BUILDING INDICATORS OF COMMUNITY RESILIENCE TO DISASTERS IN BRAZIL: A PARTICIPATORY APPROACH[1]

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1. Introduction

As from the 1980s, an expressive increase in disaster records is observed, associated to both natural and anthropogenic threats (EM-DAT, 2018). The occurrence of disasters may actually be increasing, or the sub-records may have decreased due to attention currently given to this theme. In Brazil, 10% of circa 40 thousand natural disaster records between 1991 and 2012 are concentrated in 2012 (CEPED UFSC, 2013).

Disasters result in negative social-environmental and economic impacts, constituting an important environmental health issue. To mitigate these impacts, national and local governments seek to build proactive management strategies, focusing on the identification and development of communities' capacity to prevent and cope with hazardous occurrences.

Resilience, incorporated in the international directives for Disaster Risk Reduction (DRR), has been consolidated as an essential element in disaster management. Resilience is defined by the International Strategy for Disaster Risk Reduction (ISDR) as "The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions" (UNISDR, 2017).

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The term resilience, used in the study of disasters since the 1990s, gained relevance as from the II World Conference on Disaster Risk Reduction, in 2005, which resulted in the "Hyogo Framework for Action 2005-2015: Building the resilience of nations and communities to disasters" (UNISDR, 2005).

In 2010, the UNISDR started the global campaign "Building resilient cities" on local governability and urban risk (UNISDR, 2018a). When adhering to this campaign, local public managers commit to implementing ten steps to increase the resilience of their cities: organization and coordination, budget allocation, risk analyses, infrastructure development and improvement, safety of schools and health services, land use and occupation planning, education and training programs, protection of ecosystems and implementation of warning systems. Until February 2018, 3,847 cities had adhered to that campaign, 362 of which in Brazil (UNISDR, 2018b).

A resilient city needs public management to concentrate not only on response to resulting impacts, but also on prevention and reduction of risks. This approach to resilience has as its main pillars: land use planning, improvement and adaptation of urban infrastructure, and behavioral and cultural changes. Promoting the culture of resilience may contribute to disaster prevention and, consequently, to the reduction of human, economic and social-environmental losses (WARNER; ANGEL, 2014).

Evaluating community resilience is fundamental to prepare for and to recover from disasters (FRAZIER et al., 2013), besides providing metrics to set priorities, measuring progress and helping in decision-making (CUTTER, 2010).

The importance of proactive actions to increase the ability of societies to face disasters was stressed in the III World Conference on Disaster Risk Reduction, which culminated in the adoption of the Sendai Framework for Disaster Risk Reduction 2015-2030 by the UN member countries. The Sendai framework establishes targets and global actions for reduction of disaster risk and losses, and highlights the formulation of indicators, constituting a step ahead of the Hyogo framework, in force for the previous 15 years (UNISDR, 2015).

Even though the importance of community resilience to disasters has been recognized, there is still no globally defined methodology for measuring it. However, there is a consensus on the importance of building and defining indicators (ASADZADEH et al., 2017).

In 2015, in the ambit of the Projeto Alerta (Alert Project) CEPED-SP/USP, a study was started to select indicators of community resilience to disasters associated to natural and technological threats for Brazilian municipalities. This article presents a first list of indicators of community resilience designed for Brazilian municipalities and the participatory process developed for this purpose.

2. Studies on resilience indicators

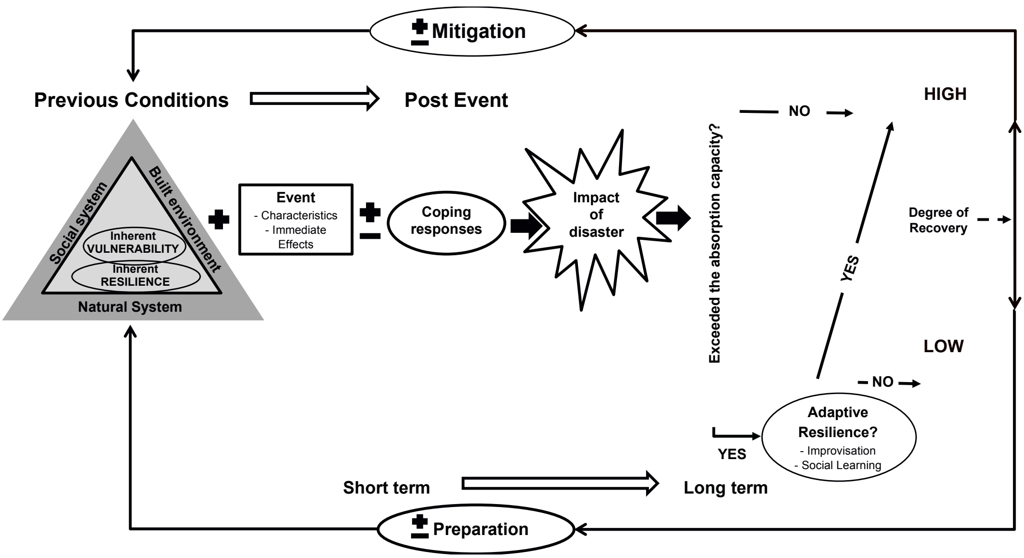
Over the last decade, different studies and initiatives have been developed to propose indicators of community resilience to disasters (ALSHEHRI et al., 2015a,b; COX; HAMLEN, 2015; CUTTER et al., 2008, 2010; EMBRACE, 2018; FRAZIER et al., 2013;

TWIGG, 2009; YOON et al., 2016). Most only consider disasters associated to natural threats, even though many risks of contemporary life are related to human activities, such as migrations that spread epidemics or failures in industrial production, transportation and power generation which result in technological disasters (GÜNTHER et al., 2017; RODRIGUES et al., 2015).

Cutter et al. (2008) conceived the conceptual framework *Disaster Resilience of Place* (DROP), in which community resilience corresponds to a dynamic process dependent on preceding conditions, disaster severity, time in between hazardous occurrences and influence of factors external to the communities. The local preceding conditions, resulting from the interaction among natural system, built environment and social systems, include *vulnerability* and *inherent resilience*.

The DROP *inherent resilience* is determined by six dimensions: environmental, social, economic, infrastructure, institutional and community capital (Figure 1). Increase of resilience is usually attributed to infrastructure improvement, which depends on economic and institutional factors: a better preparation of the physical environment by prevention works, which may involve major financial resources, indeed results in less vulnerable areas. However, impacts from disasters may also be reduced by improving social and organizational factors, e.g. building community capacity.

Figure 1 - DROP Model



Source: Cutter et al., 2008 (adapted).

DROP conceptual framework was used for the development of the BRIC (*Baseline Resilience Indicators for Communities)* index to operationalize inherent resilience. BRIC was the first initiative to build replicable and consistent indicators that measure and follow up community resilience to disasters. Cutter et al. (2010) selected the initial indicators from the literature, followed by statistical analyses, Pearson correlation coefficient[6] and Cronbach's alpha[7]. BRIC was initially applied to 736 counties (county – administrative Division of the USA, which may comprehend more than one municipality) of Southeastern USA, without including the environmental dimension because of data inconsistency for large areas. 50 indicators were selected, and 36 remained after statistical analyses.

A second application, expanded to 3,108 (99%) of the 3,144 US counties, included the six dimensions of resilience (CUTTER et al., 2014). In the first stage, Cutter et al. (2014) selected 61 indicators, reduced to 49 after statistical analyses and theoretical orientation, since some indicators had a high degree of collinearity or were not conceptually congruent with the majority. In the second stage, six sub-indices were constructed, corresponding to the six dimensions. Finally, the index was defined by the sum of the sub-indices. These applications allowed a comparative spatial analysis of the counties for the different dimensions.

Asadzadeh et al. (2017), in a review of index building for community resilience to disasters, verified the prevalence of non-participatory methods. However, some studies, after the initial selection based on the literature, sought complementary participatory methods to define the set of indicators.

Frazier et al. (2013) conducted a study in the Sarasota County, State of Florida (United States of America) to identify and to analyze specific indicators for the region. Preliminarily, resilience factors were identified by literature review and analysis of disaster management plans. Next, focal groups were conducted with county officers to identify and to classify specific indicators for the study area. The focal group technique, widely employed in social studies, allows collecting information and understanding perceptions, beliefs and attitudes of the population under study. Nevertheless, the group may be biased due to the influence of more active participants. Moreover, in studies with wide geographic coverage, e.g. national, the technique may become unfeasible (TRAD, 2009).

In 2009, the Justice Institute of British Columbia (JIBC), Canada, started the Rural Disaster Resilience Project for rural, isolated and coastal communities. This project resulted in the Resilience Rural Index (RRI), developed according to participatory research-action principles. The RRI involved integrating top-down methodology in the first stage and bottom-up in the second stage. In the first stage, indicators based on the literature and on experts' opinions were selected. The second stage involved qualitative research in nine communities in two British Columbia regions, the results of which revealed patterns of indicators similar to those identified in the top-down process (COX; HAMLEN, 2015).

Alshehri et al. (2015a,b) developed a theoretical framework for community resilience to disasters in Saudi Arabia. The indicators selected from the literature were

6. Measures the degree of linear correlation between two variables, with a value between -1 and +1. In these extreme values, the correlation between the two variables is strong, and close to zero, weak. The positive and negative signs respectively indicate direct and inverse correlation.

7. The Cronbach's Alfa Coefficient estimates the reliability of a questionnaire applied in a research, measuring the correlation among the responses by analyzing the profile of the answers given by respondents. It is calculated from the sum of the variance of individual items and from the sum of the variance of each respondent. The values of a vary from 0 to 1; the closer it is to 1, the greater the reliability.

submitted to experts' appreciation employing i) the Delphi method, which seeks a consensus of qualified opinions from a group of individuals with knowledge on a certain theme (experts); and ii) the analytic hierarchy process (AHP) to weigh the indicators.

In Brazil, there are few studies on resilience, especially on indicators. The National Policy for Protection and Civil Defense (Law number 12,608, from April 10, 2012) stimulates the development of resilient cities, making Brazil the country with the largest number of cities signed up for the Resilient Cities campaign. However, the law lacks regulation and there is no confirmation of the effective implementation of the ten essential steps for building resilient cities (UNISDR, 2018a) by the adhering municipalities. Urban resilience still has challenges to be faced in the country.

This article presents a first participatory approach for defining indicators of community resilience to disasters, therefore contributing to decision-making and identifying disaster management priorities in the country.

3. Methods

3.1 Scope

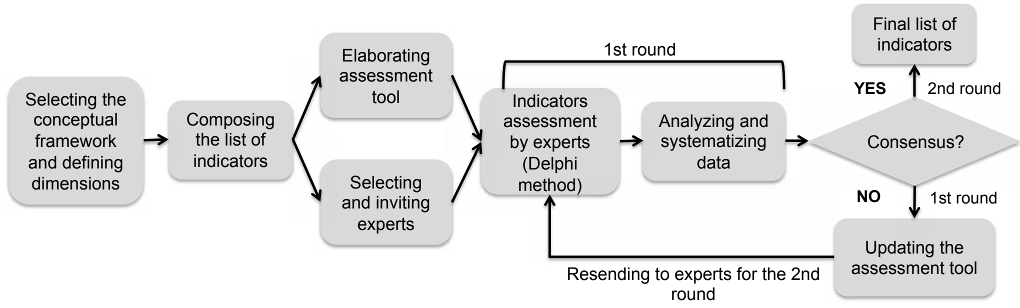
In this study, we considered natural threats deriving from hydrological, meteorological, climatic and geological-geotechnical phenomena, as well as anthropic-origin threats, such as accidents in industrial facilities and during transportation of hazardous products, urban fires and collapse of buildings.

In the field of resilience to disasters, community corresponds to social groups exposed to the same risks, due to sharing a common space, such as a neighborhood, city or state. This definition aims to facilitate disaster management actions, once it denotes a group of people subject to common threats and interests in an easily identifiable location (TWIGG, 2009; McASLAM, 2011). Therefore, disaggregated data available per region are fundamental to build indicators that allow comparing localities. In this study, "community" is the municipality, adopted as unit of analysis for obtaining data.

3.2 Developed stages

The study had six stages: i) Selecting a conceptual framework for disaster resilience indicators and defining dimensions; ii) Composing a list of indicators; iii) Elaborating an evaluation tool; iv) Selecting and inviting experts; v) Indicators evaluation by the experts (Delphi method); and vi) Analyzing and systematizing data. The indicators evaluation occurred in two rounds (Figure 2).

Figure 2 - Stages developed in the study



Source: elaborated by the authors.

Differently from other participatory methods, in the Delphi method there is no direct contact, just an interactive questionnaire seeking a consensus. A minimum of two rounds is necessary, rare being studies with over three rounds. The main characteristics of the method are participants' anonymity, statistical representation of results and feedback of the group responses for reevaluation in the subsequent rounds (GIANNAROU; ZERVAS, 2014; WRIGHT; GIOVINAZZO, 2000).

The selection of experts and the development of the data collection tool are determinant for the quality and impartiality of results. The composition of the selected group of experts and an ambiguous tool may result in research bias; conversely, anonymity and indirect contact reduce the influence of psychological factors and the dominance by some individuals (ZERVAS, 2014; WRIGHT; GIOVINAZZO, 2000).

Stage 1 - Selecting conceptual framework for disaster resilience indicators and defining dimensions

After the literature review, we adopted the part of the DROP conceptual framework corresponding to *inherent resilience*. DROP, conceived for disasters associated to natural threats, may be adapted to other types of threats, e.g. technological disasters or terrorist attacks (CUTTER et al., 2008).

We considered the six dimensions adopted by CUTTER et al. (2008, 2010): i) environmental; ii) social, iii) economic; iv) institutional; v) infrastructure and vi) social capital, rewritten as follows:

Social Dimension

Aims to capture the capacity to cope and recover from disaster impacts by association to social-demographic characteristics. Some population characteristics considered are educational level, age composition (excluding elderly and children), physical and mental capacity (absence of deficiencies), access to services and private means of locomotion, access to communication media (telephone, TV, internet), and access to health services.

Economic Dimension

Aims to reflect the economic capacity and vitality of the community by attributes that influence the feasibility of structural measures for preventing and reducing damages and accelerating reconstruction. Among the attributes are income distribution equity, employment level, dimension of enterprises, economic stability of subsistence means, and diversity of local economic activities.

Infrastructure Dimension

Represents the elements of the built environment and the existing services in the community that contribute to prevention, mitigation, response and recovery from disasters. Among the desirable infrastructure characteristics are adequate structure for medical assistance, temporary shelters, solid waste management, basic sanitation, warning systems and infrastructure for response.

Environmental Dimension

Represents environmental characteristics that contribute to the community capacity to absorb and to mitigate damages caused by hazardous occurrences. This dimension focuses on the interaction of community with territory (composed of natural resources and built environment), including land use and occupation, and environmental resources for the development of human activities. An example is the percentage of occupied area non-subject to risk, e.g. flood or landslide.

Institutional Dimension

Represents aspects related to policies, projects and programs that contribute to the community planning, preparation and recovery capacity when faced with disasters and their impacts. The indicators should express the effort made by governments and society in elaborating and implementing tools for all stages of the disaster management cycle. The indicators should capture the social participation channels for public decisions and public management tools, such as the master plan and environmental licensing.

Social Capital Dimension

Represents the cooperative relationships among individuals, their neighborhoods and larger communities. It is related to standards and social networks that facilitate collective action and solidarity when disasters occur. It seeks to capture the sense of community, fixation of individuals in the territory and social innovation (ability to produce knowledge). The sense of community is characterized by the concern about community problems, respect and service to others, feeling of connection among people and of belonging to the place.

Stage 2 – Composing the list of indicators

The second stage focused on composing the initial list of indicators, selected/elaborated from different sources: literature review, Resilient Cities Handbook[8], PNDC Law, Research on Basic Municipal Information – Brazilian Municipalities Profile from the Brazilian Institute of Geography and Statistics (IBGE, 2014), and notes from scientific events and meetings related to urban environmental risk management. This initial list totaled 98 indicators distributed into the six dimensions.

Stage 3 - Elaborating an evaluation tool

A form was elaborated in the Google Forms to evaluate indicators according to their degree of importance, employing the Likert scale (GIANNAROU; ZERVAS, 2014): (1) unimportant; (2) of little importance, (3) important and (4) very important. The alternative "I don't have a formed opinion to evaluate the indicator" was also inserted. In the introductory section, there were filling-in instructions, definitions of community resilience and of the six dimensions considered. At the end of each dimension, an optional field was inserted for suggesting other indicators or rephrasing the existing indicators. A pre-test was performed with three participants and led to adjustments of the tool.

Stage 4 - Selecting and inviting experts

For the selection of experts, we sought a balance of the interested parties, contemplating both public managers of the three federative levels, active in civil defense and in urban planning, and researchers from knowledge areas related to disasters, such as engineering, geosciences, education, psychology, collective health, applied social sciences and law. Representatives of environmental state agencies acting in chemical emergencies were also invited. Initially, 298 invitations were sent to the selected experts via electronic mail.

The strategy for selecting experts abided by the following criteria:

Public managers from the civil defense, environmental and urban planning areas in states and municipalities - initially, invitations were sent to the Civil Defense coordinators of the 27 states of the federation. Next, for including municipalities, the 27 Civil Defense State coordinators were contacted by telephone and e-mail, informed about the study and asked to indicate four municipalities they considered priority for disaster management. For the states that made no indications, municipalities with the highest number of disaster events according to the Brazilian Atlas of Natural Disasters (CEPED UFSC, 2013) were selected, whose civil defense municipal coordinators and, when possible, also representatives of the urban planning area, were invited to integrate the sample.

8. How to Build More Resilient Cities: A Handbook for Local Public Managers (UNISDR, 2012)

Furthermore, experts from environmental state agencies, identified by search of the respective websites, were also invited: to reflect the country diversity, two states by geographic region (five regions) were selected.

Public managers from the civil defense, environmental and urban planning areas at the federal level - initially, we invited representatives from the Brazilian Institute for Environment and Renewable Natural Resources, Ministry of the Cities and Ministry of National Integration who delivered lectures at the I Brazilian Congress on Disaster Risk Reduction, held in October 2016, in Curitiba, Paraná. The other participants were identified by indication or surveys in websites.

Researchers: different strategies were used, such as surveying the authors of publications on disasters in the Brazilian Scielo portal; inviting speakers from the I Brazilian Congress on Disaster Risk Reduction; inviting researchers from the National Center for Monitoring and Alert of Natural Disasters, the Institute of Geosciences, the Centre for Studies and Research on Disasters of São Paulo University and from São Paulo State Institute for Technological Research; besides inviting the scientific coordinators of the existing Centers for Research on Disasters in Brazil, asking them to appoint four other researchers.

Additionally, 22 members of the Metropolitan Theme Chamber of Urban Risk Management were invited, composed of civil defense public managers from municipalities of the São Paulo Metropolitan Region and of experts from two Sao Paulo State universities, São Paulo State Institute for Technological Research, São Paulo State Environmental Sanitation Technology Company and São Paulo State Department of Water and Power.

Stage 5 – Indicators assessment by experts

Between March and September 2017, two rounds were conducted to evaluate the indicators. The selected experts were informed about anonymity and confidentiality, a characteristic of the Delphi method.

In the first round, invitations with information on the study and a link to access the form were sent to the experts, with a 30-day deadline to fill in and return the form.

In the second round, due to the high number of indicators, we opted for only reevaluating those that did not achieve consensus in the first round, and for including new indicators based on suggestions presented in the first round. The indicators that had reached a consensus in the first round and their respective percentages were included in the form for information purposes. Thus, the assessment tool was updated, with the exclusion and/or inclusion of new indicators suggested by the participants, keeping the initial structure. In the second round, there was no possibility of including additional suggestions.

In the second round, due to the high number of indicators, we opted for reassessing only the ones without a consensus in the first round and for including new indicators, resulting from the suggestions presented in the first round. The indicators that had reached a consensus and their respective percentages in the first round were included in the form for information. Thus, the evaluating tool was updated, with exclusion and/or inclusion of new indicators suggested by the participants, however keeping its former structure. In the second round, there was no possibility of including additional suggestions.

Stage 6 – Analyzing and systematizing data

With the data of the first round, the percentages of each score were calculated. The criterion adopted for consensus was: the sum of *score* 3 (important) + *score* 4 (very important) ≥ 75% of the responses to each indicator.

The suggestions for new indicators or for rephrasing existing indicators were analyzed regarding i) alignment with the definitions of community resilience to disasters and its six dimensions; ii) possibility/easiness of measuring; iii) evaluation level (municipality) and iv) similarity/approximation with the initial list.

In the second round, the same calculation procedures and criterion were adopted for verifying the consensus on the importance of the indicator.

4. RESULTS AND DISCUSSION

4.1 Characteristics of the participants

The Delphi method is not strict about the number of participants; the group size is related to the purpose of the study. We here sought wide participation to obtain different perspectives. In the first round, the number of participants was 97, corresponding to 33% of the invitations (298). In the second round, the tool was sent to the respondents of the first round, and 72 answers were received (74%). This is a significant number of answers as compared to other studies of national dimension and similar objectives.

The board of 72 experts was composed of 43% public managers and 57% researchers from universities and research institutes. The significant participation of public managers should be highlighted, since they experience the routine issues of disaster management and are responsible for the conception and implementation of the necessary public policies. In turn, researchers usually focus their investigations on a specific aspect of disaster. Therefore, the proposed dimensions were approached both specifically and comprehensively.

We also sought to aggregate researchers and public managers from different areas of knowledge, so as to minimize bias in the research. Among the researchers, the majority act in earth sciences and engineering, and investigate natural disasters.

4.2 Evaluating indicators

In the first round, the proposed 98 indicators of community resilience to disasters were evaluated, of which 80 were considered important (grade 3 or 4) by all participants, achieving consensus. One of these was divided in two by suggestion of the participants. Therefore, the first round resulted in 81 indicators.

The indicators without consensus in the first round (18) and new indicators derived from the analysis of the suggestions presented in the first round (16), totaling 34 indicators, were resubmitted to the experts in the second round. Among the 18 indicators without initial consensus, 12 of which rewritten according to the expert's suggestions; for a better understanding, the previous and the modified versions were presented to the experts in the second round. In the second round, 20 indicators were considered important by general agreement.

At the end of the process, 101 indicators were consensually considered important to community resilience to disasters. The evolution of the number of indicators during the study process and the final list with the 101 indicators are respectively presented in Table 1 and in Box 1.

Table 1 - Number of indicators, by dimension and by round

Dimension	First Round		Second Round					Final
	Initial	A	R	A	New	A	Total	
Social	11	8	3	2	0	0	2	10
Economic	10	4	6	0	4	4	4	8
Infrastructure	19	18	1	1	5	5	6	24
Environmental	15	12	3	1	1	1	2	14
Institutional	33	33→34*	0	0	6	6	6	39
Social capital	10	5	5	0	0	0	0	5
Total	**98**	**80→81**	**18**	**4**	**16**	**16**	**20**	**101**

Source: elaborated by the authors.
A: Approved by consensus; R: Reevaluation indicators without consensus in the first round.
* One of these indicators was divided in 2, as suggested by participants.

At the end of the study, only 14 of the initial 98 proposed indicators were not considered important. On the other hand, the 16 indicators suggested by the experts achieved consensus, what stresses the importance of including experts' suggestions in the Delphi method.

Box 1 - Final list of disaster community resilience indicators, by dimension

Social
% of population aged 15 or more and under 65 years old
% of population without any type of deficiency
% of population with access to fixed or mobile telephone
% of population with access to the Internet
Municipal Human Development Index
% of private households in nutritional safety situation

% of households covered by the Family Health Program
Vaccine coverage of children up to 4 years old
% of population that owns a television or radio set
Existence of Food and Nutrition Surveillance System
Economic
% of the population with a job (18 years old or older)
Inverse Gini Index
Number of commercial and service facilities out of the areas of high risk of disasters associated to natural and technological threats/ total commercial and service facilities
Number of industrial facilities out of the areas of high risk of disasters associated to natural and technological threats/ total industrial facilities
*Ratio between the municipal budget for the municipality risk management and the necessary resources (financial capacity of the municipality to face demands)
(*) % of households with comprehensive insurance policies including coverage of catastrophic events
(*) % of business facilities with comprehensive insurance policies including coverage of catastrophic events
(*) % of population not facing poverty or extreme poverty situation
Infrastructure
Existence of specific budget for infrastructure works to prevent or reduce disaster damages
% of municipal budget destined to infrastructure works to prevent or reduce disaster damages
Number of public health services per thousand inhabitants
Number of public hospital beds per thousand inhabitants
Existence of periodical safety assessment of schools and health units
Number of psycho-social support public services per thousand inhabitants
Number of places in adequate conditions for temporary shelter per thousand inhabitants (religious centers, schools, sports arenas, among others)
% of risk areas with monitoring and alert systems integrated to the organized community
Extension (km) of arterial roads relative to the total municipality area
Number of people employed in emergency services per thousand inhabitants
Existence of material resources/necessary and sufficient equipment for disaster response activities (own or by inter-municipal agreements). Ex: backhoes, boats, individual protection equipment, vehicles, among others
Number of TV and radio broadcasters/thousand inhabitants (with previous agreement to act as a communication channel in disaster prevention and response)
% of households not located in subnormal agglomerations
% of households connected to the public water supply network
% of households connected to the public sewage system or with sceptic tank
% of households served by solid waste collection
% of households with electric power
Existence of adequate final disposition of municipal urban solid waste
% of households with municipal license
(*) Number of health professionals with university degree working in public health facilities per thousand inhabitants
(*) Ratio between the number of public facilities (health center units, schools and nurseries) not located in risk areas and the total existing facilities
(*) Existence of public institutionalized shelter, administered by qualified professionals
(*) Number of roads to access the municipality per 100 km^2
(*) Existence of rainwater drainage system

Environmental
% of territory with permeable surfaces
% of territory without exposed soil
% of territory with forest cover
% of territory with native vegetation cover
% of non-built and non-degraded territory
Water availability higher than 2,500 m^3/inhabitant/year
% of population not living in flood risk areas
% of population not living in landslide risk areas
% of area of non-built floodplain (residential and commercial buildings, infrastructure)
% of population not living in erosion risk areas
% of non-occupied permanent preservation areas
% of population not living in technological risk areas
% of working population not working in areas with high-risk of disasters associated to natural and technological threats
(*) % of population not living in areas subject to drought
Institutional
Existence of institutionalization for mutual help between nearby municipalities
% of municipal budget specifically destined to response (direct action and humanitarian service)
% of municipal budget destined to post-disaster reconstruction relative to the total resource destined to disaster management
Number of educational programs for response and attendance to disasters per thousand inhabitants (non-formal education for the community - organized or not)
Existence of continued education and training programs for disaster risk reduction in schools (formal education)
Existence of risk mapping of disasters associated to natural threats – with yearly updating routine
Existence of risk mapping of disasters associated to technological threats – with yearly updating routine
Existence/maintenance of risks and vulnerabilities database
Availability to the population of risks and vulnerabilities database
Existence of geotechnical map for urbanization
Existence of communication of the municipality with analysis and disaster monitoring centers at regional, state and national levels
Existence of programs of continued training on DRR for public agents acting on protection and civil defense activities
Existence of regular simulation programs for response to disasters associated to natural threats
Existence of regular simulation programs for response to technological disasters
Existence of list of available resources for response (with updating routine), e.g. human resources, potential shelters, equipment and volunteers (per activity)
Existence of inspection routines of buildings in risk areas, with preventive intervention and population evacuation if necessary
Existence of mechanisms for control and inspection of land use to prevent occupation in areas susceptible to disaster
Existence of incentives for investments in DRR destined to low-income population living in susceptible areas
Existence of Special Social Interest Zone (specific legislation or integral part of the Master Plan)
Existence of public technical advisory for elaborating and approving projects for the construction and renovation of low-income family houses

Existence of credit lines/subsidized financing for acquisition and construction of low-income family houses
Existence of Building Code (specific legislation or integral part of the master plan)
Existence of Building Code that includes construction in hillside areas
Adherence to the Resilient Cities Program by creating an institutional structure to support the program implementation involving different government sectors
Existence of permanent channels for sharing information between the population and the professionals involved in prevention, response and reconstruction actions
Existence of plan for disaster waste management (or insertion in the municipal integrated plan of solid waste management)
Existence of legislation for zoning or land use and occupation (specific or an integral part of the master plan)
Existence of Municipal Contingency Plans for the major environmental risks of the municipality
Existence of Municipal Contingency Plans for the major technological risks of the municipality (including transportation of hazardous products)
Existence of Municipal Risk Reduction Plan
Existence of programs destined to income generation for citizens affected by disasters
Existence of housing program for reallocating low-income population in risk areas (reallocation in a social interest housing project, payment of social rent, indemnity of improvements, purchase of new housing, specific financial aid, among others)
Existence of Municipal Protection Coordination and Civil Defense
Existence of fire brigade unit
(*) Existence of updating routine for the integrated system for disaster information
(*) Existence of mechanisms to ensure the continuity of public policies for risk management during government changes
(*) Existence of municipal policies for climate change
(*) Existence of programs of temporary financial aid to citizens affected by disasters
(*) Management of donations foreseen in the municipality contingency Plans
(*) **I**nter-sectoral practices in the municipality risk management
Social capital
Number of community organizations that are partners of the civil defense in risk management per thousand inhabitants
Number of civil organizations per thousand inhabitants
Number of non-governmental organizations of social assistance per thousand inhabitants
Number of communal living centers per thousand inhabitants
Number of communal health agents per thousand inhabitants

Source: elaborated by the authors.
(*) Added by the experts.

In the final list, there is a prevalence of indicators of the Institutional (39) and Infrastructure (24) dimensions, corresponding to 62% of the total. It is important to mention that all these indicators achieved consensus among the experts. None of the initially proposed indicators of the Institutional (33) and Infrastructure (19) dimensions, corresponding to 53% of the initial list, was discarded. Quite the opposite, new indicators were suggested and included (respectively, 5 and 6). The participatory character of the study evinced the importance of these dimensions in the experts' perception. This trend may be attributable to the approach to disasters so far observed in practice and literature:

the researched sources privilege prevention and planning elements, which fall on these two dimensions.

In turn, only 50% of the initial indicators of the Social Capital dimension and 40% of the Economic dimension remained. The percentage of *population residing in the same place for over 5 years*, indicator that represents the population's identity with the physical location, was excluded. Yet no new indicator was suggested for this dimension, which may be related to the participants' profile, most of whom act in earth sciences and engineering. In the ambit of researches on disasters in the country, Geosciences and Engineering areas predominate in relation to Human and Social Sciences (RODRIGUES et al., 2015; VALENCIO, 2010).

In the Economic and Environmental dimensions, despite the exclusion of indicators from the initial list (6 out of 10 and 3 out of 15, respectively), new suggested indicators practically maintained the number initially proposed.

The inclusion of indicators related to technological disasters can be considered a differential of our study. The first round proposed six indicators specific of technological disasters, and two indicators associated concurrently to technological and natural disasters. In the second round, only the indicator *number of acting companies non-subjected to environmental licensing/total of acting companies* was excluded, and there was no suggestion for new indicators. Despite the increasing importance of technological disasters (ESHGHI; LARSON, 2008), these results corroborate Günther et al. (2017): a large part of the initiatives for measuring resilience to disasters is still focused on disasters associated to natural threats.

5. Final considerations

Database systems on disaster occurrence (damages and losses), such as the International EM_DAT Base and the Integrated System of Information to Disasters (S2iD)[9], are fundamental to support public managers in the definition of priorities, decision making, infrastructure planning and resources allocation, as well as information to society.

However, disaster risk management also requires systematic collection of information/data on strengths and coping capacities of municipalities, i.e. community resilience. A pioneer survey of municipal information on risk management and responses to disasters was conducted by IBGE in 2013 (Survey on Basic Municipal Information[10]). Our study sought to amplify this approach by defining indicators of community resilience to disasters for Brazilian municipalities, considering the point of view of public managers and researchers from different regions in Brazil.

By the participatory method, 101 indicators of community resilience were identified and selected, most in the Institutional and Infrastructure dimensions. The predominance of these dimensions evinces the value of public policies and of urban infrastructure for community resilience to disasters in the perception of Brazilian experts.

9. https://s2id.mi.gov.br
10 Perfil dos Municípios Brasileiros 2013 (IBGE, 2014)

As a continuation of our study, we plan to reduce the set of selected indicators by systematization, statistical treatment and analysis of feasibility, with the aim of formulating an index for community resilience to disasters. This index will allow evaluating, comparing and ranking the community resilience of Brazilian municipalities in a multidimensional way, with a view to basing decision-making and public policies related to the prevention of damages caused by disasters and to the promotion of community resilience.

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Original Article

BUILDING INDICATORS OF COMMUNITY RESILIENCE TO DISASTERS IN BRAZIL: A PARTICIPATORY APPROACH

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BUILDING INDICATORS OF COMMUNITY RESILIENCE TO DISASTERS IN BRAZIL: A PARTICIPATORY APPROACH

***Abstract*:** Community resilience is essential for disaster management and its measurement is necessary to support decision-making. This paper presents as first list of community resilience indicators for Brazilian municipalities, resulting from literature review, experts' consulting and application of the Delphi method. The experts group consisted of public managers (43%) and researchers (57%). The study comprised six phases: conceptual framework selection; composition of the indicators list; elaboration of evaluation tool (Delphi method); selection and invitation to experts; evaluation of indicators; and data analysis. As a result, the importance of 101 indicators distributed in six dimensions (environmental; social; economic; institutional; infrastructure; social capital) achieved consensus among the experts after two rounds. In the first round, 98 indicators were submitted to the evaluation of 97 specialists, with the possibility of proposing new indicators, while in the second round the final list reached consensus among the 72 respondents. The Institutional and Infrastructure dimensions were predominant, evidencing the value of public policies and urban infrastructure for community resilience to disasters in the perception of Brazilian experts.

***Keyword*:** Community resilience, Disaster Management, Delphi, Indicators, Brazil

CONSTRUÇÃO DE INDICADORES DE RESILIÊNCIA COMUNITÁRIA AOS DESASTRES NO BRASIL: UMA ABORDAGEM PARTICIPATIVA

***Resumo*:** A resiliência comunitária é essencial na gestão de desastres e sua mensuração é necessária para apoiar tomadas de decisão. Este artigo propõe uma primeira lista de indicadores de resiliência comunitária para municípios brasileiros, resultante de revisão da literatura, de consulta a especialistas e de aplicação de método Delphi. Os especialistas compreenderam gestores públicos (43%) e pesquisadores (57%). O estudo compreendeu seis etapas: seleção de quadro conceitual; composição de lista de indicadores; elaboração de instrumento de avaliação; seleção e convite a especialistas; avaliação dos indicadores (método Delphi); e análise dos dados. Como resultado, 101 indicadores distribuídos em seis dimensões (ambiental; social; econômica; institucional; infraestrutura e capital social) tiveram sua importância consensuada após duas rodadas do método. Na primeira rodada, 98 indicadores foram submetidos à avaliação de 97 especialistas, com possibilidade de proposição de novos, enquanto na segunda, a lista final resultou do consenso entre 72 especialistas. As dimensões Institucional e Infraestrutura foram predominantes, evidenciando o valor das políticas públicas e da infraestrutura urbana para a resiliência comunitária aos desastres na percepção de especialistas brasileiros.

***Palavras-chave*:** Resiliência Comunitária, Gestão de Desastres, Delphi, Indicadores, Brasil