A location-based service for planning tool

Saeed Mehri*, Ali Asghar Alesheikh*

* Department of geodesy and geomatics engineering, K. N. Toosi University of Technology, Tehran, Iran. sa.mehri20@gmail.com, alesheikh@kntu.ac.ir

Abstract. The social vulnerability concept links the environment to human life and makes it clear to understand how distinct social groups are affected by disasters. In this context, the assessment of location-based social vulnerability (LBSV) in GIsystems will play an important role not only to understand the affected social groups but also to predict their geographic location to facilitate effective decision-making and rescue process. Therefore, in this paper, we looked at this concept as a base of developing location-based service for rescue purposes. This paper represents part of research which is in progress. Within this framework, the paper aims to apply a proven method for assessing social vulnerability in GIsystem to earthquakes in East Azerbaijan province in Iran. The methodology is based on Social Vulnerability Index (SoVI) approach with 23 customized variables. For validation, results were compared to the Ahar-Varzegan earthquake that happened in 2012. This research provides useful information for identifying the places most likely to experience casualties due to socioeconomic and demographic characteristics. So this information is useful for planning rescue teams. Also, results are useful for making better development plans.

Keywords. Location-based, Natural hazard, social vulnerability

1. Introduction

Vulnerability is the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt to the situation. The soul of the social vulnerability concept correlates with the modern planning model (Lee, 2014). Location-based vulnerability assessment helps to identify people or property that is susceptible to suffer due to disaster risks (UNISDR, 2015).

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Over the past decade, social vulnerability indices have emerged as a leading tool to quantify and map human dimensions of hazard vulnerability (Rufat, Tate et al., 2015). This makes it clear to understand how distinct social groups are differently impacted by disasters (de Loyola Hummell et al., 2016). Social vulnerability is the product of social and place inequalities (Cutter et al., 2003). Therefore, assessing of location-based social vulnerability (LBSV) in Geographic Information System (GIS) may better reveal those social and place inequalities in different regions.

After natural hazards estimating the number of injured and killed people and predicting location of those will play a vital role in reducing amount of casualties. To reach this goal, at first, we have to assess places that are more vulnerable to natural hazards and then use this information in location-based rescue system to manage rescue teams. In this paper we did first part. So, we used the social vulnerability index to predict more vulnerable places to earthquakes. To do this, East Azerbaijan province was selected as a study area (see *Figure 1*), and the social vulnerability index (SoVI) was used in the GIS environment to assess social vulnerability. SoIV has gained general acceptance as one of the leading tools for quantifying social vulnerability due to its fair robustness.

2. Materials and methods

In this paper, demography data of the year 2011 of Iranian population and census is used. This data made it possible to validate research's final results by comparing it to Ahar-Varzagan twin earthquakes that happened on the 11th of August 2012 with 6.4 and 6.3 on the moment magnitude scale.

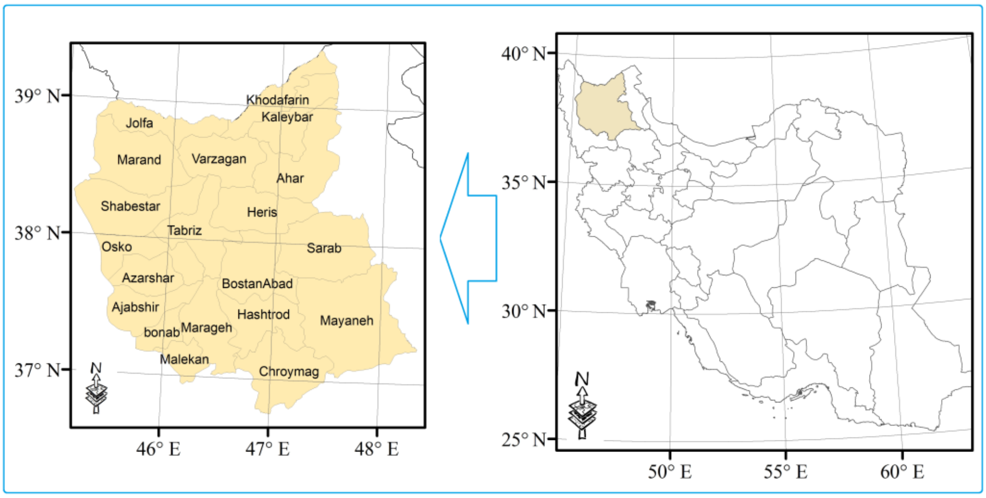

Figure 1. The study area of this research

2.1. Construction of social vulnerability indicators

In this paper, 23 variables were chosen according to the data available in East Azerbaijan that represent the socio-economic conditions (see *Table 1*). Having different measurement units, the z-score statistical method was used to normalize variables and convert them to a common scale with a mean of zero and standard deviation. To select the proper criterion, factor analysis is executed. To check the validity of this analysis, the sampling adequacy was measured using Kaiser-Meyer-Olkin (KMO). Since KMO was greater than 0.6, it was used for factor analysis.

Concept	No	Description
Family structure	1	Family with 1 component
	2	Family with more than 6 components
Education	3	Higher education index
Socioeconomic status	4	Containment index
	5	The ratio of the poor
	6	Attraction index
	7	Commuting rate
Employment	8	Female labor force employed
	9	Labor force employed
	10	Unemployment rate
Age	11	Rate of children < 14 years
	12	Rate of old > 65 years
	13	Aging index
	14	Dependency ratio
Population growth	15	Population density
	16	Urbanized index for residential use
	17	Crowding index
Race/Ethnicity	18	Foreign residents
Medical Services	19	The percentage of disable people
	20	People with social problems
	21	Total Hospital bed
	22	Percentage labor force working in human health and social work services
Quality of the built environment	23	Building quality

Table 1. Variables used in the Social Vulnerability Index (SoVI)

A factor analysis, using principal component analysis (PCA), was implemented using Kaiser Normalization and Varimax rotation to drive the most robust set of independent factors that explain the social vulnerability characteristics for East Azerbaijan. For interpretation purposes, the most significant indicators (with correlations over 0.6 and less than -0.6) were assumed as drivers of each component and provided the rationale for the naming conventions and corresponding positive or negative cardinality according to their influence on social vulnerability. Positive values mean increment in levels of vulnerability, while negative values reduce levels of vulnerability. Location-based SoVI was then calculated in the GIS environment by the sum of the components for each municipality. After the construction of the location-based SoVI it was classified based on five class according to the standard deviation: very low (< -1.5); low (-1.5 to -0.5); medium (-0.5 to 0.5); high (0.5 to 1.5) and very high (> 1.5).

3. Results and discussion

Three factors with an eigenvalue greater than one, resulting from the statistical analysis for SoVI explain 85.134 % of the variance. The parameters, their effects and the correlation of different factors in three principal components are listed in *Table 2*.

Component	Factors and their effect[1]	Correlation
C1	The ratio of the poor (+)	0.928
	Female labor force employed (-)	0.974
	Population density (+)	0.952
	Foreign residents (+)	0.986
	Building quality (-)	0.675
	The percentage of disabled people (+)	0.984
	People with social problems (+)	0.976
	Total Hospital bed (-)	0.977
	Percent of the labor force working in human health and social services (-)	0.974
C2	Commuting rate (+)	0.656
	Rate of children < 14 years (+)	-0.87
	Urbanized index for residential use (+)	0.627
	Crowding index (+)	-0.91
C3	Attraction index (-)	0.886

[1] Increment (+) and reduction (-) of SoVI

Component	Factors and their effect1	Correlation
	Rate of old > 65 years (+)	0.867

Table 2. Main factors and direction of influence to the SoVI (±)

Constructing the SoVI revealed that it varies from +4.457 (very high vulnerability) to -3.918 (very low vulnerability). Most part of the study area has a medium social vulnerability (*Figure 2*). These regions cover 33.25 percent of the whole study area (*Table 3*). 22.84 percent of the study area falls into a very high social vulnerability group.

Vulnerability class	Area (Km^2)	%
Very high (>1.5 Std. Dev)	10391.67	22.84
High (1.5 < Std. Dev < 0.5)	3660.32	8.05
Medium (-0.5 < Std. Dev < 0.5)	15124.26	33.25
Low (-1.5 < Std. Dev < -0.5)	10311.55	22.67
Very low (< -1.5 Std. Dev)	6003.12	13.20

Table 3. Percentage of different classes of social vulnerability in East Azerbaijan

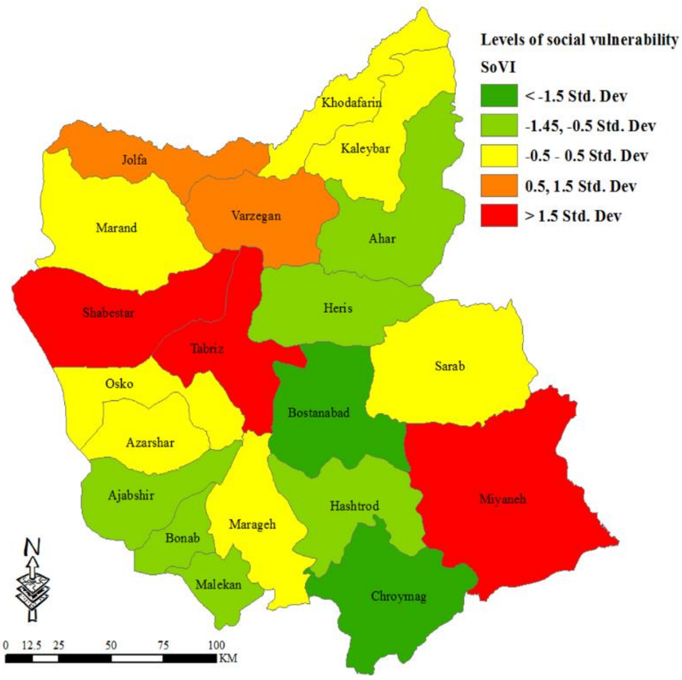

Figure 2. The study area of this research

To validate the results, the number of casualties caused by the real Ahar-Varzagan earthquake were used. At 12:23 coordinated universal time (UTC) of 11th of August 2012 two earthquakes of 6.4 and 6.3 on the moment magnitude scale occurred nearby Ahar and Verzegan (Ranjbar et al., 2016). In that earthquake, more than 20 villages have completely destroyed and cities of Verzegan and Ahar suffered different levels of damage (Ranjbar et al., 2016). The earthquake killed 74 people in Varzegan and a total of 43 men and women in Ahar.

4. Conclusion

This research is a part of our main research in developing location-based rescue planning services for natural disasters. To manage rescue teams after hazards it is necessary to estimate places with high possible injured people. So to find these places we used the SoVI method with variable customization in a GIS environment.

The SoVI map could serve as a location-based service (LBS) play a game-changing role in territorial planning and emergency management by providing an evidence-based understanding of regional and local differences in the capacities to prepare for, respond to, and recover from natural hazards.

For further research, it is recommended to use large scale maps to predict more precise places that are more vulnerable to natural hazards.

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