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Editorial Open Access

Selection of Scale in Vulnerability and Resilience Assessments

Tim G. Frazier*

Department of Geography, University of Idaho, Idaho 83844-3021, USA

Editorial

Society is vulnerable to natural disasters and impacts from climate change. Vulnerability, as discussed here, is defined as the potential for loss [1-3], and is expressed as a function of exposure, sensitivity, and adaptive capacity [2-8]. Exposure is a function of an object's proximity to a hazard, sensitivity as differential degrees of potential loss of exposed objects, and adaptive capacity as the ability of an object or system to adjust to hazards and impacts [9]. For decades hazards researchers have conducted vulnerability assessments in efforts to identify community vulnerability so that societal losses from natural hazards may be reduced. These traditional vulnerability assessments however, have paid less attention to the importance of multi-scalar spatial components when calculating a region or community's vulnerability. The literature concerning vulnerability assessments often describes the scale at which the vulnerability assessment occurs without much explanation as to how the scale of the assessment is determined [2,10-22]. One exception is the work of Luers et al. [23] and Luers [3], which uses a smaller geographic unit (the farm) to represent the overall vulnerability of the Yaqui Valley (an agricultural valley in Mexico). Luers et al. [23] however, only attempt to modify the scale of vulnerability assessments to quantify their study area, with their research not meant as a new method to alter the construction and implementation of vulnerability frameworks. Most natural hazards research to date as supported by the literature contains very little that speaks to the methods or rationale for selecting an appropriate scale for vulnerability and resilience assessments.

Many of the vulnerability assessments cited above only hint that scale selection is dependent on the spatial extent of the hazard being studied or on the most appropriate geographical unit for which data can be obtained. Schröter et al. [24] agree with Cutter et al. [15] that vulnerability assessments must be "place based," but indicate the scale of the assessment "needs to match the scale of decision-making of the collaborating stakeholder." However, the Schröter et al. [24] and Cutter et al. [15] examples of place-based vulnerability assessments did not have as a focus the consideration that place vulnerability is highly dependent on exposure from external biophysical and socioeconomic stressors, as well as from internal characteristics of a system [25,26]. Following from this logic, it is then critical to determine the appropriate scale for a vulnerability assessment in order to measure vulnerability accurately, not just measure vulnerability conveniently.

In the context of global climate change and its transformative effect on natural disaster regimes [27], it is becoming more important for communities to recognize existing vulnerability and understand what actions can be undertaken to increase resilience. Resilience is a function of a society's ability to react effectively to a crisis with minimal reliance on outside aid [2,28-30], and can occur across a variety of spatial scales. Understanding a community's resilience level can be crucial for pre- disaster preparation, post- disaster recovery and estimation of potential losses. In order to measure progress in community resilience enhancement efforts, a clear baseline condition from which to measure progress is needed. Studies have sought to identify and characterize clear baseline conditions for community vulnerability and resilience to natural disasters [31-33], but these studies are often predominately qualitative in nature and are often conducted at limited spatial and temporal scales.

Efforts have been made to quantify resilience through resilience index creation and resilience quantification models most notably of Cutter et al. [33]. Contemporary research has begun to focus more on quantification of vulnerability and resilience as a way to evaluate baseline conditions at various levels of jurisdictional and socio-political areas [2,30,34,35]. Previous resilience models, such as the Disaster Resilience of Place (DROP) and the Baseline Resilience Indicators for Communities (BRIC) models, utilize a system of indicators that can be quantified to estimate disaster resilience of a location [30,33,35]. These factors consider unique characteristics of the place and other social and biophysical factors, as well as spatial dependencies based on relationships or linkages with other places [26,35,36]. Existing research, in part for reasons of simplicity and data availability, has focused on broadly comparative resilience at specific geographic scales, most notably at the county scale. Census data is aggregated at the county level, making data acquisition simpler for studies at this scale. A widely recognized issue in geographical research is the modifiable areal unit problem (MAUP), which states that the results of a geographic study may vary depending on the scale at which the data is aggregated [34,37,38]. It is possible that MAUP exists in studies concerning resilience indicators. For this reason, it is important to look at locally derived factors, rather than relying solely on nationally collected data. The investigation of local-scale factors is an important component for measuring community resilience because resilience will vary across communities within a county [22,38,39]. Broadly comparable indicators (seen in national and regional assessments) are essential for determining disaster resilience, but there are innumerable multi-scalar and place-based factors that must be considered as well [26,35]. These factors include unique characteristics of the place in question such as hazard regimes and other social and biophysical factors, as well as spatial dependencies based on relationships or linkages with other places [26,35,36]. Furthermore, community resilience occurs across scales that are interdependent of the national, state and county scales that are commonly used for resilience analysis [40].

Often, existing research also neglects the spatial and temporal context of resilience indicators and does not consider the importance of differential weighting [33,41] and spatial autocorrelation of these indicators particularly at the community level. Therefore many of the existing studies conducted at national and regional spatial scales may be inappropriate due to their nonspecific attention to local community needs particularly if the goal is local community resilience

***Corresponding author:** Tim G. Frazier, Department of Geography, University of Idaho, Idaho 83844-3021, USA, Tel: 208-885-6238; E-mail: tfrazier@uidaho.edu

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enhancement. This lack of specific attention to local community indicators can hinder the effective allocation of resources and the effectiveness of local level hazard mitigation and adaptation which can radically impact community preparedness [31]. Lack of community preparedness and inefficient or absent mitigation and adaption can also increase the time required for movement through the disaster recovery timeline. An understanding of the differential importance of disaster resilience indicators and their temporal and spatial components can help provide an enhanced estimation of baseline resilience levels that could better assist communities in allocating limited resources more effectively to areas with higher resilience enhancement priority. In order to create a complete holistic community vulnerability and resilience assessment, vulnerability and resilience indicator quantification and analysis should occur at multi scalar, temporal and spatial perspectives [34,42] and ideally should consider differential weighting and spatial autocorrelation of these indicators in these assessments.

In short, conductors of typical vulnerability and resilience assessments first select the geographic scale for their evaluation and then analyze traditional vulnerability indicators to complete their calculations [13,15,19,21,22,25,43-45]. By ignoring critical indicators that may be external to the system, or by temporally and spatially weighting all indicators equally, vulnerability and resilience assessments may be lacking in effectiveness. Thus there is a need for research that examines the impacts of spatial autocorrelation and differential weighting of vulnerability and resilience indicators at the local level. Existing models on baseline vulnerability and resilience estimations fall short in addressing the need for place-specific indicators. Place-specific indicators are more effective for accurate baseline vulnerability and resilience assessment; without knowledge of these important factors, results of these assessments may be less accurate. Existing models can be expanded to incorporate place-specific factors using sources of local knowledge and focus groups for instance as well as more local quantitative data to collect and develop frameworks that identify important factors that contribute to vulnerability and resilience. Existing research also lacks the incorporation of differential weighting and spatial and temporal contexts of disaster vulnerability and resilience indicators. For resilience enhancement, differential weighting is crucial because it permits prioritization of indicators based on relative significance. This allows communities to make prudent and efficient decisions regarding investment in scarce mitigation resources thereby promoting resilience enhancement. Temporal and spatial factors are important for accurate resilience quantification because they can be utilized to locate disaster resilience indicators in the spatial and temporal setting in which they are most significant. A more appropriate method for vulnerability and resilience assessments might be to first select the appropriate vulnerability or resilience indicators for the community or region under consideration and then relying on the indicators to guide the selection of scale.

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