

A theoretical and methodological essay on the concept of vulnerability.

Un ensayo teórico y metodológico sobre el concepto de vulnerabilidad.

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Abstract

This paper presents a bibliographical review on the concept and methods of identifying vulnerability in urban areas. From systematic bibliographic searches, the main concepts that orbit around vulnerability are defined, as well as their concretion around the most disadvantaged groups or groups such as women, children, the elderly or immigrants. Subsequently, the causes that are usually presented to explain the phenomenon and its different variants or typologies, environmental, social, economic, residential or subjective, are analyzed. In addition, it also outlines the main methods that, from variables and indices, have been formulated to try to measure and visualize socio-spatial inequalities in a multidimensional way. Finally, geodemographic analysis is presented as another approach to the analysis of socio-spatial differentiation from Sociology and Urban geography.

Keywords:

Vulnerability; Social vulnerability; Social vulnerability index.

Resumen

Este trabajo presenta una revisión bibliográfica sobre el concepto y los métodos de identificación de la vulnerabilidad en ámbitos urbanos. A partir de búsquedas bibliográficas sistemáticas se definen los principales conceptos que orbitan en torno a la vulnerabilidad, así como de su concreción en torno a los grupos o colectivos más desfavorecidos como mujeres, niños, ancianos o inmigrantes. Posteriormente se analizan las causas que habitualmente se han planteado para explicar el fenómeno y sus diferentes variantes o tipologías, ambiental, social, económica, residencial o subjetiva. Además, también se esbozan los principales métodos que, a partir de variables e índices, se han formulado para tratar de medir y visualizar las desigualdades socio-espaciales de manera multidimensional. Finalmente, se presenta el análisis geodemográfico como otro acercamiento al análisis de la diferenciación socio-espacial desde la Sociología y la Geografía urbana.

Palabras Clave:

Vulnerabilidad; Vulnerabilidad social; Índice de vulnerabilidad social.

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1. Introduction.

Within the field of social sciences, research into urban inequalities goes back several centuries. Geographic, sociological and economic studies have inquired into urban segregation and its different dimensions, along social, economic, educational and racial lines. The majority of these contributions depart from the idea that there exist differences in the social composition of the population, but that these do not presuppose an element of variation in regards to the impacts generated by environmental decline or economic inequalities. Still, in the last decades a different focus on studies about socio-spatial differentiation in cities seems to have gained importance. Since the 1980s up until today, new avenues have opened up that accentuate how differences in social composition and spatial distribution of populations may be reflected in unequal behaviors towards environmental and social issues.

Consequentially, scientific literature has produced new concepts such as environmental justice, social disadvantage or social vulnerability, which focus precisely on how unequally distributed populations with differing socio-economic characteristics have been unequally affected by environmental, economic and social changes. In other words, there is greater recognition of the heterogeneity of populations in relation to the impact of environmental change, as well as in relation to social, urban, economic and demographic issues.

While concepts such as exclusion and poverty are both considered vulnerabilities, it is important to differentiate between the two, even though at times they might reinforce one another. The idea of vulnerability itself is much broader and affects a potentially much larger part of the population (Morrone *et al.*, 2011). In economic terms the poor are evidently more vulnerable, but the fact that we speak here of dynamic concepts does not imply that they are always necessarily related to one another. As such, this paper places emphasis on the social aspect of vulnerability, which is centered on the dynamics of socio-spatial structures and processes, and how these affect disadvantaged individuals and groups in their daily lives (Sánchez and Egea, 2011). As the previous report about human development recognizes, human vulnerability is by no means a new issue; however, it has become more palpable in recent decades as a

result of physical factors such as climate change and human factors such as financial instability. In fact, since 2008 there has been a growth deceleration of the Human Development Index (UN) and its three components in most world regions.

This paper presents a bibliographic review of the concept and measurement of vulnerability towards environmental and social dangers in urban contexts. Departing from theoretical and empirical approximations selected from existing literature, this paper will define the concept and causes at the root of vulnerability in order to sketch the main variables and indicators used to measure and visualize socio-spatial indicators in a multidimensional way.

2. Objective and methodology.

The main objective of this work is to present a bibliographic review about the concept and methodology to identify vulnerability in urban areas. For the purpose of this study, this paper has relied on systematic bibliographic searches in the field of vulnerability. It has drawn upon the most relevant academic databases (ISI Web of Knowledge, Google Scholar and Dialnet), chronologically scanning and organizing works starting from the year 2000 until nowadays. The analysis has focused on those works that either are of a theoretical nature and as such were useful in the discussion of the past and current evolution, or that present a spatial analysis of vulnerability disaggregated at the intra-urban and intra-regional level, and as such are at the basis of future development of indicators.

3. About the concept.

Vulnerability in and of itself is a multidimensional and multifaceted concept (Alguacil *et al.*, 2014; Mateos, 2013) for which there exists no consensual definition or measurement (Sánchez and Egea, 2011). From a purely etymological perspective the term eludes physical, economic, political or social susceptibility, the possibility of a population being affected by an external and destabilizing (human or natural) issue or phenomenon (Cardona, 2003), which in the case of being left unmediated could escalate in more critical situations of disadvantage, poverty or exclusion. The latter part of this definition could

well be supported by the increase of threats and risks, or by the debilitation of mechanisms that tackle these (Alguacil *et al.*, 2014). From another perspective, the term also refers to the “incapacity of individuals, organizations and societies to bear the adverse impacts derived from exposure to multiple stressors” (Warner, 2007:14). Decidedly, the exposure to risks of varying nature, the mechanisms and resources used to confront them (Morrone *et al.*, 2011; CEPAL, 2002), as well as the capacity of society to respond and adapt to them (Coy, 2010) are all linked. In addition, as other authors (Sánchez and Egea, 2011) have already pointed out, vulnerability can also be understood as a negative state in the case of being incapacitated or as a state of empowerment in the case of a capacity to confront risks. It is evident that this has an enormous influence on implemented social strategies and policies.

This being said, it is important to keep in mind that analyzing social inequalities in whichever possible context inevitably alludes to personal issues related to the individuals living there. In other words, vulnerability, just like any other phenomenon of this nature, has a clear social component; that is to say, it does not affect all populations -be they individuals, households, groups or societies- the same, but it is an internal factor corresponding to the susceptibility or predisposition to suffer harm (Cardona, 2003). More precisely, vulnerability is exactly the incapacity or difficulty that individuals or groups experience facing a threat or risk, as well as the potential inability to recover from them (Egea *et al.*, 2009). As professor Ricardo Méndez (2015:11) points out, vulnerability is also a social construct that may be conditioned by ideologies (such as neoliberalism), and which may increase the susceptibility of certain localized groups who have a harder time confronting difficult situations.

Due to the aforementioned lack of consensus, there are a significant number of additional works that attempt to define the term and cite the causes of vulnerability from a variety of perspectives. In this sense, Cutter *et al.* (2003) suggest that vulnerability helps to identify the presence or absence of certain characteristics of communities or individuals that make them capable of preventing, responding to, or recovering from environmental dangers. It determines the impact and potential losses of such dangers in a concrete community (Kuhlicke *et al.*, 2011).

Echoing this, Eakin y Luers (2006) combine various definitions of vulnerability and propose that the term really comprises three factors: first, the exposure to risk or the vulnerability of a population towards environmental risks; second, the sensitivity of a system to stress. In the words of Alguacil (2006), this would be the perception of insecurity and fear of a decrease in social mobility or a concrete worsening of the living circumstances of a population. And, finally, the capacity or ability of such a system to withstand or absorb (or to respond to or confront) the impact of those stressors. This is what some authors, departing from the literature on ecology, define as resiliency or the capacity for resistance. Or, ultimately, the ability of a community to respond to, confront, recover from or adapt to certain dangers (Cutter *et al.*, 2003). This capacity to adapt can be improved or complicated depending on the environment and strategies, which should not necessarily be read as mere acquiescence, but more so as a capacity to understand the new context and act accordingly (Méndez, 2015). It also addresses a question that could be seen from the individual as well as the collective perspective, given that, in essence, resiliency “tries to guarantee that the State, the community and global institutions work towards empowering and protecting the people” (PNUD, 2014:5). The latter would explain the existence of prejudices against certain groups of the population, especially minorities.

According to Sherrieb *et al.* (2010), this capacity would vary in function of the level of economic development, the strengthening of social capital, tangible information and communication (for example, legislation) as well as intangible (traditions) and, lastly, the ability or individual and collective aptitude across established social networks. Hence, the unequal response on behalf of more or less homogenous communities in the face of similar environmental or social dangers or disasters. Furthermore, in relation to resiliency, Gauto (2010:241) points out the importance of it not just a being matter of confronting threats, but also of the capacity to overcome them and come out stronger. This is what the literature calls “assets.” For the OECD members, Morrone *et al.* (2011) groups assets into four categories: economic capital (the total financial and fixed capital, such as homes, savings accounts, insurance, housing, investments, etc.); human capital (level of education and skills applicable to the labor market, health,

personal traits such as adaptability or perseverance); social capital (at the family or individual level these would be the social networks or personal relationships); and collective or public assets, which refer to the social support mechanisms and public services, such as public health services, education, housing or unemployment benefits.

No less certain, as Mateos (2013) points out based on previous social and economic studies, is that social vulnerability is not a phenomenon that comes about suddenly: it is a dynamic process that is influenced by diverse factors such as the unequal distribution of resources, the action or inaction of individuals, or historic patterns of social domination or marginalization. In fact, the most persistent and recurring kind of vulnerability, in addition to revealing the shortcomings of public policy and its institutions, stems from long traditions of historic exclusion, cultural practice and social norms. Understood as such, it would be interesting to focus on the fragility of individuals (Bertoux y González, 2015) in more sensitive or vulnerable groups (Thomas, 2013:80), which could be even more telling if possible. So whom are we talking about? Morrone *et al.* (2011) suggest in their study that the vulnerable are those who are in need of the so-called assets necessary to confront negative events (a decrease of income, unemployment or sickness). This implies that we are all vulnerable to a certain degree -a fact that is often overlooked- depending on our own limitations and given that, we find ourselves susceptible a diversity of risks throughout our life (Sánchez *et al.*, 2012:57). Regardless, the United Nations outlines three major types of vulnerable groups. First, there are the poor and socially excluded, informal workers, who are especially vulnerable to economic and health crises. Second, they consider women (due to their often unfavorable position in many developing societies and countries, as Coy (2010) argues), migrants, disabled persons, minorities and youths. These groups are particularly vulnerable to natural and social disasters, as a result of their geographic location, position within society, or stage in life. Lastly, there are entire communities and regions in the midst of conflict or civil unrest whose situation is worsened as the result of social disintegration, unresponsive institutions or ineffective government.

The second group also comprises children and seniors, given that they face additional difficulties to escape or confront certain risks and,

as a result, suffer greater consequences such as increased health risks due to exposure to contaminants. These two particular groups have been the focus of a number of interesting studies, such as these by Bello (2013) about senior citizens in Havana, Cuba, or by Sánchez (2009) about the aging of the population in Granada. Along the same lines there is the sizeable study about social vulnerability by Sánchez and Egea (2011), which also focus on the causes and consequences of old-age vulnerability. Significantly, fewer works have been dedicated to the study of exclusively children. Among the notable ones are those by a group of scholars at the Pontifical University of Comillas, headed by professor Lázaro (Lázaro, 2014; Lázaro and Mora, 2012). Almost all of the works analyzed refer to the problems stemming from early exposure to risk, such as children who grew up in poverty, and which are associated with a higher probability of future problems (Young, 2014), be it less apparent in the case of the most developed countries (Wachs and Rahman, 2013).

4. About the cases.

But what is behind vulnerability? And what causes and factors play into it? The range of definitions discussed earlier equally reveals the variety of causes that might underlie the concept. In order to understand such a complex phenomenon, it is necessary to consult studies that inquire into the causes that generate vulnerability. This, in turn, may strengthen the ability of individuals to confront and recover from environmental and social impacts (Mateos, 2013), keeping in mind that situation of conditions of individuals and households must be interpreted within the proper context and chronological development (Holand and Lujala, 2013; Coy, 2010). To be precise, vulnerability is a phenomenon that changes over the course of one's life, as is apparent when considering certain groups such as children, youngsters, or the elderly, who are faced with particular threats that require specific responses either in the early stages of life or at the retirement (PNUD, 2014).

Adhering to the issues discussed earlier, vulnerability is intimately linked to risks and threats, which would be considered the origins of the cause, and which do not tend to be perceived until the effects are manifested. From the literature, emerge two different hazard typologies: those ha-

zards of a natural character and those of a human character. The first can be considered to be of a strictly environmental nature, while the second are related more closely to the social sciences and are thus considered to be of a social nature. The social hazards are less well defined and would be linked more closely to specific populations that are more sensitive to its impacts; they can be divided into two types (Egea et al., 2008). First, there are urban risks or threats, such as insufficient accessibility, speculative market pressures, deterioration of the built environment, or the disappearance of landmarks due to large infrastructural interventions. Second, cities are faced with risks and threats of a social nature as well, such as social restructuring, criminal activity, migratory populations, insufficient institutional intervention, changing socioeconomic composition, housing inadequacies, the composition of households, the lack of opportunity, or even the perception of space. In relationship to the latter, Sánchez et al. (2012) even suggest that in many cases, social risks are related to the social impacts created by threat from a natural perspective, leaving aside the risks that are derived from strictly economic and social characteristics of the population, as well as existing inequalities.

Related to this point, it is also necessary to consider the importance of the historical, political and social context. For example, the different degrees of severity of the current metropolitan crisis in Spain are the result of vulnerability generated by its prior trajectory (Méndez, 2015). In addition, it is also necessary to consider other aspects such as the frequency, intensity, and degree of exposure of a group to the phenomenon in question. There is some consensus in the literature as to the most significant factors of social vulnerability. These would be the lack of access to financial, labor and knowledge resources, the disintegration of support mechanisms (public or family-bases), crime, poor health, the specific characteristics of vulnerable demographic groups (gender, age, level of education, ethnicity, etc.), the low quality of housing, shortages in resources and equipment, inequities embedded within the system itself, as well as the low level of social capital. In relation to this, Couch and Coles (2011) argue that environmental hazards such as natural disasters or extreme weather exert a strong pressure, generating a “culture of distress”, internal communal conflict and interference of external

government agencies that ultimately undermine the capacity of residents to respond.

All these causes confirm the diverse nature of risks, which explains why human vulnerability might be studied from so many different perspectives: each with its own focus, definition and methodology depending on the nature of the risk (Morrone et al., 2011:6). As a result, different types of vulnerability, attributed to a variety of causes, have been derived. In particular, there are three common classifications of vulnerability: social or social-demographic; economic or socio-economic; and environmental or biophysical. In the latter category, numerous contributions since the 1980s have focused on natural disasters and resulting food shortages, as has been reviewed in the work of Campos-Vargas et al. (2015) as well, which interestingly employs the term *sociocultural risks* to denote the duality of vulnerability with natural origins yet social effects. Hence why in many cases social vulnerability in the face of natural disaster (Thomas, 2013), in a broader sense, is used to describe all the factors that determine the outcome of a natural disaster (Brooks, 2003). Following this logic, Ruiz (2012:18) departs from an analysis of diverse definitions and suggests three principal focuses from an environmental perspective. On one level, vulnerability is interpreted as the exposure to natural hazards. On another, it is understood as a physical characteristic of the landscape, dependent on the type of risk or hazard. And, lastly, it can also be conceived as a social component. In addition, other contributions, focused on environmental risks such as sea level rise, air pollution, soil erosion or the loss of biodiversity have followed. Currently, scholarship has focused increasingly on this hazards associated with climate change as well, which contribute to an increase in vulnerability. Related to the increased natural threats are numerous studies that, among others, have cited the *Intergovernmental Panel on Climate Change* (IPCC, 2011), which dedicates significant resources to the study of vulnerability and has been the germinator of a specific group of scholars that study its impacts. Even though the work by Brooks (2003) has been the main reference in terms of the risks and adaptive strategies related to climate change, other authors such as Denton (2002) and Lampis (2013) have contributed to the discourse as well from a theoretical perspective, while authors such as Bertoux and González (2015), Córdova and Romo (2015),

Adger (1999) or Huang et al. (2005) have contributed from an applied perspective, respectively focused on the metropolitan area of Guadalajara, Mexico, the Mexican State of Coahuila, the Vietnamese coast, and Western Canada.

Domínguez et al. (2009) indicate that social or socio-demographic vulnerability is typical of urban areas whose inhabitants are at a disadvantage in terms of labor or access to goods and services. In the same vein, Sánchez and Egea (2011) point out that this is linked to certain variables that allow the identification of groups vulnerable to certain risks, such as aging of the population; declining birth rates and fertility; labor incorporation of women or family changes, which could add to the complexity of household structures and present a greater degree of vulnerability to the weakening of social and family support networks; and the arrival of foreign immigrants, which could lead to social exclusion and marginalization (Alguacil et al., 2014). In line with the above, Warner (2007) argues that this modality of vulnerability is generated from the interaction of social forces, capable of reducing or solving it through interventions and multiple stress factors that, if maintained, will reinforce it. Although Brooks (2003) specifically refers to risks linked to climate change, he argues that the nature of social vulnerability will depend on the very nature of the hazard to which the space or group in question is exposed. And, even though social vulnerability does not depend on the intensity of the natural risk per se, certain properties or characteristics do contribute to higher vulnerability. This is precisely what differentiates this modality of social vulnerability from biophysics, which is indeed a function of the frequency and severity, a function of the probability of occurrence of a certain type of risk. In any case, the intense relationship between the two types of vulnerability raised so far seems evident. Hence, some authors incorporate the concept of *socio-environmental* vulnerability (Moreno et al., 2016), to refer to the vulnerability of certain population groups to environmental conditions.

For its purposes, the United Nations narrowly interprets economic or socio-economic vulnerability as having a low and irregular income, and uses it to characterize the least developed countries with a low level of human development and a high rate of structural economic vulnerability. This modality of vulnerability is analyzed by Coy (2010) for the case of the Latin American coun-

tries in recent years. The results show an intense relationship with the incorporation of the area into global economic circuits, the turbulence of the international market, the continuous lack of distribution of wealth, and the application of neo-liberal policies. All of this has led to a growing vulnerability of large, marginalized sections of society, characterized by growing precariousness of living standards, in rural and especially in urban areas. This being the case, it is important to understand that vulnerability is not unique to developing countries. Nothing is further from the truth. As the United Nations acknowledges, the slow recovery following the global economic crisis in some developed economies is causing unacceptable levels of insecurity and vulnerability among populations, marked by high unemployment, low levels of education, decrease of disposable income and a reduction of the social safety net.

Morrone et al. (2011) argue that although the ownership of economic assets (money, savings, housing, etc.) is not sufficient to avoid vulnerability, those who do own assets are better positioned than those who do not any at the time of experiencing threats in the future. In short, economic vulnerability would be the sum of limited income and economic assets that, depending on their level, will determine the intensity of one's vulnerability. However, it is also necessary to emphasize the importance of market insecurities (e.g. work) and exposure to risk (unemployment for example). For their analysis, indicators that include information on the availability or lack of household assets as well as the subjective perception of one's own financial situation should be considered. Something that obviously is not always possible.

While Alguacil et al. (2014) argue in their conceptual and methodological review of vulnerability that vulnerability derives from social exclusion and residential exclusion, which feed one another and tend to be spatially concentrated through the effects of segregation, they add two additional types of vulnerability. First, the *subjective*, which is related to the perception of the risk that each individual has as a resident of a social space, and, second, the *residential*, which relates to deficiencies, seniority and shortcomings of not only housing, but of the built environment as well⁴. Given the important role of the built environment in the human condition itself, as well as the consideration of housing as a determining factor of social vulnerability, it is necessary to

unpack this concept a little further. Undoubtedly, a degraded habitat, both the dwelling itself as well as the neighborhood, reveals structural deficiencies that can lead to feelings of vulnerability and exclusion. Especially in the case of substandard housing, these values could reach extreme limits. In fact, as Shrestha *et al.* (2016) confirm, studies have shown that residential deprivation is one of the critical links between social structural factors and health-related environmental inequalities, in some cases even with serious illnesses such as cancer (Morello and Jesdale, 2006). However, beyond these premises, this paper raises two additional issues. First, there is significant difficulty obtaining relevant statistical information, especially in relation to the urban environment. Hence, there is a need for qualitative methodologies such as fieldwork. Second, it is necessary to incorporate socio-economic variables, such as unemployment or income level, to the analysis of residential vulnerability. In fact, the most appropriate classification, as seen in other typologies, would be socio-residential vulnerability.

Subjective vulnerability, more precisely, is defined by a plethora of physical, social and psycho-emotional factors that vary considerably from one population to another. The way in which threats are internalized is as important a factor as the objective or measured value of that threat. In this sense, Couch and Coles (2011) argue that the stress factors associated with environmental hazards of a human nature are uncertainty about the impact on one's health, insecurity generated in relation to housing and employment, social stigma, and media-related and cultural pressures. It is evident then that the perception of the risk also depends on the robustness of society and its expectations to confront the situation. Therefore, this perception is unequal among populations that share many similarities in their socio-demographic characteristics (Mateos, 2013).

In their contribution, Guezo and Verrhiest (2006) speak of two types of vulnerability: the territorial type, which depends on the geographical characteristics of space and the level of public protection; and the social type, which relates to capacity for collective (and individual) action when facing a catastrophic event. In a study on

territorial vulnerability on the island of Mallorca (Spain), Ruiz (2012) combines the two previous typologies, suggesting that vulnerability is a multifactorial attribute in which geographical factors converge, that is, locational, territorial elements and social issues related to the population and their capacity to deal with a disaster (social vulnerability). Although there is no direct correlation between the place of residence and social behavior or quality of life, some research such as that of Kennet and Forrest (2006) identifies everyday living space as a key place for access to new opportunities and a diversity of relationships. In short, vulnerability is thus a relative, contextual, and perceptive issue that also incorporates a markedly territorial perspective (Alguacil *et al.*, 2014).

5. About the method.

Now that the central concept of vulnerability has been elaborated on, it is necessary to look at how it is actually measured. In this sense, it is important to focus on, for example, the statistical variables. Which variables have been most commonly used? What quantitative indicators have been constructed and/or used? In order to answer these questions from a variety of perspectives, this paper will depart from the numerous attempts made in the last decades. There is no doubt as to the growing interest in these questions, after all, US state agencies have for long been interested in the use of social vulnerability indicators for the purpose of risk mitigation in planning processes. Similarly, the United Nations entitled its latest development report "Sustaining Human Progress: Reducing Vulnerabilities and Building Resilience." These examples both agree that there remains significant disagreement regarding the justification of quantitative indicators used for measurement, quantification and/or representation (Tate, 2013:528).

As has been pointed out, numerous attempts have been made in recent years to develop indicators and measures for social vulnerability. In the majority of the literature, definitions and causes are first conceptualized, after which they are linked to statistical variables and reduced based

⁴ Based on previous studies, Holand *et al.* (2011) propose a built-environment vulnerability index (BEVI), which was applied in 2006 to a set of Norwegian municipalities and uses housing variables (seniority and density) and infrastructures (roads or pipelines).

on indices (Holand and Lujala, 2013:313). Most of them analyze inequalities through variables and dimensions of socio-demographic conditions (age, race, sex, country of birth, education, occupation, etc.), economic status (social status, income, etc.), or of other characteristics (housing, provisions, social networks, security, etc.) referenced almost always at the individual or household level. In this sense, Morrone *et al.* (2011) develop a methodological proposal for the measurement of vulnerability based on the four variables mentioned above, and 11 unique indicators such as the proportion of people who do not have direct contact with their friends or family members, or the proportion of people excluded from two or more essential services. Linking all of the above, Mateos (2013) analyzes 22 scientific publications and shows that most of the variables used can be grouped into only eight categories: demography, identity, economic capital, human capital, social capital, material conditions, urban environment, and, finally, governance.

In this sense, when measuring social vulnerability to environmental risks, most of the studies opt for methodologies that transform and combine these variables, constructing indices of socioeconomic status or social vulnerability. Despite their intended objectivity, Lixin *et al.* (2014) point out that they remain qualitative methods and, therefore, constitute subjective valuations that are not exportable between countries. The next step would thus be to use quantitative methods in the evaluation of the obtained results, thereby achieving more accuracy. Even so, these indices help to simplify the multidimensional complexity of the phenomenon by means of a metric value (Tate, 2013:527) on the one hand, and applied and mapped Geographic Information Systems in varied urban scopes and at different scales on the other. This is what the "hazards of place model" encapsulates.

Thus, in the international literature one of the main referents is the Social Vulnerability to Environmental Hazard Index (SoVI) by Cutter *et al.* (2003), applied in the United States. For their elaboration, the authors use up to 42 different census variables (with 1990 data), which are reduced to 11 through a principal components analysis. The method allows quantifying the vulnerability and establishing different levels of intensity. This article highlights the importance of income level as a key factor, explaining 12.4% of the variance, but also of age (accounting for 11.9% of

the variance), especially in the younger segment (less than 5 years) and advanced segment of the population (over 65). Due to its importance, this index has been used in different countries. For example, Holand and Lujala (2013) applied it (a SoVI Replica) to the 431 Norwegian municipalities in 2006 and concluded that the importance of context is not to be underestimated. In fact, using an adapted replica of the mentioned index (SoVI Adapted), they observe significant differences in several localities and in the dataset. In doing so, the replicated index accounts for only 19% of the variance. Hence why they propose a necessary conceptual, technical and geographic adaptation of the index. The same conclusions are found in the work of Lixin *et al.* (2014), which applies the SoVI to 323 Chinese cities from 12 social variables such as gender, age, educational level, family structure, immigrants, economic status or employment. The results show a concentration of vulnerability in the western half of the country, coinciding with the most disadvantaged provinces characterized by aridity, depopulation, backwardness and poverty.

In the same way, the relationship between the environmental and the social is present in many works. The abundance of literature, which, through synthetic indicators, general indicators of social disadvantage, or indexes created ad hoc, addresses this, demonstrates this fact. This is the case for the Integrated Environmental and Social Vulnerability Index (IESVI) by Shrestha *et al.* (2016). The aim of this work is to identify "hotspots" of groups and vulnerable areas with accumulated burdens such as air quality (PM10 and NO2) or noise pollution, and areas with environmental benefits such as accessibility to green areas, along with social vulnerability (represented in young people, elderly, migrants or recipients of subsidies) in the city of Dortmund, Germany. The results suggest that spatial information of multiple burdens and benefits, combined with information on small-scale social vulnerability, provides a strong tool for identifying areas of the population with a higher level of vulnerability and that suffer from lower environmental quality. However, there remains only a limited degree of inequality with respect to social vulnerability for single and multiple environmental burdens and benefits in Dortmund, Germany.

In the same fashion, the RECORD Cohort Study by Havard (2011) looks at residential ex-

posure to traffic noise in Paris, and, paradoxically, concludes that the populations of the most disadvantaged districts of Paris (taking as selection criterion the spatial distribution of educational levels, the mean value of dwellings, and the proportion of foreigners), are the ones that suffer the least. Other studies include the application of Mitchell and Norman's (2012) poverty indices for England in the period 1960-2007 and Wheeler's (2004) environmental indices in England and Wales, which also reveal environmental discrepancies when relating environmental factors to social inequality. Finally, the application of the New Zealand Multiple Environmental Deprivation Index by Pearce *et al.* (2011) also concludes that environmental quality is negatively related to the health of the inhabitants of the most disadvantaged areas or districts.

Another example along the same lines is Collins *et al.* (2009) integrated risk map, which is the result of a proposal to measure social vulnerability in the Mexican city of Juárez and the American city of El Paso. The basic premise includes four basic elements: institutional capacity, socioeconomic status, access to resources, and, finally, demographic structure and dynamics. In the latter case, children and the elderly along with other dependent or non-dependent groups (ethnic minorities, women, the elderly or sick), are two of the variables used for their obvious link to vulnerability.

Furthermore, Andrey and Jones (2008) conducted a study of Greater Vancouver (Canada), using youths (under 19 years of age) and the elderly (over 65 years) as two of the 19 significant variables, demonstrating the applicability of this method for identifying the multidimensional structure of social disadvantagedness. These authors depart from the fact that groups of variables with similar patterns are identified as fundamental elements (main components), which, in turn, make it possible to reveal the unequal distribution of social vulnerability in the face of environmental and social threats.

By adapting the environmental justice measurement tool of the United States Environmental Protection Agency, the work of Sadd *et al.* (2011) proposes an analysis method (Environmental Justice Screening Method –EJSM–) that allows

evaluating the ranking of cumulative impacts and social vulnerability on the California coast from 23 metric indicators, including children (% of the population under 5 years old) and the elderly (% of the population over 60). In similar terms, Tate's article (2013) compiles a social vulnerability index applied to Sarasota County in Florida (based on its census tracts from the year 2000). Tate's article is part of a larger study that considers the use of other indices in multiple counties and proposes the use of three sub-indices and corresponding variables: differential access to resources (income per capita, average price of housing, employment or level of education); demographic structure (ethnic minorities, children, the elderly or single-parent households); and special needs (foreigners, households without a car or dependents). Its main methodological contribution lies in the use of the Monte Carlo Method, used for complex mathematical expressions that can be evaluated accurately.

The interest in quantifying vulnerability has reached such a level that supranational agencies such as the United Nations have developed an index of structural economic vulnerability. This is obtained from natural crisis indicators (victims of natural disasters) and external crisis indicators (instability in exports or agricultural production), along with the degree of exposure to these crises. The results show a high vulnerability in the least developed countries and a slower decline in the least developed countries compared to other developing countries.

In the Iberian American context, there are also numerous contributions on the analysis and measurement of vulnerability from an applied perspective. In Spain, one of the main references is the Catalog of Vulnerable Neighborhoods included in the Observatory of Urban Vulnerability, which was jointly developed by the Ministry of Development and the Department of Urban Planning of the Polytechnic University of Madrid⁵. The diachronic methodology (1991, 2001 and 2006) presented in this work by Alguacil *et al.* (2014), is based census data. The identification and analysis of these vulnerable districts is carried out at the census tract level for cities with more than 50,000 inhabitants and for provin-

⁵ This work responds to the pioneering work "Urban Inequality in Spain" by Felix Arias, which constitutes the starting point for many of the studies on vulnerability in this country.

cial capitals that do not reach that number. The work departs from four types of vulnerability: socio-demographic, socio-economic, residential and subjective. The methodology is based on the analysis of demographic features linked to each of these types, based on 20 different indicators. For example, the first type of vulnerability (socio-demographic) is related to the aging of the population, the structure of households, and the immigrant population. Thus, in order to detect and assess aging, the methodology uses the percentage of single-person households over 64 years old and the over-aging rate, that is, the percentage of people over 74 years of age compared to the total population. The rest of the phenomena and vulnerability typologies are elaborated on in a similar way, first, in order to detect and characterize vulnerable neighborhoods, and second to deepen the analysis. As a by-product of the above, the contribution of Rodríguez *et al.* (2016) focuses on the analysis of the existing residential vulnerability in Spanish cities over 50,000 inhabitants. This work uses census data from the year 2011 and identifies three variables: the percentage of the population over 16 years of age that is illiterate and uneducated, the unemployment rate, and the percentage of family dwellings in generally bad or dilapidated buildings. The results call into question current urban models and highlight the need for more comprehensive urban policies, resolving both physical as well as social problems.

In addition, the work group of the University of Granada headed by Carmen Egea also has a long history in this area. Examples include the publication of Egea *et al.* (2012), entitled "Social Vulnerability: Positioning and Angles from Different Geographies", which includes varied and interesting contributions on this subject and is the result of the Network on Social Vulnerability of the Latin American Population Association (ALAP). The same work group also published an article in 2008 on vulnerability and disadvantagedness in Andalusia, where a mixed methodology was designed to detect and analyze the disadvantaged areas of Andalusia using 32 variables relating to demographic, economic and housing data. The disaggregation scale used was the census section (5342 total), with data from the 2001 and 2006 censuses. The results showed two types of disadvantaged, potentially vulnerable areas: the historic and consolidated districts, and

the peripheral areas up for inclusion in the urban area. Along the same lines, there's a third work by Egea *et al.* (2009), in which the 182 census tracts of the city of Granada serve as the basis for a study on the level of "unfavorability", obtained from 23 socio-demographic, economic, labor and housing variables. A study by Sánchez (2009) confirms that these conditions in the city of Granada are owed to factors of exclusion, dependence and disability of the elderly population. The work uses a socio-spatial vulnerability index of aging, obtained through a mixed methodology with census data. The methodological success of these inquiries allowed for their implementation in other cities. For example, the work of Fabre *et al.* (2013) presents a socio-spatial segregation index based on nine demographic, labor and housing variables, which are applied to 155 basic analysis units and reveal the social inequalities and territorial imbalances in the Mexican locality of Xalapa.

A third reference to consider the research group on geotechnologies and socio-spatial planning (Geoteplan), which in recent years has developed several projects focused on the use of geographic technologies to investigate phenomena such as environmental justice or vulnerability. In their work, Moreno *et al.* (2016) and Moreno y Martínez (2016) have developed a socio-environmental vulnerability index (IVuSA) applied to the 1068 census tracts of Barcelona in 2015. Its main methodological contribution combines certain demographic groups, weak to environmental threats, with their socio-economic status, serving as a "modulator" that modifies the fragility of such vulnerable groups as children or the elderly.

Another important example to consider, be it for a smaller area (the island of Mallorca), is the work of Ruiz (2012), which proposes a model for the calculation of integrated territorial vulnerability (VTI) that brings together various components (the territory exposed to territorial dangers, territorial value, intrinsic vulnerability and social vulnerability). Although each of them presents relevant information on their own accord, their synthesis provides a fundamental overview, which also specifies the results in quantitative monetary units.

Numerous examples of contributions that attempt to establish vulnerability detection methods are also found in Latin America (Sánchez and Egea, 2011). Among them is a study by Zulaica (2010) that develops a representative index

of socioeconomic conditions (ICSE), applied to the south sector of the periphery of the city of Mar del Plata in Argentina. This study uses five indicators covering the same dimensions: education, health and housing services, housing, poverty and accessibility. The analysis of the 2001 Census led Zulaica to integrate environmental impacts with socioeconomic conditions in order to establish different environmental units. Also valuable is the contribution of Thomas (2013), which develops a Social Vulnerability Index against natural hazards (IVSA), based on a principal components analysis (PCA) of twelve variables that allows defining measurement indicators and gauging specific levels of social vulnerability for a population facing a given event. Its main methodological contribution lies in the fact that the construction of the indicator is based on the transformation of qualitative data into quantitative data from 143 household surveys in the Colombian town of Manzanillo. The results evidenced the absence of an excessive polarization of vulnerability facing potentially destructive events.

As demonstrated so far, a considerable number of research methods aimed at measuring vulnerability have been developed in the last decades. Most of these studies analyze socio-spatial differentiation or inequality through various variables and dimensions taken independently. However, some of these studies in urban social geography have incorporated more novel and innovative methodologies, namely geodemographic methods, aimed at creating socio-spatial typologies of zones or neighborhoods in a multidimensional and non-hierarchical way (Mateos, 2013). This approach contrasts sharply to those that independently establish spatial differentiation for each variable, summarizing differentiations through factor analysis or principal components. In contrast, geodemographic analysis constitutes a multidimensional analysis of social conditions, departing from the most detailed spatial disaggregation possible such as census tracts, postal codes, street blocks, or even households or individuals. This form of joint analysis aims to develop socio-spatial typologies that go beyond the use of a general index, while compiling a specific geodemographic classification for each typology of threat and place. This allows attributing more weight to more significant variables in a specific geo-historical context and based on mixed methodologies.

6. Conclusion.

The lack of a universally accepted definition does not deny that vulnerability is a multifaceted and multidimensional concept. Indeed, interest in the phenomenon has only increased in the last decades, especially when compared to more traditional environmental and economic scholarship. At the same time, it has allowed for a greater understanding of how exposed populations assume and respond to social and environmental risks. Through the construction of multidimensional indicators of social vulnerability, the academic literature has shown that the factors involved are of a diverse nature.

With this contribution, we have tried to present a wide and selective review of the concept itself and the indicators used for its measurement, trying to avoid the description and synthesizing the main trends and methodological approaches. Having done so, this paper identifies the development of geo-demographic analysis as an opportunity to review the development of socio-environmental indicators in studies on vulnerability.

In spite of the progress made, the analysis of social vulnerability still faces the challenge of unifying concepts and methods that come from closely related disciplines. In fact, as a future line of work, it is necessary to move towards a certain convergence or standardization in methods and vulnerability indexes, particularly when addressing some type of specific vulnerability. This would facilitate application in certain policies.

This is especially important in terms of risks, groups and responses. It is necessary to continue to probe what has been coined "double urban segregation" or the "inverse law of socio-environmental justice", in an effort to emphasize that the most socio-economically disadvantaged citizens are often the most vulnerable and exposed to certain environmental and social impacts. It is therefore necessary to advance greater knowledge in the field, to actively engage stakeholders, and to detect the most vulnerable groups and areas so that territorial planning and intervention strategies may effectively target and reduce risks and vulnerability. 

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