Estimate Social Vulnerability Index to Climate Change in Mexico

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That global climate is changing is now undisputed. Global climate is already warming at an unprededented rate, and is inevitably altering the character of local and regional weather around the world. Climate change is likely to result in societal impacts through changes in water, natural resources, food systems, marine ecosystems and due to the need to cope with weather extremes (Adger, *et al.*, 2003: 185).

The 'vulnerability' refers to the capacity to be wounded, or the degree to which a system is likely to experience harm due to exposure to a hazard (Füssel, 2009: 2 - 3). Vulnerability is therefore a socially constructed phenomenon influenced by institutional and economic dynamics. The vulnerability of a system to climate change is determined by its exposure, physical setting, ability and opportunity to adapt to change. "Social vulnerability is partially the product of social inequalities—those social factors that influence or shape the susceptibility of various groups to harm and that also govern their ability to respond. However, it also includes place inequalities—those characteristics of communities and the built environment, such as the level of urbanization, growth rates, and economic vitality, that contribute to the social vulnerability of places" (Cutter, *et al.*, 2003: 243).

In relation to climate change, vulnerability is the susceptibility of exposure to harmful stresses and the ability to respond to these stresses. It Is contextual and must always be linked to specific hazards and the exposure to the impacts of these hazards (Mertz, *et al.*, 2009: 746).

Vulnerability to environmental hazards measures the potential loss. The losses vary geographically, over time and between different social groups. In this

research, vulnerability is a social condition, which determines the impact of climatic risk regions and is a measure of a society´s resilience to climate change.

The estimation of a climate change vulnerability index is based on the theory approaches (known as deductive), using a conceptual framework to identify relevant indicators and determine their relationships, Füssel (2009). In addition, the use the induction method allows us to select indicators of vulnerability in terms of their statistical relationship with the results of the vulnerability observed.

This research uses different findings in the literature on vulnerability in relation to climate change, mainly "New Indicators of Vulnerability and Adaptive Capacity, which provides factors to determine the social vulnerability", Adger, et al., (2004), and also estimate correlations on the effects of weather events over the past in Mexico.

The research intends to demonstrate that natural disasters have a differential impact on the territory, depending on regional social vulnerability. We expect to find that the most socially vulnerable regions are most affected by adverse climatic events.

Dependent variable

Key	Variable	Source
FOND03_10	Authorized Resources Disaster Declaration (2003-2010).	Protección Civil, Secretaría de Gobernación (Interior Ministry)

The dependent variable is obtained from the normalization of the average resources authorized to ameliorate environmental effects that occurred from 2003 to 2011. These resources were awarded by the Natural Disaster Fund (Fonden, Spanish acronym) in partnership with those States affected, this variable is "Index Fonden".

The Fonden is a financial instrument which aims to support the States of Mexico, and agencies of the Federal Public Administration to respond to and to recover from effects produced by natural phenomenon. Its aim is to address the effects of

unpredictable natural disasters, whose magnitude exceeds the financial response-capacity of the States. It is a proxy that accounts for the magnitude of extreme events related to the environment.

The vulnerability index is constructed for 2000 and 2010 for six dimensions:

Health. The lack of adequate health results in people being less able to cope with disasters, at least in the short term. Households caring for the sick have less time, money and energy to mitigate the impacts of extreme risks. Diseases are closely linked to poverty in terms of cause and effect. The percentage of the population not entitled to health services is the variable used.

Education. The less educated are more vulnerable to climate risk by geographical location and quality of life. They have little participation in politics and tend to rely on economic activities associated with climate, such as agriculture. Furthermore, adaptation is sometimes associated with conflicts of interest, people with more education are in a better position negotiate equitable solutions. This item was measured by the percentage of the illiterate population over 15 years old.

Physical infrastructure. The settlements, infrastructure and transport systems determine the physical vulnerability to extreme events, because rain, floods and storms have differentiated effects on the territory. The variable used is the percentage of private homes that do not have a public water supply

Government. State institutions influence the level of vulnerability. Their inefficiency or corruption are associated with a lack of adequate health care. In this sense, we used the National Index of Corruption and Good Governance 2010 by *Transparencia Mexicana*, which measures the corruption affecting households and maintains a record of corruption in public services which are offered by the three levels of Government (Federal, State and Municipal) and private companies.

Demographic and geographic factors. Low-lying areas are more susceptible to flooding from extreme rainfall events compared to higher altitude regions. The selected variable is population density, because high densities are associated with increased risk of illness due to certain natural disasters, the result of contamination

of water supplies with human waste and the proximity of individuals to each other, which facilitates the spread of disease.

Dependence on agriculture. Drought is one of the main risks associated with climate variability and change. Agriculture is the main climate-sensitive economic activity in most parts of the world. Includes percentage of population employed in agriculture, livestock, forestry, fishing and hunting.

Based on these sectors and the same to calculate the Human Development Index (HDI) are generated six dimension, with determination of minimum and maximum values (limit values) for each indicator to transform them into indices with values between 0 and 1. The values close to 1 imply increased vulnerability, as opposed to those closer to 0, which have less vulnerability in the region. The normalization is as follows.

$$\text{Dimension Index} = \frac{\text{actual value} - \text{minimum value}}{\text{maximum value} - \text{minimum value}}$$

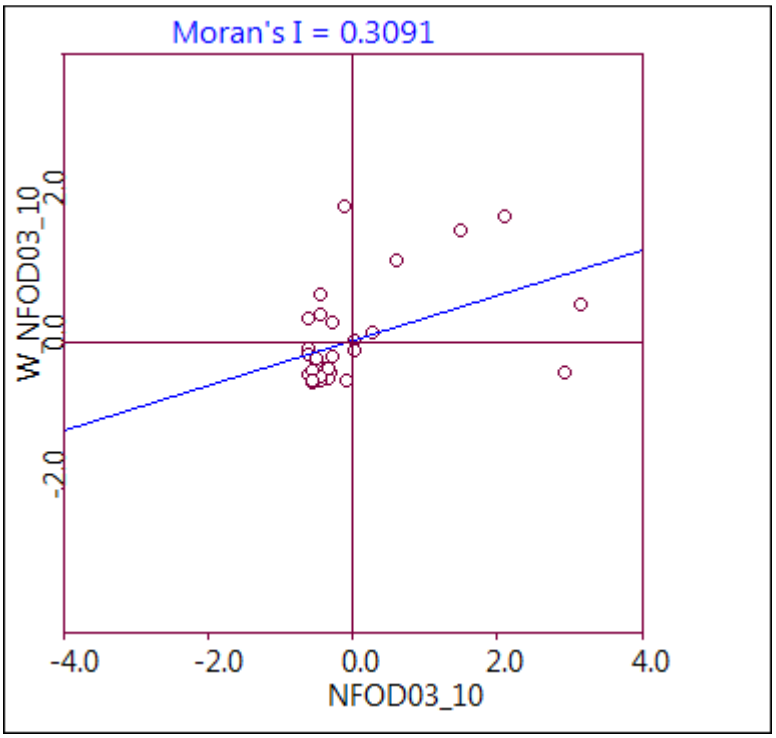
Six dimensions are assigned an identical value, . Once the indicators are estimated, the growth rate from 2000 to 2010 is calculated, and included as an independent variable.

Independent variables

Key	Variable Name
IV2000	Vulnerability Index 2000
IV2010	Vulnerability Index 2010
TCIV00_10	Growth Rate Vulnerability Index 2000 to 2010

The Moran scatter plots standardizes the background rate (2003-2010) by State and the spatial lag of this variable is obtained, both values are presented in a Cartesian axis, where the slope regression line is the value of the statistic I Moran's global spatial autocorrelation. In this case it is 0.3091, there is a spatial association of index State Fonden at 30.9% (Figure 1).

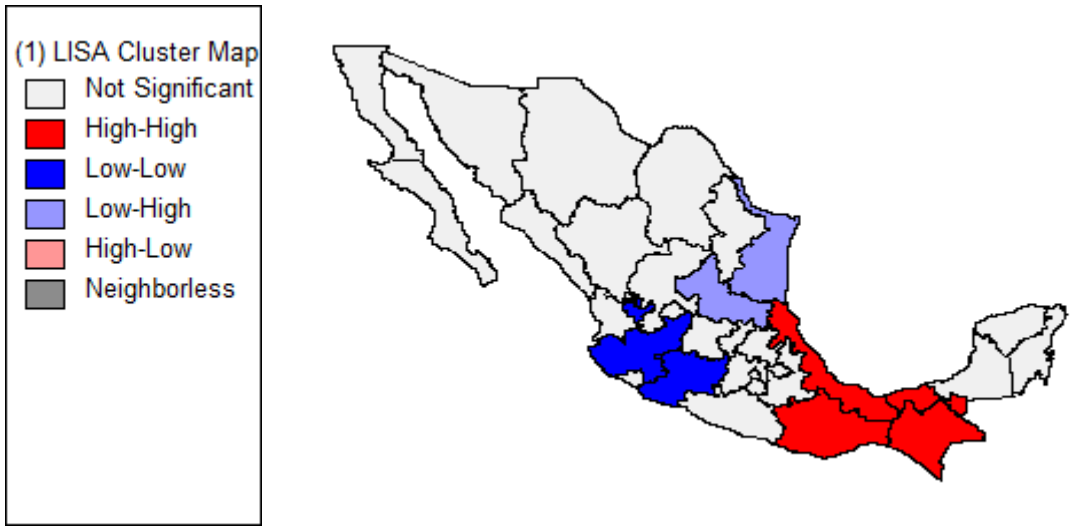
Figure 1. Moran Scatter plot



Source: Geoda

Map 1 shows the cluster formed statewide using local Moran statistics. The blue, low-low, are areas that have few weather events that used the Fonden resources and those surrounding States also with low resource requests, the case of Jalisco and Michoacan. The light blue, Tamaulipas and San Luis Potosi, have a cluster of low utilization of Fonden resources, but high neighboring states neighbors with these expenses. For its part, the red cluster groups in south, Veracruz, Tabasco, Oaxaca and Chiapas with high climatic events, and which used the greatest amount of resources from the Fonden fund

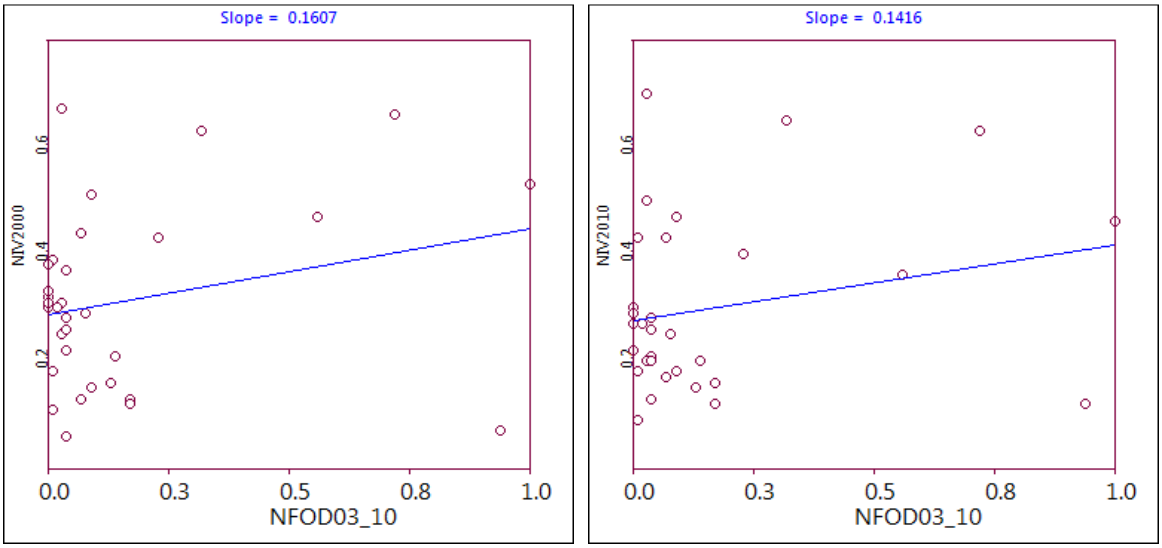
Map 1. LISA cluster of the sensitivity to climate change



Source: Geoda

The scatter diagram between index of Fonden and Vulnerability Index 2000 has a positive correlation, and proves the existence of a relationship between these two variables. Also the vulnerability Index 2010 shows the same positive relationship with the background rate (Figure 2).

Figure 2. Scatter plot between the background rate and the vulnerability index 2000 and 2010



Source: Geoda

With these estimates, we performed an Ordinary Least Square (OLS) regression.

SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION

Data set : mexico_estados

Dependent Variable	: FOND03_10	Number of Observations:	32
Mean dependent var	: 0.16	Number of Variables	: 4
S.D. dependent var	: 0.261594	Degrees of Freedom	: 28

R-squared	: 0.247154	F-statistic	: 3.06407
Adjusted R-squared	: 0.166492	Prob(F-statistic)	: 0.0442759
Sum squared residual:	1.64858	Log likelihood	: 2.04709
Sigma-square	: 0.0588779	Akaike info criterion	: 3.90582
S.E. of regression	: 0.242648	Schwarz criterion	: 9.76876
Sigma-square ML	: 0.0515182		
S.E of regression ML:	0.226976		

Variable	Coefficient	Std.Error	t-Statistic	Probability
CONSTANT	-0.05647296	0.09921632	-0.5691903	0.5737656

IV2000	3.681966	1.436779	2.562652	0.0160530
IV2010	-3.08854	1.38686	-2.227002	0.0341647
TCIV00_10	0.08292945	0.03191408	2.598523	0.0147669

REGRESSION DIAGNOSTICS

MULTICOLLINEARITY CONDITION NUMBER 27.234189

TEST ON NORMALITY OF ERRORS

TEST	DF	VALUE	PROB
Jarque-Bera	2	16.74609	0.0002310

DIAGNOSTICS FOR HETEROSKEDASTICITY

RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	3	17.64843	0.0005197
Koenker-Bassett test	3	7.972147	0.0465909

SPECIFICATION ROBUST TEST

TEST	DF	VALUE	PROB
White	9	15.79542	0.0712786

DIAGNOSTICS FOR SPATIAL DEPENDENCE

FOR WEIGHT MATRIX : Matriz de pesos1.gal

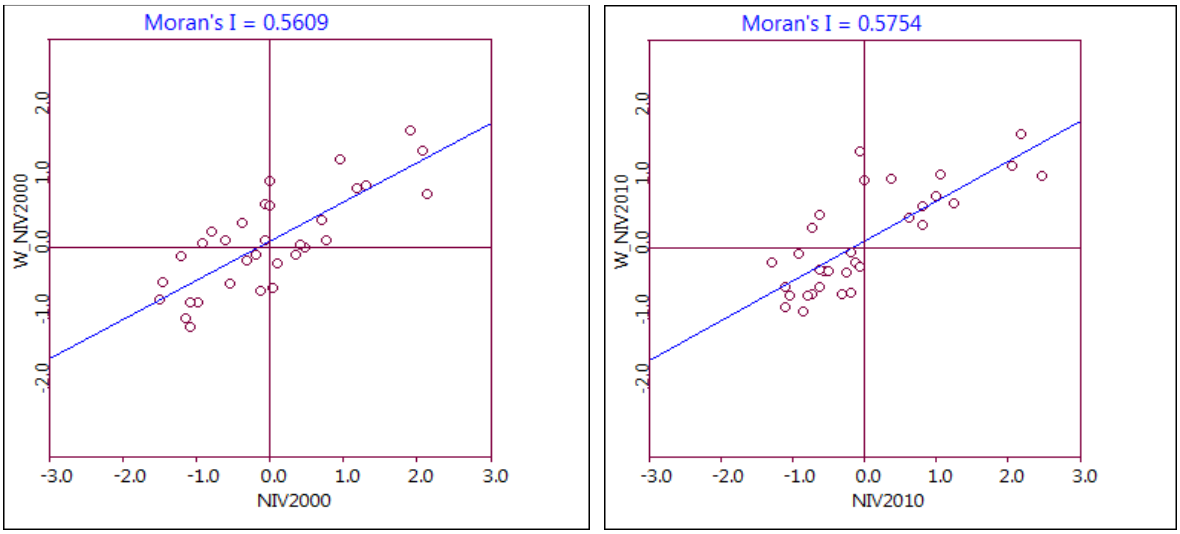
(row-standardized weights)

TEST	MI/DF	VALUE	PROB
Moran's I (error)	0.065590	1.1363804	0.2557975
Lagrange Multiplier (lag)	1	1.9792197	0.1594726
Robust LM (lag)	1	7.5089816	0.0061392
Lagrange Multiplier (error)	1	0.2448652	0.6207141
Robust LM (error)	1	5.7746271	0.0162592
Lagrange Multiplier (SARMA)	2	7.7538469	0.0207145

The model is explanatory. However, there is not a spatial relationship of the errors, the I Moran is not significant. The OLS regression is adequate for this relationship. There is a positive relationship between the vulnerability index in 2000 and the background rate (2003-2010), the same applies for the growth rate of the Vulnerability Index from 2000 to 2010. However, the 2010 Vulnerability Index shows a negative relationship.

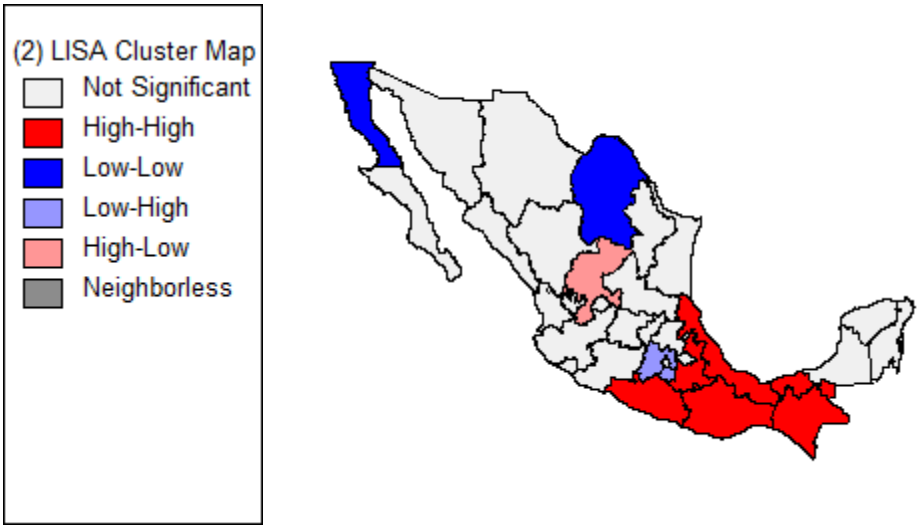
It is suggested not to use estimates with a spatial component. Thus, estimates of the I Moran for Vulnerability Index, 2000 and 2010.

Figure 3. Moran Scatter plot Vulnerability Index 2000 and 2010

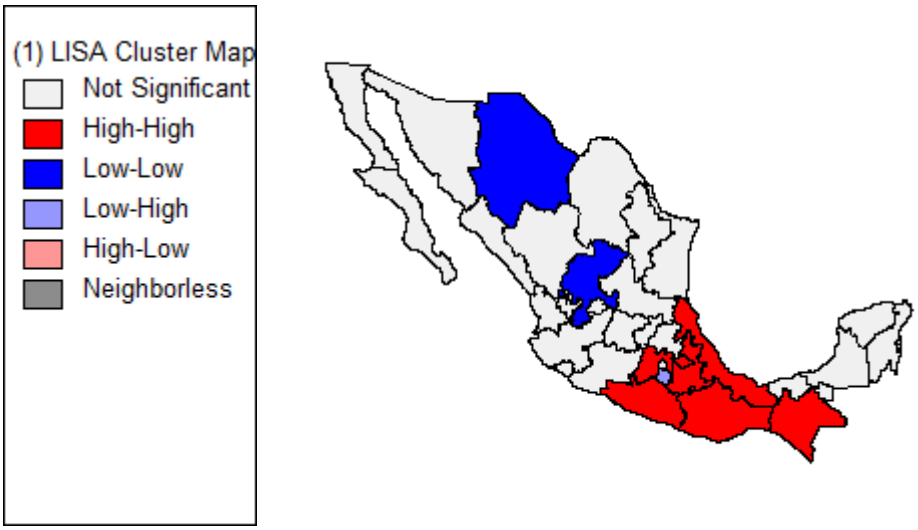


The Moran Scatter plot Vulnerability Index 2000 and 2010 have a significant spatial correlation. Meanwhile, the local Moran shows the cluster that are formed to index.

Map 3. LISA Cluster Map for Vulnerability Index, 2000



Map 4. LISA Cluster Map for Vulnerability Index, 2010



The maps of 2000 and 2010 are very similar. This means that cluster is maintained for both years. The most vulnerable States in 2000 and 2010 are Veracruz, Puebla, Guerrero, Oaxaca and Chiapas, and Estado de México just 2010. The evidence

concludes that there is a relationship between social vulnerability and natural disasters.

References

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