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# Risk perception and social vulnerability to earthquakes in Grenoble (French Alps)

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# Risk perception and social vulnerability to earthquakes in Grenoble (French Alps)

The city of Grenoble (French Alps) is characterized by a rather low seismicity as well as a tectonic context prone to the occurrence of major earthquakes (M=6). The population is therefore not used to experiencing earthquakes: this can lead to a low culture of risk, which may imply a rather high vulnerability of the population. Consequently it is necessary to better evaluate vulnerability and to find ways of reducing it. Social vulnerability is usually evaluated through surveys focusing on residential population. When these studies are carried out by geographers, they sometimes take into account a spatial dimension by mapping the results. Here, a temporal dimension is also integrated and residents as well as users of the city, i.e. users with any activity as working, shopping, having leisure time, etc., are surveyed. The method consists in building a social and spatial representative sample through three dimensions: social (age), temporal (hour of the day) and spatial (place of residence or activity). For this reason the household travel survey was used to build the sample. The risk perception survey shows that only 16% of the sample feel exposed to earthquakes. The youngest, most qualified, the students and working people seem to better know the adequate safety measures to be taken in case of an earthquake. Besides classic statistical analyses, the answers to the questionnaire were synthesized into a vulnerability index (IVS). Once more, the most qualified are characterized by a lower vulnerability. The cartography of the survey results provides interesting conclusions for authorities in charge of risk mitigation, who could then concentrate their preventive information campaign on certain districts or social groups. Among other conclusions, these maps highlight the gap between the physical vulnerability of buildings and the confidence of the population in their resistance in case of an earthquake.

Keywords: risk perception, social vulnerability, seismic risk, spatio-temporal sampling, Grenoble

## Introduction

The risk has had many definitions varying notedly according to times and disciplines. The economists for example will define the risk as the possibility to suffer a money loss due to a quantifiable uncertainty whatever the event at the origin of it. In the field of Earth science, seismologists will also consider the damages: “the likely percentage of losing goods and productive activities or human lives during a lapse of time and in a determined region” (Madariaga and Perrier 1991). Geographers have for long shown interest in the risk but their approach has changed with time. Starting from a rather physical approach, E. de Martonne (1909) or Tricart (1958) have privileged hazard. In the 1970's, Anglo-Saxon geographers like G. White, I. Burton and R. Kates, from the Chicago School have integrated the human dimension and have considered the vulnerability of populations notedly through the study of their perception of the risks (Ducret 1994). Here, risk is considered as the result of the crossbreeding of a hazard (a potentially harmful phenomenon) with a vulnerability (a proclivity to suffer damages). If one concentrates on the vulnerability of individuals, the latter has several components: one is physical and linked to the probability of being damaged, of losing one's physical integrity and one is social and was integrated by authors like Chardon

or D'Ercole in the 1990's (Chardon 1994; D'Ercole 1994). In the present article case, the interest lies more specifically in the social dimension of vulnerability which is additionally linked to the perception of risks by individuals. In this context, the aim is to evaluate the social vulnerability to earthquakes. The study applies to the city of Grenoble located in the French Alps and belongs to the MOVISS programme (Beck et al. 2010).

**General context**

The study presented in this article applies to the city of Grenoble. Located at the confluence of river Isère and river Drac and surrounded by Chartreuse, Vercors and Belledonne mountain ranges (Figure 1), this 500,000 resident urban area[1] is exposed to various natural hazards (floods, landslides or earthquakes). The presence of Seveso-classified industries and of a nuclear research complex also generates technological risks. The seismicity of the region is moderate: the annual seismicity is low but the tectonic context is favourable to the occurrence of a magnitude 6 earthquake. The fact that earthquakes rarely occur can be a constraint on the development of a culture of the seismic risk, for the population is not used to experiencing such events. This can make the population more vulnerable when facing a potentially harmful event. This is the reason why it is important to try to better evaluate vulnerability and find means of mitigation.

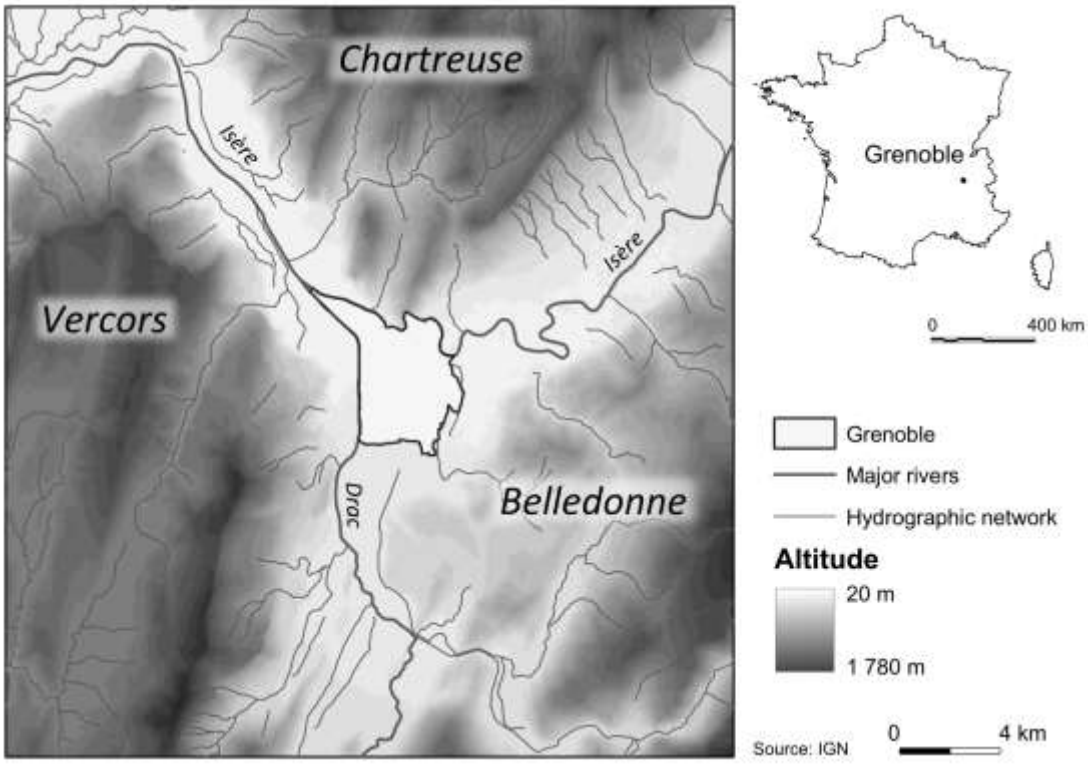



Figure 1. Scope of the area studied.

1 Source: INSEE census, 2008

## Methodology

Most studies on social vulnerability focus on residents at home (Bonnet 2002; Glatron and Beck 2008; Guéguen et al. 2009), often because databases describing the distribution of the population (INSEE census) apply to the latter in particular. A picture of population vulnerability on the place of residence is then obtained. The objective of the present study was to go beyond this approach by taking into account the diversity of the population during the day in the area studied. For that two groups of individuals were considered: the residents, those who live here, and the users. For a given district a user is somebody who has any kind of activity there (working, visiting, shopping, leisure activities, etc.) but does not live here and is not simply in transit. A district is thus characterized by residents and users in various proportions according to the time of the day.

On the question of risks more specifically, preventive information is distributed differently to the users and the residents: the latter get information at home. The users are themselves residents but from another district or another town. Both population groups do not necessarily visit the same places and the residents are likely to better know their district (according to how long they have lived here). Starting from the postulate that information and the personal experiences of populations influence the perception of their environment and a fortiori of the risks they are exposed to (Lynch 1960; Lindell and Perry 2004), one can then expect to observe different results in terms of social vulnerability between the users and the residents.

### *Questionnaire*

In order to evaluate the social vulnerability of Grenoble inhabitants, a questionnaire with 53 questions was set up. The questions were about the perception of risks, the knowledge of earthquakes and their expressions, the behaviours to be adopted should an earthquake occur, the confidence in buildings frequented as well as the social-demographic features of individuals.

1,004 people were interviewed in the streets of the city of Grenoble at different times of the day. Grenoble was split into 13 sectors (districts). This zoning takes up again the zoning of the household travel survey used for sample setup (Figure 2).

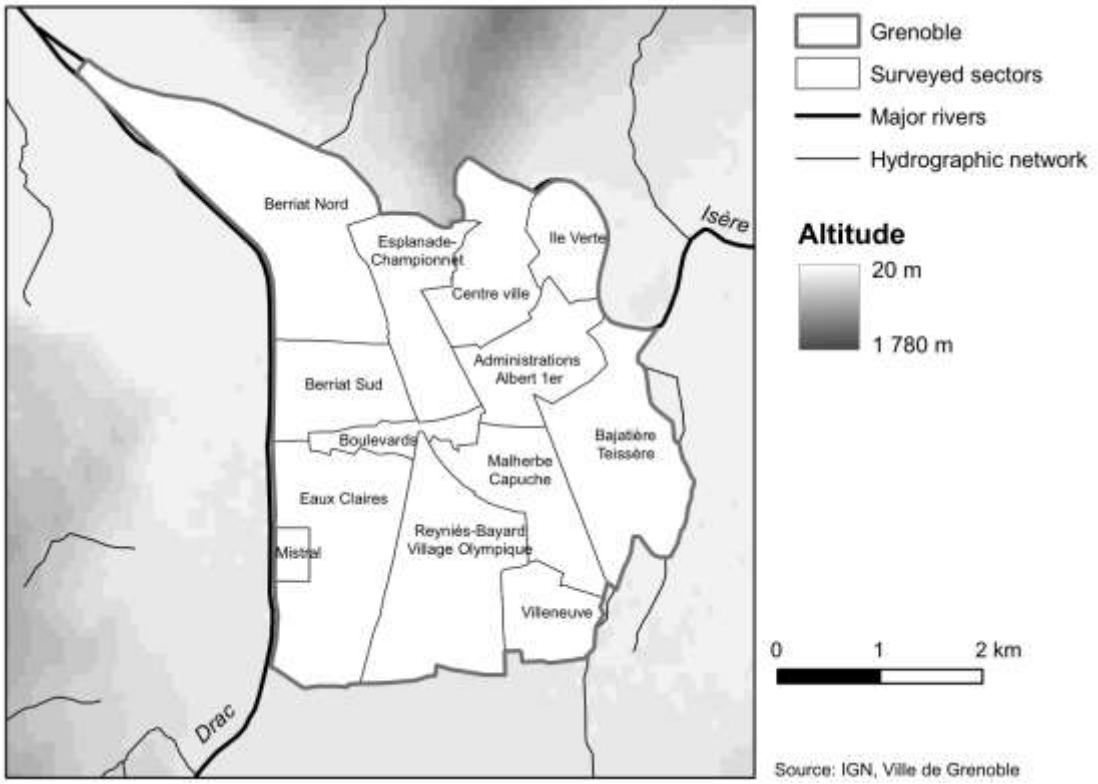
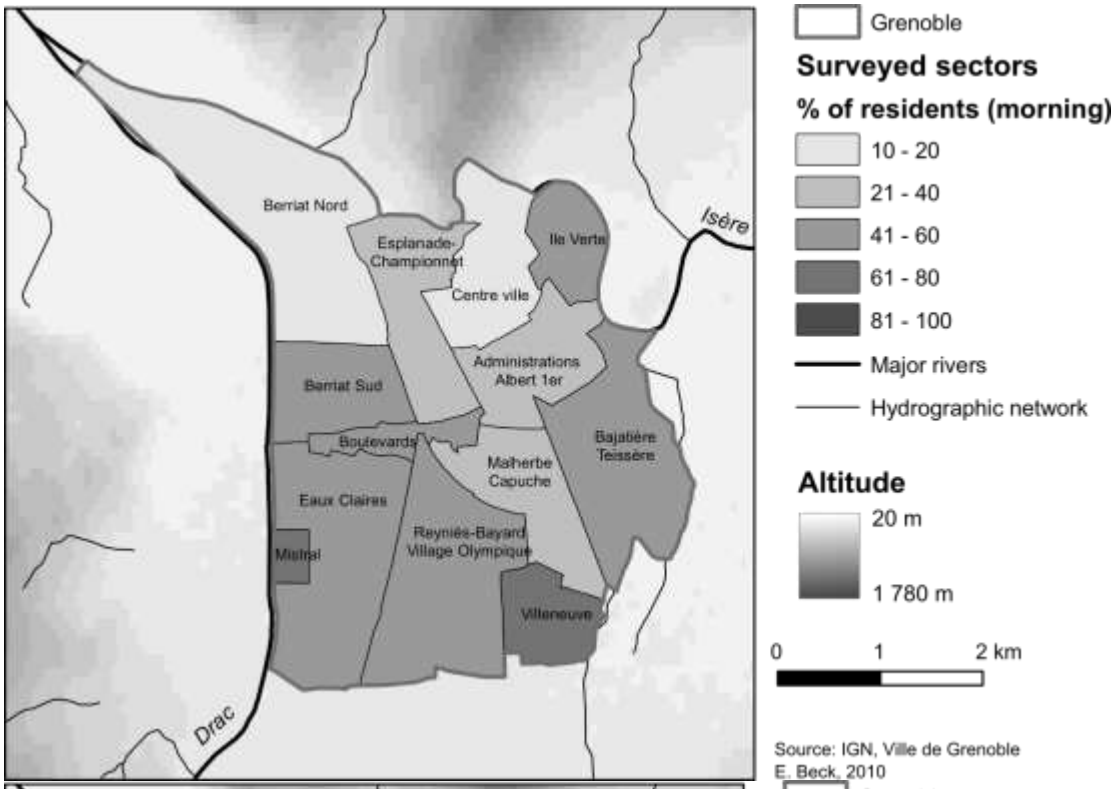



Figure 2. The 13 sectors surveyed.

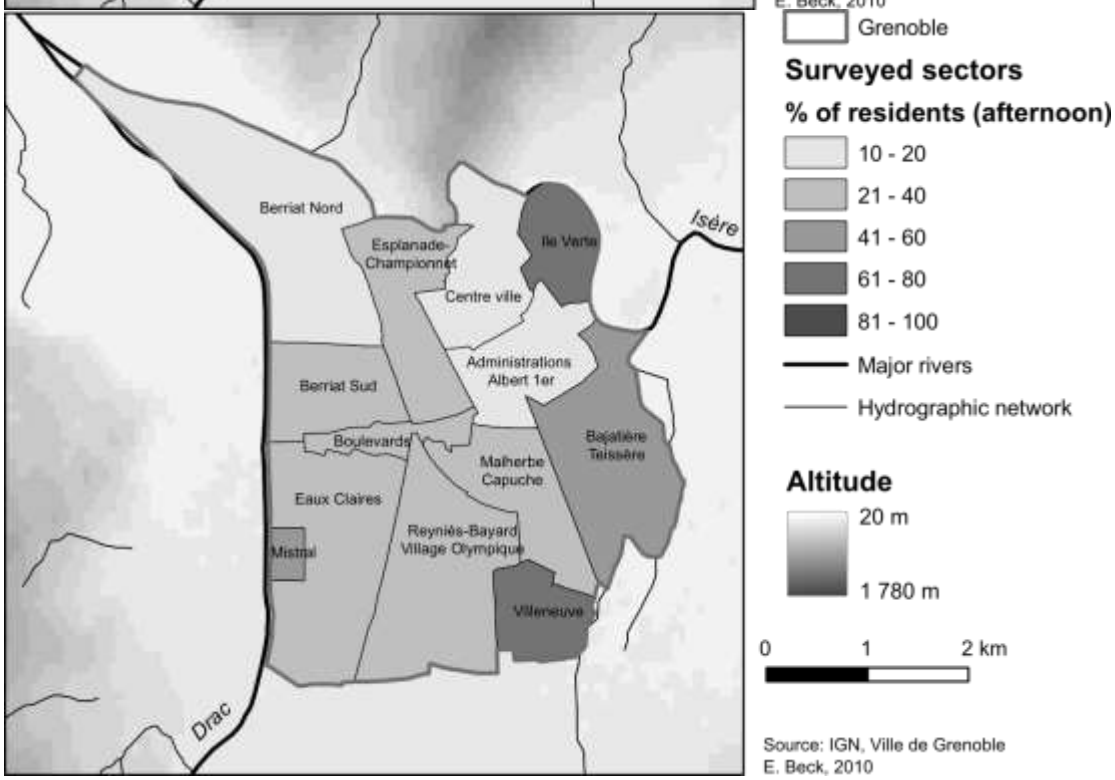
***Sampling***

To set up the sample, the results of the 2002 household travel survey in the Greater Grenoble area were taken. This survey describes on a 24 hour day (weekend excluded) all the travels made by people aged 5 and older. The survey answers the following questions: why do they travel? Where do they come from? Where do they go? What time did they leave and what time do they arrive? Via computer programming, it is possible to reconstruct the places of presence, in other words to know where the people are and for how long. These results can then be refined according to various social-demographic features like gender, sex, age or activity status.

Thus, from this database, a sample using crossed quotas taking simultaneously into account the time and place of presence and social-demographic features (age and status: resident or user) was set up. This method really seeks to portray the variety of the populations present at different times of the day in the districts of the city of Grenoble. For each sector, the number of residents and of users according to time periods (between 8.00 a.m. and 12, between 12 and 2 p.m., between 2 and 6 p.m. and after 6 p.m.) was determined, as well as the number of people according to the age groups to be studied (the 15-24 year old, 25-34 year old, 35-44 year old, 45-54 year old, 55-64 year old and the 65 year old and older; Figure 3). With a view to comparing the districts, 77 persons were interviewed in each of them.




Source: IGN, Ville de Grenoble
E. Beck, 2010




Source: IGN, Ville de Grenoble
E. Beck, 2010

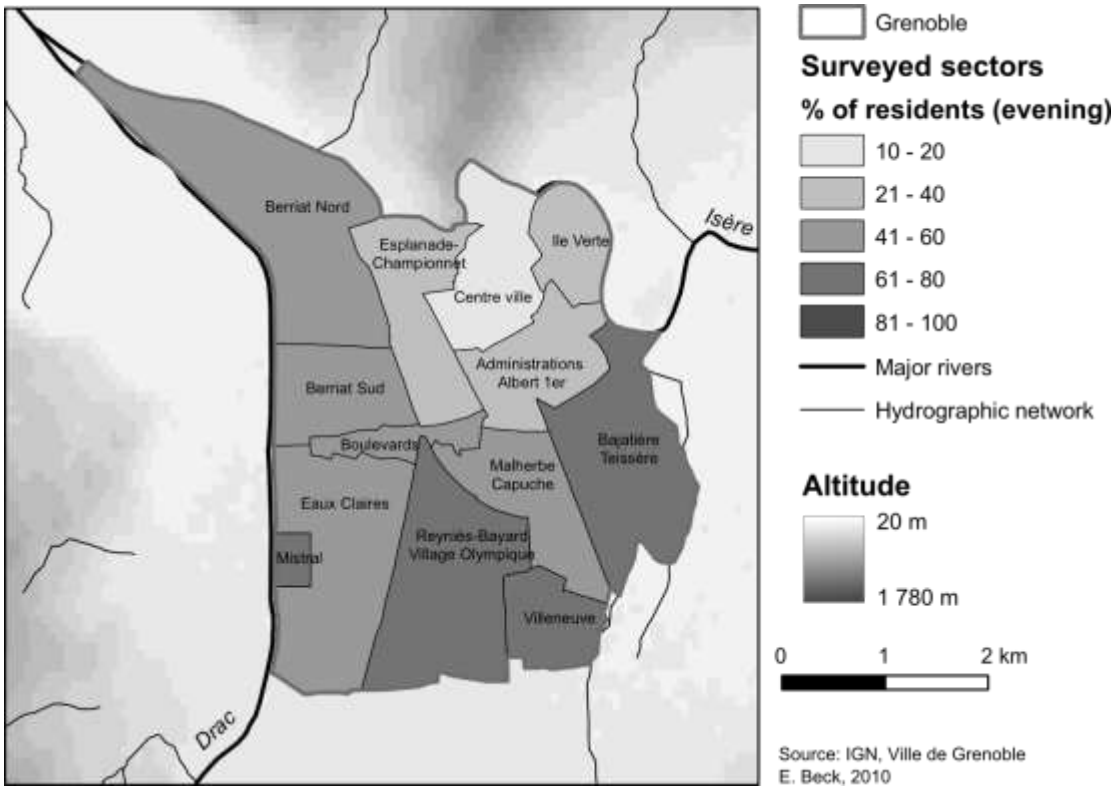



Figure 3. Spatial temporal distribution of the resident population in the 13 sectors of Grenoble surveyed, in the morning, the afternoon and in the evening and at night – a distribution reconstructed from the results of the 2002 household travel survey.

**Results of the survey**

Two types of analyses were carried on. On the one hand a classic statistical analysis of the themes of the survey (frequency table and cross tabulation); on the other hand, a synthetic index of vulnerability was set up, based on the responses to the survey.

***Thematic results***

This section presents the main results relating to the feeling of being exposed to natural risks, to the knowledge of safety instructions to be adopted in case of an earthquake, to the information received and to the confidence into the resistance of the buildings in the district surveyed.

As regards exposure to natural risks, it was initially attempted to know the three most worrisome risks for the city of Grenoble. Natural risks in general are integrated within a set of environmental, industrial, sanitary, social, economic risks (Figure 4). They come in third position (52% of the respondents named this risk), after environmental risks (air pollution, asbestos, etc., 65%) and industrial and nuclear risks (factory explosion, transportation of dangerous goods, etc., 59%). The build-up of regular pollution peaks in the summer or winter, the presence of chemical industrial sites south of Grenoble may explain this classification. It should be noted that the economic crisis that hit France in the autumn 2008, i.e. a few weeks before the beginning of the MOVISS survey, did seemingly not make any impression on Grenoble inhabitants who are in a privileged situation compared to other French regions. In the survey, social and economic risks come in 6$^{th}$ position. Major risks

thus play a large part in the region of Grenoble according to the individuals surveyed following the example of the average French opinion. Yet the barometer survey from the French Institute of Radiation Protection and Nuclear Safety (IRSN) measures among others the concern for current problems facing French people using the following question: “In France, among the following, which current problem is in your opinion the most worrisome?” (2 possible answers) (IRSN, 2009). The results from the IRSN show a greater concern of the French for unemployment, poverty and social exclusion and the consequences of the financial crisis. These three problems come first with respectively 37.0%, 32.5% and 30.0% of the respondents. Damages to the environment come just after with 21.9% of the respondents.

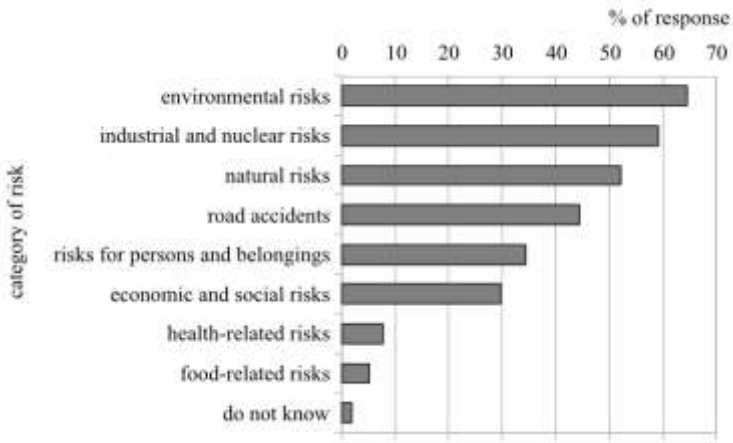



Figure 4. Distribution of responses to the question « Which are the three most worrisome risks for the city of Grenoble? » (several possible responses).

Subsequently, the feeling of individual exposure to various natural risks[2] was addressed. In the list of natural risks named, floods come first with an average score of 1.91, followed by storms (average score of 1.45) and earthquakes (1.37) (Figure 5). This hierarchy is explained by the fact that the banks of the river Isère are regularly flooded in Grenoble and that the 1999 storm is still present in people's minds. Besides, some little earthquakes sometimes occur: the most memorable earthquakes are the ones that occurred in Epagny (Haute-Savoie) on July 15$^{th}$ 1996 (M=5.3) and the one in Laffrey (Isère) on January 11$^{th}$ 1999 (M=4.2).

The age seems to have some sort of influence on the perception of the earthquake risk (Figure 6). Yet the eldest feel more exposed (average score of 1.63 for the 65 year old and older) than the youngest (average score of 1.09 for the 15-24 year old). The youngest respondents have certainly had no experience of earthquakes in this region yet.

2 The surveyed persons have to evaluate their feeling when being exposed to six natural risks (avalanche, fire, rockfall, earthquake, storm, flood) in the city of Grenoble. The scale ranges from 0 to 4 (0 when the surveyed persons do not feel exposed and 4 when they feel very much exposed).

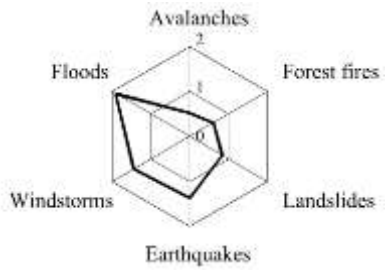



Figure 5. «For each of those risks, how much exposed do you feel? » 0 = not at all; 4 = very much exposed.

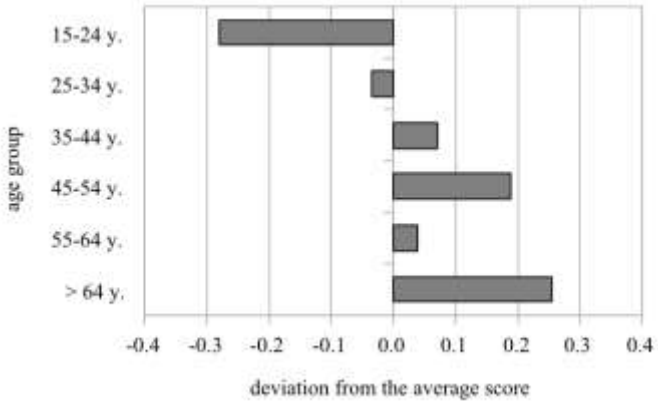



Figure 6. Deviation from the mean of the score of the earthquake risk perception according to the age group (mean: 1.37 on a 0 to 4 scale).

Another section of the questionnaire was about the knowledge of safety measures to be adopted in case of an earthquake. The surveyed persons were put into an earthquake situation. The latter had to indicate their behaviour 1) during a tremor, 2) after a tremor, 3) after a tremor with children to support and who are not with them, and finally, 4) in case of an evacuation request. For that, the respondent had to choose one or several possible responses in a list where correct and incorrect responses could be found. In this way, a score relating to the knowledge of safety instructions was established from the responses given. For questions with a unique response the partial score relating to the question is 0 in case of a wrong response, 10 points in case of a plausible response and 20 points in case of a correct response. For questions with multiple responses, the list of possible combinations was established and a 20 point scale according to the number of wrong and correct responses was set up. A maximum of points was given to the combination with all correct responses. The knowledge score for each individual is a mean of partial scores. It is established on a scale ranging from 0 to 20, 20 corresponding to a perfect knowledge of the instructions, 10 an average knowledge and 0 a very bad knowledge of the instructions.

On sample scale, the mean of the instructions knowledge score is 13.53/20, which indicates an average to good knowledge of the instructions to be followed in case of an earthquake. The youngest, who, for the most part, are still in the education system (secondary or higher education), show good results (Figure 7). Two reasons can explain these results. The recent changes in school programmes leave greater room to the question of behaviours to be adopted in the event of a natural disaster. Safety instructions are taught during the National Defence Preparation Day of the young French men and women over 18.

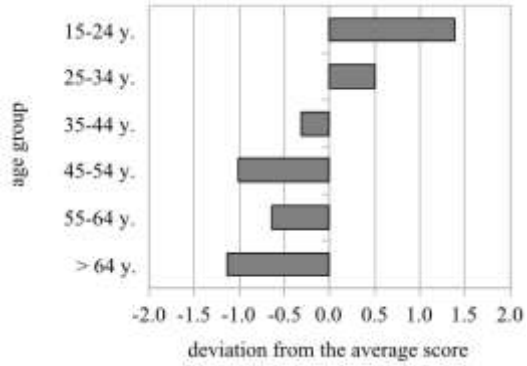



Figure 7. Deviation from the mean of the score of the knowledge of instructions to be adopted in the event of an earthquake by age group (mean: 13.5 on a scale ranging from 0 to 20).

Qualification level also has an influence on the knowledge of safety procedures (Figure 8): the most qualified know these procedures better. One can give two interpretations to this result. The first interpretation promotes the importance of teaching safety instructions in school programmes for a few years and an increasing awareness of natural risks in general in educational structures. The second interpretation aims more at an intellectual open-mindedness to some questions by means of studies, of which environmental questions and related subjects.

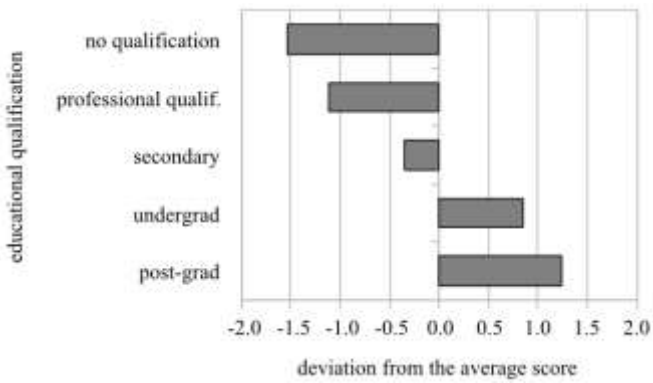



Figure 8. Deviation from the mean of the score of the knowledge of instructions to be followed in the event of an earthquake by qualification group (mean: 13.5 on a 0 to 20 scale).

Finally, the type of activity also seems to influence the knowledge of procedures since active workers, secondary and higher education students show a good score while people out of the work system like the unemployed, housewives and househusbands and the retired have less knowledge of these instructions (Figure 9). One can understand those results by the fact that isolated persons and/or persons outside the system are not a target for preventive information campaigns which may aim more at secondary/higher education students and active workers. Besides, they have generally less access to information.

It is to be noted that no significant difference could be observed between men and women.

As regards the distribution of information few respondents (26.9%) declared they have obtained information on earthquakes in general (Figure 10) while half the

interviewees declared they had obtained information on the safety measures to be applied when an earthquake occurs (42.5%; Figure 11).

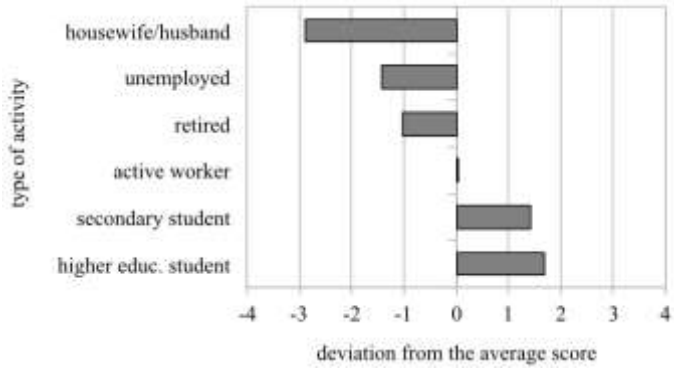



Figure 9. Deviation from the mean of the score of the knowledge of instructions to be followed in the event of an earthquake by type of activity (mean: 13.5 on a 0 to 20 scale).

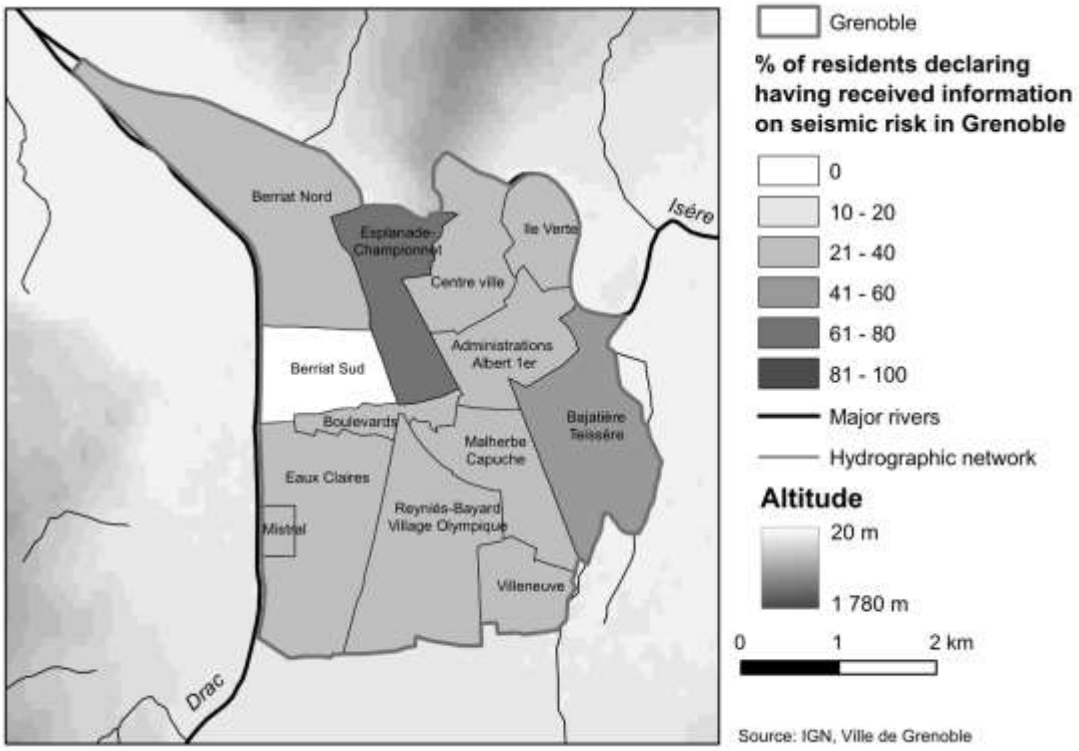



Figure 10. Proportion of individuals claiming they obtained information on earthquake risks in Grenoble.

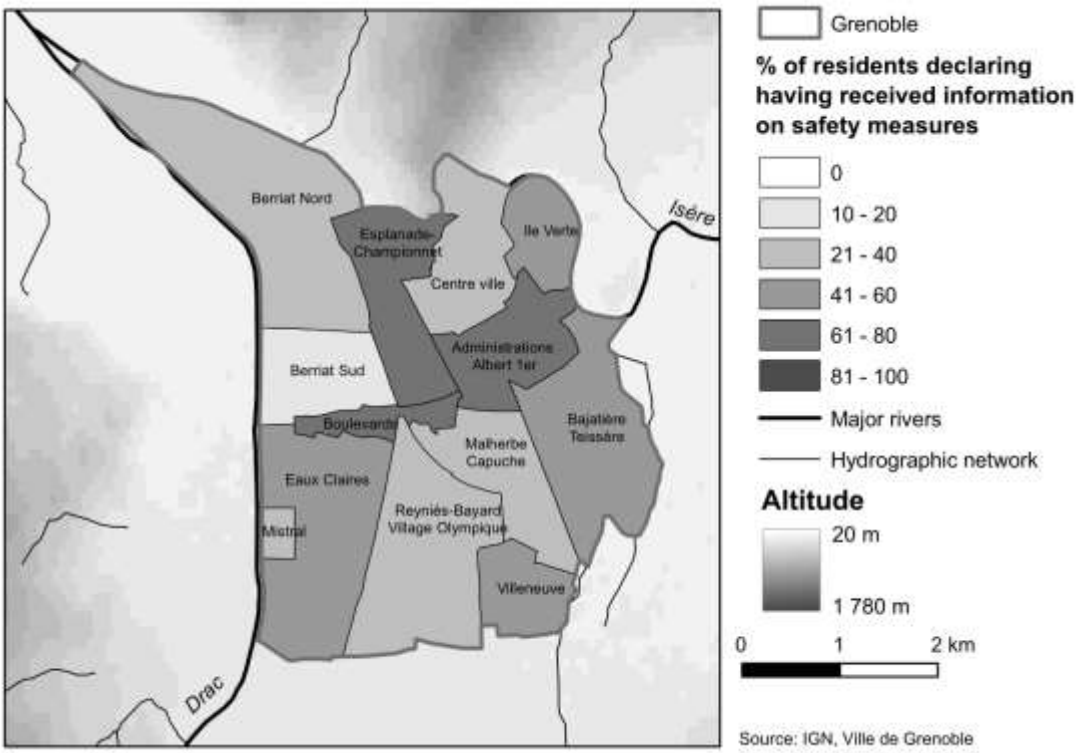



Figure 11. Proportion of individuals claiming they obtained information on the instructions to be followed in the event of an earthquake.

As the sample interviewed was established in order to be spatially and temporally representative, the results can be mapped. Maps showing that some districts are particularly misinformed are a relevant tool for local authorities. Those authorities could emphasize the distribution of information brochures or more generally their preventive information campaigns in these districts.

Responses to the question “in the event of an earthquake do you think that the buildings of this district could resist or collapse?” were also mapped (Figure 12) and compared to physical vulnerability data established by P. Guéguen et al. (2007). This map shows a city centre with a high physical vulnerability, moderately vulnerable inner suburbs and finally more recent outer suburbs with a lower vulnerability. One third of the persons surveyed cannot evaluate the behaviour of the buildings in which they would be if an earthquake occurred (figure 12). This can be explained by the fact that the earthquake magnitude was not indicated in the question. The proportion of “don not knows” varies from one sector to the other. It is far higher in the Mistral (61%) and Eaux-Claires districts (58%) than in the city centre districts (18%), of L'Ile-Verte (25%), of Administrations-Albert-1er (30%) and of Boulevards (30%). Besides, 39% think that the buildings would resist and 26% that they would not.

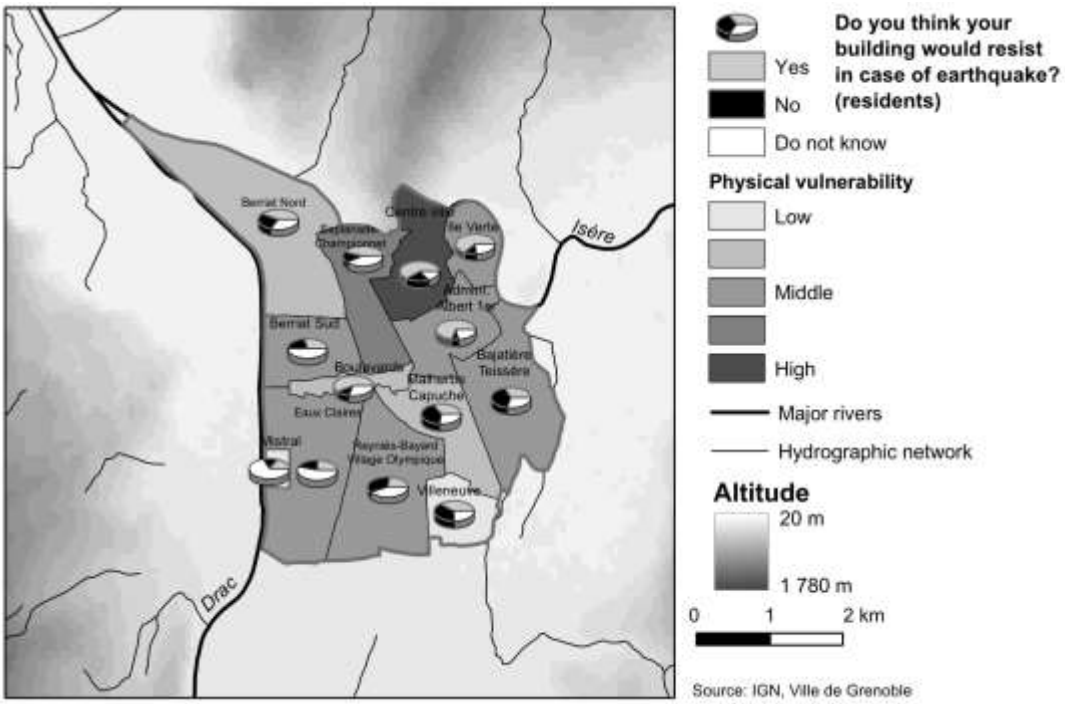



Figure 12. Confidence of the persons surveyed into the resistance of the buildings in the district surveyed in the event of an earthquake. Comparison with physical vulnerability data.

If the significativity tests are not conclusive in the analysis of the statistical correlation between the physical vulnerability and the confidence into the resistance of buildings, it visually appears that the most vulnerable districts (City centre, Esplanade-Championnet) are also the districts where the persons surveyed declare by a majority that the buildings will resist: City centre 53% and Esplanade-Championnet 53%. On the contrary, the districts that look the most vulnerable owing to their high-rise buildings are considered as vulnerable by the persons surveyed (18% in the Mistral district and 37% in the Villeneuve district, 52% in the Malherbe-Capuche district), while in reality those buildings are more recent and then comply more with earthquake resistant standards or are built according to rules guaranteeing a good resistance should an earthquake occur.

***Establishing the social vulnerability index***

To take things further than the classic statistical analysis, we processed our data so as to obtain more synthetic results. For that, a social vulnerability index (IVS) was established in the light of the responses given to 10 questions of the questionnaire (D'Ercole 1996; Cutter et al. 2000; Glatron and Beck 2008). Taking inspiration from the works of D'Ercole (1996), who considers that the social vulnerability of an individual is due to three categories of factors (1/knowledge of the phenomenon, of the instructions to be adopted; 2/perception; 3/constraints: distance from the sources of danger, rescue services, social demographic characteristics), the questions chosen related to themes dealing with the knowledge of the phenomenon and the knowledge of the behaviours to be adopted in case of an earthquake. To calculate the social vulnerability index, the mean of the scores of the perception, the knowledge of the phenomenon and of the safety instructions to be adopted in case of a tremor was

calculated. The method to establish them is described in previous section. These scores vary on a scale ranging from 0 to 20, 20 corresponding to a perfect knowledge and behaviour and 0 to a null knowledge and behaviour. It is more logical to think that the persons with a high vulnerability, i.e. who obtained a score of knowledge and behaviour close to 0 could obtain a high social vulnerability index (close to 20). For that the mean of the scores was transformed into Y=20-X. This method was applied to each of the individuals surveyed.

For the whole sample the mean of the social vulnerability index is 8.8/20. The distribution is centred on the mean.

A first analysis shows that the qualification has a strong influence on vulnerability (Figure 13). Once more the most qualified respondents are the least vulnerable because they have a better knowledge of earthquake phenomena and safety instructions. University graduates and post-graduates thus have an average IVS of 7.7 against 9.0 for holders of the French baccalauréat and 9.9 for non-graduates.

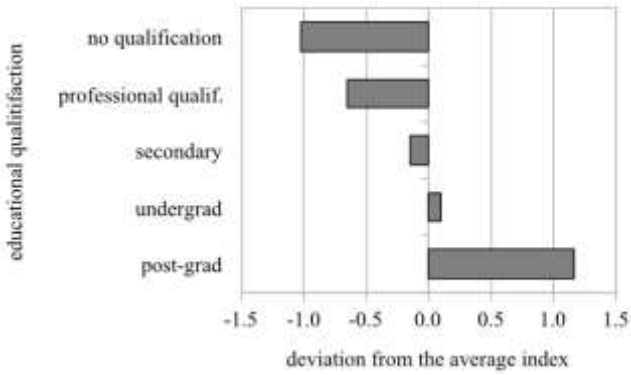



Figure 13. Deviation from the mean of individuals with an index of social vulnerability to earthquakes according to the qualification level (mean: 8.8 on a 0 to 20 scale).

The influence of age on vulnerabilities is more complex (Figure 14), as the social vulnerability index synthesizes perception data (for which we observed that the youngest were less aware of being exposed to earthquake risks) and instructions knowledge data (the youngest got the best scores). Eventually, the 15-24 year old have an 8.9 average vulnerability, the 25-34 year old 9.4, the 45-54 year old 8.9, the 55-64 year old 8.4 and the 65 year old and older an 8.3 average IVS. The least vulnerable are then the oldest and the most vulnerable the 35-44 year old. The age alone is not enough to understand the variations of vulnerability (the IVS deviations are very low from one age group to the other). A multivariate analysis would allow identifying the intrication of social determinants of vulnerability.

The district where the persons surveyed live seems to also have a significant influence on the vulnerability (Figure 15). The Mistral, Bajatière-Teissère, Berriat-Sud districts, characterized by a strong proportion of working class inhabitants, show a greater vulnerability while the Esplanade-Championnet and City centre districts are less vulnerable. Both districts have populations belonging mainly to the middle and upper classes. Though the Berriat-Sud district has experienced a gentrification process (incoming families from the upper classes) for a few years, it keeps a part of its historical population made of workers, employees and retired people. This mixed composition can explain that the mean vulnerability index of the district is still high.

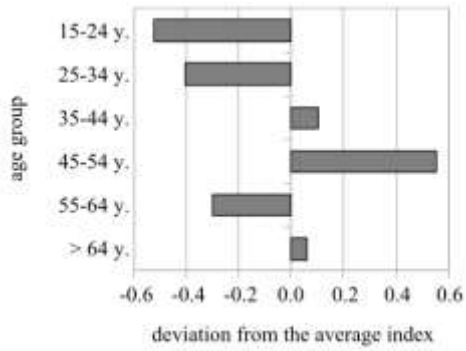



Figure 14. Deviation from the mean of individuals with an index of social vulnerability to earthquakes according to their qualification level (mean: 8.8 on a 0 to 20 scale).

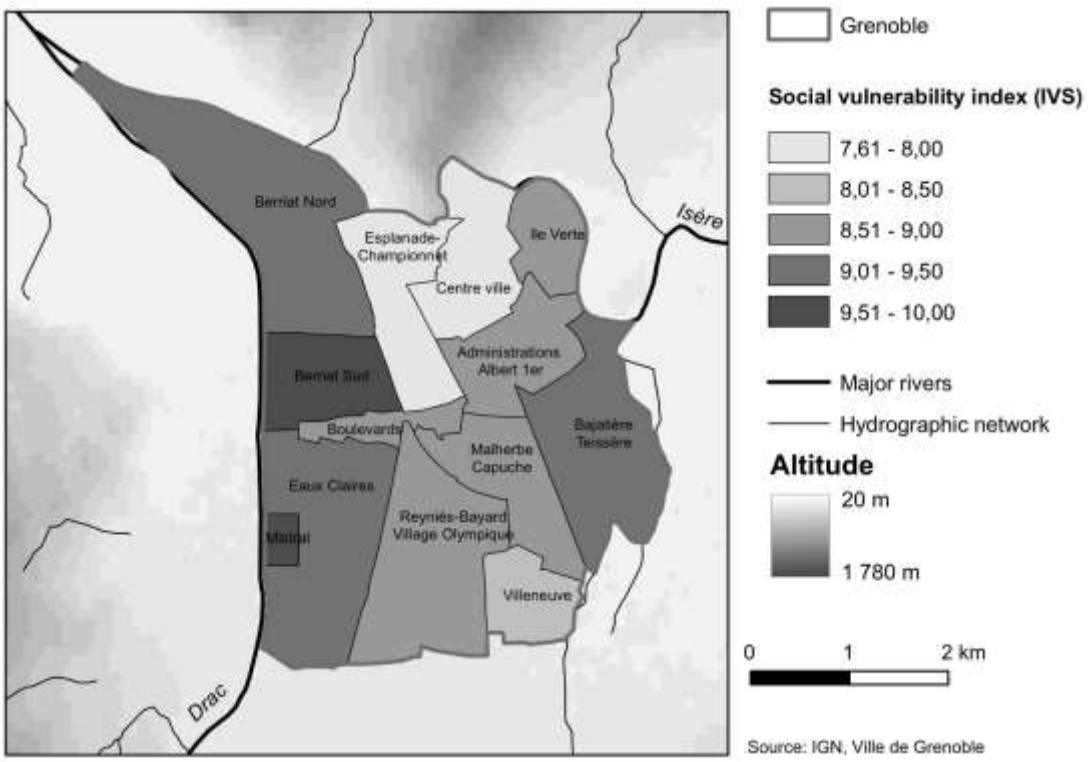



Figure 15. Index of social vulnerability to earthquakes (mean per district).

Finally, considering the whole sample, the difference between the residents and the users is not significant (8.9 for the residents against 8.7 for the users) which goes against our initial assumption.

**Conclusion**

The first statistical processing highlighted the influence of several determinants on vulnerability: age, activity. A multivariate analysis could however confirm these results or even refine them. On the contrary, the status (resident vs user) does not seem to have any influence on the vulnerability at the scale of the sample, though differentiations may be observed for a very district (this is related to the distribution between the residents and the users which is different from one district to the other). The temporal dimension intervened in the gathering of survey data and was used to establish the sample with the aim of surveying a population closer to the daily reality

of the functioning of the city (consideration of the different proportions of users and residents during the day and the evening). This dimension thus allowed making the surveyed populations vary, to obtain a greater diversity of the social demographic profiles. The survey showed that vulnerability could fluctuate according to some social demographic characteristics like the age or the educational qualification for example.

These results offer several perspectives: more uni- or bivariate statistical processing could be envisaged; multivariate analysis: this step is a short term perspective, for it is necessary to fully understand the statistical results already obtained and to better comprehend the determinants of social vulnerability to earthquakes. Yet if cross tabulations are already a first explanation of the results they do not allow to have a synthetic view of the factors influencing vulnerability. The multivariate analysis could also allow to better understand the intrication of the social determinants of vulnerability and to interpret the spatial differentiations of vulnerability.

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