Climate variability and demographic and socio-economic vulnerability in southern Brazil, 1980-2010: A TerraPop Case Study

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Extended Abstract (2-4 pages)

Climate variability affects and impacts human society in different ways, depending on the underlying socioeconomic and demographic vulnerability of specific places, social groups, households and individuals. This differential vulnerability presents spatial and temporal variations, and is rooted in historical patterns of development and relations between human and ecological systems.

These data will include geo-referenced climate data, and data describing demography and socioeconomic characteristics of individuals, households and places. This study will focus on three states of Southern Brazil –Parana, Santa Catarina and Rio Grande do Sul – and will examine rural and urban populations and assess the impact of climate variability on livelihoods and well-being, and their changes over time and across space.

This paper is based on previous work on climate variability, vulnerability and governance in urban and rural areas of Southern South America (Brazil, Uruguay, Argentina and Chile) (Adamo, Baptista et al. 2013). This work explored factors related to the emergence of areas of critical vulnerability to climate variability based on aggregated georeferenced census data from 1990 to 2010, but was not able to include any analysis at the household and individual level for lack of appropriate data sources. The use of data from Terra Populus will allow incorporating those levels of analysis.

Climate variability and extreme events

Climate variability is an inherent characteristic of the Earth's climate, including but not limited to climate change. "The mean conditions which have been the focus of the climate change studies are the summary (central tendencies) of a distribution of (variable) conditions" (Smit et al. 2000:231). Variations can happen at different temporal (days, weeks, months, seasons, years, decades, centuries) and spatial (local to global) scales, and they include extreme events or anomalies such as droughts and storms, their frequency and occurrence. Extreme events are part of the variability, located at the farther ends of the distribution (Baethgen 2010; Lavell 2007; Smit et al. 2000).

The analysis of the impacts of climate variability includes dealing with "conflict of scales" (Baethgen 2010:S-72) between the spatial and temporal scales of climate scenarios (global to regional, 70 to 100 years in the future) and the scale of local decision making needs. Related to this is the issue of uncertainty, which is particularly relevant for the development and use of

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forecasts in the decision process of local policy makers and framers, for example (Grimm 2011; Hill 2012).

Research on climate variability in the study areas have focused on the intra-annual, inter-annual and inter-decadal variability in temperature and precipitation (Grimm 2011;); its connections with the ENSO episodes (IRI 2007, 2009); the impacts of associated extreme events, for example floods in the urban areas of southern Brazil (Pscheidt and Grimm 2009; Teixeira et al. 2011), and heat waves in cities (Hardoy and Romero Lankao 2011). Other work has looked into the change trends, among them warming and wetting drifts (Baethgen 2010; Skansi et al. 2013; Collins et al. 2009; Giménez et al. 2006). Finally, some research has look into the heterogeneous impacts of climate variability on agriculture and ranching, including but not limited to the spatial variability of the trends.

Vulnerability

The risk of being affected by environmental hazards is not only related to the nature of the hazard but also and maybe more importantly to the vulnerability of individuals, households and communities (Blaikie et al. 1994: 21; Bohle et al. 1994). Socioeconomic vulnerability, sometimes shortened to just vulnerability, can be approached from different angles. It could be considered as the reduction or elimination of the ability of a person or groups of people to respond (i.e. to resist, recover or adapt) to external threats or pressures on their livelihoods and well-being. Alternatively, it may refer to the relationship between exposure to physical threats to human welfare and the ability of individuals and communities to deal with these threats (which are derived from a combination of physical and social factors), as well as the differential capacity of people to cope with the occurrence of catastrophic events, or the predisposition of humans, their livelihoods, and infrastructure to loss or damage (Blaikie et al. 1994; Kelly and Adger 2000; Cardona 2001; CELADE 2002; Barrenechea et al. 2000).

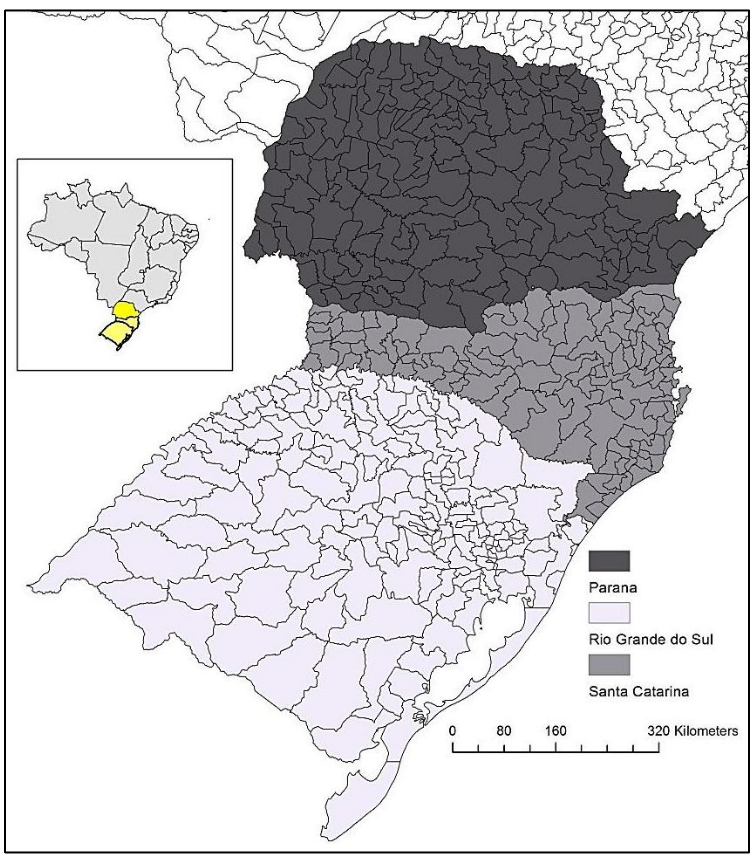
It is useful to consider two analytical dimensions: an external one, represented by the exposure to hazards that results from being present at the place and time of occurrence of the particular event, implying that vulnerability varies across space and over time following the distribution of natural resources, populations, availability of housing, infrastructure, and economic opportunities (Kasperson et al. 1995; Schneider et al. 2007), and that the impacts of climate variability are embedded in contexts and history (e.g., prior stresses, level of development, or political institutions) (Adger et al. 2007:720; Adamo and de Sherbinin 2011).

Then there is the internal dimension, which represents the influence of group, household and individual characteristics such as age, gender, race or ethnicity, education, household composition, and life cycle. It is known that "vulnerability to climate change differs considerably across socio-economic groups" (Schneider et al. 2007:784), there will be *degrees* of vulnerability. How vulnerable individuals, households, communities, institutions, or systems are depends on a number of factors, from individual demographic characteristics to macro-level indicators such as level of development and economic and social contexts. Patterns and degrees of vulnerability differ across scales and levels of analysis (e.g. Adamo and de Sherbinin 2011). For example, poor or deprived populations facing environmental hazards are more vulnerable than the non-poor or affluent populations. The AR4 states that "the poor and marginalized have historically been most at risk and are more vulnerable to the impacts of climate change" (Adger et al. 2007:720). Poverty has been used as indicator of socioeconomic vulnerability because of its link to marginalization and lack of access to resources.

Farming and ranching are particularly uncertain economic activities, exposed to several types of risk, from climate variability to unstable markets and volatile prices, which highlights the role of diversification in reducing socioeconomic vulnerability of smallholders (ECLAC 2013). The context and content of the diversification strategies is relevant. Anjos and Caldas (2007) analyzed the heterogeneity of diversification strategies and pluriactivity among family farms in Rio Grande do Sul. They found different diversification opportunities according to the dominance of commodities (mainly soybeans), tourism, or extensive activities (cattle or rice). Uncertainty and risk in agriculture and ranching could end in poverty, not only of farmers but also of farm workers, often the most vulnerable group in our study areas. Urban areas in Latin America are hotspots of vulnerability to extreme events (floods, heat wavers, etc.). Issues of socioeconomic vulnerability in urban areas are linked to high concentration of population and infrastructure combined with spatial segregation, all of which amplifies the impacts of extreme events (Hardoy and Romero-Lankao 2011; Marandola 2012).

Combination of factors creates unique place-based vulnerabilities (de Sherbinin et al. 2007). Nicolodi and Petermann (2010) found that climate change-related events, high population density, poverty, and the presence of technological nodes were relevant factors to understand the vulnerability of the Brazilian low-lying coast (Rio de Janeiro and Santos among them).

Figure 1: Study area in southern Brazil



Data and Methods

Data

Data for this study will come from the Terra Populus project (TerraPop). The goal of this project is to lower barriers to conducting interdisciplinary human-environment interactions research by making data with different formats from different scientific domains accessible and easily interoperable. The TerraPop database includes data on human population characteristics, land use, land cover, and climate from a variety of source datasets, The TerraPop data access system allows users to select variables from multiple source datasets and combine them into a customized, integrated output dataset. The integration performed by the system includes transformations between microdata, area-level, and raster data structures.[d]

TerraPop is housed at the Minnesota Population Center (MPC) at the University of Minnesota. The project is a collaboration of the MPC with two other organizations at Minnesota and two external organizations: the University of Minnesota Institute on the Environment (IonE), the University of Minnesota Libraries, the Center for International Earth Science Information Network (CIESIN) at Columbia University, and the Inter-university Consortium for Political and Social Research (ICPSR) at the University of Michigan. The first phase of the project is funded from 2011 to 2015. A public beta release of the data system is scheduled for late 2013, and the official release in 2014.

Microdata records for individuals –containing demographic and other variables such as age, sex, occupation, education, and migration -- are linked to households, providing information about family structure and variables related to household characteristics such as utilities and dwelling characteristics. The TerraPop system also links area-level data for population characteristics and raster data of climate characteristics to microdata records as contextual variables.

Specifically, the paper uses the following data from TerraPop's georeferenced and integrated databases for Brazil in 1980, 1990, 2000 and 2010: (1) Harmonized census microdata describing the characteristics of individuals and households; (2) Aggregate census data at the municipality level and matching boundaries, describing the population characteristics of places; (3) climate data describing temperature, precipitation, and other climate-related variables since 1950. We also make use of agricultural census and climate variability variables added or created for previous work (Adamo, Baptista et al. 2013)

Methods

Climate variability in the study area is characterized using means, standard deviations and anomalies. Analyses of seasonal anomalies for both precipitation and temperature from 1970 to 2000 were conducted for the three study areas. Seasonal averages for summer (December, January and March) and winter (June, July, August) for both temperature and precipitation were calculated, as well as a seasonal climatology for temperature and precipitation. The relative standard deviation, expressed as a percentage of the seasonal climatology, was the preferred metric to assess seasonal variation in both climatic factors (Hansen et al. 2012:18). Counts of anomalous seasons were conducted for each cell when its seasonal value exceeded the range of plus and/or minus one standard deviation from the 30+ year seasonal climatology. The count also

[d] http://www.nsf.gov/pubs/2007/nsf07601/nsf07601.htm.

differentiated cells with above and below normal values in order to identify potential climatic hotspots, or anomalous wet and dry areas.

The characterization of socioeconomic vulnerability of places, households and individuals aims to address the two analytical dimensions of exposure and gradient mentioned before, for urban and rural populations, in each target year (1980, 1990, 2000 and 2010), and integrating micro- and areal data. Among others, variables include:

- aggregated data: populations (total and by sex and age) and households (total and by type and size); education of households' heads; characteristics of the labor force; infant mortality rates as proxies for living conditions; degree of urbanization; informal settlements.

- microdata: ages and sex of household members; size and composition of the household; access to and tenure of assets (house, land, etc.); access to services and infrastructure; income sources; size and composition of households; and human capital variables; urban/rural residence.

The identification of vulnerability hotspots starts with the selection of a group of variables assumed to differentiate (a) degrees of climate variability (CV), and (b) degrees of socioeconomic vulnerability (SV) for the administrative units in the area (place vulnerability), based on the reviewed literature. We first used correlation and simple linear regression to look for relationships among the socioeconomic variables. We then used descriptive statistics (central tendency and dispersion) to determine preliminary cutoff points for including or excluding administrative units into the higher climate variability or higher socioeconomic vulnerability categories for the three study areas.

After identifying and mapping the administrative units with higher CV and SV, the resulting maps are overlaid or superimposed (O'Brien et al. 2004; Fraser el al. 2013) to delineate the areas where both dimensions are present according to our previous analysis. We then examine households and individuals within the hotspots, aiming to identify internal variation or degrees of vulnerability (Weinreb et al. 2008)

Next steps

The analysis of the data is currently under way, and we expect to have the paper completed on March 2014.

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