Mexico. The debate on whether such events are potentially affecting the development of affected areas is still under way. In this context, this paper analyzes a dataset for social indicators at the municipal level in Mexico and the effect on them from natural disasters between years 2000-2005. We specifically analyze the impact on the Human Development Index, and three different measures of poverty (food, capacities and assets).

We use an adjusted difference in difference regression, where we control for different sets of pre-shock variables. We control for local variables such as geographical and natural characteristics, socioeconomic factors, institutional and local administrative capacity, as well as for coping mechanisms and their political covariates.

Results show that there is a significant impact from natural disasters on reducing the Human Development Index and also on increasing poverty levels. The impact on the HDI is similar to going back about 2 years in development for affected areas. The impact is on increasing about 0.036 percentage points food or severe poverty, 0.03 percentage points of capacities poverty, and 0.015 percentage points of assets poverty. Floods and droughts are the more significant natural events affecting social indicators. In addition, we also find that the impact is higher the lower the localities are in the distribution of social indicators regarding long term indicators such as the HDI, but the effects seems to take a form of u regarding poverty levels.

This paper has made a contribution to the debate on the impact of increasing natural disaster events. As it has been shown that such events reduce social indicators at the local level, public policies for attenuating such impacts must be more focused on those under the poverty lines and in implementing mechanisms for keeping elements considered in the human development index that are affected due to these shocks. Additional research could focus on the micro effects on households and the analysis of the u form derived from the natural shocks on poverty, which may help to focus the public mechanism mentioned.

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Annexes

The DesInventar database

DesInventar is a conceptual and methodological tool for the construction of databases of loss, damage, or effects caused by emergencies or disasters. As a system of consultation DesInventar includes Methodology, Database and Software. It defines a disaster as the combination of effects produced by an event on human lives, infrastructure or economy in a geographical unit. In this setting an event may be registered as many times as geographic units affected. The database contains information such as location, date, source, causes and effects (on population, housing, infrastructure and services).

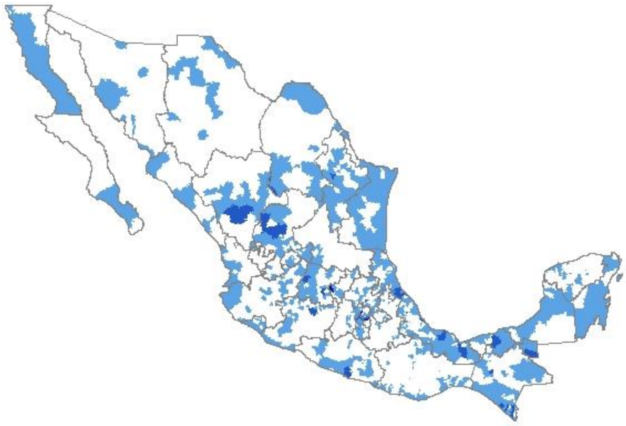
DesInventar is an initiative of the Social Studies Network for Disaster Prevention in LatinAmerica (LA RED). It contains information for a set of countries such as Mexico, Guatemala, El Salvador, Costa Rica, Colombia, Ecuador, Peru and Argentina. This system follows a methodology for recording information that includes characteristics and effects of various types of disasters. This methodology was designed to capture the effects of disasters on politico-administrative units.

The module for Mexico contains information from 1980 to 2006 with a total of 17 thousand 177 disasters. Over 60% of these disasters are due to flood (22.1%), epidemic (8.4%), drought (7.0%), frost (6.6%), forest fire (5.6%), fire (5.6%) and rains (4.6%). The disaster information is collected from national and local newspapers.

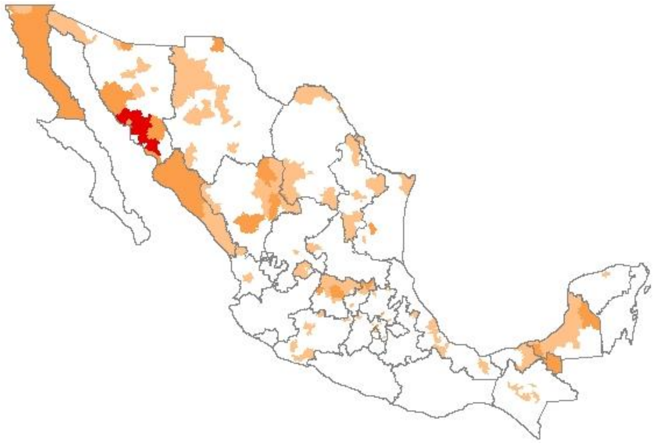
Source: La Red. 2003. Guía Metodológica de DesInventar 2003. Universidad del Valle. Consulted www.desinventar.org.

Maps

Floods distribution



Droughts distribution



Frost distribution

Rains distribution