Identifying the Underlying Risk Factors of Local Communities in Chile

Natalia Silva Bustos, Cristóbal Mena Amigo,

National Emergency Office of the Ministry of the Interior and Public Security,

Santiago, Chile

1. General Context

Disasters are not natural but a product of developments that face backwards to risk having a profound impact on welfare and livelihoods of local communities. Moreover, if disasters are understood as the crystallisation of the vulnerabilities within a group of individuals, determined by underlying risk factors such as the physical attributes of territory and qualitative ones like poverty and governance (Dickson et al., 2012), it opens a window to identify and assess such vulnerabilities to design ways of reducing them.

As a general physical context, it is mentioned that Chile complies with seven of the nine criteria of climate change vulnerability according to the United Nations Framework Convention on Climate Change (UNFCCC, 2015). Moreover, given its location on the eastern margin of the Pacific Ring of Fire, Chile is one of the countries with the highest volcanic and seismic activity in the world (Scholz, 2002). Likewise, it is one of the OECD member countries most exposed to natural origin disasters, with 54% of its population and 12.9% of its total surface exposed to three or more types of threats (Dilley, 2015).

The consequences of these physical conditions are projected in different ways (Tironi, 2014) and are manifested in various levels, which can hinder the sustained development of the country. Therefore, Chile is constantly challenged to learn from its experiences and strengthen a disaster risk management (DRM) approach, with an emphasis on strengthening the resilience of local communities and their governments.

Thus, in recent years Chilean policies for Disaster Risk Reduction (DRR) have had an active development and alignment with the global policies such as: 2030 Agenda for Sustainable Development, the Paris Agreement, the Sendai Framework for DRR 2015-2030 and its predecessor the Hyogo Framework for Action 2005-2015, the New Urban Agenda – Habitat III, among others. Consequently, Chile has a National Policy for Disaster Risk Management and a National Strategic Plan that was developed by the National Platform for Disaster Risk Reduction[1], an entity

[1] The National Platform for DRM, integrated with more than 120 national organizations members ranging from ministries, government services, academia, private sector, UN agencies and non-governmental organizations.

formed in Chile since 2012 and which is the most important mechanism of intersectoral coordination for the formulation, implementation and evaluation of public policy in this area.

The National Platform for DRR is a cornerstone for DRM efforts in Chile. In this sense, it took charge of one of the priorities established in the National Policy as it is the reduction of the underlying risk factors (URF), which allowed the development of the Methodology of Identification and Characterization of the Underlying Risk Factors to local level, in 2016. This tool is applied in the country starting in 2017 with the close collaboration between the National Emergency Office of the Ministry of the Interior and Public Security (ONEMI) and local governments.

Therefore, this paper presents the background and context for the methodology, to describe then its components and preliminary results to provide a new approach to assess the vulnerability of local communities for better decision making towards reducing disaster risk. The methodology was formulated by reviewing and considering the methodologies applied in different regions of the world[2], which generally coincide in the dimensions that group the main underlying factors of disaster risk. However, the numerical treatment of the variables obeys to novel statistical processing, which provides robustness to the model and, therefore, to the results obtained.

2. Background

Since O'Keefe, Westgate and Wisner (1976) suggested that disasters are not natural, communities are an active and responsible element of managing risk (i.e. Twigg, 2009) as a social construct (Wisner et al., 2004), and also that the individual vulnerability, as a relevant risk factor, is explained mainly by social features and an

[2] Undoubtedly, the most similar methodology found in the literature review at the date of design of this proposal is that which calculates the risk reduction index in West Africa. However, most of the methodologies found correspond to qualitative analysis and / or perception against a list of conditions and coping capacities related to risk at the local level. In addition, the novelty of this method is that it does not focus on a particular hazard / exposure or is it structured around the phases of risk management, instead it presents an integral view of all the base dimensions that determine a possible situation risky.

inadequate development process (Lavell, 2000) than merely the physical environment, i.e. the physical environment doesn't determine the disaster per sè.

Under this holistic approach, the notion of the underlying risk factors refers to the condition of inherent vulnerability, that is, those conditions prevailing in the communities that favour or facilitate their effects (Briguglio, 2003).

The Global Assessment Report on Disaster Risk Reduction (GAR, 2009) refers to the underlying risk factors or risk drivers as: "*processes, both physical and social, that contribute, drive or determine in an important way the construction, creation or existence of conditions of disaster risk in society* ".

The Sendai Framework identified gaps related to the UFR indicating that *"more dedicated action needs to be focused on tackling underlying disaster risk drivers, such as the consequences of poverty and inequality, climate change and variability, unplanned and rapid urbanization, poor land management and compounding factors such as demographic change, weak institutional arrangements, non-risk-informed policies, lack of regulation and incentives for private disaster risk reduction investment, complex supply chains, limited availability of technology, unsustainable uses of natural resources, declining ecosystems, pandemics and epidemics".*

Additionally, the 2030 Agenda for Sustainable Development, emphasises the importance that its implementation must align with the other related global commitments. This indivisible relationship between the objectives pursued by each one is crucial to achieving the integral development of the countries, considering social, economic and environmental dimensions; reducing vulnerability and enhancing the resilience (UNFCCC, 2017).

3. Methodology

3.1. Instrument Design

The definition of the purpose and design of this tool was the result of a year of work by a group of national experts from the public, private, organised civil society and academia members of the National Platform for DRR. This initial stage has sought to capture the different sectoral visions with a multidimensional approach that considers the territorial differences, cautioning that, local governments are key actors to achieve risk reduction and are also the first respondents and responsible for managing their territory and community.

In order to help local governments, understand their situation, the expert group established that the assessment should consist of a guided self-diagnosis using a survey.

The purpose of the instrument is to favour and strengthen, in a timely and relevant manner, the processes of design, planning, investment, execution and evaluation of various public and private initiatives in the territory, thereby strengthening the preventive, response and adaptation capacities of the communities, institutions and territory. The instrument allows the generation of single community diagnosis; a definition of a baseline which leads to progress assessment at different levels; and provide specific risk management recommendations to municipalities.

The whole instrument includes an initial approach to the local government staff, a guiding document (suggested official sources of information and terminology) and four survey booklets, corresponding to each of the assessed dimensions.

The dimensions considered are: Governance, Territorial Planning, Socio-Economic and Demographic Conditions, and Climate Change and Natural Resources. The four dimensions encompass 41 variables that are considered relevant for the DRM discipline, as described in the tables below.

Table 1: Territorial Planning Dimension (9 variables)

Factor	**Variables**
1.1. Territorial Planning Policies	1.1.1. Territorial Planning Instruments.
1.2. Exposure	1.2.1. Location of Human Settlements. 1.2.2. Type of Human Settlements.

Factor	Variables
	1.2.3. Isolated Locations[3].
	1.2.4. Coexistence with Productive Economic Activities.
	1.2.5. Critical Infrastructure Location.
1.3. Built Environment	1.3.1. Regulatory Compliance Regarding the Age of the Building[4].
	1.3.2. Investment Plan for Mitigation Works.
	1.3.3. Regularization concerning Building Permits Granted by the Municipal Works Directorate.

Table 2: Climate Change and Natural Resources Dimension (8 variables)

Factor	Variables
2.1. Climatic Variability	2.1.1. Behaviour Pattern of Extreme Weather Events.
	2.1.2. Access and Update to Information about Impact of Climate Change.
2.2. Environmental Degradation	2.2.1. Soil degradation.
	2.2.2. Deforestation.
	2.2.3. Water Shortage.

[3] It is understood by isolated territory one with a low level of accessibility, scarce and highly dispersed population, low presence and coverage of basic and public services rendering into a situation of disadvantage and social inequality regarding the development of the country.

[4] Considering the current structural and constructive requirements, according to the Chilean Standard N° 433, 1996 for Seismic Design of Buildings.

Factor	Variables
	2.2.4. Soil Erosion. 2.2.5. Waste Disposal[5]. 2.2.6. Existence of Pathogens and Environmental Vectors.

Table 3: Socioeconomic and Demographic Conditions Dimension (7 variables)

Factor	Variables
3.1. Poverty and Inequality	3.1.1. Incidence of Multidimensional Poverty[6]. 3.1.2. Incidence of Poverty by Income[7]. 3.1.3. Socio-Economic Distribution.
3.2. Demographic Feature	3.2.1. Index of Demographic Dependency[8]. 3.2.2. Disabled Population. 3.2.3. Homeless Population.

[5] Related to the existence of policies and environmental management programs.

[6] Compounded by five relevant dimensions of well-being: (1) Education; (2) Health; (3) Work and Social Security; (4) Housing and Environment; and, (5) Networks and Social Cohesion. Households that accumulate 22.5% or more of deprivation are in a situation of multidimensional poverty.

[7] Persons considered poor are those part of households whose total monthly income is less than the "poverty line per equivalent person", or minimum income established to satisfy basic food and non-food needs in the same period, of according to the number of members of the household.

[8] It refers to the ratio between the number of people in dependent ages (0 to 14 years and over 60 years) with the economically active population (15 to 59 years) of the municipality.

Factor	Variables
	3.2.4. International Immigrant Population.

Table 4: Governance Dimension (17 variables)

Factor	Variables
4.1. Institutional	4.1.1. Inclusive Approach in Municipal Management Scope. 4.1.2. Local Management and Climate Change Adaptation. 4.1.3. Citizen Participation. 4.1.4. Municipality's Capacities for DRM. **Sub-variables**: 4.1.4.1. Municipality's Structure[9]. 4.1.4.2. Municipality's Training. 4.1.4.3. Financial and Decision-Making Autonomy. 4.1.4.4. Local Policies for DRM. 4.1.4.5. Civil Protection Committee[10]. 4.1.5. Public Safety and People Protection in Emergencies. 4.1.6. Accountability Mechanisms.

[9] Related to the existence of a municipal office/department responsible for disaster risk management / civil protection, its level of exclusive dedication and its hierarchy within the municipal structure.

[10] Working group integrated by public and private institutions of the Civil Protection System, that by legal mandate, competence or interest, can contribute to the disaster risk management.

Factor	Variables
	4.1.7. Coverage of Social Protection Programs.
4.2. Social Cohesion	4.2.1. Construction of Official Information. 4.2.2. Citizen Representation. 4.2.3. Social Integration[11]. 4.2.4. Civil Society Organizations.
4.3. Sectoral Commitment	4.3.1. Responsibility on Private Investment. 4.3.2. Risk Transfer Mechanisms.

3.2. Model Construction

[11] Belonging is not only built with greater equity, but also with greater acceptance of diversity. Multiculturalism is one of the indicators with which membership is measured and understood as a manifestation of diversity and coexistence in a society of groups with different cultural codes.

Constructing the model was carried by using a multicriteria statistical processing method; the Analytical Hierarchical Process (AHP[12]) applied to the variables at all levels aforementioned. The relative importance -specific weights- of each component and answers in the model was assigned by expert criteria[13] considering their incidence in local disaster risk management. One of the possibilities that multi-criteria methodologies contribute, is the diversity of factors that can be integrated into the evaluation process. Its particularity is in the form of transform measurements and perceptions on a single scale to compare the elements and establish priority orders that allow to add the effects of a project in a metric common (Contreras et al., 2007).

The hundred priority vectors, calculated between each pair of model components at each hierarchical level carried out using the weights of the absolute scale known as the Fundamental Saaty´s Scale, allows obtaining the measurement rule[14] (Graphic 2). Six comparisons were needed to cover the four dimensions, 45 comparisons for the ten factors, 630 comparisons for the 36 variables and 10 to the five sub-variables. The same exercise was carried out in each range of possible answers: Null, Low, Medium and High; where medium and high correspond to the worse performance for the 41 questions involved in the survey. The survey presents 4 possible answers for each of the 41 variables that are asked, which represent different possible scenarios described (which were formulated by the same expert group, intend to capture scenarios generic enough to be representative throughout the national territory), inviting the municipal team to identify with only one of them.

As a result of this process, the expert group concluded that the highest weight was associated to the Governance dimension since it lays the foundation for all interrelationships between stakeholders and therefore set the

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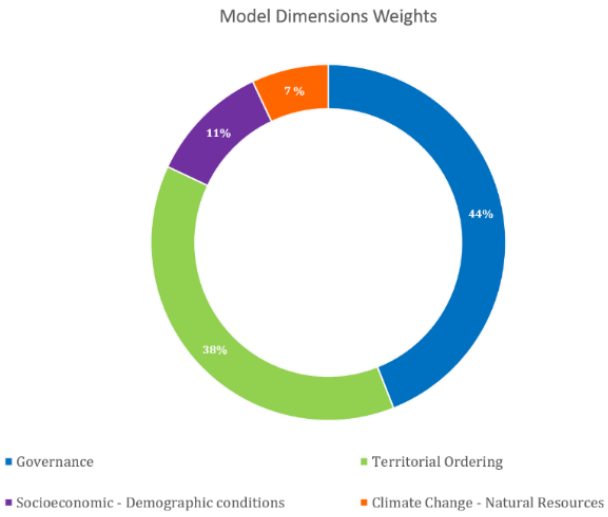
[12] First of all it is necessary to separate a problem of decision on the "elements" that compose it for the subsequent comparison between them, in this way the decision making involves making measurements that allow applying the criteria of comparison to establish preferences between them (hierarchies).

[13] A group of more than 30 specialists from different sectors that belong to the National Platform for DRR, in a couple of full working days built the hierarchical model, assigning weights for each of the 41 defined variables.

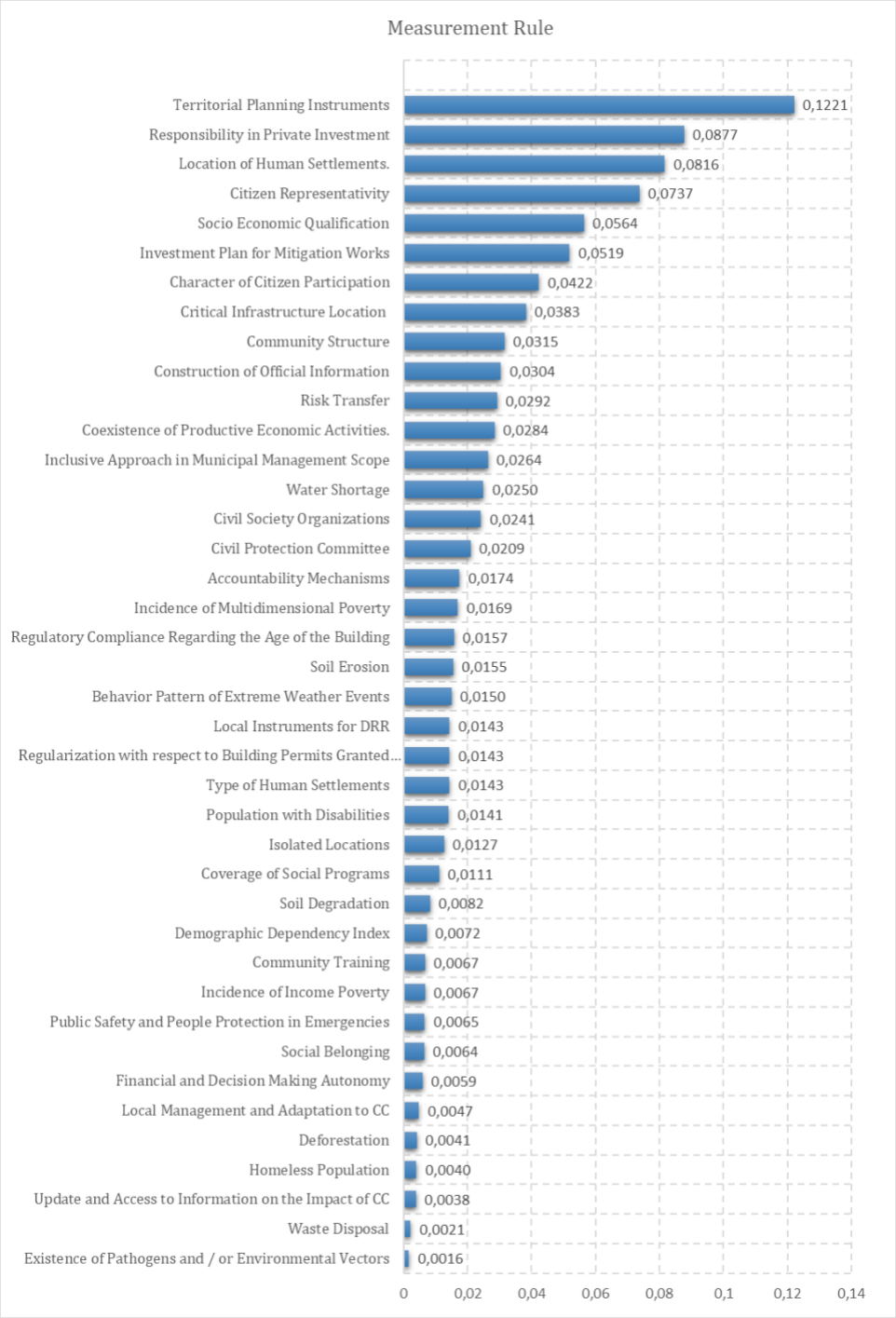
[14] The attention vectors come from a pair comparison matrix, and correspond to the main eigenvector of the comparison matrix. Each level of the hierarchy requires a pairwise comparison matrix from which the vector of priorities results and which defines the importance of the variables belonging to that level.

potential strength of DRR public policies. The second highest weight was assigned to Territorial Ordering, followed by the Socioeconomic and Demographic Conditions, and Climate Change and Natural Resources dimension understood as a modulator of threats and exogenous conditions. Graphic 1 shows the overall dimensions weights in the generic model.

Graphic 1: Model Dimensions Weights



Graphic 2: Measurement Rule built by expert group *criteria*, using the AHP method[15].



[15] Using *Expert Choice* software for processing. The measurement rule is the result of the set of weights of the terminal criteria of the model for the 41 variables.

The hierarchy, the basis of the AHP multicriteria method, is an abstraction of the structure of a decision system, which allows studying the functional interactions of its components and global impact on a system. This method generates indicators for each dimension and an overall indicator for each surveyed local government. The global indicator was named: Communal Underlying Risk Factors Index (CURFI).

Each surveyed local government gets a classification based on their CURFI obtained. The categories estimates are: minimum, low, medium and high-risk levels, obtained after a numerical process of defining thresholds considering the expert criterion.

After the construction of the hierarchical model, the ONEMI team submitted the survey to testing in 4 municipalities considered *as control,* this, given the knowledge that the regional offices of ONEMI (as the coordinating of the National Civil Protection System) have of the municipalities from a multidimensional point of view. In this sense, after the results obtained some adjustments were made in the weights of some variables or some scenarios of answer, so that the model replicated the expected behaviour in those well-known communes in terms of DRM (two municipalities in the Metropolitan Region and two in the south of the country, of rural and urban context and different in size population and available capacities). Once this calibration was done, it was decided to start the massive application of the instrument, which, by the way, provided the national results of the survey are available, can be reviewed, updated and improved if deemed necessary.

3.3. Survey Application

Before the application of the survey by ONEMI members, they contact their focal point at the local government to coordinate the survey workshop and provide, in advance, all materials in electronic formats including sources of official information. The application requires a local government team be composed at least by the following officials: the civil works, social development, civil protection, emergency operations, environment, planning, community participation and priority groups focused programs, among others municipal officials according to the different contexts and capabilities available.

Typically, the application of the survey does not exceed two hours in the company of ONEMI members which act as a facilitator and provides guide and support to the local teams to complete the questionary using the official information sources, which leads to uniform criteria and reliable answers.

Each booklet needs to be signed by those who answered at each dimension, and all questions must be answered to provide all results, report and recommendations.

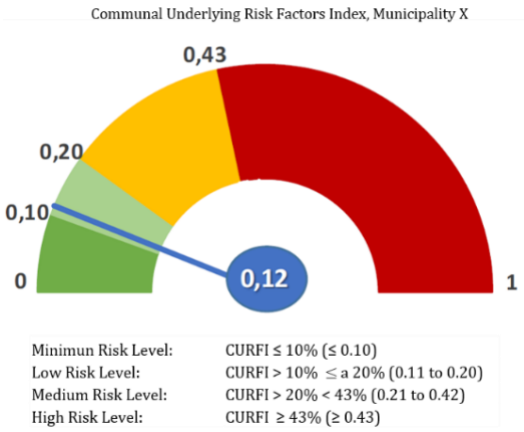
3.4. Processing

An ONEMI member performs a quality assurance and control process contrasting some official information to the provided answers before continuing the numerical analysis of the survey.

The purpose of statistical processing is to provide local governments with an Individual Report, which includes the following items:

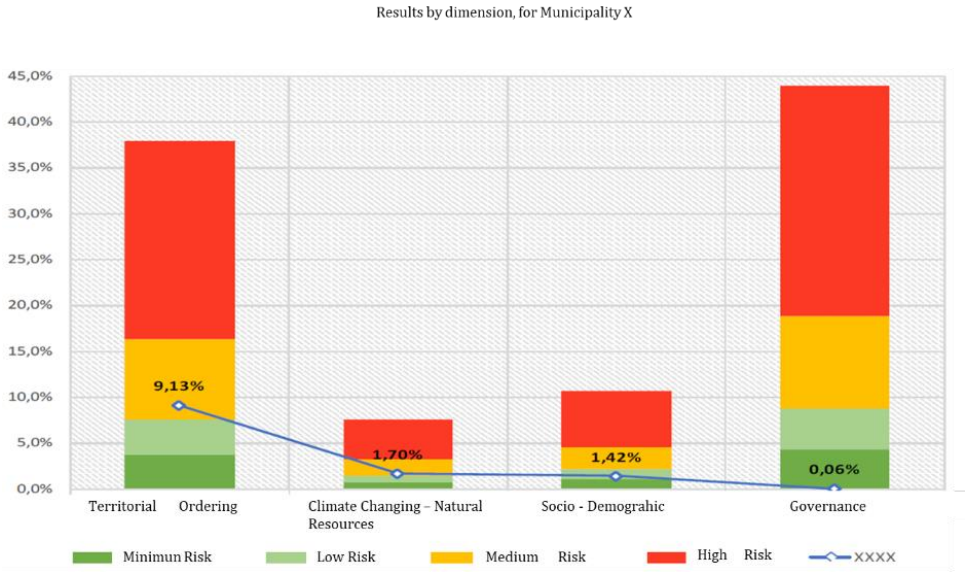
a) Communal Underlying Risk Factors Index (CURFI) indicating the rank in which it classifies, in the manner in which it is exemplified by graphic 3.

Graphic 3: Communal Underlying Risk Factors Index. Example Municipality CURFI=0.12 (12%), i.e. Low-Risk Level.



b) Performance graph by dimension, which allows knowing the level at which the municipality is located for each of the four dimensions (blue line), as exemplified in the following graph.

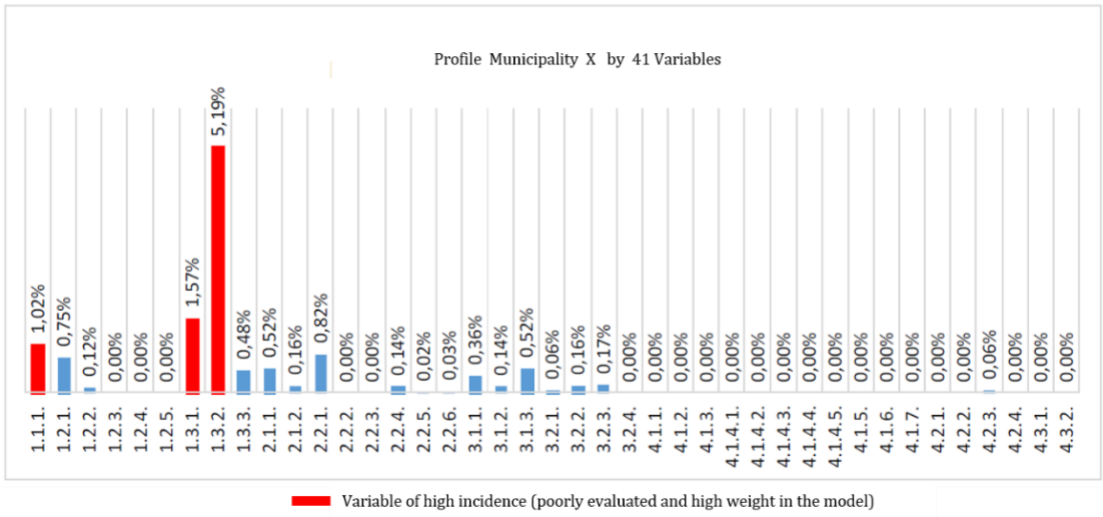
Graphic 4: Results by Dimensions. Example Municipality CURFI=0.12 (12%) Low-Risk Level.



c) Performance profile by variable, which shows the behaviour of the municipality for each of the 41 variables measured. Highlighted in red are *High-incidence variables*, which correspond to poorly evaluated variables and also whose weight is relevant in the model, as shown in Graphic 5. In this way, the Municipality receives advice over variable prioritisation[16], appealing to the efficient use of resources in both structural and non-structural measures.

[16] Those variables that are considered high incidence, imply that their treatment could change the index to the level immediately below, allowing efficient risk management, reducing key underlying factors according to their local reality.

Graphic 5: Profile by Variables. Example Municipality CURFI=0.12 (12%) Low-Risk Level.



d) Set of generic recommendations for those variables with a high incidence to incorporate them as part of the local management goals. Ideally, it is expected that in a period of no more than 3 years to reapply the survey, it is therefore important that the municipal team receives support and technical advice to encourage the consideration of the recommendations given.

4. Partial Results

After a pilot process and calibration of the instrument, survey application initiated in 2017. That year a total of 60 municipalities, distributed nationwide in a representative manner, were sampled[17]. The results, concerning the CURFI show in Figures 1a to 1e.

Complete coverage of all 345 municipalities in Chile is expected to be achieved by the end of 2019.

[17] For the first year of application, it was required to survey at least one municipality per province. There are 53 provinces in the mainland, excluding island and Antarctic territory. During 2018, around 120 municipalities were surveyed, which are not analyzed in this paper.

Figure 1 a: Communal Underlying Risk Factor Index, 2017 Sample (60 municipalities).

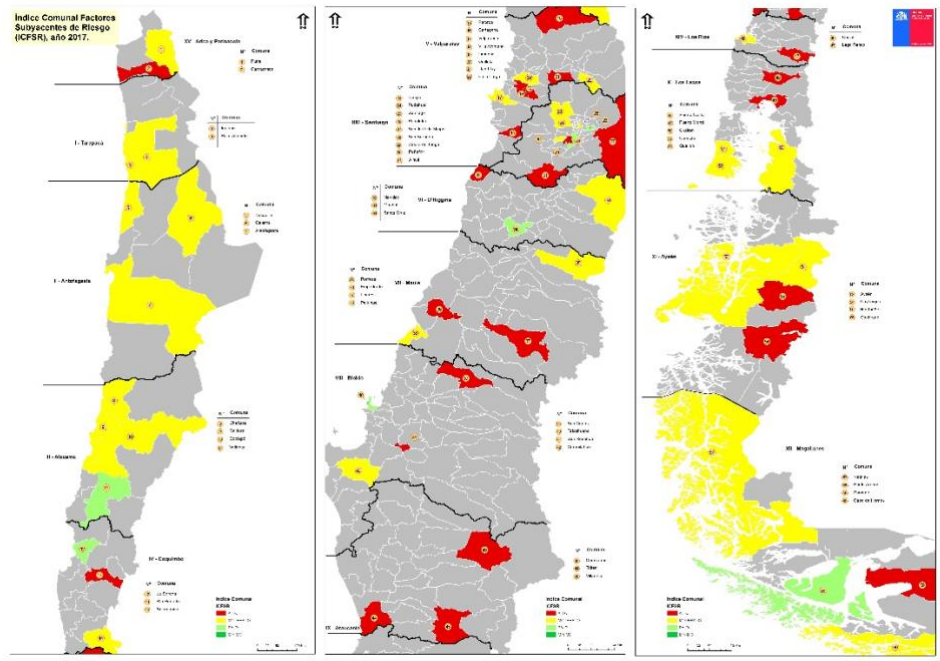
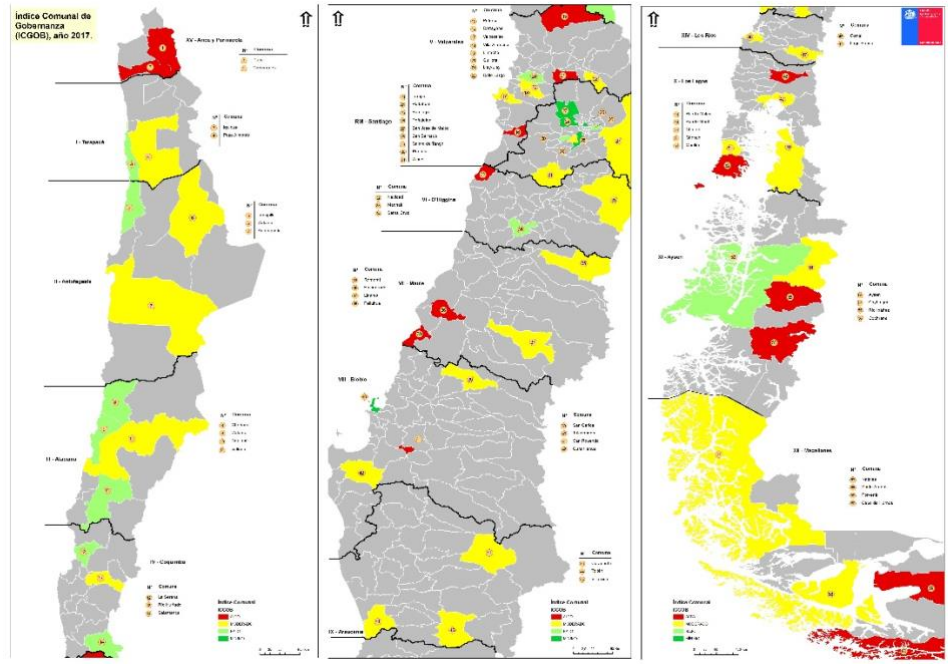
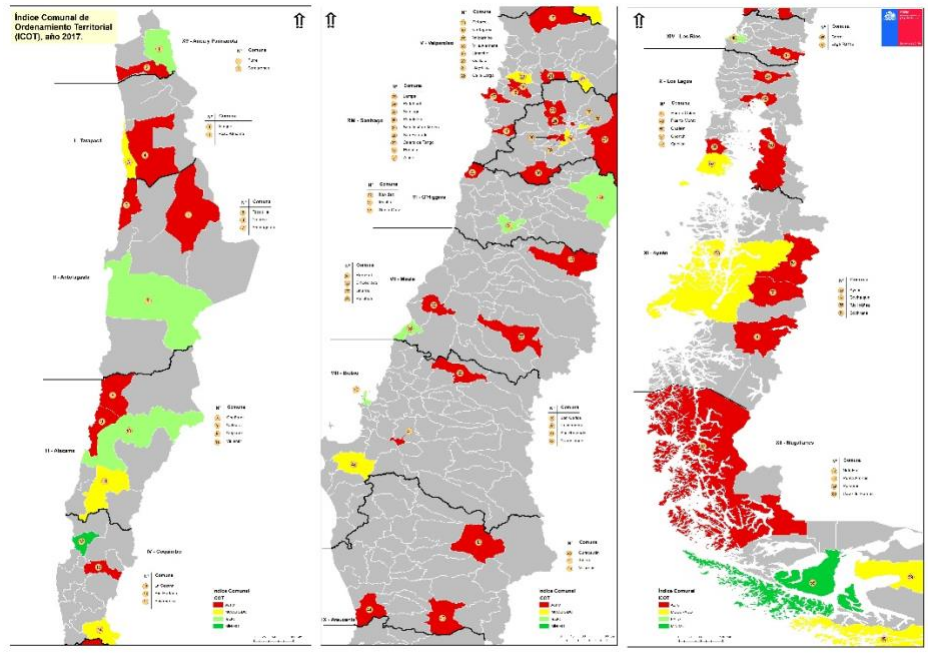


Figure 1 b: Communal Underlying Risk Factor Index, 2017 Sample. Governance Dimension.



CI_GOV ≤ 4.39 | 4.40 < CI_GOV ≤ 8.78 | 8.79 < CI_GOV < 18.88 | CI_GOV ≥ 18.89

Figure 1 c: Communal Underlying Risk Factor Index, 2017 Sample. Territorial Ordering Dimension.



CI_TO ≤ 3.79 | 3.80 < CI_TO ≤ 7.58 | 7.59 < CI_TO < 16.30 | CI_TO ≥ 16.31

Figure 1 d: Communal Underlying Risk Factor Index, 2017 Sample. Socio-demographic Dimension.

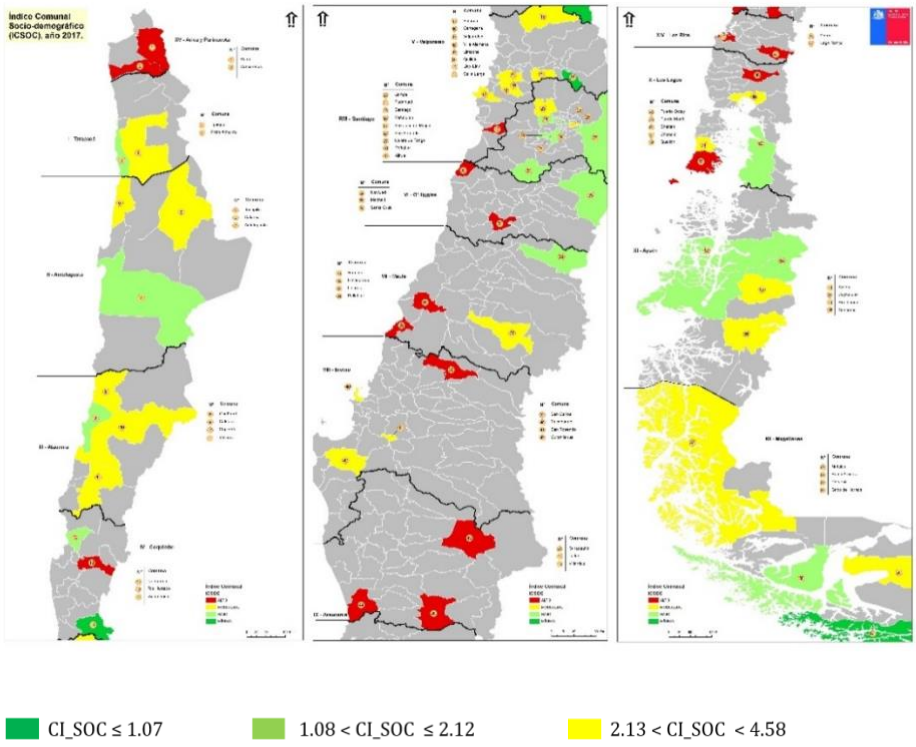
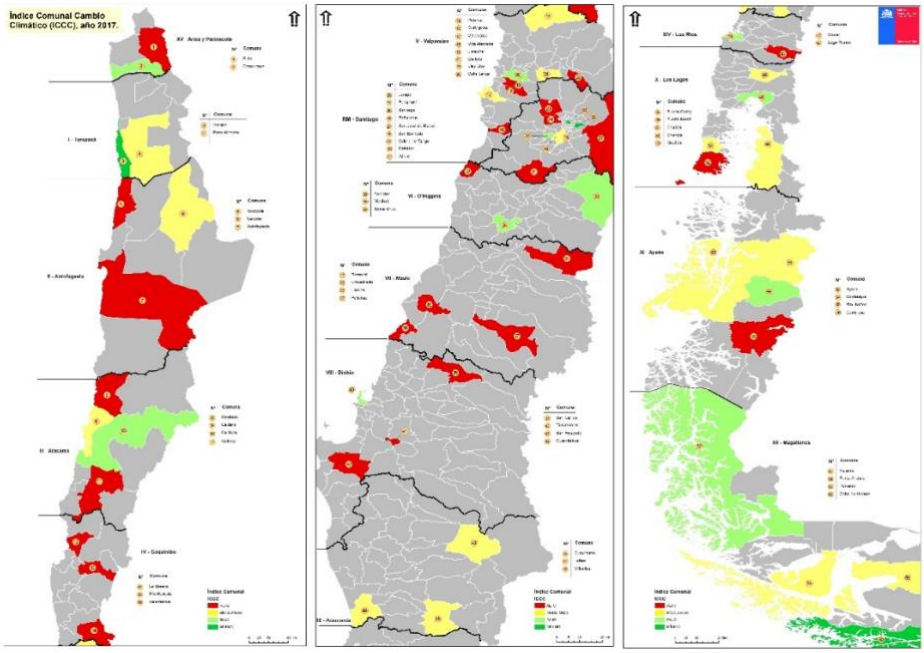


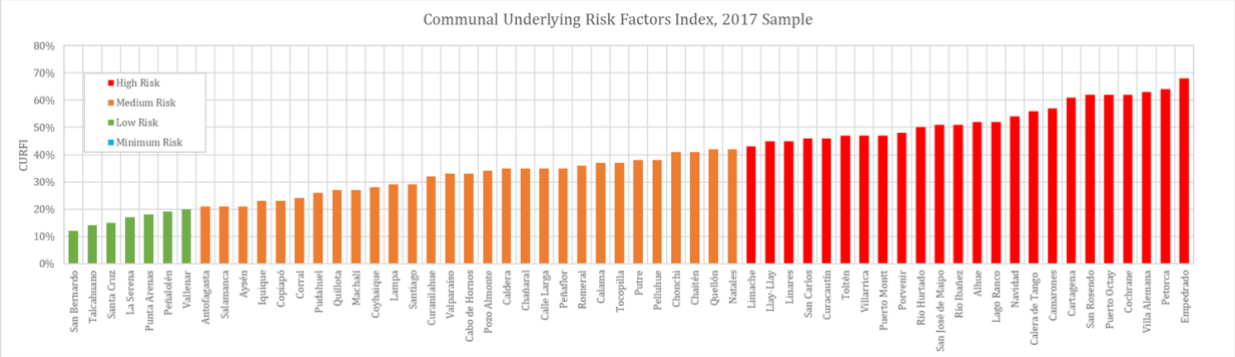
Figure 1 e: Communal Underlying Risk Factor Index, 2017 Sample. Climate Change – Natural Resources Dimension.



CI_CC ≤ 0.75 | 0.76 < CI_CC ≤ 1.50 | 1.51 < CI_CC < 1.72 | CI_CC ≥ 1.73

The following summary graphic shows the risk management performance obtained by the 2017 sample. Municipalities are ranked by CURFI (Figure 1a) from better to worse performance.

Graphic 6: Communal Underlying Risk Factors Index (CURFI), 2017 Sample.



Graphic 6 shows that no municipalities obtained a Minimum level (CURFI ≤10% or 0.10), about 10% of the sample have a Low CIURF, 50% of the sample has a Moderate level and 40% showed High-level risk.

It is important to note that the same global index (CURFI) can be obtained from different conditions, so a comprehensive assessment should be made using the performance profile for each of the 41 variables allowing understanding the singularities of each local government and to prioritised initiatives.

The sample of 2017 corresponds to 20% of the total of municipalities in the country, involves 25% of the Chilean population, covers all the provinces of the country and are mostly of urban or semi-urban character. About 60% of the selected municipalities have an income poverty index higher than the national average percentage.

Concerning urban planning instruments, 73% of the sample indicates having a Communal Regulatory Plan (not necessarily updated), and regarding integral growth strategies, 95% of the municipalities evaluated declares having its current Community Development Plan (PLADECO).

50% of the municipalities in the sample have a high level of dependency on the Common Municipal Fund[18] (that is, low generation of own resources and direct dependents of the distribution of the fund), while only 17% of the communes in the sample, it has a low dependency (high capacity to generate own resources).

It is important to emphasise that what this methodology seeks is to focus on those variables that have a high impact on the model. The reason for latter is that a wrongly evaluated variable that weighs little, its remediation may not have such a strategic or practical impact on management local as if it could have the attention of a poorly evaluated variable, but of high weight in the model.

The main findings after analysing the sample are:

a) The rural to semi-urban municipalities classified as medium or low development, according to the national standard[19], present a high-risk level in the dimension of Territorial Ordering.

b) The municipalities that show a moderate to low dependence on the common municipal fund have a low risk in all the evaluated dimensions, related to greater financial autonomy and own or self-management of resources.

c) The municipalities with lower percentages of poverty by income are better evaluated in all the dimensions, showing a low level of the CURFI.

d) A high percentage of communes with a low level of the CURFI have low urban growth in the last 15 years.

[18] The Municipal Common Fund is the primary source of financing for Chilean municipalities, as defined by the Political Constitution itself in Article 122: "Mechanism of solidarity redistribution of own revenues among the municipalities of the country".

[19] This category of SUBDERE classifies the communes according to their degree of urbanization and development, distinguishing five communal typologies that move between large metropolitan communes and semi-urban and rural communes.

5. Conclusions

The development of this instrument represents a pioneering effort to capture the different features that shape vulnerability and guide effective disaster risk management at the local level. We advocate that the creation of this tool allows local governments to participate in the process of identification, management and monitoring of the diagnostic situation detected after the application of the survey.

The instrument represents direct benefits as exposed, but also encompass numerous indirect benefits as observed during its application. Among the latter is facilitating work among various areas of the municipality, discuss topics not in direct association with DRM, provide background and current data of each municipality, just to name a few detected.

It aims to strengthen the governance of local administrators to reduce the risk disasters factors presents, allowing to address those conditions of existing vulnerability in order to accept, reduce, mitigate or transfer local risk. Given that there are threats that go beyond the administrative limits, it is crucial to promote collaborative work with other local governments that share similar realities, being able to promote projects or joint initiatives, share good practices, engage and sensitise external actors to the communal territory that affect the local disaster risk management.

Based on the available data and the relationships evidenced in different countries of the world, Chile carried out the exercise of appropriation of the concept and adaptation to the national and cultural context, building a standard methodology that can be adapted and adopted by other countries to identify and characterize these risk - driving conditions, such as the underlying risk factors.

Given the importance of the process of capturing information, yet also its potential complexity because it is a new management instrument in the country and requires the transversal participation of the municipality, is that the survey considered a process of accompaniment carried out by ONEMI. Moreover, it is expected to follow up on the recommendations delivered within a period not exceeding three years, understanding the dynamism of some risk conditions and new background that may arise from official sources used in the survey. Therefore, the importance of accompanying from the national level and regional the processes of implementation of structural and non-structural measures/initiatives that municipalities consider following this evaluation. Also, it is essential

to understand that there are different approaches for the reduction of risk drivers, some from community-based DRR, as well as alliances between local governments or between public and private sector.

Given the multidimensional nature of the survey, there can be multiple analyses that derive from the results obtained. About the 2017 sample, it was decided to verify if there is a relationship between the indicators obtained and some conditions that are recognised internationally as drivers or aggravating risk. The conclusion is that there is a direct relationship between income poverty, accelerated urban development, deficient territorial planning and scarce financial resources destined to mitigate the present risk, with conditions of high predisposition to disaster risk. This partial conclusion must be validated whenever the behaviour of all the municipalities present in the country is known.

Finally, this instrument is expected to contribute to effective disaster risk management at the local level by favouring the attention on conditions of potential vulnerability that compromise the country's sustainable development. In the same vein, it invites all actors of the National Civil Protection System to know the results, focus measures, and generate collaborative alliances towards a sustained and inclusive disaster risk reduction to foster a culture of prevention.

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