Applied Geography 94 (2018) 262–271

Contents lists available at ScienceDirect

Applied Geography

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

Risk and Resilience Monitor: Development of multiscale and multilevel indicators for disaster risk management for the communes and urban areas of Chile

Daniela P. González[a,*], Mauricio Monsalve[a], Roberto Moris[b,c], Cristóbal Herrera[d]

[a] Research Center for Integrated Disaster Risk Management (CIGIDEN), CONICYT/FONDAP/15110017, Chile
[b] Institute of Urban Studies, Pontifical Catholic University of Chile, Chile
[c] Urban Plans and Projects Program UC, Pontifical Catholic University of Chile, Chile
[d] Observatory of Cities UC (OCUC), Pontifical Catholic University of Chile, Chile

ARTICLE INFO

Keywords:
Multiscale indicators
Multilevel indicators
Disaster risk management
Urban areas
Communes

ABSTRACT

Chile is a country faced with a variety of natural hazards, such as earthquakes, tsunamis, and volcanic eruptions, which often test its coping capacity. Disaster risk management plays a critical role in the protecting the welfare of society as well as in preserving the governability of the country. This work introduces multilevel indicators for measuring dimensions of risk and resilience, to identify and quantify spatial disparities among communes and urban areas in a multiscale perspective. The indicators summarized in the Risk and Resilience Monitor (RRM), are developed using techniques of Principal Component Analysis combined with Varimax Factor Analysis.

The results introduce evidence for the consideration of an adequate scale of risk management. Despite middle-sized communes appearing in first places of RRM, extended urban areas exhibit a greater potential for resilience strategies. Given the methodology used, the structure of the indicators suggests how to adjust risk management for different scales. Furthermore, the indicators allow the identification of areas and dimensions that have been left relatively unprotected and require disaster risk management actions.

1. Introduction

Chile is a country affected by frequent and sometimes extreme natural hazard events, which test the coping capacity of its society. When this capacity is overwhelmed, the events become disasters, that cause widespread harm, as it happened in the 2008 Chaitén volcano eruption (Major & Lara, 2013), 2010 Maule earthquake (De la Llera et al., 2017), and the extreme rains in the cities of the Atacama Desert, the most important in the last 15 years, which caused large floods (CIGIDEN & OCUC, 2016; Wilcox et al., 2015). In such a context, disaster risk management plays a critical role in protecting the welfare of society as well as in preserving the governability of the country. National and local governments along with the public and other organizations must be aligned to make this management successful, which can be assisted through the sharing of common goals and measures (Ahrens & Rudolph, 2006; UNDP, 2015; Waugh, 1994).

Disaster management seeks to mitigate the negative effects of extreme natural hazard events of the by identifying different threats of a given territory, and through actions that cover the areas of prevention, mitigation and preparedness (UNISDR, 2009). The understanding of disaster risk for its management must necessarily include in its diagnosis the levels of vulnerability and exposure of the population and the built environment, where the comprehension and measuring of resilience is one of the greatest challenges faced by risk governance (Cumming et al., 2005; Schipper & Langston, 2015).

Indicators can serve as a complement to other evaluation methods such as loss estimation and expert opinion when it comes to the evaluation of policies and performance of disaster risk management (Hardoy, Pandiella, & Velásquez, 2011), they also help to build confidence, establishing clear definitions on which disaster risk management will be measured (Mitchell, 2003). However, even though recent advances have been made in the assessment of vulnerability, exposure and mitigation, these developments are only concerned with specific areas, dimensions of interest, and territories (Peacock et al., 2008; Scolobig et al., 2014). This is troubling, because low comprehension of disaster risk impedes a multidisciplinary approach (Cardona, 2007). Furthermore, the absence of measurement methods can become a risk itself, affecting and even increasing the exposure and vulnerability of members of the community to disasters (Florin & Xu, 2014).

The objective of this work is to develop multilevel indicators for

* Corresponding author. Vicuña Mackenna Ave. 4860, Hernan Briones building, 3rd floor, Macul, Santiago of Chile, Chile.
E-mail addresses: daniela.gonzalez@cigiden.cl (D.P. González), mauricio.monsalve@cigiden.cl (M. Monsalve), rmoris@uc.cl (R. Moris), caherre9@uc.cl (C. Herrera).

https://doi.org/10.1016/j.apgeog.2018.03.004
Received 8 November 2017; Received in revised form 7 March 2018; Accepted 8 March 2018

evaluating disaster risk management in Chile through the Risk and Resilience Monitor, a goal deemed worthy considering the absence of such measurements in the country, despite the variety, frequency, and intensity of the natural hazards it is exposed to. The indicators introduced in this work also provide a heuristic way to assess the state of disaster risk reduction on specific spatial divisions for two different scales: urban areas and communes. Providing multiscale indicators is key in disaster risk reduction because certain hazards impact beyond administrative boundaries and their effects are usually greater in metropolitan areas (Wilkinson, 2012). However, it should be noted that there is still little research on the issue of the proper choice of scale in disaster research and related decision-making (Adger et al., 2009; Siembieda, 2010). Furthermore, urban or metropolitan areas in Chile are not recognized as formal units that share some kind of administration or governance, but rather correspond to urban sprawl, which increases the problems of coordination between communes (Rodríguez-Acosta & Rosenbaum, 2005). This phenomenon is a major trend in middle-sized cities (Da Gama, 2011).

The indicators introduced in this work are defined as multilevel and multiscale. They are multilevel in the sense that the indicators are organized in a hierarchy (see Fig. 1) where indicators in one level are computed from the aggregation of the indicators in the level below. These relations are inspired by the nested nature of the concepts they measure, as explained in Sections 1.1 and 2.1. Multilevel interactions allow characterizing resilience from cross-scale thinking. This model has demonstrated to be more successful than top-down approaches, on evaluating and finding solutions, adding a political and ecological management (Berkes, 2007; Cash et al., 2006).

The indicators are also multiscale in the sense that they are provided for two distinct spatial representations, communes and urban areas, where communes correspond to smallest administrative division in Chile. Urban areas correspond to the urbanized space delimited by an officially established urban limit (commune). Some urban areas are made up of a set of spaces with an independent urban boundary. These spaces are linked together by frequent public transport systems, constituting a single city, from the operational or functional point of view (Ministry of Housing and Urban Planning, 2007).

Available and consistent information is crucial to establish roles and responsibilities among actors as an accountability exercise which reinforces the importance to count with suitable data to strengthen disaster risk governance (Aysan & Lavell, 2014; Gupta, 2010). This task could be seen as the first step to boost citizen's demands for more quality information and being participant stakeholders of the entire disaster risk reduction cycle. Although policymakers usually do not see indicators as a transparency instrument (Birkmann, 2007), these are a powerful tool to prioritize actions that tend to reduce disaster risk, relying on baseline conditions of variables at different scales in the territory.

1.1. Research preamble

The construction of the list of indicators is based on a bibliographic review of the variables that make up risk and resilience. It is important to be clear that the objective of this work is not to review and critically analyze these concepts, but rather to be able to identify the possible concepts that can be calculated and measured through a variable and its indicator.

Risk, in a disaster context, is defined in Chile as the "possible losses that would result from a disaster in terms of lives, health conditions, livelihoods, goods and services, and which could occur in a particular community or society in a specific period of time in the future" (Ministry of Interior and Public Safety, 2016, p. 51).

Risk can be understood as resulting from the combination of exposure and vulnerability. Exposure refers to "the presence (location) of people, livelihoods, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by physical events and which, thereby, are subject to potential future harm, loss, or damage" (Lavell et al., 2012, p. 32). The inclusion of frequency and intensity of hazard events provides a better spatialization of risk exposure (Tate, Cutter, & Berry, 2010).

The concept of vulnerability is theoretically open to a wide range of dimensions and characteristics (Birkmann, 2007), although, particularly in disaster risk reduction strategies, this concept is still characterized using socio-economic profiles (Birkmann et al., 2015). Consequently, data collection efforts have been constrained by this conceptual narrowness. This, together with the usual difficulty of collecting socio-economic data, has resulted in a less-than-ideal availability of data for characterizing vulnerability. Without access to more complete and richer data, it is possible that many factors that can explain vulnerability, and which might be used to mitigate it, go undetected.

Vulnerability is generally related to the susceptibility resulting from the precariousness of physical and social systems (Adger, 2006; Peacock et al., 2008; Wisner, Blaikie, Cannon, & Davis, 2003). Inside physical systems, rapid population growth in cities can result in an increase on vulnerability (Birkmann, 2007; Holzmann, 2001), due to a greater number of families inhabiting risky areas in informal settlements, deprived from the access to basic services and lifelines (Alesch & Siembieda, 2012; Cutter, Boruff, & Shirley, 2003; Kahn, 2005; Siembieda, 2010; Toya & Skidmore, 2007). Within social systems, income plays a crucial role in terms of victims (Anbarci, Escaleras, & Register, 2005), as informal employment leads to slower recovery (Cutter et al., 2003; Lassa, 2011). Poverty not only refers to the economic definition but also includes the lack of social networks and assets to confront vulnerability (Woolcock & Narayan, 2010). Gender issues arise as critical factors to address when reducing vulnerability (Chakrabarti, 2013).

The key characteristic that entities subjected to risk must have is resilience. In 2016, the Chilean Commission for Resilience to Disasters of Natural Origin defined resilience as "the capacities of a system, person, community or country exposed to a threat of natural origin, to anticipate, resist, absorb, adapt and recover from its effects in a timely and effective manner, to achieve the preservation, restoration and improvement of its structures, basic functions and identity" (National Council for Innovation for Development, 2016, p. 5). This definition can be seen as quite traditional within disaster risk management due to its

Fig. 1. Dimensions and sub dimensions Risk and Resilience Monitor.