Carpathian Journal of Earth and Environmental Sciences, July 2017, Vol. 12, No. 2, p. 549 - 562

ASSESSMENT OF SOCIAL VULNERABILITY TO NATURAL HAZARDS IN ROMANIA

Ibolya TÖRÖK

"Babeş-Bolyai" University, Faculty of Geography, 5-7 Clinicilor Street, 400006, Cluj-Napoca, Romania, e-mail: ibolya.torok@ubbcluj.ro

Abstract: Over the last decades more and more households have had to face significant human and material losses due to extreme weather conditions and natural disasters. This issue has gradually underlined the need for determining and measuring social vulnerability, both from a local, as well as from a global perspective. Although a vast amount of scientific material has been produced on the topic, there is still a strong need to develop an in-depth and holistic approach for measuring social vulnerability which can later be adapted to different scales (individual, communities) and social categories. The purpose of the paper is twofold: first it strives to contribute to the ongoing research on vulnerability by quantifying the social vulnerability of Romanian settlements in the face of natural hazards. It represents a novel contribution to the advancements in this field since up to now there have been no attempts to delimit the most vulnerable areas in the country from this point of view. Second, it aims to facilitate decision-making processes and planning efforts looking to increase the resilience of local communities. Quantifying social vulnerability can not only help identify places which are most vulnerable, but also the pillars which are its key drivers. Within this study, by using data from the 2011 Census and applying the principal component analysis (PCA), the number of the initially selected indicators has been reduced to a total of 38. By summing up and rescaling the created factor scores, a Social Vulnerability Index (SoVI) has been obtained for all settlements in Romania. Based on Exploratory Spatial Data Analysis (ESDA) I have managed to reveal the spatial pattern of settlements characterized by higher or lower levels of vulnerability. In general, high levels of vulnerability associated with low levels of resilience characterize peripheral rural areas, places which are further affected by natural hazards, especially by earthquakes and floods (rural areas found in the eastern and south-eastern parts of Romania). As the results of the study have confirmed, even the most developed urban areas can show signs of vulnerability (generally due to the high concentration of population and economic activities), indicating that highly developed urban centres do not necessarily have low levels of social vulnerability. Thus, the analysis is able to provide a more comprehensive overview on communities in desperate need of financial resources in order to diminish the negative impacts of natural hazards.

Keywords: social vulnerability, natural hazards, SoVI model, exploratory spatial data analysis, Romania

1. INTRODUCTION

Over the last decade the negative impact of natural hazards has shown significant increase due to the rise in the frequency and intensity of extreme events as a consequence of climate change (IPCC, 2007). Since economic losses and fatalities are unevenly distributed among and within nations, regions, communities and individuals, a series of studies have focused on determining the impact of natural hazards, phenomena which have manifested themselves differently through time and space, putting the livelihood of people at risk much more than any other event. Nevertheless, the vulnerability of populations and communities in the face of natural hazards does not only depend on the population's proximity to the source of risk, but it also derives from its social vulnerability status (Cutter, 1996; Kasperson et al., 2001; Yoon, 2012). Thus, understanding social vulnerability can hold the key for explaining why the same hazard can affect certain communities differently (Morrow, 2008). In spite of the fact that in the last decade social vulnerability has gained considerable attention in academic studies, in many societies there is little empirical evidence on how social differences within their population can influence the impact of disasters. In this sense, the importance of quantifying the social dimension of vulnerability lies in the fact that it allows for the identification and delimitation of the most affected regions along with key factors which, once addressed, can contribute to increasing the resilience of the respective local communities (Morrow, 1999; Müller et al., 2011; Blaikie et al., 2014). Moreover, although natural disasters cannot be prevented, the assessment of vulnerability, hazard mitigation and emergency management planning can significantly reduce the negative impact of such events. All these highlight the importance of better integrating the results of research on vulnerability into territorial planning and emergency management decision making (Cutter, 1996; Yoon, 2012; Armaș & Gavriș, 2013, Chen et al., 2013; Blaikie et al., 2014; Constantin et al., 2015; Huang et al., 2015; Frigerio et al., 2016).

Typically, vulnerability is defined as the 'characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard' (Wisner et al., 2004). The literature highlights that different areas and communities can fall in very different categories according to the degree of vulnerability, and, in this sense, social stratification can lead to significant inequalities (Bolin & Stanford, 1998; Adger et al., 2004; Boruff et al., 2005; Balica et al., 2012). Natural hazards do not strike at random, the most affected local communities being those already marginalized from a socioeconomic point of view (i.e gender, ethnicity, occupation or education). In this context Blaikie (2014) argues that the most vulnerable groups are those who find it hardest to reconstruct their livelihood after a certain disaster. Therefore, populations belonging to poverty-stricken groups do not only have a limited capacity to absorb the negative impacts of natural hazards, but their possibilities to engage in adaptive livelihood strategies are also confined. Furthermore, these groups have fewer opportunities for education as well as employment, and are also less likely to benefit from health- and property insurance (Cutter et al., 2003; Blaikie et al., 2014; Frigerio et al., 2016). In addition - as it has been pointed out in the scientific literature - female groups are more vulnerable compared to their male counterparts, not necessarily as a result of their role within society, but mainly because of their biological characteristics and psychological features (Morrow, 1999; Chen et al., 2013). There is also a general consensus that children and the elderly are the most vulnerable groups due to their fragile age and limited mobility (Bolin & Stanford, 1998; Morrow, 1999; Frigerio et al., 2016). Vulnerability is also determined to a certain extent by occupation through means of earning, which in turn has an impact on the ability to recover from disasters (Adger et al., 2004). In this sense the most vulnerable groups of people are the ones working in primary activities, thus being more likely to be affected by hazard events (Cutter et al., 2003). People's accessibility to different infrastructural services (educational infrastructure, entrepreneurial facilities, built environment) is another factor with influence on their ability and preparedness to cope with the effects of natural hazards (Morrow, 1999; Cutter et al., 2003; Adger et al., 2004; Elstad et al., 2006). Thus we can clearly see how social vulnerability appears to be a product of social inequalities (Bolin & Stanford, 1998; Cutter et al., 2003; Blaikie et al., 2014).

In addition to exposure, the differentiated vulnerability to disasters also depends on the capacity of a society to cope with its effects (Watts & Bohle, 1993, Cutter, 1996; Clark et al., 1998). This coping capacity has been defined as a combination of resistance (the ability to absorb the negative impacts of a hazard) and resilience (the ability to recover from losses relatively quickly) (Cutter, 1996; Clark et al., 1998, Wu et al., 2002). As Miller et al., (2010) put it, vulnerability depends not only on the grade of exposure and the potential to incur losses, but also on the capacity of a system to recover, to rebuild and to return to a steady state of "normality" (Miller et al., 2010). The interrelation between the two concepts has been well described by Cutter et al., (2003) who defines vulnerability as an array of attributes or features of a system before a disruptive event is produced, which are responsible for both the potential to incur losses as well as the differentiated capacity to recover after the respective event. As a result, we can see that the concept of vulnerability is once again defined as being dependent not only on the exposure to a threat and the degree of sensitivity, but also on the ability to adapt, indirectly implying that the concept of vulnerability comprises the notion of resilience. According to Goudie (2011), besides resilience vulnerability also includes susceptibility. In this context, resilience is related to „existing controls" and the capacity to limit the effects of harm, while susceptibility is linked to exposure.

As we could observe, in the last two decades the concept of vulnerability has evolved continuously by incorporating concepts such as susceptibility, exposure, the capacity of coping and adapting – and by addressing different thematic areas, such as physical, social, economic, environmental and institutional vulnerability (Birkmann, 2006). Along with the extensive debate on the conceptualisation of social vulnerability, there are ongoing debates on the issue of developing methods for measuring social vulnerability as well. From this point of view, some of the most important pioneering works belong to Cutter et al., (2003) who – while examining social vulnerability in the United States – have developed the SoVI® index, a method which has grown to be widely embraced due to its continuous evolution, pertinence and adaptability (Fekete, 2009; Holand et al., 2011; Chen et al., 2013; Cutter & Morath, 2013; Rufat et al., 2015). In spite of the fact that over the last decades a series of studies have dealt with the issue of social vulnerability, in Romania there is still a significant research gap in the field, especially in the case of local administrative units. The most relevant research papers belong to Armaş (2008), Stângă & Grozavu (2012), Armaş & Gavriş (2013), Bănică & Muntele (2015), Constantin et al., (2015), although it is worth mentioning, that these studies focus mainly on smaller spatial scales, applying comparative case studies for various parts of regions or for different territorial administrative units (i.e. the Municipality of Bucharest, rural mining settlements in the Apuseni Mountains, Iaşi and Bacău cities and metropolitan areas). By applying the SoVI index to the Romanian (local) context, the present paper contributes to closing the research gap from at least two points of view. First, it offers evidence on the workability of the model in a Central- and Eastern European context and second, the outcomes of the paper provide a comparative assessment of vulnerability for the entire country at settlement level.

Therefore, the main purpose of this paper is to quantify the social vulnerability of Romanian settlements to natural hazards by elaborating a SoVI index on a local scale. In this sense, relying on exploratory spatial data analysis, one of the main tasks was to find out whether it is possible to detect a spatial pattern in the relations of social vulnerability by analysing the main features of the neighbourhood effect.

The paper has been divided into three parts. In the first part it presents Romania's socio-economic development structure, as well as the major consequences of the existing natural hazards. The second part of the paper focuses on determining and measuring social vulnerability in the study area by highlighting spatial patterns and hotspots where the different elements of vulnerability show particularly high levels of concentration. By identifying and delimiting the most exposed areas, the findings of the analysis presented in the third part can not only represent a valuable input for the elaboration of future policy instruments and relevant actions for decreasing vulnerability, but can also offer a proven toolkit for the elaboration of similar analyses.

2. MATERIAL AND METHOD

2.1. Study area

In order to make the assessment of social vulnerability much more comprehensive, I have included all 3181 Romanian settlements in the study area, representing 2861 communes as well as 320 towns and cities (according to the last Census). When addressing the relationship between natural hazards and social vulnerability, two aspects need to be highlighted: the existing social and economic inequalities and the intensity and frequency of different natural hazards.

Studying the social and economic structure of the country, significant internal inequalities can be found not just among-, but also within regions, counties and smaller territorial units (especially between communes and municipalities). The deepening of disparities at county level is very well illustrated by the fact, that while in the mid nineties the difference in the GDP/capita between the most developed and least developed territories (Bucharest and Vaslui county) was threefold (Benedek & Kurkó, 2010), today this difference has increased to almost five times. At a lower territorial level, I have been able to explore the development differences in much more detail by using the Local Human Development Index (LHDI) (Sandu et al., 2016). According to this index the least developed areas – with a few exceptions – are located in the eastern and southern parts of the country, especially in the historic provinces of Moldavia, Oltenia and partially Walachia. On the other hand, most of the western and partially the central parts of the country show a much more dynamic development, being considered among the most developed areas of Romania (Fig. 1). In relation to natural hazards, Romania is considered a country with high seismic activity and frequent extreme phenomena. Four of the most significant hazards – by the number of deaths, affected individuals or economic damages – are earthquakes, floods, droughts and excessive temperatures. As far as earthquakes are concerned, the seismicity of Romania is concentrated in several epicentre areas (Vrancea, Făgăraș, Banat and the Black Sea coast), the Vrancea area being the most active with regard to energy and frequency of quakes. Romania is also known as one of the most flood-prone countries in Europe with major economic and social consequences, floods usually incurring along the course of internal rivers and the Danube (Marinescu et al., 2010). These two types of natural hazards account for the most devastating losses as far as the number of deaths, total number of affected individuals and estimated damages (Table 1).

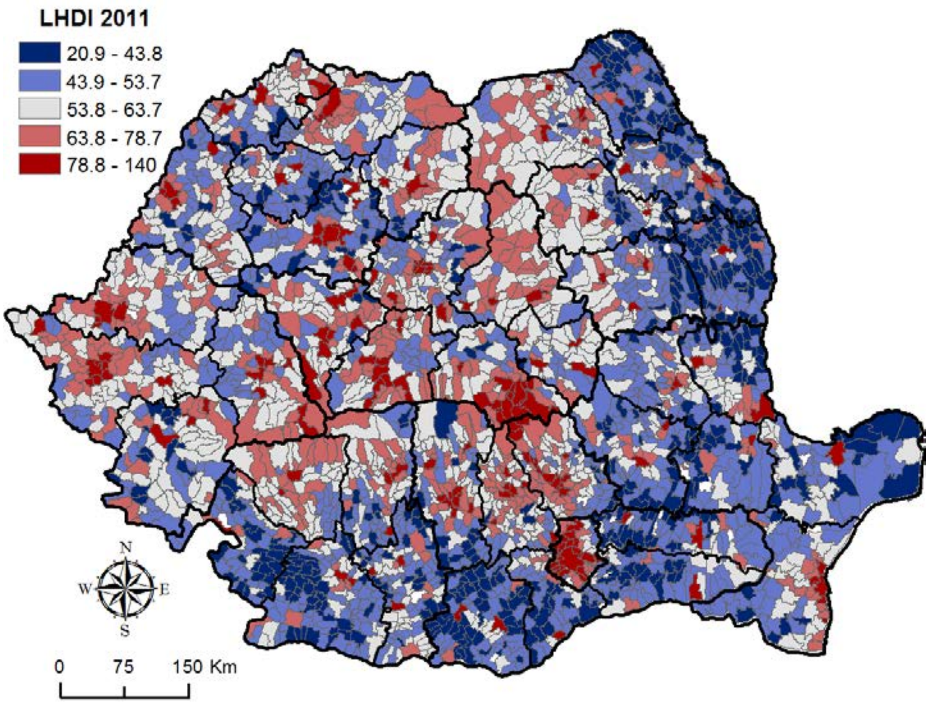

Figure 1. Local Human Development Index in 2011

Table 1. Major natural disasters in Romania from 1970 to 2012 (death toll above 25 / more than 5000 affected individuals / more than 150000 million US$ in damages)

Dates	Location	Type	Total deaths	Total affected	Est. Damage (US$ millions)
11/05/1970	Botoşani, Neamţ, Vaslui	Flood	215	238755	500000
00/07/1975	Giurgiu, Ialomiţa, Galaţi, Brăila, Buzău	Flood	60	1000000	50000
04/03/1977	Bucureşti	Earthquake	1641	3863000	2000000
29/07/1991	Bacău, Suceava, Neamţ	Flood	108	15000	50000
15/06/1998	Bacău, Vaslui, Vrancea, Neamţ, Sălaj, Mureş, Cluj, Alba, Sibiu, Hunedoara	Flood	31	12000	150000
18/11/1998	Iaşi, Bucureşti	Cold Wave	60	1700	-
00/06/2000	Botoşani, Vaslui, Brăila, Olt, Dolj, Mehedinţi, Teleorman, Constanţa	Drought	-	-	500000
29/06/2006	Bucureşti, Galaţi, Mehedinţi	Heat wave	26	200	-
23/01/2012	Tulcea, Botoşani, Neamţ, Olt, Constanţa, Sibiu, Vrancea, Teleorman, Călăraşi, Brăila, Galaţi, Giurgiu, Buzău, Ialomiţa	Cold wave	86	7539	-

Drought as a phenomenon is also relatively common in Romania, and, although it lacks a cyclical character, it can have a serious economic-, social-, as well as environment impact, affecting mostly the non-irrigated southern and eastern plains of the country (Bărăgan, Dobrogea, Southern Moldavian Plateau), which represent the main agricultural areas of Romania. Although from the point of view of damages, excessive temperatures (heat or cold waves) and severe winter conditions do not play a significant role in Romania, they still appear quite frequently and can persist for several days in a row.

In conclusion, considering the effects of natural hazards mentioned earlier as well as the almost perfect overlap of low LHDI territories and areas severely affected by earthquakes, floods and droughts, it is becoming increasingly obvious that the identification and detailed analysis of the most vulnerable locations, along with the elaboration of more effective development strategies is becoming not only indispensable, but more and more urgent as well.

2.2. Selecting the variables

The core of my analysis on social vulnerability – the first of its kind in Romania – is made up of territorial statistical data obtained from the Romanian National Institute of Statistics, including the 2011 Census, as well as the Tempo Online web database. These databases have made it possible to use data at settlement level, in the present case the level of communes and municipalities. Nevertheless, the study still has some limitations, since not all indicators are available at the same level of granularity, making the compilation of holistic and up-to-date information on social vulnerability in Romania a challenging task. With regard to the SoVI variables and their impact on social vulnerability, due to space limitations only a brief description is given below (Table 2).

When choosing the indicators, I have also had in mind the context and framework set by the main purpose of the study, namely to be able to identify the most vulnerable areas. Even though the analysis is intended to be a replication of the original SoVI model, considering the chosen variables, some modifications had to be made in order to adapt it to the Romanian context. Therefore, variables which in the context of social vulnerability have not been considered representative for the Romanian society have been omitted or replaced by other, more relevant ones. In other cases, where data could not be found, the respective datasets have been substituted with similar indicators. Within my approach, aspects related to political views and people participating in civilian moments have not been included, partly because of the absence of such information, but also because in Romania civilian initiatives are still relatively weak, their impact on the evolution of social vulnerability being thus considered quite low (Baba et al., 2009; Tudor et al., 2015). Nevertheless, having in mind their increasing role in informing society on different aspects as well as their more and more frequent lobbying activities, their position and impact could well become significant in the near future.

Table 2. Considerations for the selection of variables

Variables	Considerations	Sources
Access to services	Improves living conditions and creates awareness, thus helps in recovering from disasters.	Adger et al., 2004
Population density	High density areas increase the chance for more people to be affected by disasters, increasing at the same time the risk of fatalities as well as the damage potential.	Cutter et al., 2003; Balica et al., 2012; Hummell et al., 2016
Education	Shows ability to understand warning information, emergency plans and to avoid dangerous situations.	Morrow, 1999; Cutter et al., 2003; Elstad et al., 2006
Age	Elderly may have limited mobility and physical difficulties in evacuations. The very young also have high physical fragility and dependency.	Morrow, 1999; Cutter et al., 2003; Fekete, 2009; Blaikie et al, 2014; Fernandez, 2016
Family structure	Families with a large number of dependents or single-parent households have limited financial resources, affecting resilience and ability to recover from hazards.	Hewitt, 1997; Fekete, 2009; Cutter et al., 2003
Land use	Agricultural areas can have higher economic losses resulting from temporary inundation of crops or severe droughts.	Morris & Brewin, 2013
Poverty	The poorest and least developed areas are usually more easily affected by natural hazards and have a harder time recovering from	Cutter et al., 2003; Fekete, 2009; Fernandez, 2016
Employment	Occupation, as a means of earning, influences the ability to recover after a disaster. An economically active population has the ability to recover faster from the negative effects of natural disasters.	Cutter et al., 2003; Adger et al., 2004; Mazumdar & Kumar, 2016
Wealth	Enables communities to recover from losses more quickly due to existing financial resources.	Blaikie et al., 2014; Cutter et al., 2003
Demographic aspects	Rapid population growth puts pressure on housing stock, quality of life, basic services. This can often result in difficulties when reacting to-, as well as recovering from disasters.	Morrow, 1999; Cutter et al., 2003; Hummell et al., 2016
Public expenditure	Health care expenditures and insurance enable communities to absorb the negative effects and recover from losses more quickly.	Blaikie et al., 2014; Hewitt, 1997; Cutter et al., 2003
Accessibility	The proximity to major public roads and railway transport provides the possibility of a quick evacuation in case of a natural disaster.	Mazumdar & Kumar, 2016
Gender	Women can encounter more difficulties when facing disasters, often due to lower wages and more numerous family responsibilities.	Cutter et al., 2003; Fekete, 2009; Fernandez, 2016
Ethnicity	Existence of several ethnic groups can result in language and cultural barriers that affect access to post-disaster funding and can favour the establishment of residential locations in high hazard areas.	Bolin & Stanford, 1998; Cutter et al., 2003

Another indicator omitted in the present analysis was race. While within the American society, due to the relatively high rate of immigrants (African, Hispanic, Asian) and ethnic diversity, cultural and language barriers can indeed represent an important aspect of social vulnerability, in Romania the share of immigrants compared to the total number of the population is insignificant, in conclusion, this group does not represent an obvious and highly vulnerable community. On the other hand, some ethnic minorities, especially the Roma population, due to the high poverty rate and low education level raise more serious concerns. Having this in mind, within the analysis race has been substituted by the presence of socially segregated communities. In addition to these, I have also introduced aspects related to land use, access to basic services and accessibility to major public roads as well as railway transport. In fact, the SoVI model proposed by Cutter et al. (2003) is based much more on following the exact steps of the methodology, rather than using all the same variables. The use of different indicators could also be observed in Norway (Holand et al., 2011), Vietnam (Adger et al., 2012), China (Chen et al., 2013), Portugal (Guillard et al., 2014), Brasil (Hummell et al., 2016), India (Mazumdar & Kumar, 2016) etc.

2.3. Methodology

Following the selection of proxy variables, the next step has been their normalization. The main purpose of this process was to bring variables with different measurement units to a common, dimensionless scale. In this case, the Z score standardization procedure was used, which produces variables with a mean of zero and a standard deviation of one. Next, a Principal Component Analysis (PCA) was performed on the already normalized data. PCA is a mathematical procedure (also called dimension reduction tool) used to reduce a large set of variables to a smaller set, but which still accounts for most of the variance observed in the case of the initial data. Afterwards, a Varimax rotation with Kaiser Normalisation is applied to the component matrix in order to make the interpretation of data variations easier. For the interpretation, only components with eigenvalues greater than 1.0 were extracted, while components with absolute loading values below 0.5 have been left out. To sum up, after 10 rotations, the PCA has identified ten multidimensional components, explaining 75.38 % of the total variance (Tab. 3). In the final step, the component scores have been summarized for each territorial unit in order to generate the final SoVI scores. Starting out from the methodology proposed by Cutter et al., (2003), equal weighing of scores seemed like the most adequate method. Thus, each score has been considered to have an equal contribution to the overall vulnerability assessment. The cardinality of each factor was determined in such a way that positive values would increase social vulnerability, while negative values would decrease the overall value. In order to detect spatial differences in the levels of social vulnerability across the studied area, the SoVI scores for each territorial unit were mapped in ArcGIS based on five categories, according to the standard deviation from the mean; negative values representing low vulnerability and positive values a high vulnerability.

To determine patterns of similarity and dissimilarity in the clustering of social vulnerability, I have proceeded to examine the spatial autocorrelation among settlements. In essence, spatial autocorrelation tests whether the value of an observed variable depends or not on values of the same variable in neighbouring localities (Cliff & Ord, 1973). The index is calculated according to the following formula (Eq. 1):

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\left(x_i - \overline{x}\right)\left(x_j - \overline{x}\right)}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\sum_{i=1}^{n}\left(x_i - \overline{x}\right)}, \quad (1)$$

where *I* is the global Moran's I, x_i represents the value of the monitored variable in unit *i*, x_j is the value of the monitored variable in unit *j*, $\overline{x}$ is the arithmetic average of the monitored variable, while w_{ij} represents the generic element of the contiguity matrix. The concept of contiguity can be defined as a generalized matrix of W weight, usually symmetrical, representing a pattern of connections or ties and their intensity (Badaloni & Vinci, 1988), where w_{ij} weights denote the effect of the territorial unit *i* on unit *j*. Within this study, a contiguity matrix was used, where $w_{ij} = 1$ if the boundary of area *i* touches the boundary of area *j*, in all other cases $w_{ij} = 0$. This definition of neighbouring areas is based on rook neighbourhood. Moran's I can reach values between -1 and +1; the closer the value of Moran's I to -1 or +1, the stronger the spatial autocorrelation. While global Moran's I measures the spatial autocorrelation as a whole, indicating whether the spatial pattern of the analysed index is random or not, the Local Indicator of Spatial Association (LISA) makes it possible to quantify the degree of spatial autocorrelation in each specific location (Anselin, 1995) (Eq. 2).

$$I_i = \frac{(x_i - \overline{x})\sum_{j=1}^{n} w_{ij}(x_j - \overline{x})}{\sum_{i=1}^{n}(x_i - \overline{x})^2} \quad (2)$$

A high positive local Moran's I value indicates that the location under study is surrounded by locations with similar values of the observed variable. This location is then part of a cluster, which can include either high-high type clusters (high values in a high value neighbourhood) or low-low type clusters (low values in a low value neighbourhood). The negative value of local Moran's I on the other hand implies that the analysed location is a spatial outlier, representing either a high-low type cluster (high values being surrounded particularly by low values) or a low-high type cluster (low values surrounded mainly by high values) (Anselin, 1995). Within this paper, I will make use of both spatial autocorrelation methods, i.e. Global and Local Moran's I. To achieve this, the GeoDa software has made it possible to build a Moran Scatter plot with the calculation of Moran's I.

Table 3. Significant components and their adjusted loadings used to assess social vulnerability in Romania

Component	**Percent variance explained**	**Dominant variables**	**Component loading**	**Sign**
Access to services	24.850	Percentage of households with access to piped water	-0.756	-
		Percentage of households with access to sewage network	-0.774	
		Entrepreneurial activity rate	-0.704	
		Employment rate	-0.700	
		Percentage of households with access to central heating	-0.890	
		Percentage of households with a fixed bath	-0.805	
		Local Human Development Index	-0.808	
		Number of housing permits per new residential construction per square km	-0.576	
		Population density	0.674	
		Percentage of population with university education	-0.905	
		Percentage of households with access to electricity	-0.917	
		Number of physicians per 1000 residents	-0.831	
		Accommodation capacity	-0.741	
Family structure and housing conditions	11.955	Number of housing units per square km	0.833	+
		Percent of population under 5 years	0.541	
		Percentage of population aged 65 years and above	0.835	
		Percent of widows in female population	0.796	
		Average number of people per household	0.746	
		Average living area in square meter per person	0.556	
		Demographic dependency ratio	0.809	
Land use	5.959	Average utilized agricultural area per holding	0.961	+
		Percent of forest area from the land area	0.958	
Poverty	5.422	Illiteracy rate	0.714	
		Percent of Roma population	0.755	+
		Number of births per 1000 persons	0.636	
Employment	5.165	Percent employed in services	-0.605	
		Percent employed in primary extractive industries (farming, fishing, and forestry)	0.699	+
		Percent of unqualified workers	0.824	
Wealth	4.994	Per capita income	-0.763	-
		Percent of expenditure on education	-0.819	
Demographic vitality	4.772	Net international migration rate	0.695	+
		Average growth rate	0.545	
Public expenditure	4.465	Percent of expenditure on health care and insurance	-0.787	-
		Tax collection rate at local budget level	-0.523	
Accessibility	4.314	Access to major public roads	-0.773	-
		Access to railway transport	-0.796	
Gender and Ethnicity	3.492	Percent of ethnic minorities in total population	0.788	+
		Share of women from the total population	0.589	
Cumulative variance explained	**75.387**			
Kaiser-Mayer-Olkin Measure of Sampling Adequacy .854 Bartlett's Test of Sphericity .000		Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization Rotation converged in 10 iterations.		

Note: The symbol indicates whether the used variable has a negative or a positive effect on social vulnerability (+ = increases social vulnerability, - = decreases social vulnerability)

3. RESULTS

3.1. Measuring Social Vulnerability

By applying the Principal Component Analysis over a set of 38 variables and a total of 3181 settlements, I have managed to uncover ten latent factors which account for 75.3 % of the cumulative variance existing among all variables. The factorial reduction procedure has indicated a statistical significance, since the value of the Kaiser-Meyer-Olkin measurement for the set of variables has been 0.854, thus confirming the adequacy of the correlation matrices for the PCA analysis. On the other hand, Bartlett's test also indicates a high probability for the existence of significant relationships between the analysed variables ($p < 0.001$) (Table 3).

3.2. Identifying highly vulnerable areas

Taking the results of the PCA, I have proceeded to calculate the Social Vulnerability Index. At first glance it can be observed that the SoVI values range from -17.78 (low social vulnerability – Otopeni city near Bucharest) to +10.49 (high social vulnerability – Tănăsoaia commune, Vrancea county). According to the analysis, the most vulnerable settlements are to be found in the eastern and southern parts of the country, places which are further affected by natural hazards, especially by earthquakes and floods. Furthermore, due to a less favourable economic situation as well as limited access to resources and services, these areas are often associated with low levels of education and a lack of sanitation facilities, decreasing their ability to cope with the impact of natural hazards. These factors also represent the main cause of socio-spatial inequalities, being reflected at the same time in the territorial distribution of the SoVI model. Looking into the factor scores, we can see that the localities most in need of assistance are Seaca, Sârbeni and Sfinţeşti from Teleorman county, Bărbuleţu and Bilciuresti from Dâmboviţa county, along with Tănăsoaia from Vrancea county. On the other hand, the least vulnerable areas can be found in the western and partially in the central parts of country, which have already stood out as early as the 18th century as the most developed areas in the region. According to the factor scores, the least vulnerable areas are Moşniţa Nouă, Remetea Mare and Gioroc from Timiş county; Otopeni, Chiajna, Corbeanca and Mogoşoaia from Ilfov county, as well as Gilău from Cluj county – all of them belonging to the suburban areas of Timişoara, Bucharest and Cluj-Napoca (Fig. 2).

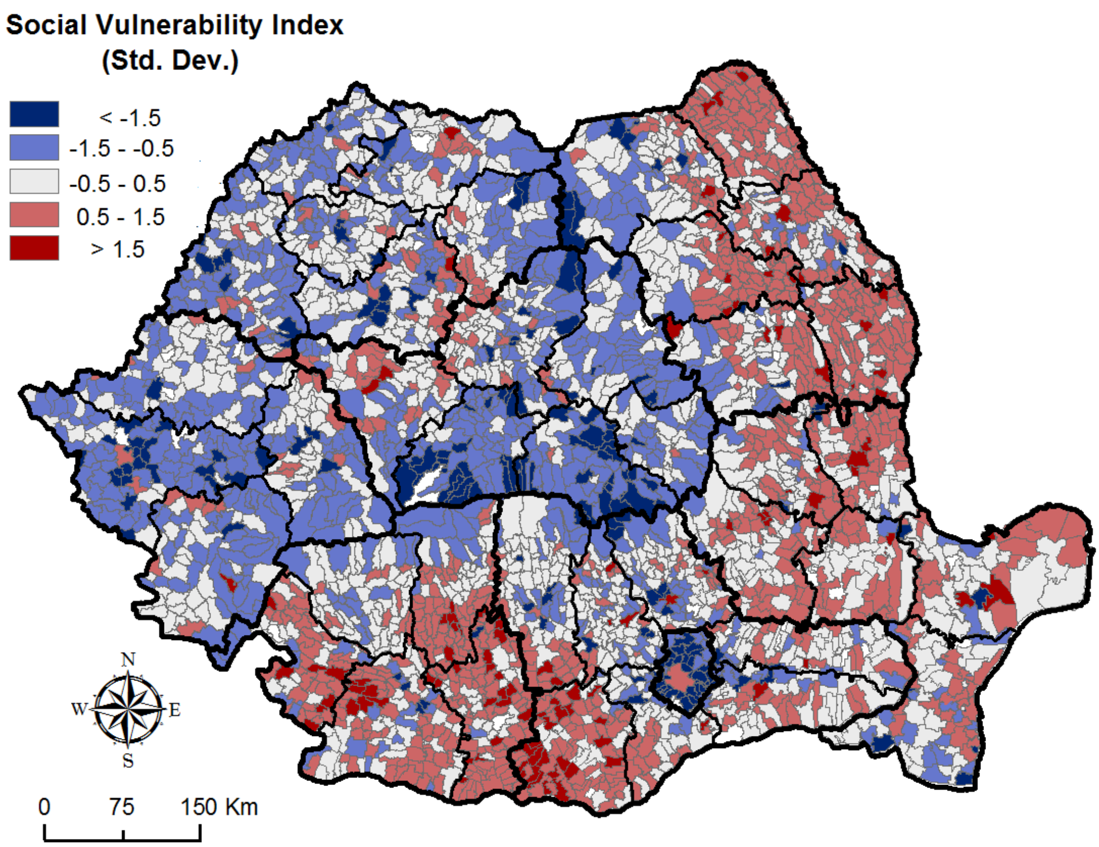

Figure 2. Overall Social Vulnerability Index scores

As the analysis has revealed, even the most developed urban areas can be vulnerable (generally due to a high population density), indicating that highly developed urban centres are not necessarily associated with low levels of social vulnerability and that economic development is not always inversely proportional to the vulnerability in the face of natural hazards. Even so, as mentioned earlier, the respective communities have much better capabilities to cope with-, resist-, and recover from losses.

3.3. Assessing spatial patterns of social vulnerability

In order to improve the overall assessment of social vulnerability, with special focus on finding clustered areas with extremely high values, I have used the ESDA technique. As Fig. 3 shows, the value of Moran's I calculated for the social vulnerability scores is equal to 0.52. Since the value is higher than zero, it suggests a positive spatial autocorrelation for the analysed variables. Thus, the null hypothesis could be rejected as the *p* value is statistically significant (p = 0.0001) and the z-core is positive (50.4) (Fig. 3).

Since the Global Moran's statistic has clearly identified a strong spatial autocorrelation among settlements, I have conducted a computation for revealing the territorial dispersion and patterns of spatial clustering. As a result, I have been able to identify 4 main clusters. Clusters 1 and 3 represent the social vulnerability "hot-spots" and correspond to a positive high-high spatial autocorrelation, indicating spatial clusters of settlements with above-average vulnerability rates. Clusters 2 and 4 are "cold-spots" which correspond to a positive, but low-low spatial autocorrelation, indicating spatial clusters of areas with below-average vulnerability rates (Fig.4.).

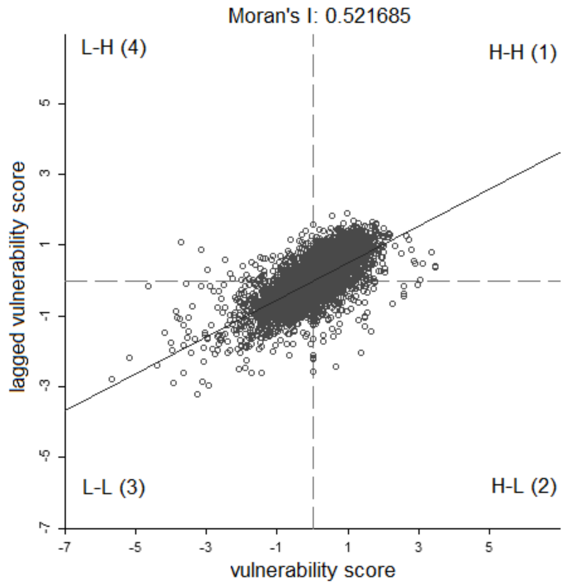

Figure 3. Moran Scatter Plot for measuring the overall social vulnerability index scores

The territorial dispersion of the results of spatial autocorrelation shows us that 14 % of settlements belong to the group characterized by high vulnerability rates (high-high groups), 14.6 % represent areas with low social vulnerability (low-low groups), while in 1.2 % of cases social vulnerability is high in the core area, but low in the neighbouring areas. Last but not least, 2.2 % of the analysed territorial units account for those areas where social vulnerability is low in the core area, but high in the neighbouring areas.

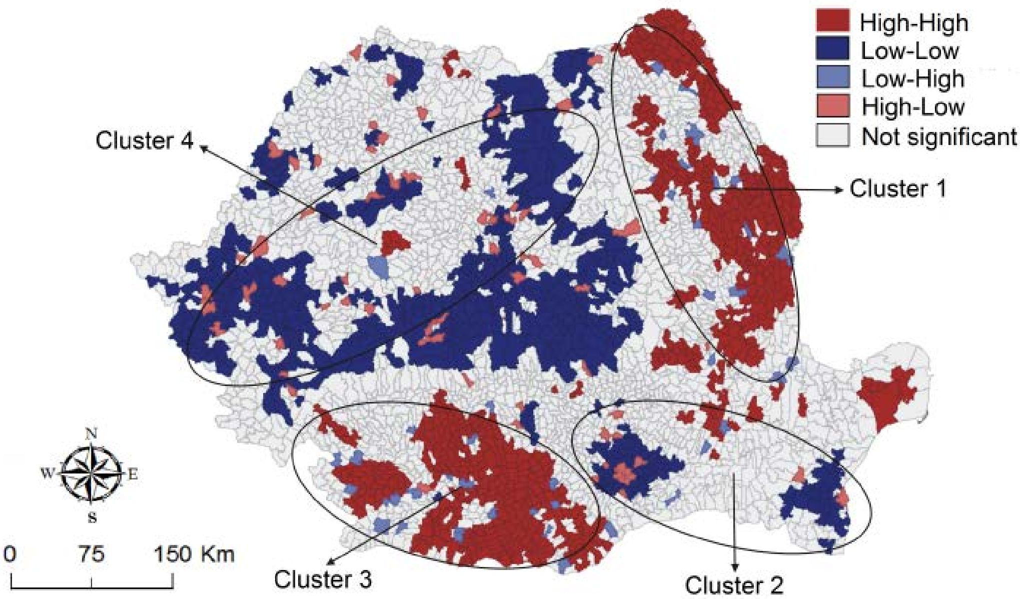

Figure 4. Cartogram of clusters representing the SoVI index for measuring the overall social vulnerability index scores

4. DISCUSSION

With some exceptions, the settlements with the **highest rates of vulnerability** are situated in the eastern and south-eastern parts of Romania, perfectly overlapping the social and economic development structure of the country (see Fig. 1 and Fig. 2). These settlements generally have a low level of development which – coupled with the high population density (including the average number of people per household) – increases the vulnerability of the built environment. All these impact the areas' overall level of social vulnerability in the face of natural hazards. In these territories, social vulnerability is aggravated by the high proportion of children (mainly in the eastern part) and elderly people (concentrated mostly in the southern and south-western parts), by the limited access to resources and lack of infrastructure, an influence which has also been pointed out by Cutter et al., (2003), Holand et al., (2011) and Hummell et al., (2016) when applying the SoVI model to countries like the USA, Norway or Brazil. In a Romanian context I could add not just the high illiteracy rate and the proportion of those with a low level of education, but also the fact that the majority of these people are working in (subsistence) agriculture, an economic sector highly sensitive to natural conditions. In this context, rural areas in the southern parts of the country are not only ranked on top of the list because of the highest rate of elderly people – especially in Giurgiu and Teleorman counties, where in some localities the rate exceeds 48 %, but they also "excel" in the high illiteracy rates (in rural areas the variable alternates between 5 and 8 %) and poverty, affecting especially Roma communities. One of the main reasons for rural poverty in Romania is in fact the low education level and the relatively high rate of illiteracy. According to the 2011 Census, only 4.7 % of the stable population (10 years and older) living in rural areas has had a university degree (the percentage was 22.4 % in urban areas) while more than 3 % have had no education whatsoever, 1.4 % being completely illiterate. Moreover, in Romania the declining economic situation starting in the mid-nineties, the high level of urban unemployment and the industrial restructuring have all induced important changes in the occupational status (increasing the rate of people working in agriculture from 28.6 % in 1990 to 41.4 % in 2000, registering a slight decrease in the following years). All these have had a major impact on reinforcing the vulnerability of certain groups of people.

Similarly, a higher vulnerability score can be observed in the north-western parts of the country, coinciding with the area of the Apuseni Mountains, where the isolation of the population and the lack of infrastructural development have put their mark not only on the present level of development, but also on the future of these places and the people living here. The only exceptions to the rule are the medium-sized cities and suburban localities where job opportunities, quality of life and educational opportunities are significantly better, thus lowering the chance for social vulnerability to increase (Fig. 2). Similar results have been found by Constantin et al., (2015) when analysing the vulnerability of rural mining settlements in the Apuseni Mountains, as well as by Stângă & Grozavu (2012) while studying human vulnerability in rural areas of the Tutova Hills.

The **least vulnerable settlements**, on the other hand, are concentrated in the western and partially in the central parts of the country, sharing some key characteristics. In these areas the population is generally well-educated and employed mostly in the services sector; it has good access to social services and a relatively high income per capita in comparison to the eastern or south-western parts, these characteristics being also reflected in the quality of housing as well as other specific expenditures on education, social services, and insurance. As it has been pointed out earlier, a high level of economic development is not in all cases inversely proportional to the vulnerability in the face of natural hazards, meaning that that highly developed agglomerations are not necessarily areas with low levels of social vulnerability (Huang et al., 2015). This is mainly due to the fact, that a high level of efficiency and development can severely increase the level of internal inequalities. This can be observed well in large urban areas (of more than 200 000 inhabitants) where a high population density and the concentration of economic activities increase the vulnerability of the built environment. Furthermore, the existence of social inequalities and social segregation within cities, along with wealth-poverty dichotomies amplify the exposure of the latter to social risks. This finding has also been well outlined by Holand et al., (2011) when measuring social- and built environment vulnerability for the municipalities of Norway. According to the SoVI index, Iaşi, Timişoara, Constanţa, Craiova, Galaţi, Brăila and the capital, Bucharest are labelled as areas with particularly high levels of social vulnerability. This becomes increasingly obvious, if we consider that in the agglomeration of Bucharest the occurrence of any natural hazard (considering the geographic localization along one of the most active seismic zones in the country) could cause much higher levels of damage and greater loss of material goods. Even so, the higher rate of ensured properties, social safety nets and the access to significant material resources can indeed enable these communities to recover from disasters more quickly compared to others. A case study analysis conducted by Armaş & Gavriş (2013) has also revealed the high degree of social vulnerability in most districts of the capital.

By applying the ESDA techniques to reveal the spatial pattern of settlements characterized by higher or lower levels of vulnerability, the results of the spatial autocorrelation analysis underline the already identified spatial pattern: localities characterized by high social vulnerability can mainly be found in the eastern and south-eastern parts of Romania, especially in Botoşani, Vaslui, Giurgiu, Teleorman, Dâmboviţa and Mehedinţi counties (Cluster 1 and 3), which have almost always stood out as the least developed areas of the country (Fig. 4). The high demographic dependency ratio, low values of the Local Human Development Index and the high share of people living off the land in these places, all confirm their disadvantaged position on multiple levels. Of course, we can find some less vulnerable territories of an insular nature, which in the case of spatial autocorrelation represent the low outliers among high neighbours. Unfortunately, their numbers are quite small, not being able to counterbalance the overall position of these regions. Clusters 2 and 4 indicating low social vulnerability rates are situated along the southern horizontal axis of Transylvania – partly connected to Bistriţa-Năsăud and Mureş counties in the north, as well as the area surrounding Constanţa county and the Bucharest-Ilfov region in the south, as separate entities. The low levels of social vulnerability in these areas can also be attributed to their more homogenous spatial structure, where social resources like education opportunities, medical services, and job opportunities are much more equally distributed between urban and rural areas.

As we could observe, some of the most important factors influencing social vulnerability in Romania are the economic development level, education and occupation. But these aspects are not only valid for Romania. By integrating these indicators into the vulnerability assessment model, similar results have been achieved by Holand et al., 2011 for the municipalities of Norway, by Hummell et al., 2016 for Brazil and by Guillard et al., 2014 for Portugal, to name just a few in a wider European context.

5. CONCLUSION

The state of the art regarding social vulnerability clusters captured through the above in-depth analysis may offer a viable and integrative **practical** guide for authorities and policy makers when choosing and rationalizing necessary measures for diminishing social vulnerability in specific areas. In this sense Morrow (1999) points out the importance for policy-makers and planners to use community vulnerability maps in order to identify high risk areas, including them in disaster preparedness-, as well as response action plans.

At the beginning of the new century Law no. 575/2001, regarding the approval of the National Development Plan – Section V. Natural risk zones, has pointed out that highly vulnerable areas are also affected by major natural hazards: for example Tănăsoaia commune (Vrancea county) is not only situated in a highly active seismic zone, but is also affected by floods and landslides; the latter two also affect Bărbuleţu commune (Dâmboviţa county), while Seaca, Sârbeni, Sfinţeşti (Teleorman county) are mostly exposed to floods and droughts. In order to increase the resistance of these communities it would be necessary to take measures like the construction of levees to deal with river flooding, or the development of well organized emergency services. By establishing shelters and evacuation planning, by organising community volunteer teams as well as community disaster recovery task forces, the resilience of the respective communities could be greatly increased. Therefore, besides taking the necessary measures for diminishing the negative impact of natural hazards, there is also a strong need for improving the demographic and social issues in these areas. This is absolutely necessary since all of the aforementioned settlements are characterised by high emigration and high demographic dependency ratios, which in turn could be a direct consequence of low wages (as the majority of the people are working in agriculture) and poor access to infrastructure and services as well as housing conditions. In this sense development plans capitalizing on local assets and local resources (cultural heritage, tourism potential, local values and natural factors) could improve the social and economic situation, which in turn – on the long run – might have spill-over effects. Further on, collaboration between researchers of specific hazards and local practitioners on effective vulnerability assessment can contribute not only to the sharing of knowledge, but it could also help facilitate the inclusion of specific local needs into local policy decisions.

Even though the analysis has made it possible to explore essential social, environmental and economic phenomena, it still has some **limitations**. For example, in some cases due to the absence of reliable and up-to-date information at local level, it has not been possible to use the same datasets contained in the original SoVI model. In conclusion some of them have been left out, while others have been replaced by more context-specific ones. However, as highlighted in the literature, since the specificity of each location and the societal context can differ, a 'one size fits all' or same indicator-based approach of social vulnerability cannot serve as the right solution. This is also because the meaning and measurement of certain indicators can vary greatly across nations. Therefore, the transfer of the SoVI model to the Romanian context has been done according to the recommendations of the original authors, following an in-depth review and the reconfiguration of the selected indicators.

Another limitation of the study lies in its static character, the data for the year 2011 allowing for just one cross-sectional analysis. In order to get a longitudinal perspective on social vulnerability, it would be essential to measure the changes for a given time period, as the frequent transformations of the built environment, the fluctuations of the population and economic activities, as well as the diversity of the surrounding environment can lead to major changes in the frequency and impact of natural hazards. Therefore, a comparison with data from the previous Census could provide a more comprehensive understanding on the existence-, as well as the (re)emergence of vulnerability hotspots. Furthermore, integration of the environmental aspects and the testing of other methods and models for comparison could further enhance the current perspective we have on social vulnerability. In this way, the method could provide the foundation-stone for a more precise assessment regarding the risks associated with natural hazards.

Overall, the study has confirmed that Romania's social vulnerability to natural hazards is strongly influenced by factors which were deeply explored through the national and international literature; therefore, the results can serve as an input for comparative studies elaborated in a wider trans-national context as well as a starting point for policy measures aiming to reduce exposure to natural hazards or social and economic disparities.

Acknowledgements

The author would like to thank the anonymous reviewer for the constructive comments and corrections.

REFERENCES

Adger, W., Brooks, N., Kelly, M., Bentham, S. & Eriksen, S. 2004. *New indicators of vulnerability and adaptive capacity*. Tyndall Centre for Climate Change Research, Norwich, UK.

Anselin, L., 1995. *Local indicators of spatial association – LISA*. Geographical Analysis, 27, 2, 93-115.

Armaş, I., 2008. *Social vulnerability and seismic risk perception. Case study: the historic centre of the Bucharest Municipality/Romania.* Natural Hazards, 47, 397–410.

Armaş, I. & Gavriş, A., 2013. *Social vulnerability assessment using spatial multi-criteria analysis (SEVI model) and the Social Vulnerability Index (SoVI model) – a case study for Bucharest, Romania.* Natural Hazards and Earth System Science, 13, 1481–1499.

Baba, B., Cherecheş, R., Mora, C. & Ţiclău, T. 2009. *Public participation in public policy process - Case study in seven counties from North-Western Region of Romania.* Transylvanian Review from Administrative Sciences, 26E, 5-13.

Badaloni, M. & Vinci, E., 1988. *Contributi all'Analisi dell'Autocorrelazione Spaciale.* Metron, 46, 119-140.

Balica, S. F., Wright, N. G. & Meulen, F., 2012. *A flood vulnerability index for coastal cities and its use in assessing climate change impacts.* Natural Hazards, 64, 73-105.

Bănică, A., Muntele, I., 2015. *Urban vulnerability and resilience in post-communist Romania (Comparative case studies of Iaşi and Bacău cities and metropolitan areas).* Carpathian Journal of Earth and Environmental Sciences, 4, 159-171.

Benedek, J. & Kurkó, I. 2010. *The evolution of regional economic disparities in Romania*. Transylvanian Review, 4, 143-159.

Birkmann, J., 2006. *Indicators and criteria for measuring vulnerability: Theoretical basis and requirements.* Measuring Vulnerability to Natural Hazards: Towards Disaster Resilient Societies, 55-77.

Blaikie, P., Cannon, T., Davis, I. & Wisner, B., (eds) 2014. *At risk: Natural hazards, people's vulnerability and disasters*. Routledge. London.

Bolin, R. & Stanford, L., 1998. *The Northridge Earthquake: Vulnerability and Disaster.* Routledge, London.

Boruff, B. J., Emrich, C. T. & Cutter, S. L., 2005. *Erosion hazard vulnerability of US coastal counties.* Journal of Coastal Research, 21, 932-942.

Chen, W. F., Cutter, S. L. & Emrich, C. T., 2013. *Measuring social vulnerability to natural hazards in the Yangtze River Delta region, China.* International Journal of Disaster Risk Science 4, 169–181.

Clark, G. E., Moser, S. C., Ratick, S. J., Dow, K., Meyer, W. B., Schwarz, H. E., 1998. *Assessing the vulnerability of Coastal Communities to* extreme storms: The case of Revere, MA, USA.* Mitigation and Adaptation Strategies for Global Change, 3, 59-82.

Cliff, A.D. & Ord, J. K., 1973. *Spatial autocorrelation. Monographs in spatial environmental systems analysis*. Pion, London, 76-83.

Constantin, V., Ştefănescu, L. & Kantor, C. M., 2015. *Vulnerability assessment methodology: a tool for policy makers in drafting a sustainable development strategy of rural mining settlements in the Apuseni Mountains, Romania.* Environmental Science & Policy, 52, 129-139.

Cutter, S. L., 1996. *Vulnerability to environmental hazards.* Progress in Human Geography, 20, 4, 529–539.

Cutter, S. L., Boruff, B. J. & Shirley, W. L., 2003. *Social vulnerability to environmental hazards.* Social Science Quarter 84, 1, 242-261.

Cutter, S. L. & Morath, D. P., 2013. *The evolution of Social Vulnerability Index (SoVI).* In Birkmann, J. (ed) Measuring vulnerability to natural hazards, 2nd edition. United Nations University Press, Bonn, 304-321.

Elstad, J. I., Dahl, E. & Hofoss, D., 2006. *Association between relative income and mortality in Norway: A register-based study.* European Journal of Public Health, 16, 640-644.

Fekete, A., 2009. *Validation of social vulnerability index in context to river floods in Germany*. Natural Hazards and Earth System Science, 9, 393-403.

Fernandez, P., Mourato, S., Moreira, M. & Pereira, L. 2016. *A new approach for computing a flood vulnerability index using cluster analysis.* Physics and Chemistry of the Earth, 94, 47-55.

Frigerio, I., Ventura, S., Strigaro, S., Mattavelli, M., Amicis, M., Mugnano, S. & Boffi, M., 2016. *A GIS-based approach to identify the spatial variability of social vulnerability to seismic hazard in Italy*. Applied Geography, 74, 12-22.

Goudie, D., 2011. *Evacuation as a Communication and Social Phenomenon.* In Mayers, R. (ed.) Extreme environmental events complexity forecasting and early warning, Springer, 484-516.

Guillard, C. C., Cutter, S. L., Emrich, C. T. & Zêzere, J. L., 2014. *Application of Social Vulnerability Index (SoVI) and delineation of natural risk zones in Greater Lisbon, Portugal.* Journal of Risk Research, 18, 651-674.

Hewitt, K., 1997. *Regions of risk: a geographical introduction to disasters*. Themes in Resource Management Addison Wesley Longman, Essex, England.

Holand, I., Lujala, P. & Ketil R.J., 2011. *Social vulnerability assessment for Norway: a quantitative approach*. Norwegian Journal of Geography, 65, 1-17.

Huang, J., Su, F. & Zhang, P., 2015. *Measuring social vulnerability to natural hazards in Beijing-Tianjin-Hebei Region, China.* Chinese Geographical Science, 25, 4, 472–485.

Hummell, B. M. L., Cutter, S. & Emrich, C., 2016. *Social vulnerability to natural hazards in Brazil.* International Journal of Disaster Risk Reduction, 7, 111-122.

IPCC, 2007. *Climate change 2007: Synthesis report. Contribution of working groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Chang* [Core Writing team, Pachauri R. K. & Reisinger, A. (eds)], IPCC Genova. Switzerland.

Kasperson, R.E., Kasperson, J.X. & Dow, K., 2001. *Vulnerability, equity, and global environmental change.* In Kasperson, R.E. & Kasperson, J.X. (eds) Global environmental risk. United Nations University Press, London, 247-272.

Marinescu, M., Stanciu, C. & Marinescu, G., 2010. *Four important natural hazards from Romania.* Romanian Journal of Mineral Deposit, 84, 11, 113-115.

Mazumdar, J. & Kumar, S. 2016. *Socioeconomic and infrastructural vulnerability indices for cyclones in the eastern coastal states of India.* Natural Hazards, 82, 1621-1643.

Miller, F., Osbahr H., Boyd, E., Thomalla, F., Bharwani, S., Ziervogel, G., Walker, B., Birkmann, J., Van der Leeuw, S., Rockström, J., Hinkel, J., Downing, T., Folke, C. & Nelson D., 2010. *Resilience and vulnerability: complementary or conflicting concepts?*, Ecology and Society 15(3): 11–37.

Morris, J & Brewin, P. 2013. *The impact of seasonal flooding on agriculture: the spring 2012 floods in Somerset, England.* Journal of Flood Risk Management, 7, 128-140.

Morrow, B., 1999. *Identifying and mapping community vulnerability*. Disasters, 23, 1, 1-18.

Morrow, B. 2008. *Community resilience: A social justice perspective* (The community and regional resilience initiative research report 4). Oak Ridge, TN: Community and Regional Resilience Initiative.

Müller, A., Reiter, J. & Weiland, U., 2011. *Assessment of urban vulnerability towards floods using an indicator-based approach. A case study for Santiago de Chile.* Natural Hazards and Earth System Science, 11, 8, 2107-2123.

Rufat, S., Tate, E., Burton, C. & Maroof, S. A., 2015. *Social vulnerability to floods: review of case studies and implications for measurement.* International Journal of Disaster Risk Reduction, 14, 470-486.

Sandu, D., Corad, B., Cioinaru-Iamandi, C., Man, T., Marin, M., Moldovan, C. & Neculau, G., 2016. Dezvoltarea umană locală în zonele rurale şi urbane mici din România. In Teşliuc E., Grigoraş, V. & Stănculescu, M. (eds.) Atlasul zonelor rurale marginalizate şi al dezvoltării umane locale din România. World Bank, 153-264.

Stângă, I. C. & Grozavu, A., 2012. *Quantifying human* *vulnerability in rural areas: case study of Tutova Hills (Eastern Romania).* Natural Hazards and Earth System Science, 12, 1987-2001.

Tudor, C. A., Iojă, I. C., Rozylowicz, L., Stupariu, I. P. & Hersperger, A. 2015. *Similarities and differences in the assessment of land/use associations by local people and experts*. Land Use Policy, 49, 341-351.

Watts, M. J. & Bohle, H. G., 1993. *The space of vulnerability: the causal structure of hunger and famine*. Progress of Human Geography, 17, 43-67.

Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (eds) 2004. *At risk: Natural hazards, people's vulnerability and disasters*. Routledge. Oxford.

Wu, S. Y., Yarnal, B. Fisher, A., 2002. *Vulnerability of coastal communities to sea-level rise: a case study of Cape May County, New Jersey, USA.* Climate Research, 22, 255-270.

Yoon, D. K., 2012. *Assessment of social vulnerability to natural disasters: a comparative study*. Natural Hazards, 63, 823-843.

***** Law no. 575/22.10.2001** published in Official Monitor no. 726/14.11.2001 regarding the Approval of the *Spatial Planning of the National Territory* – Section V – Areas of Natural Risk

Received at: 04. 07. 2016
Revised at: 06. 03. 2017
Accepted for publication at: 13. 03. 2017
Published online at: 06. 04. 2017