Georeferentiation and Social Sciences: An Interdisciplinary Way To Detect Vulnerability

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Abstract: This paper is concerned with using georeferenced information in Social Sciences as a concrete case of interdisciplinary research and building of knowledge related to vulnerability. Geospatial framework is a central factor in analyzing data from sociology, psychology, anthropology and economics. That notwithstanding, its potential contribution has been substantially ignored. In the last years, the reconciliation between GIS techniques and Social Sciences is occurring, mainly because of improvements in software to manage complex data.

The paper arises from CLARA project, an Italian national project on risk assessment and management in the field of natural disasters. The article discusses the theoretical and technical steps aimed at georeferencing specific data on a geographical map. This process entails two main pros: information on a map are more quickly readable and relations among them stand out more easily. Furthermore, georeferenced data bring back complexity to the object studied, because they allow a multidimensional, contextual and integrated reading of it. The multidimensionality highlights the importance of interdisciplinarity as an opportunity for encounter of scholars and technicians and for acquisition of diversified, deeper and richer perspective, which allows better outcomes. Finally, the paper discusses several advantages for interventions and policies.

Keywords: Vulnerable people, Georeferenced data, Risk, Risk exposure

Introduction

Why interdisciplinarity

Despite the ideal of *unity-of-knowledge* and the hope of a the convergence of the Natural and Social Sciences, the awareness in academia that unlikely will reappear a Renaissance Scholar *a la* Leonardo da Vinci is widespread. On the other side, "disciplines are convenient but artificial constructs, and while academia may be divided into them, the world is not" [1:3]. Many researchers agree upon that the complex nature of current challenges that our societies have been facing – poverty, pollution, energy, (fair) economic growth…- more and more let the limitations of (important but) one-sided studies emerge [2][3][4]. As Brewer [5] states "world has problems but universities have departments" (328), but could you entrust fight to poverty to smart people who knows everything about minimum wage legislation and nothing about empowering individuals? The complexity of these issues demands flexibility, adaptability, and innovation but also pulling together insights and methodologies from a variety of disciplines, thus acknowledging great premises to interdisciplinarity for solving contemporary problems [6].

According to Rosenfield [7], "interdisciplinarity consists of researchers work[ing] jointly but still from disciplinary-specific basis to address a common problem" (p.1351). Then again, [8] wonders if interdisciplinarity is still interdisciplinary, or has acquired by now the substance of a *standalone* discipline, whereas Roland Barthes even recognizes to interdisciplinarity the potential to create new objects:

> *Interdisciplinary work, so much discussed these days, is not about confronting already constituted disciplines (none of which, in fact, is willing to let itself go). To do something interdisciplinary it is not enough to choose a "subject" (a theme) and gather around it two or three sciences. Interdisciplinarity consists in creating a new object that belongs to no one.* [9:72].

Undoubtedly, interdisciplinarity wards off the risk of compartmentalization [10], one of the main negative sides of specialization, and that researchers isolate themselves in their own tiny province [1], but above all opens up new prospects for research. Indeed, the world around us gives us plenty of examples of advantages related to adopting an *outsider's perspective* [3]: Herodotus was an immigrant; the French political thinker, Alexis De Tocqueville, wrote one of the most relevant essays on American society; the father of 'Joule's first law', James Joule, was a brewer; Paul Gauguin, at the beginning, a stockbroker whose main hobby was painting. As emerges

from a study carried out by one of the most important Italian university, students who graduate with best grades at scientific majors (Mathematics, Engineering) come from higher school focusing on humanities, ancient Greek and Latin (*Liceo Classico*)[11]. The reason of this phenomenon is quite clear: people coming from other fields of knowledge bring fresh insights and outlooks to the *natives*, triggering creative breakthroughs [3] and fostering the possibility of producing innovative chances [12][13]: "Intellectual cross-pressures generated by an interdisciplinary outlook liberate a person's thinking from the limiting assumptions of his own professional group, and stimulate fresh vision" [14:103].

Besides undeniable pros, interdisciplinary work entails possible risks and difficulties: in addition to superficiality, that may lend the air of *naive generalism* if work is not well anchored to disciplinary training [15], main issue is related to building a common ground of encounter of experts. Just to make few synthetic examples, languages must be reciprocally understandable; is necessary to make sure that various methods in fact address the "same" phenomenon [15]; tools must be built and applied preserving a strong connection to views and theories from different fields of knowledge [5], but operating the effort needed so that the combination of them become consistent and effective for the study. Paying attention to these aspects is necessary because legitimately people may own different representation of the same phenomenon.

The study presented in these pages describes a course of action-research realized in the context of Italian national research project CLARA (CLoud plAtform and smart underground imaging for natural Risk Assessment), funded by Italian Ministry of Research. This project aims at enhancing mitigation of seismic and hydraulic risk by building models social and cognitive process and developing innovative systems for non-invasive diagnostics of subsoil in the territory of the city of Ferrara.

The action-research described in this article has aimed at using Georeferentiation in order to combine data regarding vulnerability and coming from Social Sciences and geologic data, related to seismic danger of the territory. The preliminary outcome of this work is a georeferenced map that allows viewing, at a glance, which is the level of seismic danger of areas in which more vulnerable groups of people are located. This path required integration of knowledge (approaches, procedures, tools and data) from different scientific fields, that is Social, Statistical and Earth Sciences.

In the next paragraphs, a brief description of what Georeferentiation is and which could be the main advantages of using it in the Social Sciences will be provided. Then the empirical path of building the map will be described, highlighting the specific steps needed. In the final paragraph will be explained why this map can be considered both an *arrival point* and a *starting point*.

What is Georeferentiation?

The term "Georeferentiation" refers to the process by which certain objects, such as individuals and their characteristics, are placed on a geographical map, and are aligned to a set of known coordinates, so that they can be identified and analyzed, together with the geographic characteristics of the space in question[1].

It is a mediated process, because it requires an intermediate step of matching between the object that you want to contextualize and the geographical coordinates, and may be direct or, more frequently, indirect. The direct georeferencing refers specifically to the use of a geographic coordinate system, for example a GPS (Global Positioning System), which locate on the map an object. In this case, the coordinates are obtained from field measuring (e.g. direct acquisition of the position by a GPS), remote sensing, or the digitization of documentary sources (maps). In most cases, the information relating to the location are not acquired directly. Indirect Georeferentiation, more used especially in the Social Sciences, does not refer to explicit coordinates but intermediate geographical indicators, such as an address, a ZIP code, an area / district or administrative area.

Three types of geographical information are most commonly used in Georeferentiation. The first type refers to *common geographical addresses*, that is individual addresses which include residential or business addresses of respondents, addresses of other organizations and addresses of places where events take place - for example, shops or facilities in which services are delivered. Second type of geographical information is *areas*, which may be used for statistical electoral or administrative purposes, such as "Comune di Roma". Sometimes reference is made to the areas where it is not possible to specify a more precise point, but more often because the individual-level data were aggregated to ensure privacy of respondents. An important aspect to be considered, especially in urban sociology, is that sometimes the official names of the areas do not coincide with those used in common way of speaking: e.g., the large area of Rome, located between the neighbourhoods *Castro Pretorio* and *Esquilino* is currently designated as *Termini* because of the presence of the train station. Finally, *linear features* consists of linear elements that connect two or more points: roads, hiking trails, home-office or migration routes,

[1] Source: http://support.esri.com/en/knowledgebase/GISdictionary/popup/georeferencing

but also the transport of goods or communications (eg, telephone calls). Generally, a start and an end, for example a pair of addresses (home and work), indicate this type of references.

Georeferentiation and Social Sciences

The role of context has been being fundamental for the theoretical and empirical works in sociology, economics and anthropology [17]. Social Sciences focuses on individuals, families, networks, organizations, environments, but also events or processes, as *subjects of research*. Of course, you can consider these subjects apart from the space in which they exist, act or occur: for example, you can study the relationship of an individual with his co-workers without taking into account information concerning the context in which these relations take place. However, it is important to recognize that each of these *subjects* is geographically located, or has a spatial position that can be relevant for the purposes of the study. Georeferentiation is fundamental for the growing community of interdisciplinary scientists, which focus their studies on the interaction between man and environment – e.g. sustainable development, pollution prevention - and need to compare the social and environmental data on the same spatial/temporal scale (*ivi*). Furthermore, examining the relation between individuals and the space they move into - and it brings us to the focus of this study - is definitely valuable to observe *at a glance* how (people owning) specific characteristics spread out in a given area. This information may allow understanding, for example, the way in which the concentration of vulnerable people (elderly, children or people suffering from concurrent sources of vulnerability) varies in the different districts of a city. Starting from this data, the decision-maker can define interventions more effectively, for example by displacing social services addressed to specific categories of users in a more efficient way. The use of georeferentiation in the Social Sciences may also make visible more immediately relations between indicators of different types (belonging to different scientific branches. *Ivi*), providing a valuable comparison of information (*data integration*, [18]). The image shown in Figure 1 [19] comes from a study that, starting from georeferenced maps, identified a relationship between environmental quality (depending on model *V-I-S, Vegetation, Impervious surface, bare Soil*. [20]) and the quality of the dwellings that are placed in it.

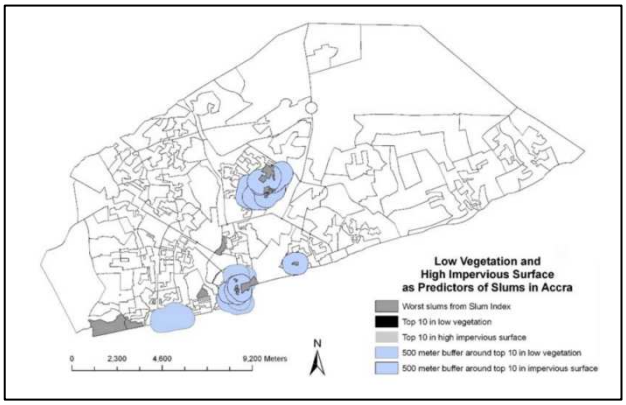

Figure 1: Weeks, 2007

This brief overview allows us stating that the possibility of locating the data coming from the Social Sciences, that is *georeferentiation*, can open ways for research and for *action* (policies) that would be otherwise precluded to them.

In view of a number of advantages, the use of georeferentiation in the Social Sciences also raises critical issues, mainly related to the protection of privacy [21]. Vicente [22] identifies three specific threats to privacy: *location privacy*, which is revealing that a person is in a certain place at a certain time. Symmetrically, the *absence privacy* refers to the information that a person *is not* in a certain place, whereas the ability to deduct from the positions of a group of people that a specific individual is with them is considered an invasion of *co-location privacy*.

The main strategy adopted to protect the privacy was the *aggregation*, which, however, may reduce the spatial resolution of the analysis that can be taken and thus reduces the overall effectiveness of the research [23][24]. In this regard, some authors propose techniques to "modulate" the balance between aggregation and details, as the *geographical masks*, that is areas of aggregation that add *noise* to the geo-referenced data, thus protecting the confidentiality [25]. Apart from the available techniques, we need to define each time a satisfactory balance between bettering "resolution" of data and protecting privacy, starting from the purposes of our study.

Georeferentiation in CLARA project

According to the *Action-research* model [26], building a georeferenced map combines purposes of improvement of intervention and theoretical enhancement. In terms of *intervention*, georeferentiation helps improving strategies of support because it allows the identification of areas where the population has specific characteristics. For example, a communication campaign will definitely benefit in terms of efficacy if it will consider the nationality of the recipients, by adjusting the terms used. Furthermore, identifying areas where the population is predominantly elderly will help to define appropriate strategies of aid, in the event of a disaster, which will take into account the vulnerability of this specific group of citizens.

Nevertheless, the most interesting premises triggered by using Georeferentiation in Social Sciences are consequences of involvement of scholars and technicians with diverse cultural/disciplinary identities and regard the theoretical enhancement: first, this interdisciplinary path of research has allowed facing *on the field* with

advantages, difficulties and risk of such an approach, as emerged from literature (see the Introduction paragraph). Second, and more specifically, building the map has opened the way to two interesting outlooks: several relevant indicators of vulnerability can be depicted on the map, also contemporarily (possibly, integrated in an index). Furthermore, usefulness (necessity!) of thinking/building multidimensional and integrated indexes, in order to make this research tool legible and then adequately usable, has emerged. Both these topics will be developed in the Conclusion paragraph.

The empirical process of construction of georeferenced map "Age / areas with different seismicity"

Considering what mentioned above, aim of the present study is to make a georeferenced pilot map that represents, along with aspects of seismic hazard, the *age*, a characteristic of the population that can be deemed a relevant source of vulnerability in relation with potential natural disasters. A so built map will show, both *at a glance* and more precise, the distribution of population of different groups of age on areas with different seismic hazards. The age is something that has a strong influence on the way people deal with a natural disaster (potential or occurred), especially for issues related to dependence on others [27][28][29]. Several studies indeed show that the elderly are more vulnerable to seismic risk [30]: problems in mobility, a strong dependence on social services and a lack of support from informal networks (family, neighbours, friends) can affect both their coping skills and the recovery in the post-disaster [31][28]. Also children may be vulnerable, especially if they lack an adequate family support [32].

The first step in defining such a map is to identify vulnerability characteristics of the population, mainly through the psycho-social literature, which are relevant in the risk-assessment and/or management of natural disasters.

Once *age* is chosen as the vulnerability characteristic, a synthetic indicator of the people's age – the mean - is defined, assuming that the distribution is normal and trying to find the best compromise between the smallest loss of information and the need of the most readable depiction of data on the map. The age of citizens has been extracted from databases provided by the Statistical Office of Ferrara.

The next step consists of condensing in a *value*, which later will become a *dot* and placed on the map, the mean age of the citizens with their home addresses. The colour of dots gradually tends to darken as the value of the mean age grows (see the legend).

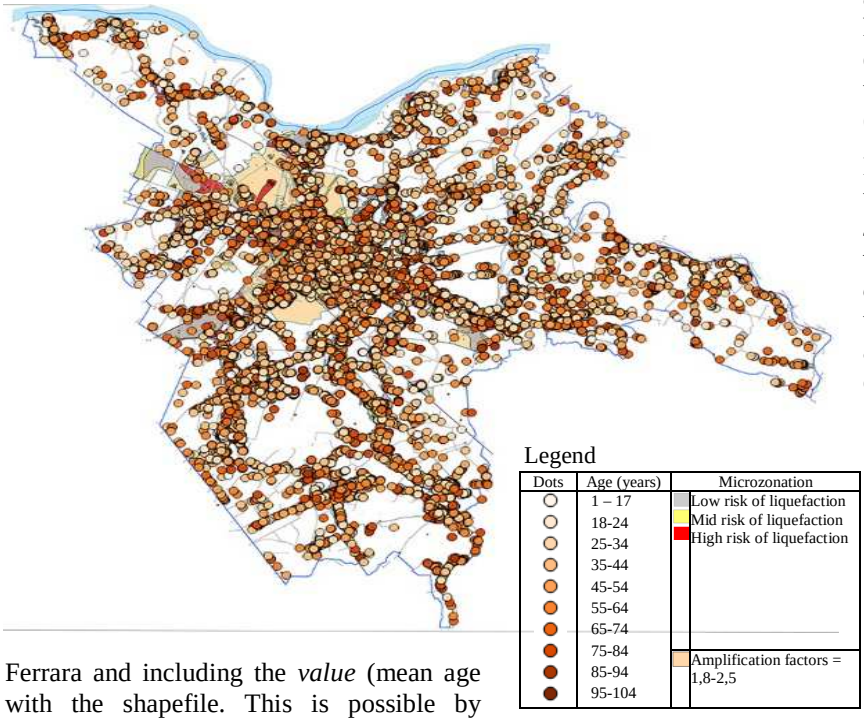

Figure 2: Georeferenced map "People's mean age * seismic microzonation"

Later is obtained what, in technical jargon, is called *shapefile*, that is a database of vector data (in the format *value*, *direction* and *sense*) to record the position, the shape and attributes of geographical objects. The shapefile (in spite of the name might suggest otherwise) consists of several files and can be combined with a database, in order to place data on the map ("geo-referencing").

Then, the database provided by the Statistical Office of Ferrara and including the *value* (mean age & home address), is joined with the shapefile. This is possible by matching the "hooks" present both on the database and on the shapefile.

Eventually, the georeferenced map (mean age & addresses) is superimposed to the level 3 microzonation map (the most accurate level, following the Italian code of seismic microzonation). On this map different levels of soil liquefaction[2] and amplification[3] are depicted.

[2] The soil liquefaction happens when a sediment under pressure and vibration temporarily but suddenly loses strength and behaves like a thick liquid.

The map resulting (Fig.2) puts in relation (georeferenced) citizens' mean age to the areas characterized by a homogenous seismic response.

Conclusions

This map can be definitely considered as a *starting point*: Social sciences literature identifies several variables which may contribute to produce *vulnerability* in the relation between man and natural disaster. Considering sex, in fact, literature show that women are potentially more at risk in the event of disasters. This difference occurs in a more pronounced way in the case of contexts where the sex gap is greater: when women encounter more difficulties to integrate into their community or into the labour market, this often leads to greater difficulty in coping with (or to recover from) an exceptional natural event [27][33].

Also family structure, according to literature, has a significant impact on the way people are able to deal with a natural disaster, after it has occurred. People who live alone or, on the contrary, that belong to large families encounter greater difficulties in giving /receiving support, especially in the presence of socio-economic vulnerabilities [32][28]. Lastly, another dimension that can be considered is nationality: difficulties associated with a weak/less-supportive social network or with language may affect the relationship between the person and the risk of environmental disaster, for example in post-disaster phase.

These variables may act both singularly and synergically, multiplying exponentially, in the last case, their effect. Considering more variables together, as well as producing a synergic effect, appears to be the most effective (*the only?*) approach for studying multidimensional topics, such as the relation between people and their environment. If picking different variables from the same *basket* – the Social Sciences – forces to face with complex interactions, analysing variables coming from different *Sciences* will considerably increase this complexity. But, at the same time, it triggers relevant reflections on encounter of different disciplines. The georeferenced map presented in this paper, is definitely something that brings back multidimensionality to vulnerability, by *bravely* complementing different scientific knowledges (approaches, cultures, tools and data) coming from Social Sciences and Natural Sciences.

"Encounter", "common ground" and other powerful but theoretical concepts brought out, in this interdisciplinary study, several basic and practical issues related for instance to the need of looking for common languages or defining combined indexes. Picture above (see Fig.2) is hardly readable, it is glaring[4]. The map comes as an experimental integration of information coming from different disciplinary fields (psycho-social indicators, statistical analyses and seismic risk maps) which are supposed to be used separately. This highlights the difficulty in interpreting a map built, at least partly, as an assembly of contents of a different nature.

The main challenges faced over the course of this *interdisciplinary* study, however, are related to the encounter between perspectives, languages and techniques coming from very different research fields - you only need to think of the conceptual distance between Social Psychology and Geology – and they provides much food for thought for people working in these disciplines. Mainly these challenges relate to sharing of meanings and priorities and combining indicators of a different nature. Establishing mutual understanding among team members who have to agree definitions, terms and symbols, is important both for sensemaking and consensus formation. First, sensemaking increases the likelihood that communication will be successful, since it helps to make clear issues at a macro level – i.e. which part of a message is the most important – and at a micro level the meaning of the terms: just imagine the bewilderment when a geologist introduced to the social psychologist (me!) a *threatening* shapefile! Then, mutual understanding is important to create consensus, that is necessary to detect the most adequate steps to be taken. But, earlier, the terms of the issue must be shared, and their meanings must be *mutually understood*.

The second challenge emerged in this interdisciplinary work regards potential new ways of handling data in order to achieve a combined representation of information, that is a sole index condensing information coming from different disciplines. In this study the attempt was made to find the best compromise solution between the loss of information due to data aggregation and readability of geo-referenced information. However, mean age of citizens living at a certain address flatten (too?) much the variance of the information. 100 individuals live in a building, 20% are 90 years old, whereas 80% are 25, then mean age is 38: can we calmly decide that vulnerability is not present in that situation? This is an example of risks entailed in use of central tendency indicators like mean.

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[3] How characteristics of the soil in the top layer modulate the shaking originated from the earthquake.

[4] Inserting the picture in this paper required a considerable reduction of its size and this has provoked an overlap among dots. Consulting the map – and properly zooming in - by using the software QGis 2.10.1-Pisa® [Open Source Geospatial Foundation (OSGeo)] remarkably enhances its readability.

Nevertheless, more work is needed to achieve even a greater synthesis. To make a practical example related to the map described in this paper, the reflection could be addressed to an additional engagement of the various scholars (each owning his specific knowledge) who contributed to the building of the map, aimed at creating a synthetic index (typological or additive) i.e. “age*seismic-risk of the ground” which would allow an easier readability.

If the main dangers of using the *mean* as a synthetic indicator are those explained above, which could be the risks of creating a new, deeper, synthesis? Combining not just sociodemographic characteristics (age & address) but sociodemographic and geologic dimensions (age & level of seismic danger of the area) will imply just a *quantitative* (more indicator to be combined = more risks) or *qualitative* differences (different risks)?

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