Article

Local Politics of Environmental Disaster Risk Management: Institutional Analysis and Lessons From Chile

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Abstract

Why do some local governments successfully address issues related to environmental disaster risk management (EDRM), while others do not? This research contributes to a growing literature about the relationships between institutions, multilevel governance, and EDRM at the local level in developing countries. Supported by the frameworks of institutional analysis and polycentric governance, as well as an in-depth case study of three municipalities in Chile (Cauquenes, Lebu, and Panguipulli) with data from primary sources (e.g., interviews, surveys applied to representative samples of householders, and archival research), this study identifies the types of institutional responses that appear to improve governance outcomes. The analysis reveals that municipal operational rules combined with representation, municipal structures, institutional trajectories, and polycentric relationships between municipal governing councils and society are influential factors for successful EDRM.

Keywords

environmental management, disaster risk reduction, institutional arrangements, polycentricity, municipalities

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The central puzzle of this research is why there is such great subnational variation in public decisions about environmental disaster risk management (EDRM) in a developing-country context. This is of particular interest given that all subnational units have access to the same public programs, are part of the same national governance regime, and are subject to the same public policies. We address this question through an institutional analysis with a focus on local institutional arrangements and polycentricity, which seeks to disentangle how these institutions affect decisions, actions, and outcomes with regard to EDRM.

In line with holistic international frameworks and a growing literature, our study aims to explain decisions and outcomes in EDRM at the subnational level: for example, financial and human resources and investment, planning and procedures or protocols, structural and nonstructural measures, environmental protection measures and actions, environmental impact assessment, risk reduction actions, citizen education, and involvement (Intergovernmental Panel on Climate Change [IPCC], 2012, pp. 421–424). We use the term *EDRM* when we refer to these decisions, activities, and outcomes.

The institutional analysis for the study of EDRM integrates several factors and relationships that influence individual and organizational behaviors, decisions, and outcomes (e.g., McGinnis, 1999; E. Ostrom, 1990, 2005). In this article, we consider polycentricity as particularly important for EDRM analysis (E. Ostrom, 1990, p.135; V. Ostrom, Tiebout, & Warren, 1961, p. 831). A polycentric order is conceptualized as a complex system of nested jurisdictions, where interactions of linked autonomous agents and rules operate at various scales. Decisions and outcomes in one dimension or scale affect decisions at other levels (Andersson & Ostrom, 2008, pp. 71, 74–76; McGinnis, 1999, p. 6; E. Ostrom, 2005, pp. 60–61; V. Ostrom et al., 1961, p. 831).

Chile is an interesting case for this type of institutional analysis because Chilean municipalities are threatened by environmental degradation and disaster risk but have modest performance and notorious variation in EDRM outcomes (Barton et al., 2014; Economic Commission for Latin America and the Caribbean [ECLAC], 2012; IPCC, 2012; Sánchez, 2010; World Bank, 2009). This study aims to generate quality information and useful analysis for scholars and decision makers on institutional factors of EDRM. Employing institutional analysis, we study three Chilean municipalities affected by environmental degradation and natural disaster risks but with differences in EDRM outcomes during the period 2008 to 2014. We use qualitative and quantitative methods to do a contextualized analysis of why these outcomes differ even though the three sites appear to face very similar environmental risks. Our methodology allows us to generate parameters for these three sites based on information from primary sources (e.g., interviews, surveys applied to representative samples of householders, and archival research).

We develop and examine an argument about the effects of institutional arrangements, polycentric relationships, and social resources on decisions

related to EDRM. Our theoretical framework and research on the three municipalities suggest a more complex relationship between inputs and outcomes than previously discussed in the literature. The comparison enables us to specify how combinations of these factors explain variation among the municipalities. The three municipalities differ when it comes to their operational rules and representation in municipal councils, internal municipal organization, routines during municipal council meetings, and patterns of interactions of municipal structures with social organizations and other actors with jurisdiction in EDRM.

Our research shows that knowledge of the barriers and opportunities for EDRM can be enriched through institutional analysis and a multisystem perspective on how local governments make their decisions and how institutional arrangements and polycentric interactions generate incentives for decision makers.

Literature Review and Theoretical Framework

Previous Literature

During the past two decades, scholars have made great strides in showing how local governments may contribute to EDRM (e.g., Agrawal & Ribot, 1999; Anguelovski & Carmin 2011; Anguelovski, Chu, & Carmin, 2014; Burch, 2010; Cashmore & Wejs 2014; Groven, Aall, Van den Berg, Carlsson-Kanyama, & Coenen, 2012; Measham et al., 2011; Mees & Driessen, 2011; Van den Berg & Coenen, 2012; Wilkinson, 2012). In addressing this broad subject, often under diverse local conditions, this literature draws attention to factors and processes occurring within municipalities, such as legitimacy and institutionalization, administrative and managerial capacities, human and financial resources, patterns of institutional organization, organizational culture, and procedures, which are identified as institutional barriers and enablers that appear frequently in different contexts (Anguelovski & Carmin, 2011, pp. 170–171; Anguelovski, Chu, & Carmin, 2014, p. 157; Burch, 2010, pp. 7579–7581; Groven et al., 2012, pp. 680–689; Cashmore & Wejs, 2014, p. 208; Mees & Driessen, 2011, pp. 279–280; Van den Berg & Coenen, 2012, p. 442). According to this research, opportunities to enhance governance capacity and effective EDRM at municipal level lie in reforms to facilitate institutionalization, coordination, and support for EDRM across departments (e.g., specialized units, regulations, policies, codes, programs, assessments and plans, and coordination procedures), integration of adaptation considerations into land-planning processes, links among environmental, adaptation, and mitigation policies, investment in training programs, and infrastructure for learning processes, integration of climate change adaptation policies into disaster risk reduction through administrative changes, procedures, and planning, managerial

efforts for integration within departments, and personnel policies related to the environment (Anguelovski & Carmin, 2011, p. 171; Groven et al., 2012, pp. 680–689; Mees & Driessen, 2011, pp. 279–280; Van den Berg & Coenen, 2012, pp. 456–458). These studies support the theoretical expectation that progress results from introducing changes and reforms in municipal structures to institutionalize EDRM.

The decentralization literature argues that decentralization policies may lead to better outcomes, strengthening legal, administrative, and financial capacities of municipalities for EDRM (e.g., Ribot, 2002; Twigg, 2004). However, EDRM decentralization policies have had mixed results (e.g., Agrawal & Ribot, 1999; Andersson & Ostrom 2008; Andersson & van Laerhoven, 2007; Gibson & Lehoucq, 2003; Libecap, 1989; E. Ostrom, 1990, 2001; Wilkinson, 2012). Decentralization research contains evidences that it does not necessarily lead to better local governance and improvements in EDRM because of the lack of transfer of necessary capacities, reinforcement of power asymmetries and inequalities in society, conflicts among users of common pool resources, and unsustainable management of environmental resources (Andersson & Ostrom 2008, p. 82; Andersson & van Laerhoven 2007, p. 1091; Gibson & Lehoucq, 2003, p. 29; Ostrom, 1990, pp. 111–112; Wilkinson, 2012, pp. 156–159).

Social capital (SC) has also been described as a resource with the potential to influence EDRM (e.g., Adger, 2003; Putnam, 1993; Wilkinson, 2012). Bonding ties may transform into networking relationships and linking SC, defined as ''norms of respect and networks of trusting relationships between people who are interacting across explicit, formal or institutionalized power or authority gradients in society'' (Szreter & Woolcock, 2004, p. 655).

The literature on participatory democracy, good governance, new institutionalism, and linking SC stresses the importance of relationships between the broader society and local institutions for EDRM (e.g., E. Ostrom, 1990; Szreter & Woolcock, 2004; Woolcock & Narayan, 2000). Case studies in different contexts document positive effects of inclusion of citizens and social organizations in municipal programs (e.g., Ackerman, 2004).

New institutionalism and linking SC literature focuses specifically on relationships between the three forms of SC (bonding, bridging, and linking), local institutions, and EDRM outcomes (e.g., Aldrich, 2011; E. Ostrom, 1990, 2005; Rubin, 2015; Szreter & Woolcock, 2004; Vervisch & Titeca, 2010; Vervisch, Vlassenroot, & Braeckman, 2013). While some studies highlight the positive process of coproduction resulting in innovative solutions to complex environmental management problems, authoritarian practices have been linked to the exclusion of vulnerable populations in communities affected by environmental conditions (Aldrich, 2011; Rubin, 2015; Szreter & Woolcock, 2004; Vervisch & Titeca, 2010; Vervisch et al., 2013).

Examining a large number of municipalities in Bolivia and Guatemala, Andersson (2003, pp. 14, 22–23) and Gibson and Lehoucq (2003, pp. 30–33) present evidence that interactions of autonomous citizens, social organizations, and nongovernment agents with municipalities increased the likelihood of actions by local governments and had positive effects for forest conservation activities. Szreter and Woolcock (2004, p. 658) illustrate the experience in Britain in the health sector in the last quarter of the 19th century. The authors document that linking SC and institutional agents articulated by Mayor Chamberlain enabled a process of coproduction of innovative solutions to solve complex problems of water supply and sanitation. The balance of SC in three forms—bonding, bridging, and linking—may be the foundation for robust local institutions and sustainable EDRM outcomes (Szreter & Woolcock, 2004, pp. 600, 659–660). In municipalities of Guatemala, Perú, and Bolivia, Andersson and Ostrom (2008) show the effects of social organizations on local government incentive structures and forest conservation. In a comparative study of many rural villages in different countries on three continents, Andersson and Agrawal (2011) demonstrate that the existence of local institutions for collective action in communities have positive effects on forest conservation.

However, studies in other contexts show that linking SC may have different effects on SC formation and EDRM outcomes. Vervisch and Titeca (2010, pp. 497–501) document four aid intervention cases in rural areas of postconflict Burundi, where a linear evolution from bonding into bridging and linking capital did not occur. Linking social organizations created through technical and participatory approaches for improvement of irrigation systems, recovery of eroded soils, and rice commercialization ended when incentives ran out. In another case, farmer associations with a cooperative were under the control of local elites with patronage and clientelist practices. In these cases, historical experiences, features of institutions, and power relations in society were factors influencing possibilities and trajectories of associational life. In a study of communities affected by tsunamis and floods in Tamil Nadu, India, Aldrich (2011, pp. 90–92) researched four villages with fishing communities and a high degree of bonding, with social councils (i.e., linking SC) controlling social order as gatekeepers between people at risk and aid for recovery, excluding population. Two other villages without councils and with less bonding SC had more difficulties in recovery. In other words, communities with bonding and linking SC may have better chances for recovery, but negative influences such as discrimination against nonmembers get in the way. Analyzing food security in communities of Burundi affected by civil war, violence, and floods, Vervisch et al. (2013) report horizontal networks of households, relatives, and friends with cooperation activities (i.e., bonding SC) facilitating access to nonstrategic resources, lower stocks of networks (bridging SC), paternalistic cooperative and church associations, and authoritarian networks with vertical relationships and control

mechanisms (linking SC). While bonding SC decreased as a consequence of conflicts, linking SC increased by vertical relationships to address food security, thus reinforcing the lack of bargaining power in markets, labor dependence, and impotence in the community. In another study on SC and communities threatened by floods in the Quang Nam Province of Vietnam, Rubin (2015) shows low levels of bonding capital and links between the Communist Party and social organizations. Most householders participated in formal associations related to the Communist Party, receiving support from the authorities in times of floods. Disaster preparedness and mitigation consisted of informational announcements by the authorities and infrastructure measures such as roads, drainage systems, and dikes, without community involvement. Rubin concludes that this is an unresponsive SC that depends on the will of and control by the authorities.

During the past two decades, Chilean national policies have introduced institutional reforms in municipalities, such as internal restructuring, management improvement, certification procedures, transparency, increased participation, and environmental and emergency offices, with the clear purpose of improving performance of and strengthening EDRM (Ministry of Environment, 2011; Organisation for Economic Co-operation and Development/Economic Commission for Latin America and the Caribbean [OECD/ECLAC], 2016; National Emergency Office [ONEMI], 2014; Subsecretary of Regional and Administrative Development [SUBDERE], 2016; Valdivieso, 2012; Valdivieso & Bernas, 2014; Valdivieso & Vallejos, 2014; World Bank, 2009). Local governments have the ability to allocate budgetary and human resources to EDRM, develop plans, and create specialized departments to balance risk exposure and vulnerability, national policies, and municipal reforms. However, persistent environmental degradation and recurring experiences with disasters reveal high variation in municipal EDRM success (e.g., Barton et al., 2014; Sánchez, 2010). We conclude that national legislation, decentralization, reforms in municipal structures, and more mechanisms for social participation taken in isolation do not provide sufficient insights to explain observed patterns of EDRM variation. Considering only one influencing factor at a time limits the analysis to a particular level of governance and factors or actors at this level. In view of this limitation, we have built a framework that enables us to integrate several influencing factors in a system-level analysis.

Framework

The theories of institutional arrangements and polycentric governance offer a suitable framework for multilevel analysis of EDRM (Andersson & Ostrom, 2008; McGinnis, 1999; E. Ostrom, 1990, 2005; V. Ostrom et al., 1961). Considering these theories and previous research on Chilean municipalities, we begin with some conceptual clarifications and background information for the development of our theoretical propositions (Valdivieso, 2012; Valdivieso & Vallejos, 2014).

Micro-institutional theory recognizes that the contexts in which EDRM decisions are made are affected by complex and dynamic physical, biological, and social conditions (E. Ostrom, 1990). These conditions give rise to uncertainties and information gaps that have consequences in decision-making processes. Chilean communal contexts are complex, geographical entities composed of diverse physical, human, and environmental conditions changing over time. Available information and knowledge about these conditions are incomplete, and as a result, Chilean municipalities operate with information gaps and uncertainty, especially regarding EDRM issues.

Institutional analysis also focuses on repeated decisions and outcomes (E. Ostrom, 1990, p. 8). Chilean local governments, including a mayor and six to eight councilors elected to 4-year terms, meet semimonthly to make decisions related to community plans, expenditures, investments, and municipal programs. As such, municipal EDRM is the result of repeated decisions made by local governments.

Chilean municipalities have structured systems to guide behavior, which consist of operational rules with the ability to influence local government decisions. Operational rules prescribe what is permitted, prohibited, or required, such as powers and responsibilities of the mayor and councilors, internal organization of the council and the municipality, information to be considered by the council and municipal offices, tasks and responsibilities of different departments and officials, and procedures to consider in each field of action, monitoring, and compliance.

Many Chilean local governments tend to ascribe relatively low values to distant benefits such as EDRM outcomes. They work with a large number of issues competing for a place in municipal agendas and resources, incomplete information about issues and behaviors of others, uncertainty on environmental conditions and risks in the community, and less clarity about the net benefits of EDRM in terms of visibility, electoral support, and other returns. Therefore, the discount rates for decision actors in these types of situations tend to be high (E. Ostrom, 1990, pp. 34–35, 37).

In the theory of polycentricity, local government decisions and outcomes are affected by rules, decisions, and outcomes of organizations operating at other levels of governance (Andersson & Ostrom, 2008, p. 73; McGinnis, 1999, pp. xii–xiii; E. Ostrom, 2005, pp. 60–61). In each level, organizations operate and make decisions according to their contexts and constraints, institutional arrangements, available information, and incentive structures. The information, resources, and capabilities of one level may help overcome problems of information and restrictions on another level. Particularly illuminating in polycentric theory is the focus on multiscale relations that affect the incentive structures of decision makers. Empirical research on polycentric governance supports the expectation of polycentric relationships affecting EDRM performance (e.g., Andersson & Ostrom 2008, p. 74; Gibson & Lehoucq, 2003, p. 30; Horning, 2005, p. 149).

Applying this framework to our research questions leads us to articulate five basic institutional conditions that favor effective EDRM in Chilean municipalities. First, environmental conditions and risks are viewed as problems or relevant issues by a large number of local actors. Second, local governments may consider EDRM issues only if those issues actually enter the municipal agenda. Third, operational rules and organizational conditions—interactions, coordination, and routines—may function as barriers or enablers in this process. Fourth, polycentric relationships have the potential to provide additional information and resources for EDRM. Fifth, municipal institutional arrangements combined with polycentric dynamics may increase the likelihood of successful EDRM outcomes.

This framework opens the possibility for a contextualized analysis and exante theoretical propositions to be examined through empirical field observations (E. Ostrom, 1990, 2005). First, we propose that variations of EDRM outcomes at municipal level depend on the nature of institutional arrangements, particularly operational rules and the flexibility of municipal structures (e.g., autonomy in municipal council, responsibility, representation, planning, and spaces for coordination and collaboration). These conditions affect incentives, evaluations, and routines of those involved in municipal decision-making processes, and they mediate the effects of other factors, such as decentralization and national EDRM policies. Second, we propose that polycentric relationships combined with municipal institutional arrangements may increase the likelihood of effective EDRM, particularly relationships between municipalities and society with information and jurisdiction in EDRM.

Research Design

Case Study Selection

In selecting our cases, we began by focusing on municipalities (communities) in central-southern Chile, where 86% of the population lives. These municipalities have similar administrative and budgetary structures and are affected by disaster risks and deterioration of environmental conditions. We searched cases by identifying municipalities with populations at risk with regard to social, economic, and environmental conditions, such as natural resource dependency and rurality, socioeconomic fragility, habitability, and frequency of natural disasters. Eighty-three highly vulnerable communities were identified. We adopted purposive sampling criteria to find illustrative cases—representativeness of Chilean geography (mountain, valley, and coastline), environmental conditions, socioeconomic indicators, and availability and access to information and data. From this process, we identified Cauquenes, Lebu, and Panguipulli (Figure 1). Approximately one third of the populations in these localities live below the poverty line. These communities rank in the lowest one third of the Human Development Index among municipalities in Chile, have environmental

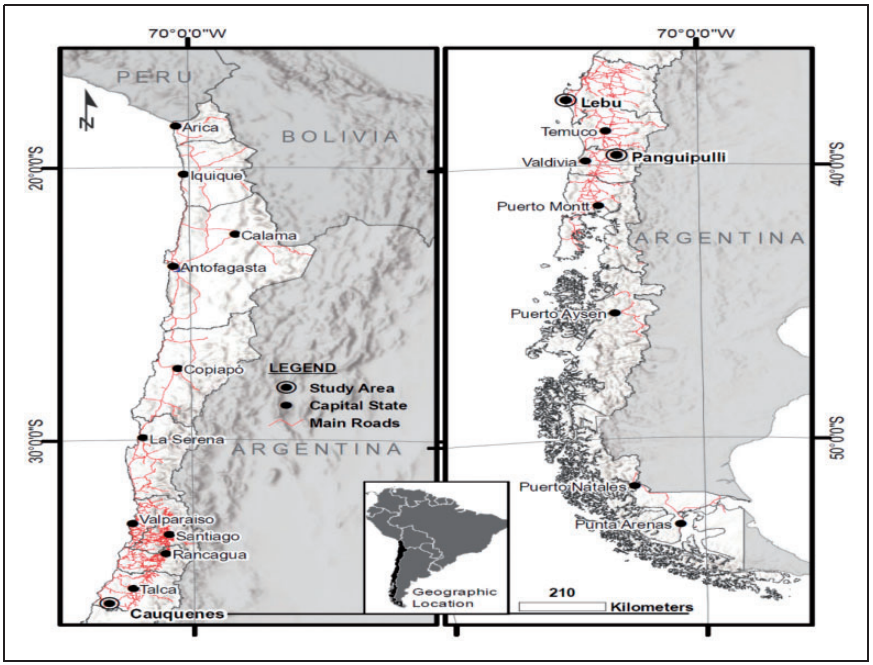

Figure 1. Selected municipalities.

challenges due to overexploitation of natural resources (marine, soil, and forest), and have experience with and are at risk for recurring natural disasters (earthquakes, tsunamis, volcanic eruptions, floods, and forest fires). In searching for information on these communities, we also discovered contrasting EDRM outcomes. While records from Cauquenes and Lebu indicate a lack of investment and conditions for good EDRM performance, Panguipulli appears to enjoy much better institutional conditions and have both greater investment and better outcomes.

Sources and Methodological Steps

Between 2014 and 2016, we collected information and quantitative data from primary and secondary sources in these three sites. The research team (eight individuals) conducted semistructured interviews and focus groups with qualified informants: municipal officials such as mayors, directors of planning or environment, and emergency personnel (12 for all three municipalities), social leaders (13), and householders (140). The respondents provided information regarding communal contexts (e.g., socioeconomic characteristics, environment, and risks), local governments' EDRM decisions and outcomes (e.g., budgets,

investments, and activities), municipal regulations, polycentric relationships between local governments and internal and external agents, and social participation.

We designed a questionnaire and applied it to representative samples of households in each community (Panguipulli 210, Cauquenes 200, and Lebu 200). The design, validation, and application included seven steps: (a) operationalization of information of preliminary analysis, concepts, and terms contained in the literature, questions used in other EDRM surveys, and consulting experts; (b) inclusion of 30 questions about experiences with and perceptions of environmental conditions and risks, municipal activities in neighborhoods, social resources, demographic information; (c) statistically representative sample selection ($n > 30$ per municipality); (d) training of research team and 10 social work students; (e) household registration and application in Panguipulli; (f) examination of results in four focus groups and workshops; and (g) adjustments and application in Cauquenes and Lebu.

In searching for relationships between institutional arrangements, polycentricity, and EDRM decisions and outcomes, we identified municipal spaces that met the following criteria: (a) routines in repeated situations where individuals make decisions, (b) operational rules with effects on decisions, (c) possibilities of relationships with external agents, and (d) accessibility to accurate documentation. Municipal councils meet these specifications. Municipal departments generate information for municipal decisions and implement them. Planning departments and environmental and emergency offices were particularly important for our analysis.

Municipal councils have relationships with external actors through public hearings and correspondence. We made the analytical distinction between unidirectional, bidirectional, and multidirectional relationships: (a) Unidirectional interactions consist of input or output information; (b) bidirectional or reciprocal relationships occur when, for example, an organization submits a request and the council makes a decision and responds in support of the request, promising municipal resources, or denies the request; (c) multidirectional relationships occur when the council interacts with a third party, for example, when the response to a request requires the intervention of another organization. Assuming that bidirectional and multidirectional relationships increase the likelihood of information flows, coordination, cooperation, and coproduction processes, we quantified information for the 1-year period of 2014. For each municipality, data were stored in a matrix, where each row represents an EDRM topic addressed by the council, columns represent the multiple actors with which the council interacts with respect to EDRM, and attributes of these relationships.

When documenting these cases, we populated databases with information from primary sources on EDRM decisions and outcomes, municipal councils, and municipal structures: investments, expenditures, measures and activities, internal regulations, municipal organizations, departments, staff, and

internal interactions. For the analysis of social resources, interactions with the municipality, and EDRM activities, we triangulated information from household surveys, interviews, and archival municipal records.

While examining theoretical propositions, we designed indexes of EDRM outcomes (dependent variable) and institutional factors (independent variable) (see Table A1). For EDRM outcomes, we included (a) ''Topics'' addressed by each local government during 1 year (45 meetings on average), (b) ''Emergency Funds Surplus''[1] based on longitudinal data on municipal budgets between 2008 and 2014, (c) ''Municipal Investments'' between 2011 and 2014, (d) ''Investments by NIS'' entered into the National Investment System, (e) Municipal ''Top-Down Activities'' based on a list of 18 aspects identified in the literature (e.g., IPCC, 2012; UNDP, 2004; United Nations International Strategy for Disaster Reduction [UNISDR], 2005; World Bank, 2010), (f) ''Fieldwork'' carried out by municipal workers, and (g) ''Reported Activities'' by surveyed householders. We express these EDRM indicators in proportions.[2]

Eleven indicators represent three categories of explanatory factors of institutional arrangements, polycentricity, and social resources: (a) ''Councilors' Autonomy'' quantifies regulatory information on operational rules with binary criteria (0,1), such as restrictions on councilors' interventions during meetings, access to municipal information, and accountability procedures; (b) ''Coordination''; and (c) ''Planning'' committees quantify the existence of operational rules and structures facilitating interactions between departments and personnel and relationships among planning, environment, and emergencies; (d) ''EDRM Staff'' is the proportion of municipal staff working on EDRM; (e) ''Education'' is the proportion of municipal staff with degrees; (f) ''Interactions'' represents the proportion of council interactions with external agents; (g) ''Bidirectional''; and (h) ''Multidirectional'' are proportions of interactions representing reciprocity and collaboration; and percentages of householders reporting (i) bonding, (j) networking, and (k) linking capital.

Contextualized Analysis of Cases

We have structured our analysis of each case into four topics: (a) context, (b) municipal institutional arrangements and polycentric relationships, (c) social resources and municipality, and (d) EDRM decisions and outcomes.

Cauquenes

Context

Due to geographical conditions, Cauquenes is affected by frequent droughts and forest fires in summer, floods in winter, and earthquakes. The 2010 earthquake

was particularly strong, registering 8.9 on the Richter scale. Furthermore, overexploitation of natural resources since the 19th century (e.g., soil, forest) and contamination have damaged environmental conditions (Cauquenes, 2010).

During 2008 to 2014, at least one third of householders were at risk due to socioeconomic fragility and lack of basic services, that is, more than three members with monthly income less than $873 USD, low educational level, fragile housing conditions, and inadequate sanitation. Surveyed and interviewed householders reported that extreme events and natural disasters caused interruption of usual activities and damages, particularly decreases in agricultural productivity, shortages of basic goods and services, increased prices, and worse health conditions.

Municipal Institutional Arrangement and Polycentric Relationships

Since 2000, the local government has modernized the municipal structure following guidelines of national legislation and decentralization policies (Cauquenes, 2010; SUBDERE, 2016). This has included introducing internal regulations, changes in municipal structure, new managerial procedures, offices of environment and disaster risk reduction, civil protection plans, environmental ordinances, and participatory goals and programs (interviews with municipal officials, July 2014).

During 2008 to 2014, the council's internal regulations gave broad authority to the mayor to run the municipality and the council sessions and to control information flows (e.g., agenda topics, voting procedures, and sanctions). The mayor was represented in the council's study commissions and authorized external actors' access to municipal offices and hearings. Moreover, the ordinance of citizen participation prescribed 100 signatures to require hearings. The municipal internal regulations stated that the mayor was the highest authority of the municipality (e.g., leadership, senior management, supervision, and mechanisms to ensure collaboration). The mayor was elected in 2008 and reelected in 2012 with an absolute majority, the same as the council candidates of his political coalition (SERVEL [Electoral Service of Chile], 2016). These electoral results combined with internal regulations reinforced his position as agenda setter and his ability to prioritize economic development and infrastructures.

The hierarchical municipal organization had a low degree of worker professionalization (e.g., 19% of staff had academic degrees). The environmental office was located in the Department of Community Development without specialized personnel (interview, July 2014) and was, therefore, not able to generate information on social and environmental conditions. The director of emergencies and one assistant were in charge of risk prevention, consisting of activating the municipal plan for extreme events and disasters, assessing risks, and asking for support from regional and national governments (interview and focus group, July 2014).

The local government adopted new legislation on transparency, social participation, and municipal management (SUBDERE, 2016). However, the operational rules previously described were unchanged. External evaluations of transparency and accountability reported little progress and irregularities (Comptroller General of the Republic, 2016; Council for Transparency, 2016). The assessment of the Municipal Development Plan regarded the vertical nature of the municipal structure as a challenge (Cauquenes, 2010, p. 131).

In council meetings, the mayor and the administrative staff reported topics and held votes. The role of the councilors consisted of approving initiatives. During 2014, the councilors intervened 17 times on 33 EDRM topics, formulating questions and comments and approving mayoral decisions. In addressing these topics, the council interacted with 72 external actors. These relationships consisted mainly of unidirectional and reciprocal information flows.

Social Resources and Municipality

Surveyed households were potentially rich in social resources for EDRM: frequent communication with family and friends (82%), neighbors' support (77%), trust and willingness to enter into reciprocal relationships (76%), and mobilization for disasters (96%). Conversely, householders had low rates of network relationships (9%), mainly in neighborhood associations. Networking householders reported regular meetings (78%), information flow (87%), opportunities to meet representatives of institutions (90%), and interactions between leaders of different organizations (83%). Few reported engagement of social organizations with socioeconomic fragilities, risks, and environmental degradation or links with the municipality (20%).

Social leaders and householders involved in social networks explained that the municipality did well in ''delivering information,'' ''giving basic food baskets,'' and ''participating in festivities'' (focus group and interviews, July 2014). On the other hand, interactions of social organizations with the municipal council consisted of written requests and references about them in municipal workers' reports.

EDRM Decisions and Outcomes

During 2008 to 2014, EDRM issues had low priority in municipal politics, and the local government barely invested in EDRM. Municipal officials reported dissemination of information in schools and social organizations and improvements in infrastructures (interviews, July 2014). In turn, 65% of surveyed householders recognized measures for risk reduction in their neighborhoods, such as paving roads and cleaning ducts.

Following the 2010 earthquake, municipal actions led to coordination problems and polycentric conflicts (interviews, July 2014). The director of

emergencies applied protocols to estimate damages and coordinate with different institutions and organizations; ignoring protocols, the major visited affected places, compromising delivery of aid and generating conflicts with the governor of the province. Vulnerable householders developed critical perspectives toward the municipality for its poor distribution of aid (interviews, July 2014).

Lebu

Context

Lebu is affected by frequent droughts and forest fires in summer and floods in winter. The 2010 earthquake and tsunami caused changes in the local environment, such as rising sea levels, and the economy and infrastructure were seriously affected. Surveyed householders perceived high risks, especially from earthquakes and tsunamis, pests, rain flooding, changes in biodiversity, and forest fires. They reported effects on agriculture and livestock, difficulties with cropping systems, shortages of agricultural products, and effects on fishing. Additionally, overexploitation of natural resources (e.g., coal industry until the 1980s, fishing, forestry) has also caused severe environmental damages.

At least 40% of surveyed householders were vulnerable due to housing conditions, lack of basic services and infrastructures, and other socioeconomic fragilities. They were further stressed by increasing unemployment and rising prices of essential goods and services.

Municipal Institutional Arrangement and Polycentric Relationships

As in Cauquenes, Lebu's local government modernized the municipal structure during 2000 to 2010 (Lebu, 2012). The municipal council regulations of 2008 to 2014 delegated authority to the mayor to control all activities of the municipality, including council meetings, interactions between councilors and municipal officials, authorize public hearings with external actors once per semester, and control municipal departments.

Twenty-seven percent of municipal staff had academic degrees, the environmental office was located in the Department of Community Development, without specialized personnel and resources, and the emergency office was in the Department of Public Works and had only two workers (interviews, August 2014). Risk-reduction activities consisted of allocating aid during emergencies. The assessment of a communal development plan identified challenges in coordination and procedures (Lebu, 2012). The United Nations Development Programme interviewed workers who highlighted difficulties during the post-2010 tsunami period (interviews, August 2014; UNDP, 2011).

With growing social dissatisfaction, a mayoral candidate with experience in municipal affairs won the 2012 election with absolute majority, along with council candidates of his coalition (Electoral Service of Chile, 2016). The mayor's priorities were economic recovery, job creation, and reinforcement of municipal structures and routines.

In the council, the mayor and his staff controlled procedures and the agenda, and the councilors received reports on issues. Between January and December 2014, 51 topics related to EDRM were on the council agendas; the councilors discussed only 20 topics, asking questions, but approved all the mayor's proposals. The interactions with 61 external actors consisted mainly of unidirectional and reciprocal information flow, with effects on municipal EDRM. Most topics and relationships had to do with activities led by public services at the regional scale, information on administrative procedures, and budgetary issues and expenditures.

Social Resources and Municipality

Surveyed householders reported frequent communication with family members, friends, and neighbors. They interacted to solve problems and had trust and disposition to reciprocal relationships, and during the recovery phase of the 2010 earthquake or tsunami, they participated in some forms of networking organization to address their needs.

Forty-seven percent of interviewed householders actively participated in social organizations with recognized leaders. Interviewed householders reported on their tradition of associative life in the coal industry, fishing cooperatives, and evangelical churches. By these repeated social relations, they obtained returns such as information, improvement of common spaces, and opportunities to repair housing. Only 37% of householders identified links with the municipality. The relationships with the municipal council consisted of written requests to obtain benefits, and the matters were sent to different municipal offices.

EDRM Decisions and Outcomes

Between 2008 and 2014, the local government invested in machinery to rescue boats, public works, eradication of unsafe emergency villages, and evacuation routes to reduce risk. Environmental management investments consisted of trucks for solid waste collection, cleaning services, and beach caretaking. Expenditures for EDRM activities reached a surplus within 3 years. The top-down activities engaged in were the application of protocols, rescue work in emergencies, and dissemination of information by local radio. Few surveyed householders identified municipal activities in their neighborhoods, but they were able to identify the municipal action in repair of damaged infrastructure (36%) and cleaning of public spaces (49%).

Panguipulli

Context

Panguipulli is threatened by volcanic eruptions and climate change, such as changes in temperatures and rainfall patterns and glacial melting (Panguipulli, 2013). These conditions combined with overexploitation of native forests and soil degradation caused a severe socioenvironmental crisis during the past four decades (interviews, June 2015). Surveyed householders perceived high risk from volcanic eruptions, climate change, and transformations in biodiversity. These stressors particularly affected agriculture, tourism, basic services, market opportunities, and the price of basic goods and services. During 2008 to 2014, more than 40% of households were at risk due to socioeconomic fragilities, lack of basic infrastructures and services, and environmental threats.

Municipal Institutional Arrangement and Polycentric Relationships

Until the 2000s, the municipal institutional arrangement was similar to other Chilean municipalities: council agenda controlled by the mayor, centralized municipal structure, isolation of departments, and few relationships with vulnerable populations and other external agents. Between 2000 and 2008, new Mayor Kohler fostered institutional change through the reform of internal municipal regulations. He created a territorial and environmental office in the Planning Department, hiring 30 young professionals, promoting new methods to strengthen the coordination between departments and external links, and introducing Local Agenda 21 for municipal planning (Panguipulli, 2005). The municipality made alliances and collaborative agreements with diverse actors in the private, social, and public worlds.

The new operational rules of the council facilitated balanced relationships within local government: The mayor drove the municipality overall, but councilors audited and evaluated the mayor and municipal departments, monitoring compliance with municipal plans, integrating study committees, and requesting background information. With no restrictions on interactions with external actors, the councilors could autonomously form study commissions and request records they considered necessary. Subsequent elections in 2008 and 2012 were highly competitive, with the mayor receiving less than the majority of votes and more than half of the councilors not belonging to his political coalition (Electoral Service of Chile, 2016).

Municipal regulations (2005) prescribed that the Office of Territorial and Environmental Planning in the Planning Department take into consideration international and national environmental standards, and the Department of Community Development carry out risk reduction activities in coordination with the Office of Emergencies and the Department of Public Works. The municipality also had a system of active technical committees coordinating activities

in the different departments, with the responsibilities of policy, planning, program, and project analysis. Panguipulli's institutional arrangement was reinforced by the combination of national legislation and decisions of the municipal council to strengthen transparency and EDRM, while pursuing environmental certification and declaration of the community as a special tourism area in 2014 (Council for Transparency, 2016).

Institutional changes introduced during Mayor Kohler's management, and reinforced later, gave way to routines with effects on EDRM: study commissions and planning and environmental workers sharing information during council meetings; agreements and cooperation with external organizations; social leaders, businesses, and research institutions reporting on physical and environmental conditions; fieldwork, deliberation, and consideration of the mayor's and council's proposals; and citizens bringing concerns into the discussions. In 2014, 52 issues related to EDRM were on the council's agenda. The councilors intervened 59 times, presenting initiatives, providing information, and approving 87% of the projects considered. The council had relationships with 145 external actors operating at several levels. Of these, 44% were social organizations and 46% consisted of institutional support.

Social Resources and Municipality

Surveyed householders had relationships of trust and reciprocity with their relatives and neighbors, mobilizing social resources to cope with risks and disasters. Thirty-four percent (34%) of householders reported participation in social organizations with recognized leaders, frequent meetings, and exchanging information with effects on welfare. Municipal participatory programs offered opportunities to communicate issues, and social organizations had interlinks.

In council meetings, public hearings with social leaders to address EDRM issues were frequent for community initiatives to manage water resources, recycling, cleaning of public spaces, sanitary solutions, contamination, water rights, and emergency situations. The municipality offered investment initiatives, review of municipal plans and programs, public campaigns to encourage joint responsibility among neighbors, elaboration of environmental reports on contamination, ground topography, water resources and rights, and contacting public services and ministries to request support and actions. Some interventions of nongovernment organizations (NGOs) made way for studies and actions by the council to control contaminating sources and protect forests.

EDRM Decisions and Outcomes

Between 2008 and 2014, the council prioritized municipal investments in EDRM—studies, closure of the municipal well, minimization of solid waste, composting, recycling, regulation of lake activities, monitoring environmental

sustainability, and providing firefighters and emergency shelters. Even with these expenditures, the budget for emergencies had a surplus in 5 of the 7 years.

The activities for risk reduction consisted of plans, protocols, simulations, monitoring volcanic activity, acquisition of machinery, coordination with police and other organizations, and dissemination of information in schools and on the radio. Survey participants recognized this work—education about risks (43%) and informative workshops (29%).

Insights

The three community contexts were similar, and interviewees and householders expressed high concern over the fragile socioeconomic predisposition to risk of natural disaster. Overall, they perceived the conditions in which they lived as vulnerable. There were market restrictions and few economic options, and municipalities lacked human resources and were highly dependent on external funds. In all cases, the local government agendas were complex, with a large number of issues competing for attention and resources. Furthermore, there were strong incentives to prioritize investments with short-term returns.

The descriptions of the cases also show differences: municipal internal regulations, politics within the councils, characteristics of municipal structures, patterns of interactions with external agents, links and relationships between municipality and society, priorities in agendas, and EDRM outcomes. In these municipalities, structured institutional systems—operational rules and municipal commitments—affected information flows regarding environmental conditions, risks in communal context, and evaluations and decisions made to address them.

Polycentric relationships that included external actors and community-level EDRM jurisdiction made a difference, mediating evaluations and collective local government decisions. Panguipulli illustrates clearly the potential of these interactions for improved EDRM outcomes.

Comparative Analysis and Discussion

Our comparative analysis finds that Panguipulli was the municipality with the most successful and balanced EDRM performance outcomes across indicators, which correlates with institutional arrangements and polycentric relationships, particularly within local society. We structured our analysis of these results into two parts: empirical examination and discussion.

Empirical Examination

Our theoretical propositions say that under similar communal contexts, differences of municipal EDRM outcomes at municipal level depend on the nature of

institutional arrangements, particularly operational rules, municipal structure, and polycentric relationships. We expect EDRM outcomes to be modest in Lebu, given weak institutional context and fewer polycentric relationships, and the opposite in Panguipulli.

Figure 2 synthesizes indicators of institutional factors and EDRM outcomes (selected from Table 1). Panguipulli was the municipality with the highest scores and most balanced EDRM outcomes across indicators: operational rules of municipal council autonomy, coordination and planning, polycentric relationships, linking SC, municipal investments, and EDRM activities reported by householders.

Contrasting with the councils of Cauquenes and Lebu, Panguipulli's council prioritized EDRM in its agenda, taking time to discuss issues and municipal resources for investments and expenditures in this area. Over a 12-month period, an average of 43 EDRM issues was on the council's agendas (Panguipulli 52, Lebu 51, and Cauquenes 33). Panguipulli councilors intervened 59 times, presenting initiatives, providing information, and approving 13 investment projects (12%). In Lebu and Cauquenes, councilors intervened 17 times, consenting to two EDRM investments on average (1.5%). Annual EDRM expenditures

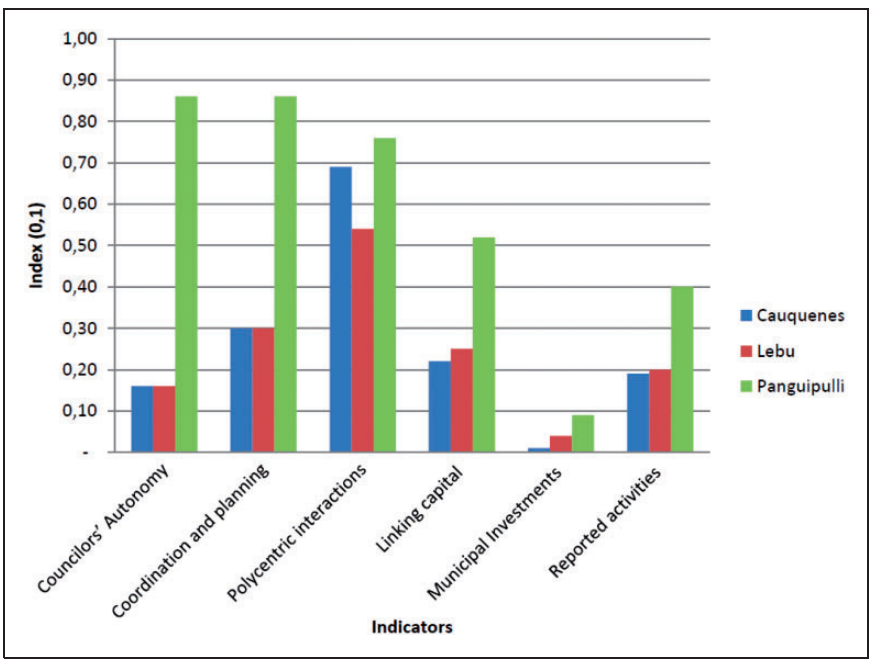

Figure 2. Indicators of institutional explanatory factors and outcomes.

Table 1. EDRM Outcome Indicators for Cauquenes, Lebu, and Panguipulli, Chile.

Indicators	Cauquenes	Lebu	Panguipulli
EMDR outcomes			
Topics	Lower (0.10)	Middle (0.17)	Higher (0.18)
Emergency funds surplus	Lower (0.00)	Middle (0.57)	Higher (0.71)
Municipal investments	Lower (0.00)	Middle (0.0)	Higher (0.9)
Investments by NIS	Lower (0.00)	Middle (0.00)	Higher(0.03)
Top-down activities	Higher (0.55)	Lower (0.33)	Middle (0.34)
Fieldwork	Low (0.50)	Low (0.00)	Low (0.50)
Reported activities	Lower (0.19)	Middle (0.20)	Higher (0.40)
Institutional factors			
Councilors' autonomy	Lower (0.16)	Lower (0.16)	Higher (0.86)
Coordination and planning	Lower (0.30)	Lower (0.30)	Higher (0.86)
EDRM staff	Lower (0.22)	Higher (0.80)	Middle (0.40)
Education	Lower (0.19)	Middle (0.28)	Higher (0.31)
Interactions	Lower (0.69)	Middle (0.54)	Higher(0.76)
Bidirectional	Lower (0.24)	Middle (0.29)	Higher (0.36)
Multidirectional	Middle (0.32)	Lower (0.24)	Higher (0.33)
Bidirectional + Multidirectional	Middle (0.56)	Lower (0.53)	Higher (0.69)
Bond capital	Higher (0.80)	Middle (0.76)	Middle (0.76)
Networking capital	Lower (0.09)	Higher (0.49)	Higher (0.34)
Linking capital	Lower (0.22)	Middle (0.25)	Higher (0.52)

Note. EDRM = environmental disaster risk management; NIS = National Investment System. Numbers in parentheses are proportions.

during 2008 to 2014 for Panguipulli and Lebu show considerably more emergency fund surplus than for Cauquenes (5, 4, and 0 years, respectively). Additionally, Panguipulli had an ordinance for environmental protection and conservation (2005), several plans, and environmental certification (interviews, June 2015). These differences also correlate with the perceptions of householders: In Panguipulli, 39% reported municipal activities in EDRM, followed by Lebu (20%) and Cauquenes (19%).

On the other hand, Cauquenes stands out for technical top-down measures for EDRM: The director of emergencies reported 10 activities in the areas of EDRM, followed by Panguipulli (7) and Lebu (6). Cauquenes and Panguipulli also carried out activities involving local communities, such as workshops, evacuation drills, and environmental education (UNDP, 2004).

The municipalities' institutional arrangements were notably different. In contrast to Cauquenes and Lebu, Panguipulli's internal regulations strengthened the autonomy of the council, the flexibility of the municipal structure, and its

accountability (e.g., study commissions, access to municipal information and external actors, and checks and balances). This municipal structure facilitated coordination of planning and EDRM.

Panguipulli's municipal council had the largest (and highest intensity) network, interacted with the most diverse network of actors with jurisdiction in EDRM, with emphasis on local social actors. Panguipulli had interactions with 145 external actors, Cauquenes 72, and Lebu 61. Cauquenes and Panguipulli put more emphasis on external actors (69% and 76% of the people and entities they interacted with, respectively), while Lebu concentrated on municipal departments (46%). In Panguipulli, the core of relationships occurred at the local level: 64 (33%) interactions with community organizations and NGOs. In terms of the direction of these interactions, Panguipulli had the largest number of reciprocal and institutional support relationships: 69 bidirectional (36%) and 64 multidirectional (34%), Lebu had 33 (29%) and 27 (24%), and Cauquenes had 24 (24%) and 32 (32%). Panguipulli's municipal council signed agreements with external agents for environmental management—forest conservation, monitoring of volcanic activity, conditions and uses of lakes, and environmental certification.

Interestingly, in Cauquenes, the polycentric relationships in the area of EDRM helped compensate for the lack of municipal support (interview, July 2014). The director of emergencies participated actively in a collaborative network of public actors at provincial and regional levels and assumed a leadership role at the community level. In Panguipulli, the director was supported by an institutionalized policy of collaborative agreements and networks with external agents. In Lebu, the director was supported by a director of field operations and emergency workers.

While the three localities had social resources with the potential to be mobilized to EDRM (e.g., ties of trust and reciprocity, social participation, and social organizations), Panguipulli stands out regarding links and synergistic relationships between residents, social organizations, and the municipality, with interactions, information flows, and support. In the three cases, 77% of surveyed householders responded with a high degree of confidence in their relatives, neighbors, and friends and indicated their willingness to enter into relationships of giving and receiving trust. During disaster situations, 62% reported mobilization of social resources in their neighborhoods to help those affected and solve common problems. Social participation rates were 49% in Lebu, 34% in Panguipulli, and 9% in Cauquenes. Most of this took place in neighborhood associations. Regarding returns, householders in Panguipulli reported more exchange of relevant information and effects on welfare than Lebu and Cauquenes (85%, 28%, and 13%, respectively). From the point of view of linking ties and synergistic relationships among residents, social organizations, and municipality offices, householders observed more interactions in Panguipulli than in Lebu and Cauquenes. These interactions and relationships included

social organizations reporting risks (70%, 40%, and 33% in Panguipulli, Lebu, and Cauquenses, respectively), providing information about municipal activities and allocation of municipal resources (46%, 26%, 19%, respectively), applying pressure when needed (57%, 28%, and 15%, respectively), participating in coproduction activities (54%, 24%, 14%, respectively), and municipal officials consulting on risks (43%, 5%, 32%, respectively) and participating in territorial working groups (29%, 5%, 13%, respectively).

The quantity and quality of relationships in municipal council meetings adds further evidence to the differences already observed. In Panguipulli, social leaders reported 10 instances of community initiatives seeking to improve environmental conditions and risk reduction, which were integrated into the municipal portfolio of projects. Four times, their information encouraged the review of three studies: municipal plans, programs, and policies. Six reports by NGOs made way for monitoring contaminating sources and forests. In Cauquenes and Lebu, submitted concerns over social risks were sent to different municipal offices, without discussion or initiatives.

This comparative exercise shows that variation in EDRM outcomes correlate closely with differences in the indicators of institutional arrangements and polycentric governance, particularly linking relationships between municipalities and civil society.

Discussion

Focusing exclusively on the national scale, where national policies and selected aggregate indicators such as government effectiveness, quality of democracy, and gross domestic product explain EDRM outcomes, we would expect to observe similar behaviors in all municipalities in Chile because the country has strong political institutions, economic performance, and the availability of national policies and instruments for EDRM (Ministry of Environment, 2011; OECD/ECLAC, 2016; ONEMI, 2014; Sjöstedt & Povitkina, 2016). From a narrow and conventional view of EDRM, where geophysical and natural factors define problems and drive the answers, experiences and risk perception justify the expectation of better EDRM performance in Cauquenes and Lebu because these communities had the most devastating disasters during 2008 to 2014 (Collenteur, de Moel, Jongman, & Di Baldassarre, 2015). Following that same rationale, from the perspectives of financial, human resource, and technical capacities, with more staff for environmental management and emergencies, we should expect better results in Lebu (Blackwell, Downs, Pong, Hagnauer, & Guardado, 2015). From a sociological perspective, higher levels of SC in the forms of bonding and networking relationships would justify better performance in Cauquenes (González-Muzzio, 2013). If EDRM outcomes were to depend exclusively on one of those factors, Panguipulli should be the municipality with the highest barriers and lowest EDRM outcomes. However, our

overview of the cases and comparative analysis lead to a very different conclusion.

A theoretically plausible explanation as to why Panguipulli EDRM outcomes are relatively high could be provided by a more conventional, sociological perspective. According to such a perspective, the potential effects of social resources on municipal EDRM manifest when people participate in repeated social relationships to mobilize information and reach objectives (Lin, 2001). To have an effect on municipal decisions, these forms of social relationships transcend community borders and synergistically connect with decision-making institutions (Woolcock & Narayan, 2000). In turn, these relationships provide returns that benefit communities and EDRM outcomes (Adger, 2003). This would imply that it is primarily these social resources that drive local government decisions and concrete actions related to investments in EDRM. But our analysis suggests that it is not that simple. In line with the new institutionalism and linking SC literature, underlining the importance of ''institutional arrangements'' (Ostrom, 1990, p.190), ''the nature of the state—society relations'' (Szreter & Woolcock, 2004, p. 661), ''local institutions'' (Aldrich, 2011, p. 93), ''institutional syncretism'' (Vervisch & Titeca, 2010, p. 504), ''power relations'' (Rubin, 2015, p. 780), and ''policies, institutions, and processes'' (Vervisch et al., 2013, p. 287), our empirical analysis shows that bonding and networking capital do not have direct and automatic effects on EDRM outcomes. In fact, even more important than these social resources is the local institutional context. The relatively higher Panguipulli EDRM outcomes are better explained by a more balanced combination of all three types of social resources—bonding, networking, and linking (Szreter & Woolcock, 2004).

National and local policies of the past two decades fostered linking SC at the municipal level but have not produced the expected effects in Chile. Our theoretical framework and research on the three municipalities suggest a more complex relationship between inputs and outcomes. The specific municipal institutional arrangements (e.g., operational rules, autonomy and representation in councils, institutional trajectories, municipal organizational structures, routines) do a better job of accounting for variation in EDRM outcomes. Moreover, our evidence shows that polycentric relationships—bidirectional and multidirectional interactions—between municipal councils and institutional actors at other governance levels, such as regional governments, ministries, and NGOs, also play a role in the explanation.

Our institutional analysis proposes a multisystem perspective to achieve a better understanding of the variations at the municipal level. The evidence suggests that municipal EDRM is a function of a combination of factors related to institutional processes and polycentric governance. Our comparative analysis shows that a deeper understanding of EDRM performance can emerge only when multiple dimensions and factors are considered rather than only one dimension, factor, or driver.

The mere existence of a decision or outcome is not what we are seeking to explain, but rather how it grows out of complex institutional and political incentives that motivate local politicians to make decisions. Indeed, our research is not simply why Paguipulli invested more than Cauquenes and Lebu or what policy prescriptions may be available for interventions aiming to increase local investments. To strengthen EDRM at the local level, one would have to change the conventional lens, moving beyond specific factors, drivers, and prescriptions to an approach of institutional decisions in a multisystem perspective. Both scholars and professionals in public policy will benefit through a greater effort to understand the relationships between decisions, outcomes, and multiple institutional drivers in complex socioenvironmental contexts. Understanding informed by institutional analysis will ultimately allow us to design more comprehensive and holistic strategies to improve EDRM.

Conclusion

Our study's results are consistent with one of Elinor Ostrom's main contributions: "We must learn how to deal with complexity rather than rejecting it" (E. Ostrom, 2009, p. 436). What needs to be done in EDRM research is to leap from static to dynamic analysis, testing theories that are configurational rather than additive and linear. Our research suggests that knowledge about the barriers to and opportunities for EDRM will be enriched if we try to better understand through institutional analysis and a multisystem perspective how local governments make their decisions and how institutional arrangements and polycentric interactions generate incentives for decision makers.

This article provides two new contributions. We develop and test an argument about the effects of a combination of three institutional factors—structure, polycentric relationships, and social resources—on decisions related to EDRM. The results from the comparative analysis provide new insights about how different forms of social resources interact with institutional structures and polycentric relationships to influence EDRM governance outcomes. This is a substantive finding that adds to the existing institutional literature related to local EDRM outcomes.

The second contribution is methodological. Our analysis moves beyond conventional methods for qualitative data collection to generate parameters for the sites based on representative samples of local actors in each site. Most existing case studies rely on data acquired through secondary observations or through interviews with key informants who estimate qualitatively the values of given variables. Our methodology provides for more reliable estimates of true population characteristics, such as social vulnerabilities, concerns, and needs, and will allow researchers to draw more robust inferences from patterns in the data that actually reflect the realities faced by decision makers on the ground.

Appendix

Table A1. Descriptions of Indicators.

Indicators	Description
Outcomes	
1. Topics	Number of EDRM topics covered by each council during 12 months (Panguipulli 52, Lebu, 51, Cauquenes 33) divided by the total number of topics covered during the same period (288, 295, 300, respectively)
2. Emergency funds surplus	Number of years with surplus in emergency funds in each municipality divided by seven (number of years 2008–2014)
3. Municipal investments	Investment in EDRM by each municipality divided by the total investment during 2008–2014
4. Investments by NIS	Costs of EDRM investments by each municipality entered to NIS divided by the total cost investment during 2009–2014
5. Top-down activities	Number of EDRM activities in each municipality divided by 18 (maximum possible activities listed in the questionnaire for municipal officers)
6. Fieldwork	Number of activities with community involvement implemented by each municipality divided by two (number of possible activities listed in the questionnaire for municipal officers)
7. Reported activities	Percentage of risk reduction and environmental protection measures reported by surveyed householders (transformed to proportions)
Institutional factors	
8. Councilors' autonomy	Score for each municipality in an index that quantifies regulatory information on operational rules with binary criteria (0,1)
9. Coordination and planning	Score for each municipality in an index that quantifies regulatory information on municipal structure with binary criteria (0,1)
10. EDRM Staff	Number of personnel hired for EDRM activities divided by the total number of municipal staff
11. Education	Number of personnel with degrees and titles divided by the total number of municipal staff
12. Interactions	Number of interactions of each council with external actors during a twelve-month period divided by the total number of interactions

(continued)

Table A1. Continued

Indicators	Description
13. Bidirectional	Number of bidirectional relations of the council with external actors divided by the total number of relationships
14. Multidirectional	Number of multidirectional relations of the council with external actors divided by the total number of relationships
15. Bidirectional + Multidirectional	Sum of bi- and multidirectional relations with external actors divided by the total number of relationships
16. Bond capital	Percentage of surveyed householders reporting bonding SC stated as a proportion
17. Networking capital	Percentages of surveyed householders reporting networking SC stated as a proportion
18. Linking capital	Percentages of surveyed householders reporting bonding SC stated as a proportion

Note. NIS = National Investment System; EDRM = environmental disaster risk management; SC = Social capital.

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Notes

1. These funds provide resources for preparedness (e.g., equipment, planning, and early-warning systems) and responses, and are allocated annually based on municipal estimations of activities and possible emergencies. Surplus implies that available emergency funds cover preparedness and disaster relief costs (interviews, June–August 2014).
2. The selected EDRM indicators were expressed in proportional terms (in a 0–1 scale). The observed results were divided by maximum scores. For example, in the case of emergency expenditures, the number of years with surpluses was divided by 7 years (length of study).

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