International Journal of Disaster Risk Reduction 31 (2018) 203–211

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr

Societal resilience indicator assessment using demographic and infrastructure data at the case of Germany in context to multiple disaster risks

Alexander Fekete

TH Köln - Technology Arts Sciences (University of Applied Sciences), Institute of Rescue Engineering and Civil Protection, Risk and Crisis Management, Betzdorferstr. 2, 50679 Köln, Germany

ARTICLE INFO

Keywords:
Resilience index
Social vulnerability index
Social resilience
Disaster risk reduction

ABSTRACT

Disaster resilience assessments are in high demand and intertwined with vulnerability components, yet the specific qualities and differences are hardly addressed by spatial indicator assessments. Selected resilience indicators are tested at the area of Germany at county-and city-level units using demographic, socio-economic and infrastructure data. Findings are divergent usages and interpretation possibilities depending on resilience conceptualisation; either related to a 'bounce back' a flip-side of vulnerability, or a transformation understanding. National area assessments and especially change maps over periods of 5 or 10 years allow for tracing resilience aspects, yet in a limited way. With resilience conceptualisations still differing strongly, basic research is still needed to outline what can be interpreted from such indicators and maps.

1. Introduction

Resilience and vulnerability are tightly intertwined. Some studies have revealed interchanging usages of resilience and vulnerability being counterparts or components of each other [1]. However, there is a need to differentiate them when it comes to applied research such as semi-quantitative measurements using indicator approaches. Since both resilience and vulnerability are in usage in similar areas of risk assessments, especially indicator assessment using Geographic Information Systems (GIS), this paper will analyse if there is a significant difference between vulnerability and resilience indicators. A few resilience assessments for Germany using indicator maps have been conducted already in recent years [2–4]. However, usages of 'resilience' are conceptually still patchy; many use resilience as an alternative umbrella term for what was termed vulnerability before [1,5]. Therefore, this paper aims to investigate aspects underlying vulnerability assessments that are specific (if not unique) for resilience investigations.

Resilience is not simply the opposite of vulnerability or, another term for capacities or capabilities. Resilience is separated into a generic resilience ability existing through all phases before, during and after a crisis, disaster [6,7]. Within this understanding, resilience captures only a certain range of all possible capabilities compensating vulnerabilities. Resilience furthermore incorporates aspects not limited to reacting to vulnerability only, such as transformation etc. Resilience, however, is a process to be experienced mainly when a crisis or disaster strikes and describes recovery and transformation into a new state of stability [8,9]. Vulnerability is broader; a person might be vulnerable to a number of hazard impacts, or susceptible to a great range of impacts by a single hazard. But that person might not possess or need to possess all types of resiliencies to counter all those vulnerabilities; only a selected set that allows for recovery or transformation. Social vulnerability captures a certain range of vulnerability aspects focusing on societal aspects of disaster and is an established terminology and approach [10]. Social in this regard relates to demographic but also individual and community aspects of the human or societal side of disaster risk as in addition to hazard probabilities and magnitudes. In the area of resilience assessments, the term social resilience [11] is used lesser than community resilience [12], or societal resilience [13,14]. Regarding the national focus in this paper with an emphasis on demographic variables and not including social network information from communities, the term societal resilience seems appropriate.

Some studies have identified communalities within resilience conceptualisations [8,15,16], and this paper will select the most prominent usages of resilience for the indicator assessment. Studies have identified resilience approaches to cover 'bounce back' or 'bounce forward' aspects [9], robustness/buffering/cushioning aspects [17], which is also found in conceptual papers summarising resilience into four key components; robustness, redundancies, rapidity and resourcefulness [18]. Despite the literal translation of resilience meaning 'jump back', there is substantial critique on returning to normal conceptions [19]. But

E-mail address: alexander.fekete@th-koeln.de.

https://doi.org/10.1016/j.ijdrr.2018.05.004
Received 12 March 2018; Received in revised form 4 May 2018; Accepted 4 May 2018

already early studies on socio-ecological systems, closely following system theory and complex adaptive systems research have identified several stability states, not just bounce back [20,21] and social science approaches currently endorse mainly transformation aspects connected with the dynamic development aspect of resilience [22] if not embracing resilience as an overall catch-term for any aspect improving development and well-being of a human individual, group, city or other boundary object [23]. From this quite varying range of interpretations of resilience we have selected the following to analyse the indicator maps; 'bounce back', robustness/buffering/cushioning aspects (also as direct 'compensation' of susceptibilities, i.e. the flip-side of vulnerability) and transformation.

2. Concept and methodology

The paper concept is to reflect on application and further advancement of demographic and infrastructure spatial indicators used for indicating resilience aspects in context to natural and man-made hazards and disaster risks. This reflection is conducted not just as a literature review or analysis, the paper instead showcases examples of such indicators and how they could be used or interpreted in context to resilience. Resilience assessments, just as risk and vulnerability assessments as well, often have to capture the hazard context, as it is proverbially put in 'resilience to what?' Therefore, this paper first discusses indicators without hazard context in chapter 3, however, with spatially explicit visualisation, as maps. In chapter 4, hazard context is reflected upon based on occurrences in the past years in the research area of Germany, in order to identify which hazard context is most prevalent. Both chapter 3 and 4 thereby deliver discussion of two main components necessary to conduct a spatially explicit, or, 'place-based' [10], risk assessment.

As an analytic concept, the currently much discussed resilience concept [5] is selected. In order to capture a wide range of possible (academic) users of spatial risk assessments, several key conceptualisations of resilience are selected. While introducing our understanding of moderation between the diverging perspectives on definitions and conceptualisations in the introduction of this paper in order to state our conception, we do not wish to impose our vision on the examples and discussion. The intention of this paper is rather to demonstrate the diverging interpretations of indicator maps resulting from different definitions of resilience.

The methodology for composition of the spatial indicators follows an established method of place-based vulnerability [10] or, community resilience assessments [1], developed in the USA. In our previous work, we have adopted this approach and applied it for social vulnerability and infrastructure to Germany at county-level [24], adding also studies on scale-effects [25], validation methodology [26] and reflection on shortcomings [27]. However, we have not applied it yet on resilience indicators, which will be the focus of this paper. Conceptual and theoretical understandings of resilience as well as benefits and challenges had been addressed already [5], but spatial applications have only been shown for critical infrastructure in our previous work [28]. The set-up of the indicators including variable and data selection, aggregation and visualisation follows closely the social vulnerability indicators assessments we have conducted and is in line with data and variable selection justification and common usage in literature [1,10,29–33] as well as computation and aggregation, including normalisation [33,34]. For consistency and comparability with previous vulnerability indicators, we have selected the same data sources for demographic data and for the administrative units, both Federal State Offices of statistics and cartography in Germany, which have a good reputation for data quality criteria such as completeness, accessibility, updating, and long-time monitoring. The data has been screened for data gaps and county values with missing values are not interpolated, but marked with yellow as data gaps. Normalisation of data to z-scores is conducted. Individual justification of usage of, for example, birth rates, are described in the chapter below, citing literature. However, usage of such demographic indicators is state of the art in context to vulnerability and also, increasingly, (spatial) resilience assessments as noted in review papers [30,35,36] or case study research papers [12,37–39]. However, constraints and caveats must be mentioned as well of such spatial indicator approaches, such as aggregation or scale-effects [40], lack of match with local needs and contexts [41], misfits to envisioned users and limitations of 'measurability' [27,42]. Therefore, we have decided not to aggregate the indicators to an index, so as to avoid 'blurring' of underlying conditions by aggregation. Scale limitations such as county scale being too general for allowing household level interpretations of 'real' existing resilience are obvious to mapping experts, but probably less to other experts and must therefore be stressed here. Caveats in measurability are addressed in the following chapter directly, by the discussion provided. Audience for this paper is academic or scientific and it is not presumed that such maps could be directly helpful to decision-makers without further explanation.

As for chapter 4, the EM-DAT database is selected since it is in usage for several years already, has a reliable academic institution hosting it and is recognised much in the field of disaster risk. Caveats are limitations in the range of years, hazard and damage categories and scale; for example, county-level resolution is not included, and damage categories do not cover any breadth of variables or aspects targeted by resilience or vulnerability assessments. Still however, for enabling later comparisons of relevance of hazard contexts between Germany and other countries, this database seems the best in coverage, independency and future availability.

3. Societal resilience assessment using indicators and change assessment from 2005 to 2015

The following section discusses information typically available from indicator based social vulnerability assessments according to aspects that could also be used to assess resilience aspects. This brief discussion cannot replace a substantial analysis and it will therefore focus only on social vulnerability indicators discussed already in the sections above [26]. These indicators from the original approach in 2009 have been redeveloped for the years 2005, 2010 and 2015 to allow for dynamic comparison of changes at a regular common 5 years interval instead of using 2007, 2012 and 2017. Since 2009 a plethora of resilience publications have emerged, somehow overtaking vulnerability in popularity [5]. Conceptual debates persist on the range of attributes of resilience and for the purpose of this section in brief, we will limit the resilience understanding to aspects of the indicators relating to explain 'bounce back', robustness/buffering/cushioning aspects (also as direct 'compensation' of susceptibilities, i.e. the flip-side of vulnerability) and transformation. From a range of possible indicators, a sample has been selected that is helpful to explain different facets of usability of such indicators for resilience. The purpose here is for an academic audience for advancement of methodological understanding and not intended to cover German resilience aspects as such.

The number of births (Fig. 1) in a given year (here 2015) can serve as an indication for a multitude of general demographic aspects. In context to resilience to natural or technological/ man-made hazards, birth rates can be understood as an indication of a recovery capability, enabling a bounce back from population losses, for instance, after heat waves, epidemics or war. However, direct correlation may be weak, which will be similar for the following indicators. Birth rates can hardly help to explain buffering aspects except for compensating high death rates. Birth rates can indicate transformation of society when, for instance, regions with better socio-economic, political, institutional, or health conditions are allowing for or, in the case of Germany, encouraging, more births. Declining fertility in Germany is a longitudinal problem, related to job conditions for women, child-care and other socio-economic and political backgrounds [45]. Transformations of birth rates following singular hazard events is not been researched