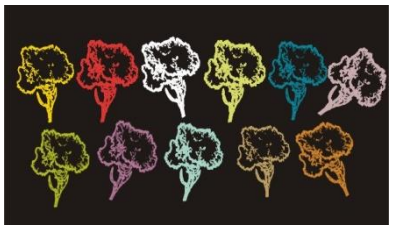

VIII CONGRESSO PORTUGUÊS DE SOCIOLOGIA
40 anos de democracias: progressos, contradições e prospetivas

ÁREA TEMÁTICA: Teorias e Metodologias [AT]

FOR A NEW METHOD TO BUILD A SOCIAL VULNERABILITY INDEX. REACHING RESILIENCE. RECONSTRUCTION OF SOCIO-DEMOGRAPHIC VARIABLES

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Resumo

Capturar antecedentes e consequências de desastres faz parte da construção de modelos descritivos e explicativos de perigos e desastres. Os desastres são eventos não rotineiros que envolvem perturbação social e dano humano (Kreps, 2001). Antes, durante e depois que eles ocorrem, os desastres são catalisadores físicos e sociais da ação coletiva (Tierney *et al*., 2001). Os fenómenos naturais (ou *hazards*/perigos) por si só não constituem desastres. Tornam-se desastres quando impactam as comunidades e as regiões que são vulneráveis aos seus efeitos (Aguirre, 2006), (Diego Gonçalves, 2013). A Universidade das Nações Unidas, em 1973, criou o Instituto para o Ambiente e Segurança Humana (UNU-EHS) com o objetivo de lidar com os riscos e as vulnerabilidades, com as consequências dos complexos, graves e latentes riscos ambientais. Assim, a UNU-EHS desenvolveu metodologias para a avaliação da vulnerabilidade e investigação de vulnerabilidades tendo em conta vários impactos de fenómenos perigosos, afetando principalmente as áreas costeiras, especialmente as cidades costeiras. Ao longo das duas últimas décadas, o desenvolvimento sustentável tornou-se também uma das questões políticas mais relevantes, estimulando diferentes tipos de abordagens e respostas. De referir também um crescente reconhecimento da importância da gestão de vulnerabilidade e resiliência na abordagem de questões de desenvolvimento sustentável. Neste âmbito, pretende-se desenvolver um novo método para a construção de um Índice de Vulnerabilidade, cuja proposta será aqui apresentada e para o que se espera a reconstrução das variáveis sócio demográficas usadas no Censos. A conjugação do sistema humano-ambiente, quaisquer que sejam as suas dimensões espaciais, constitui a chave de análise.

Abstract

Capturing antecedents and consequences of disasters is part of constructing descriptive and explanatory models of hazards and disasters. Disasters are non-routine events that involve social disruption and human harm (Kreps, 2001). Before, during, and after they occur, disasters are physical and social catalysts of collective action (Tierney *et al*., 2001). Natural phenomena (or hazard) by themselves are not disasters. They become disasters when they impact communities and regions that are vulnerable to their effects (Aguirre, 2006), (Diego Gonçalves, 2013). The United Nations University in 1973 created the Institute for Environment and Human Security (UNU-EHS) to address the risks and vulnerabilities, the consequences of complex, acute and latent environmental risks. Thus, the UNU-EHS has developed methodologies for vulnerability assessment and vulnerability research taking into account various impacts of dangerous phenomena, affecting mainly the coastal areas, especially the coastal cities. Over the last two decades, sustainable development has also become a more relevant political issue, stimulating different types of approaches and responses. There is also a growing recognition of the importance of managing vulnerability and resilience in addressing sustainable development issues. Within this scope, we intend to develop a new method for the construction of a Vulnerability Index, whose proposal is presented here and for what is expected the reconstruction of the socio-demographic variables used in Census. The coupled human-environment system, whatever its spatial dimensions, constitutes the key of analysis.

Palavras-chave: vulnerabilidade, resiliência, variáveis sócio demográficas; índice

Keywords: vulnerability; resilience; socio demographic variables; index

The United Nations University in 1973 created the Institute for Environment and Human Security (UNU-EHS) to address the risks and vulnerabilities, the consequences of complex, acute and latent environmental risks. Thus, the UNU-EHS has developed methodologies for vulnerability assessment and vulnerability research taking into account various impacts of dangerous phenomena, affecting mainly the coastal areas, especially the coastal towns. Over the last two decades, sustainable development has also become a more relevant political issue, stimulating different types of approaches and responses. There is also a growing recognition of the importance of managing vulnerability and resilience in addressing sustainable development issues. Within this scope, we intend to develop a new method for the construction of a Vulnerability Index, whose proposal is presented here and for what is expected the reconstruction of the socio-demographic variables used in Census. The coupled human-environment system, whatever its spatial dimensions, constitutes the key of analysis.

The concept of vulnerability has different connotations in the literature on disasters, depending on the orientation and perspective of research, (DOW, 1992), (Cutter, 1996, 2001). There are three main research directions on vulnerability: (a) an exposure model, referring to the identification of conditions that make people and places vulnerable to extreme natural hazards, (Burton *et al*., 1993), (Anderson, 2000); (b) a measure of social resistance or resilience to hazards associated with the assumption that vulnerability is a social condition, (Blaikie *et al*., 1994), (HEWITT, 1997); (c) the integration of potential exposures and social resilience with a specific focus in particular places or regions, (Kasperson *et al*., 1995), (CUTTER ET AL., 2000, 2010).

Considerable research attention has been paid to different components of biophysical and environmental vulnerability, namely by Mileti (1999) and to the vulnerability of the civil infrastructure. However, our current knowledge about the social and individual aspects of vulnerability is minimal. Social capital is an emerging concept as a key dimension on disaster preparedness and mitigation. Social capital refers to social networks, the reciprocities that arise from them, and their value in achieving mutually beneficial goals. It is about trust, associations, and norms of reciprocity among groups and individuals, including beliefs and customs. And it can act in reducing social vulnerabilities and increasing resilience, namely in aging, frail and physically limited individuals (Tierney *et al*., 2001), (PUTNAM, 2000), (Blaikie *et al*., 1994).

Risk analysis requires a multidisciplinary evaluation that takes into account not only the expected physical damage, the number and type of casualties or economic losses (direct impact), but also the conditions related to social fragility, which enable second order effects (indirect impact) when a hazardous event strikes in a urban center, as pointed out by (Carreño *et al*., 2005), namely littoral ones.

Most of the activities implemented by Institute for Environment and Human Security (UNU-EHS) were centered on vulnerability assessment – the most crucial and least known part of the risk equation. Multiple complex assessment tools are necessary to conceive models systems and to define the quantification thresholds, in the characterization of the states of these systems. Nature cannot be dissociated from social systems; both interact in complex, non-linear, and unsteady stochastic ways. Community vulnerability of single or multiple hazards is thus best analyzed by considering environmental, social and economic dimensions, or by analyzing coupled human-environment or socio-ecological systems, which requires improved dialogue between several scientific disciplines and between them and decision making.

The Idea[i]

The goal is to study and (re)interpret the concepts of vulnerability and resilience in order to construct a new Method for a Vulnerability Index, which can configure a good way to achieve resilience characteristics of places and people at risk, which can be used also in several situations; as in people who works for rescue and emergency teams, namely in which concern vulnerability related with organizational and events stress factors. For that we'll need to consider the reconstruction of socio-demographic variables historically used in Census, in Portugal; therefore to promote the possibility of local, transversal and comparative and longitudinal studies.

The identification of metrics and standards for measuring vulnerability and resilience is still a challenge. Composite indicators are useful tools to accomplish this task, namely to designate a manipulation of individual variables to produce an aggregate measure of disaster vulnerability and resilience.

The 2011 census for Portugal lists values for several demographic and infrastructural attributes for the 4050 parishes of Portugal (exclusive of Madeira and Azores). The idea here is to rank the parishes according to their perceived vulnerability, separately from the viewpoint of each of these attributes (the method would be the same if we had used more attributes, and in general it is preferable to use as many attributes as may be available). Once this has been completed, we have independent rankings of all the parishes (accordingly to the attributes selected), from least vulnerable to most vulnerable. Then we combine the rankings in a way that is consistent and that produces an overall ranking of the parishes, and that assigns a vulnerability score to each of them.

This way of building a vulnerability index is entirely data driven, and its strength lies in its ability to combine multiple facets of vulnerability.

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To illustrate a new method to build a vulnerability index, we have selected three attributes: age distribution of the population; educational level of the population and structural type of residential buildings -- further details on these attributes are given below.

The idea is to rank the parishes according to their perceived vulnerability, separately from the viewpoint of each of these three attributes (the method would be the same if we had used more attributes, and in general it is preferable to use as many attributes as may be available).

Once this has been completed, we have three independent rankings of all the parishes, from least vulnerable to most vulnerable. Then we combine the three rankings in a way that is consistent and that produces an overall ranking of the parishes, and that assigns a vulnerability score to each of them.

These scores are numbers between 0 and 1, and the larger the score the greater the vulnerability.

This way of building a vulnerability index is entirely data driven, and its strength lies in its ability to combine multiple facets of vulnerability.

Another strength is the fact that it relies on rankings, rather than on any social arithmetic whose adequacy naturally would be arbitrary to some extent, hence would be questionable.

Apllication to Cascais and Lagos cities

The 2011 census lists numbers of residents of each parish in eight age classes:

0-4, 5-9, 10-13, 14-19, 15-19, 20-24, 25-64, and 65+.

We computed the corresponding proportions for each parish, and then partitioned the parishes into 10 clusters, using the procedure Partition Around Medoids (PAM) described by L. (Kaufman and ROUSSEEUW, 1990).

We selected 10 clusters based on an inspection of a series of silhouette plots, for different numbers of clusters, as described by those authors. We used the procedure as implemented in function pam of package cluster for the R environment for data analysis and graphics (Maechler, Rousseeuw, StruyF, Hubert, Hornik, 2013).

We then assigned the same rank to the parishes in the same cluster. For example, all 91 parishes in cluster 5 are deemed most vulnerable (vulnerability rank 1) because the medoid of their cluster has the largest proportion of residents who are 65 years old or older. These are the definitions of the medoids determined by function pam and the ranks assigned to them based on the proportion of 65+ years old people in the medoid.

More complex ranking criteria may be used, and one of them will be illustrated below.

Cluster	0-4	5-9	10-13	14-19	15-19	20-24	25-64	65+	Rank
1	3	4	4	5	5	5	49	26	6
2	4	4	4	6	5	5	50	23	7
3	5	5	4	6	5	5	54	15	9
4	4	4	4	6	5	5	52	19	8
5	1	1	1	2	2	2	31	59	1
6	3	3	3	5	4	5	47	30	5
7	2	3	3	5	4	4	44	35	4
8	5	5	5	7	6	6	53	11	10
9	2	2	2	4	3	4	42	41	3
10	2	3	2	3	2	3	38	8	2

STEP 2

The 2011 census lists numbers of residents of each parish that can read and write, or that have completed several different levels of schooling (7 levels: LERESCRV, 1BAS, 2BAS, 3BAS, SEC, POSEC, SUP).

We computed their proportions in each parish, and clustered the parishes based on the logarithms of these proportions (because the distributions of schooling are rather skewed), using the same pam procedure described above, with 12 classes in this case.

And we ranked **as most vulnerable** the parishes with the highest proportions of residents **who can only read and write but have no further e**ducation, breaking ties according to the proportion of residents that have completed secondary education.

STEP 3

The 2011 census lists numbers of buildings in each parish in the following structural categories: BETAO, COMPLACA, SEMPLACA, ADOBEPEDRA.

We computed their proportions in each parish, and clustered the parishes based on the square roots of these proportions (because the distributions of schooling are fairly skewed), using the same pam procedure described above, with 12 classes in this case.

And we ranked as most vulnerable the parishes with the largest proportions of ADOBEPEDRA buildings, breaking ties according to the proportion of SEMPLACA buildings.

STEP 4

Now we have three independent rankings of the 4050 parishes, which we combine using a robust rank aggregation procedure described by R. Kolde and S. Laur and P. Adler and J. Vilo (2012) Robust rank aggregation for gene list integration and meta-analysis, Bioinformatics, 28 (4), 573-580, DOI 10.1093 /bioinformatics/btr709.

We did the computations using function aggregate Ranks of the R package RobustRankAggreg (Raivo Kolde and Sven Laur (2011) RobustRankAggreg: Methods for robust rank aggregation, R package version 1.0, http://CRAN.R-project.org/package=RobustRankAggreg).

The result of this computation is a numerical score that is assigned to each parish, between 0 and 1, with the vulnerability increasing with increasing score.

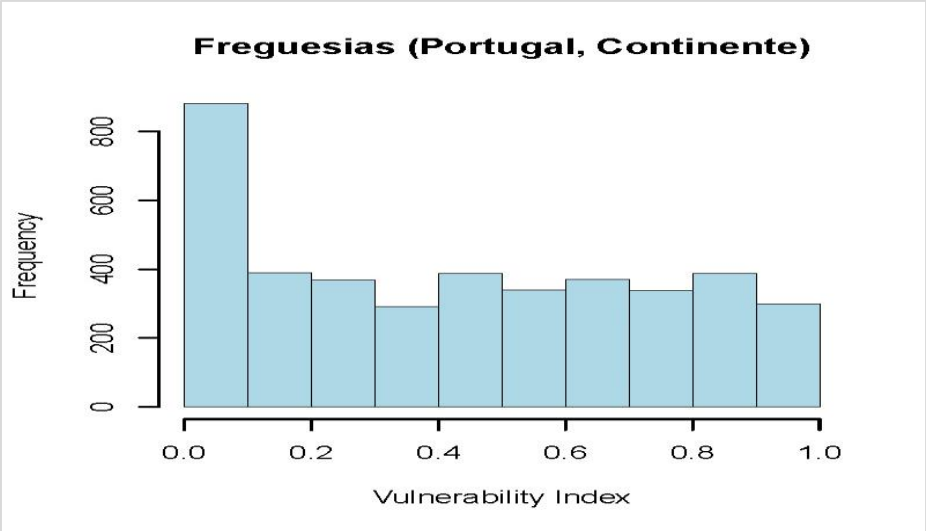
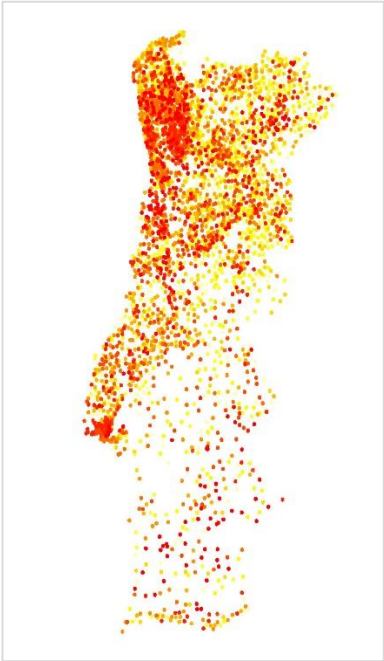


Fig. 1 - Here is a histogram of the vulnerability scores assigned to the 4050 parishes.

These scores are depicted in the accompanying map, where each circle represents a parish, and the colors increase from pale yellow to red according to increasing vulnerability (see Fig. bellow)



The index can be improved by considering additional vulnerability attributes. The clustering steps may be replaced by other means of ranking the parishes according to increasing vulnerability gauged from the viewpoint reflected in the corresponding attribute.

The particular assignment of vulnerability scores to these parishes is preliminary because it relies on just these three attributes that do not fully capture the spectrum of vulnerability factors that should be taken into account. But our objective is methodological, and for this purpose this simple illustration suffices.

Additional information is available for the parishes of Cascais and Lagos.

Cascais, has the following parishes: Alcabideche, Carcavelos, Cascais, Estoril, Parede, São Domingos de Rana.

(a) These have been ranked from most vulnerable to least vulnerable from three complementary viewpoints: age distribution; (b) educational level distribution; (c) local geology

The first two evaluations were done as already described for all the parishes of continental Portugal.

The evaluation of local geology was done by an expert who is familiar with the area.

These are the rankings of the parishes, in order of decreasing vulnerability, according to each of the three criteria above:

(a)[ii] Parede, Estoril, Cascais, Carcavelos, Alcabideche, São Domingos de Rana

(b) Alcabideche, São Domingos de Rana, Cascais, Estoril, Carcavelos, Parede

(c) Estoril, Cascais, Carcavelos, Alcabideche, Parede, São Domingos de Rana

The results of robustly aggregating these three rankings are the following (the larger the vulnerability score, the greater the composite vulnerability):

Parish	***Vulnerability Score***
Cascais	0.7
Estoril	0.4
Parede	0.2
Alcabideche	0.2
Carcavelos	0.07
São Domingos de Rana	0.03

Lagos has the following parishes: Barão de São João, Bensafrim, Lagos (Santa Maria), Lagos (São Sebastião), Luz, Odiáxere.

These have been ranked from most vulnerable to least vulnerable from three complementary viewpoints: (a) age distribution; (b) educational level distribution; (c) local geology; (d) fire hazard; (e) fire risk.

The first two evaluations were done as already described for all the parishes of continental Portugal.

The evaluation of seismic risk, fire danger, and fire risk, were done by experts who are familiar with the area.

These are the rankings of the parishes, in order of decreasing vulnerability, according to each of the five criteria above: (a) Luz, Bensafrim, Odiáxere, Barão de São João, Lagos (Santa Maria), Lagos (São Sebastião); (b) Luz, Odiáxere, Bensafrim, Barão de São João, Lagos (São Sebastião), Lagos (Santa Maria); (c) Lagos (São Sebastião), Luz, Odiáxere, Bensafrim, Barão de São João, Lagos (Santa Maria); (d) Odiáxere, Bensafrim, Barão de São João, Lagos (Santa Maria), Lagos (São Sebastião), Luz; (e) Lagos (Santa Maria), Lagos (São Sebastião), Luz, Odiáxere, Barão de São João, Bensafrim.

The results of robustly aggregating these three rankings are the following (the larger the vulnerability score, the greater the composite vulnerability):

Parish	*Vulnerability Score*
Odiáxere	0.5
Luz	0.4
Barão de São João	0.08
Bensafrim	0.05
Lagos (São Sebastião)	0.02
Lagos (Santa Maria)	0.01

Cascais & Lagos

The vulnerability Scores for Cascais and Lagos are not yet comparable because the rankings for the two sets of parishes were done separately.

Furthermore, they are based on different criteria (more criteria for Lagos than for Cascais).

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[i] The idea of this Index was already published in: Diego Gonçalves C (2013b) A new method to build a Vulnerability Index. Livro de Homenagem Prof. Doutor Fernando Rebelo, Soc. Geograf. Fac. Letras Univ. 22p.