

# Socioeconomic Vulnerability and Seismic Risk

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## SUMMARY

The report presented exposes results of a research work, with regard in the socioeconomic vulnerability and seismic risk of San Juan city, the main urban agglomerate area in the province with the same name, Argentina.

Socioeconomic traits of the resident population of that area were inquired, analyzed and interpreted, as part of a larger research project, which evaluated the seismic risk in a holistic way and was developed by the National University of San Juan.

There were designed specific instruments to identify and measure the socioeconomic vulnerability of the population, working with secondary data which were compared with others, obtained from a thorough survey on the area. Indicators were constructed to simplify description and qualification of situations of vulnerability.

The results of this research have complemented the main project, in which this work is framed, and have been transferred to the agencies of the Province's Government, related to the topic.

*Keywords: Socioeconomic vulnerability, Seismic Risk, Risk Management*

## 1. INTRODUCTION

The Regional Institute of Planning and Housing (IRPHa) of the UNSJ has studied since 1991 the interrelationships among the major conditioning factors of natural subsystem and the elements of a city as a subsystem built.

It starts from the conception of the city, as all socio-technical system is a complex result of the interplay of multiple subsystems, which influence and condition one another, in a given space and time. To speak of a complex system, is to refer to an organized whole, whose elements are not separable and cannot be considered separately because are interdefinibles. (Garcia R, 2006).

From this perspective, the city is understood and analyzed as the material realization of social, political and economic changes that were developed through its own process of formation and development. Its growing, the changes of its functions, its internal structure and composition of the population, are elements that strongly affect the risk levels and are reflected into space.

Risk means the possibility of dangerous phenomena occurs, predisposing to a human settlement to suffer damage in varying degrees, according to their characteristics. It is a complex variable, consisting of the interplay among threat, vulnerability and responsiveness. It takes into account both, the strengths (capacities) and the weaknesses of a given system, generated in their own development process, whose unwanted products are human casualties and disruption of economic and social activities of a community or territory.

Consequently, if we want to influence effectively in mitigating risk, it should be approached interdisciplinary, including the study of environmental issues not only physical but also economic and

social. A biased view of risk, coupled with the lack of awareness and information, often causes that members of society (including leaders, professionals, etc.) contribute to its increase, taking wrong decisions. Also results not implement effective programs to reduce the risk, nor it takes into account in development plans.

For the towns of San Juan province, Argentina, one of the most important environmental conditions is the earthquake. The Republic of Argentina has almost 30% of its area located in areas of high seismic hazard, which is concentrated in the central-west and northwest. Its territory is affected by the convergence between the Nazca Plate and South American Plate. Due to the strong compressive stress generated by the contact between them, generate earthquakes that often occur at considerable distances from the contact zones, usually associated with active faults.

The province of San Juan, is located in one area characterized by the standard CIRSOC INPRES-103 as the highest seismic hazard in the country (INPRES-CIRSOC, 1991). Has been shaken by five major earthquakes in the past 150 years (1863, 1894, 1941.1944, 1952 and 1977), which caused large numbers of deaths and material losses.

Therefore, for the towns of San Juan, Argentina, among the multiple causes of socioeconomic and environmental development, highlights the importance of the dimensions and positions of physical vulnerability and socioeconomic risk associated with earthquakes.

Sufficient evidence shows disasters, arising from the occurrence of natural phenomena, impact and converging associated with the high vulnerability that settlement offer. This is due to the unplanned and the type of technology used in the construction thereof. Also the resident population in this settlement is characterized by being exposed to vulnerabilities. This condition of physical - materials and socioeconomic - environmental vulnerability of certain social groups or sectors limits its ability to prevent and respond to emergencies as well as their rehabilitation and recovery from the effects caused by these phenomena.

The paper presents a methodology aimed at obtaining indexes of social vulnerability assessment, as part of a methodology for urban seismic vulnerability evaluation. Developed tools had been applied to the urban metropolitan conglomerate called Grand San Juan. It also shows in-depth study conducted in one area identified as most vulnerable in the overall analysis of the city, the neighborhood known as "Villa Lourdes".

The project was developed within the frame of a Research Program funded by the National Agency of Science and Technology Promotion (ANPCyT) of the National Ministry of Science, Technology and Productive Innovation (MINCyT), to study the seismic risk in Argentina. It was carried out by a team of researchers of the IRPHa, the Institute of Socioeconomic Research (both units of the UNSJ) and the National Institute of Seismic Prevention (INPRES).

## **2. DEVELOPMENT METHODOLOGY**

### **2.1. Some conceptual and operational definitions**

The theoretical and methodological discussion on the concepts of asymmetry, poverty and inequality led to resort to more comprehensive approaches, such as the social and economic vulnerability, trying to incorporate the effects of economic and social development. Its aim is to understand and tend to solve the problems of poverty, inequality, disadvantage and welfare, thence to rescue the approach of the social vulnerability as a risk status.

The concept of poverty is a statement of social actors expressing the dissatisfaction of those human needs, and whose coverage depends on economic conditions. The metrics available to quantify the levels of poverty are based on the status of deficiencies that have homes and people living in them

(structural poverty NBI) or from income (poverty line). Both concepts refer to situations that are immutable or have very few changes along the time. Thus, the population (social group, homes-housing) is identified in dichotomous positions (it is poor or not), or distributed according to their relative position in the income structure.

In contrast, the focus of social vulnerability rescues and finds another perspective tangible and unequivocal: people have different assets and resources mobilized by specific tactics to respond to changing contexts and opportunities available (Busso, 2001).

In essence includes situations where groups, households or individuals are exposed to be affected by changes in their lives, therefore, are in a situation of greater uncertainty compared to other groups, households or individuals. Thus, the vulnerability of the population comprises those segments between the extremes of "integration" (steady income, strong social ties) and "exclusion" (lack of work, weak relational ties), a situation that can affect any group or individual from the social structure, and not only those who are classically defined as "poor."

In this sense, individuals would outweigh the risk conditions through assets they have and the most effective ways on how they move it. However, sometimes, the resources available (economic, currents) of individuals or households are not sufficient to cope with periods of vulnerability or exposure to economic shocks.

In terms of Castel (1991; 1995; 1997), social vulnerability is the result of increasing overlap between economic insecurity and social instability. Unable to obtain a stable place in the forms of work organization becomes a fragile medium that guarantees individual survival, but also weaken the bonds of social recognition that ensures belonging to a community.

Consequently, the prospect of risk (vulnerability), conceptualized as a change of status or exposure, leads and includes both existing and circumstantial contingencies. So, efforts to analyze this problem are valuable contributions in social sciences and formulation – decision of public policy.

## **2.2. Methodological background**

Regarding the methodological and metric references available to quantify the levels of poverty, the most commonly used in Latin America and Argentina, refer to the approaches of Unsatisfied Basic Needs (NBI) and the Poverty Line (LP).

The method (NBI) reflects the state of deprivation, associated with lack of access to goods and services such as housing and education. The resulting indicators measure structural poverty, identifying dichotomous situations and relate to the traditional view of the most critical and chronic situations. Instead the LP methodology is associated with poverty circumstantial, being derived from the availability or not to pay or failure thereof. The final indicator facilitates to know the relative position of households in the income structure of the context, being more sensitive to business cycle fluctuations (Beccaria and Minujin, 1985; 1991; Beccaria, 1993; INDEC, 1990; Katzman, 1989; Minujin 1995; 1999).

Different authors integrated both methodologies to categorizing poor households by both methods not only by some of them. Most background refer to the construction of vulnerability indexes, with information coming from censuses or surveys organized to capture data about to the household assets to reduce their chances of risk. They characterize the vulnerability as a heterogeneous and dynamics problem, but also conditioned by structural issues. Only in a few cases it has been used weighted averages for vulnerability evaluation. In this project this method was used and it is present in this report.

The socio-territorial structure of the city was studied and there was built a Socio-residential Index Level (INS) to identify areas of similar characteristics. The analysis units were the enumeration

radios. To categorize each of the households in the areas resulting from this aforementioned study, it was defined the Social Vulnerability Index (IVS).

The dimensions and indicators included in the Socio-residential Index Level were applied to the study of agglomeration Great San Juan, during the periods for which statistical information was available from the Census 1991 and 2001. This uncovered areas of similar characteristics and identify trends.

There were built a Physical Vulnerability Index (EVI) and a Social Vulnerability Index (IVS) for a detailed study of households which live in the most critical areas that were defined by the procedure above described. They helped to identify the physical-external vulnerability (housing) and the socio-economic-domestic vulnerability (everyday life tactics) of houses, people and households.

Both indexes were constructed from primary information, by applying a survey specifically designed to harness the power of this source, to perform the physical, environmental and socio-territorial characterization of the community resident there.

### 2.3. Analysis of the socio-territorial structure.

The study was carried interrelated population, territory and social stratification, which allowed us to determine "socio-territorial structure". The concept of socio-territorial structure, as used herein, arises from a theoretical framework that takes into account the existence of reciprocal interactions between spatial structures and social processes, an approach that is shared with large groups of recent urban studies. (GCBA / FADU-UBA, 2000).

From the methodological point of view, the study considered as spatial units of analysis the census enumeration radius, which allows that the analysis of patterns of socio-territorial structure were made at the appropriate level of spatial disaggregation. Was also available on level of census enumeration the information of Population and Housing included in the 1991 and 2001 Census. The 2010 Census data in enumeration Radio is not yet available.

The mapping information and statistical indicators constructed from the original census data were incorporated into a geographic information system (GIS). It allowed performing a simultaneous and interrelatedness analysis of all information and obtaining statistical and cartographic output.

A Socioeconomic Index, which summarized the situation of education, health and economic activity status of the population census enumeration, was constructed. It allowed characterizing the Great San Juan, in four types of areas based on the values obtained: Areas with a Very bad, Bad, Medium or Good socioeconomic level.

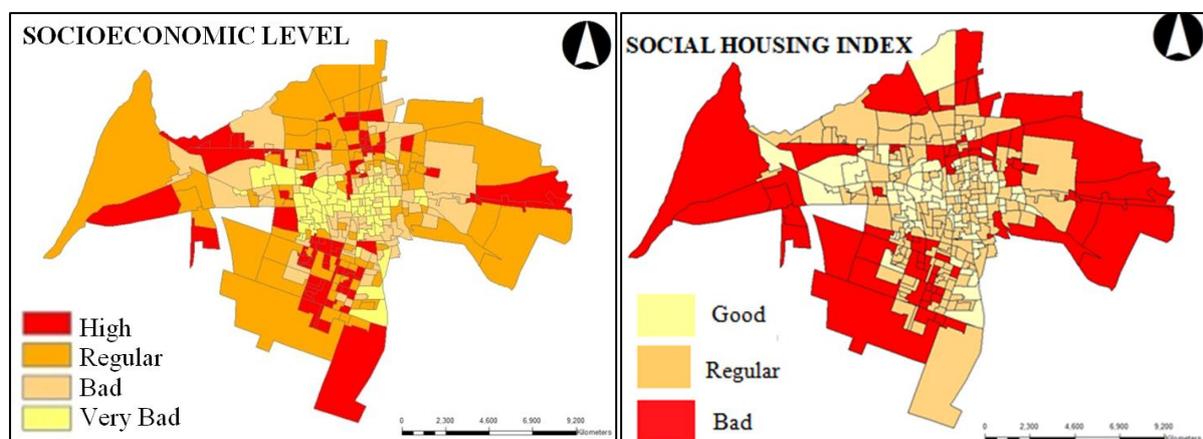


Figure 1. Socioeconomic level of the Great San Juan

Figure 2. Social-housing level of the Grand San. Juan.

Good areas resulted from the radio group with a socioeconomic level higher than the average of the agglomeration of Great San Juan. Census enumeration in which two of the variables met the condition that their values were equal to or were above the mean value of the agglomeration, formed the areas designated as Socioeconomic Medium level, while those where they had values lower than average, were Socioeconomic Bad level areas. The level was characterized as very bad in those sectors in which all variables were below the average.

Finally, the Socio-housing Level was determinate as a summary measure that let identified areas with similar characteristics. It was built interrelating the index described above in the Quality of Construction Materials and Unsatisfied Basic Needs allowed.

The map in Figure 2 can be interpreted as an approximation of general type "social vulnerability map" of the city. In it, the different levels and their spatial distribution can clearly distinguish.

#### **2.4. Study in depth: analysis of the neighborhood called "Villa Lourdes".**

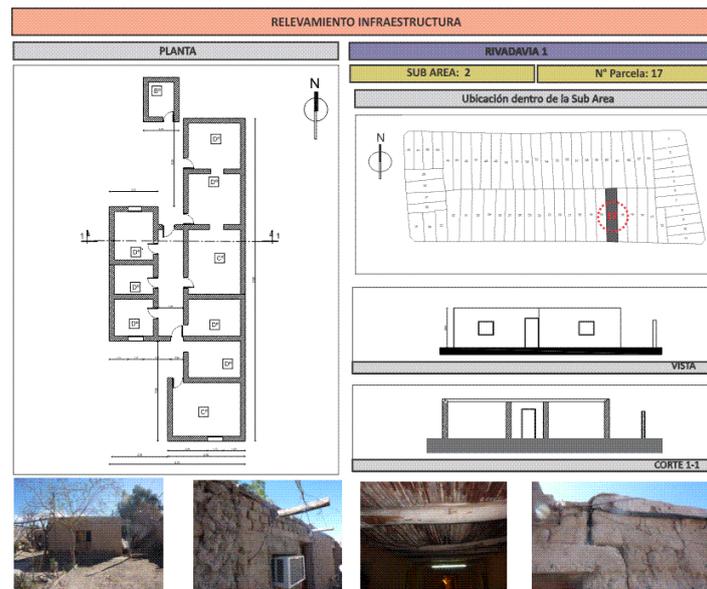
Retrieved social vulnerability map of the city, an in-depth survey of the buildings and the households was done in the five most vulnerable areas of the San Juan city. These activities were conducted through an agreement, with the Department of Planning and Urban Development (UTPD), an agency of the government of the Province of San Juan in charge of territorial planning.

It is developed by way of example, the work carried out in one of these areas, the neighborhood known as "Villa Lourdes". The same is located in the Northeast area of Rivadavia Department, within the city limits established by the UTPD. This area is predominantly residential, with an average population density. In the vicinity to the same neighborhoods are located large earthquake resistant constructions.

The villa comprises 215 parcels, of which 184 are for residential use. They are 196 houses, living in 224 households. Despite its location just 45 blocks from downtown, it is an enclave that has a high physical and socioeconomic vulnerability.

The survey was conducted over all the houses of this neighborhood, to get the most complete information and allow it be able to propose solutions to mitigate the vulnerabilities. It incorporated an ample photographic record and were detailed the construction characteristics, the maintenance condition of the building, the pathologies detected, the service infrastructure they have, etc. Plants, cuts and facades were digitized, and syntheses of information were made by cards. Figure 3 shows one of these cards.

Was compiled a database in DBF format, which besides the data covering the aspects that have to do with the materiality of the house (building materials of walls ceilings and floors, condition, detected pathologies, size and position of openings, or connection to infrastructure networks, etc.) were loaded data relating to ownership status, presence or absence of approved plans, year of construction, type of housing, etc.



**Figure 3.** Summary card of information from the surveyed households

#### 2.4.1 Construction of Physical Vulnerability Index

It was found that of the 196 houses, 178 were built on crude land (adobe), a material that behaves extremely fragile to seismic effects. Addition of 18 houses built with ceramic brick and reinforced concrete structure, only 4 had approved plans by the Department of Planning and Urban Development (UTPD), an agency of the Province of San Juan in control and function of police in building industry the province.

From a methodology designed by team members, was assessed the level of the physical vulnerability of each of the 192 houses that had no approved plans. It is known that adobe buildings collapse in an earthquake which IMM is equal to or greater than VII. However, adjusted vulnerability analysis based on several parameters, to categorize into four ranks according to the priority of intervention, the first corresponding to the highest priority.

The parameters used in the evaluation took account of morphological, structural, Land, Environment and Pathologies detected. See Table 1.

Each of these parameters was characterized into three categories, which were valued at 0, 0.5 and 1 respectively. In was used a weighting factor for each of the four parameters. A weighted polynomial formula was built. The results vary between 0 and 1. Following the evaluation, the houses were categorized into four ranks according to their level of physical vulnerability.

We obtained the following situation: 38 houses had very high physical vulnerability, 59 high vulnerability, 55 medium vulnerability and 44 low vulnerability.

**Table 1.** Parameters for determining the physical vulnerability of households

A. Morphological appearance				B. Structural System						C. Soils		D. Environment		E. Pathology			
A1	A2	A3	A4	B1 Horizontal enclosure		B2 Vertical enclosure		B2 Structure		C1	C2	D1	D2	E1	E2		
Regularity in plan	Slenderness in plan	Regularity in height	Number of walls in both directions	Ceiling cover	Resistant elements	Masonry locks	Location of openings	Location of the walls	Vertical structure	Horizontal structure	Location of the walls	Bearing capacity	Foundations	Cesspool location	Different level	Moisture in walls	Maintenance

#### 2.4.2 Construction of the Social Vulnerability Index

For detecting the levels of social vulnerability of Villa Lourdes and, with the background information of people (age, sex, educational attainment, employment status, type of activity and household income) and households there resident, was built and calculate the IVS.

The IVS is a weighted index that assigns a score to each household depending on its condition against a set of features. Each of the dimensions that comprise it: Overcrowding, quality of materials, relationship between contributors and non-contributors, health and educational environment, provides a total score which can be subdivided according to the intensity or depth of the deficit.

Because each of the selected dimensions may represent problems of varying intensity, and herein lays the nature of social vulnerability, these dimensions are defined for differential ratings within.

In mathematical terms, we constructed a weighted polynomial formula; the results vary between 0 and 1. This made it possible to categorize the households into four levels: Very High, High, Medium and Low Social Vulnerability.

**Table 2.** Parameters for determining the social vulnerability of households

Social vulnerability index	Dimensions	Categories	Value	Weighing
	Crowding (number of persons per room)	from 0 to 2	0	0,15
		more than 2 to 3	0,5	
		more than 3	1	
	Physical Vulnerability Index (EVI)	from 0 to 0,30	0	0,3
		from 0,31 to 0,60	0,5	
		more than 0,60	1	
	Relationship between contributors and non contributors	from 80% to 100%	0	0,2
		from 50% to 79%	0,5	
		less than 50%	1	
Health Coverage	from 80% to 100%	0	0,2	
	from 50% to 79%	0,5		
	less than 50%	1		
Educational measure	more than 12 years	0	0,15	
	more than 7 years to 12 years	0,5		
	from 0 to 7 years	1		

### **3. RESULTS**

A methodology for the identification of socio-territorial structure of an urban conglomerate, from census enumeration was developed. Its application to the study of the San Juan city allowed identify areas of similar level, which could be located in spatially from work with a GIS.

The analysis of inter-census changes also allowed identifying the main trends. The identification of these areas, will allow management activities to mitigate identified vulnerabilities from different instruments: projects of urban intervention, creation of management units and decentralized participation, implementation of certain regulations, etc.

For in-depth study of the physical and socioeconomic seismic vulnerability were designed two methodologies. Was built a Building Vulnerability Index (EVI) and applied to the categorization of each of the buildings located in areas identified as most vulnerable in the general study of the city. It also generated a Social Vulnerability Index (IVS) that allowed us to evaluate the socioeconomic status of each of the households that live there.

The construction of indices and their breakdown in various indicators help to identify the causes for which an area or locality in the city is more vulnerable than another, or in what aspect is its greatest weakness. This eases the verification of the results and ultimately guides the planning and management actions to be carried out to modify the conditions that influence the vulnerability. It is also important in the sense of allowing design tactics and possible courses of action, depending on the socioeconomic detected.

The results have been transferred to the Department of Planning and Urban Development and the Provincial Institute of Housing, Government of the Province of San Juan.

### **4. CONCLUSIONS**

The concept of risk and the terminology associated with its definition has varied over time and with the disciplinary perspective from which has been addressed. A holistic view of risk, which eases its estimation from a multidisciplinary approach, can achieve more effective management of it.

From this approach, the work presented has developed methodologies for the evaluation of the Social Vulnerability, which have supplemented the study of physical vulnerability to allow development of more effective plans and programs for mitigation.

This will be enabling to generate special programs for those high-risk urban areas. They may include, among others, restructuring and consolidation of existing buildings, the possibility that the population has access to credit for the improvement and construction of houses or self-organizing systems, sanitation titles, employment generation, creation of programs for high risk groups: children, elderly, disabled, homeless, etc.

The stated above is part of the philosophy of prioritizing public policies that tend to reduce risk from a set of measures and tools designed to act primarily on the vulnerability, over another set of actions that tend to intervene when it has the disaster.

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