The network of actors and its social representations: Method of emergency and risk management evaluation in Saint-André de Kamouraska.

Martin Laroche and Steve Plante

Author's Note:

Martin Laroche, PhD candidate in regional development, Université du Québec à Rimouski (UQAR)

Steve Plante, Professor, Department of Society, Territory and Development, UQAR

We hereby declare that we have no conflict of interest in relation to the research or publication of this article. We undertake to report any change in this regard.

The opinions expressed in this work are those of the authors and do not necessarily represent the views of any organizations affiliated with the authors.

Questions and comments may be directed to this address: martin.laroche@uqar.ca

Abstract

In this paper, we evaluate emergency and risk management by combining social network analysis and the study of social representations. We use a classical, bipartite network analysis method to highlight the key actors in emergency and risk management. The use of social representations anchors our data in a particular territorial experience. Indeed, the proposed article is a case study of the municipality of Saint-André-de-Kamouraska located in the Bas-Saint-Laurent administrative region of Quebec. We argue that the main advantages of our method are a) to reveal the key actors in emergency and risk management; b) to reveal the impact of these actors on the governance of emergencies and risks; and c) to draw the socialization to risk and emergency of the studied population.

Key words:

Actor network analysis, social representations, adaptive governance, transformative governance, risks, emergencies, climate change, social-ecological system

The authors wish to acknowledge the financial support of MEOPAR, the Marine Environment Observation, Prediction and Response network.

Introduction

The extent of the effects of climate change (CC) depends on the social and environmental context of the territory. The effects of CC lead to a dynamic redefinition of the balances between the social and ecological subsystems. Both subsystems are marked by uncertainty and complexity (Barnes et al., 2017; Holling, 1973; Olsson et al., 2006; Walker et al., 2004). The territory of the municipality of Saint-André-de-Kamouraska (SAdK) is an example of a social-ecological system (SES). This SES is characterized by its link to the middle estuary of the St. Lawrence system, an ecological system of importance to the northeastern North American continent and the north-western Atlantic (Comtois et al., 1993; Dubois, 1993; El-Sabh & Silverberg, 1990; George, 1986). This portion of the St. Lawrence-Great Lakes system is home to a number of different issues, including the reproduction and survival of emblematic animal species such as the beluga whale and the common eider, and social and economic issues such as fishing, tourism and shipping. Located on the south shore of the estuary (Figure 1, red box), the Kamouraska lowlands are known for their fertility and are dotted with monadnocks, which are rocky structures that are part of the Appalachian mountain range. Tides can reach up to four metres and bathe the brackish marshes that form the coastline (Government of Canada, 2019). The church of Saint-André-de-Kamouraska (SAdK), built between 1805 and 1811, as well as the heart of the village, are national historic sites of Canada (Culture et communications Québec, 2004).

Figure 1: Geographic location of the research area

Image 1: Flooding of the aboiteau during the 2010 storm

Courtoisie de la municipalité de Saint-André-de-Kamouraska

On December 6, 2010, a wave passes over the village's aboiteau[1] (Image 1). The storm is raging while the tide is at its highest. The heart of the village, located below sea level, is threatened by the water. This flooding episode caused more than $300,000 in damage and affected some 60 homes (Municipality of Saint-André-de-Kamouraska, 2012). A similar event occurred in the municipality in 1914 (Municipality of Saint-André-de-Kamouraska, 2015). The multiplicity of risks (erosion, storms or invasive plants) and the flooding episode experienced in SAdK demonstrate the catastrophic potential of emergencies, when the risks materialize. To understand the complexity of the issues at stake in SAdK's SES, it is necessary to reflect on the community, its actors and its ways of dealing with risks. How do network actors depend on modes of governance involved in risk and emergency management in a context where the occurrence of extreme weather events is exacerbated by CC (Aldunce et al., 2015; Burton et al., 2004)?

In this paper, we develop a methodology that proposes to assess risk and emergency management, through the use of actors network analysis (ANA) and social representations (SRs). Social representations can be the basis for unveiling the network of actors and the relationships between actors and risks, on the one hand, and reveal the socio-historical contexts of representing science and expertise in the face of risks, on the other hand (Rinck, 2010). We adopt a definition of SRs that makes them collectively shared images of social objects (events, situations or values) (Garnier & Doise, 2002). The use of SRs allows the network to be described and makes it possible to qualify the relations maintained by the actors using qualitative methods (discourse analysis).

Using GEPHI software, we generate network visualizations from our semi-structured interviews. This ANA answers the need to identify the actors involved in management and reveals the structure and nature of the relationships that exist in a given network (Borgatti et al., 2009; Jones, 2017). With

[1] An aboiteau is a construction of Acadian origin, which resembles a dyke and allows the drying and desalination of a coastal marsh for agricultural purposes. Through gates in the structure, fresh water is allowed to drain out and brackish water is prevented from entering. (Hatvany, 2003, 2009)

this analysis, we assess the relationships between the actors and the risks present in the SAdK territory. To do so, we propose the bipartite network analysis (BpNA) to relate the variables "actors" and "risks," which are represented by two distinct sets of vertices[2] (Beauguitte, 2013; Tackx, 2018).

The method we propose allows us to achieve three objectives: a) to reveal the key actors in emergency and risk management; b) to reveal the impact of these actors in emergency and risk governance mechanisms; and c) to paint a picture of the socialization of actors to risk and emergency. Finally, we begin a reflection on the forms and modalities of responses to the challenges of CC, risks and emergency that we have identified.

Do the graphs allow us to qualify the modes of governance?

The characteristics of modes of governance influence the effects of CC. For some authors, the risks, their complexity, the uncertainty of the effects of the materialization of these risks and the form that CC takes represent governance challenges (Berkes & Folke, 1998; Gunderson, 1999). The notion of governance is used in a very wide range of contexts and has multiple meanings. In this paper, we understand it to mean the coordination of actions between various actors to address specific collective challenges (adaptation, resilience, development). Some modes of governance, such as adaptive and transformative governance, partially respond to the challenges of governmentalities posed by CCs (Castán Broto, 2017; Casteigts, 2017; Jessop, 1997). In recent years, modes of governance, described as adaptive (Folke et al., 2005; Garmestani et al., 2009; Olsson et al., 2006) and transformative (Barnes et al., 2017; Chaffin et al., 2016; Potapchuk et al., 1999), have been introduced into the scientific literature and into management practices (Table 1).

[2] In the study of graphs, two components allow us to read the structure of graphs. The vertices, which represent the object of study (actors, organizations, individuals, etc.) and the edges, or links, which represent the relationships between the vertices (Borgatti et al., 2009; Cherven, 2013, 2015).

Table 1: Key characteristics of adaptive and transformative governance according to Boswort (2018), Chaffin et al. (2016) and Hatfield-Dodds et al.

Adaptive Governance	Transformative Governance
• Horizontal integration of actors present on the territory • Openness • Transparency • Accountability • Reflexivity • Monitoring • Adjustments • Actions in line with SES	• Horizontal integration of actors present on the territory • Openness • Transparency • Accountability • Reflexivity • Monitoring • Adjustments • Critical actions on SES

Both modes of governance seem appropriate for challenges marked by complexity and uncertainty. Adaptive governance implies a capacity of local authorities to offer responses to exceptional situations (emergencies and disasters) and to the changing nature of the characteristics and needs of social and ecological systems (Plante et al., 2018). Adaptive governance does not demonstrate a capacity or even a willingness to transform the social-ecological system in which it operates. Transformative governance, on the other hand, aims to modify the social-ecological context in order to increase the capacity for resilience and adaptation to climate change (Bosomworth, 2018; Chaffin et al., 2016; Hölscher, 2019). To illustrate our point, let us consider the implementation of public policies, a process in which transformative governance requires reflexivity and constant adjustments that take into account all the components of the ESS (Lovan et al., 2004; Rhodes, 1997). Transformative governance also requires the involvement of actors, organizations and citizens linked

to the geographical territory as well as expertise, in the face of climate risks and challenges. Transformative governance challenges "classical" hierarchies (Ciplet et al., 2018 ; Potapchuk et al., 1999) and encourages the search for dynamic balances between social and ecological subsystems through the recognition of their respective needs (healthy environment, reproduction, habitat, diversity, resources and security) (Brock & Carpenter, 2007; Costanza, 2014; Shoko & Umetsu, 2014).

So why focus on the network of actors? Modes of governance, adaptive or transformative, are expressed through the management norms (transparency, horizontality, reflexivity, etc.) practised by the actors of these governances. Unveiling the network of actors makes it possible to observe the expression or absence of these management norms and thus to feed a critical reflection on the modes of governance of risks and emergencies. The social representations of the links between actors and risks can be useful in reflecting on the ways in which actions are deployed in adaptive or transformative modes of governance (responsibility and legitimacy).

Understanding modes of governance through actors and their links to the network.

The actor network is a concept that links a subject to their social circle. Sociology analyzes this kind of network by describing and explaining the forms taken by the connections between subjects, as Scott points out:

> "*Social network analysis, […], depicts agents—individuals or collectives—as embedded in webs of connections, and the task of the sociologist is to describe and explain the patterns exhibited in these connections*" (Scott, 1988, p. 112).

To achieve our research objectives, we mobilize "social network" or "actor network" analysis in a manner that is descriptive, analytical and formal (Borgatti et al., 2009; Butts, 2008; Carrington et al., 2005; Lemieux, 1999). It is a descriptive and analytical approach, as the ANA is used as a "guide for systematic observation of relationships and interactions" (Jones, 2017, p. 4) on one hand, and on the

other hand, it is a formal approach, as the elements of the network (the system) are measurable by the relational and interactional patterns found in the individual or group (Cherven, 2013, 2013; Lemieux & Ouimet, 2004). The system-network is measured using tools from graph theory (Berge, 2001; Fournier, 2013; Thulasiraman & Swamy, 2011). The use of social representations tempers the tendency of formal analysis to disembody the reality of social relationships by presenting them through mathematical tools (e.g., boundary diameter, connectivity, etc.). For example, in the case where respondents have a compartmentalized view of the action of groups of actors from different administrative scales, this representation would not be expressed in the agglomeration coefficient, which shows a low value (low presence of subgroups in the network). In this example, the use of the SR details the analysis of social dynamics that statistics sometimes have difficulty in expressing and justifies its use to understand modes of governance.

The graph is a predominant figure in ANA. It is an elegant, statistically and sociologically interesting tool as it generates visualizations that present the actor and his network connections[3] (Berge, 2001; Thulasiraman & Swamy, 2011). Graphs evoke three components in networks. Each component joins the others in distinct ways. The first component is the network itself and it is expressed by indicators such as density, diameter and modularity (Amat, 2014; Cherven, 2013, 2015). The second component is the nodes (or vertices), which is the form that actors take in the visualization of the network. To describe the nodes in our research, we retain characteristics including degree, centrality and betweenness (Borgatti et al., 2009; Butts, 2008; Cherven, 2015; Serrat, 2017). Finally, the third component is the link, which represents the relationship between two nodes. Links are characterized by weight and frequency indicators that offer the possibility to represent some nominal and qualitative variables (Borgatti et al., 2009; Mercklé, 2011; Serrat, 2017).

[3] The GEPHI software generates graphs in which colours play a major role in the visualization of results. The choice of colours is parameterised and cannot be modified. We understand the difficulty that this may represent for some of our readers. This is a limitation of the software and we will try as far as possible to avoid this pitfall when presenting the results.

While the classical graph paints the relationships between two nodes (individuals, organizations, companies or authors), the bipartite graph allows us to represent the relationships linking a first type of variable to a second (Guillaume & Latapy, 2004; Newman, 2001; Tackx, 2018). In our study, the management links between network actors (citizen, municipal, provincial and parapublic groups) and risks are illustrated in bipartite graphs. Most real networks are the result of this type of interaction, with one of the two variables present being the reason for the expression of these relationships (Guillaume & Latapy, 2004; Watts & Strogatz, 1998).

We use an actors-events bipartite network analysis in which a unit of analysis (the actors of the SAdK network) participates in events (the management of particular risks) (Beauguitte, 2013). A BpNA does not take into account the relationships within these sets, which justifies combining it with a classical ANA. BpNA has the advantage of increasing the reliability of the interpretation of the information presented in the graphs. Thus, by combining ANA and BpNA, we avoid important biases that are usually attributable to direct relationships. Data that deal with affiliation (the management of risk by one or more actors) can be determined more accurately than data of a relational type (the relationship between two actors and its evaluation) (Newman, 2001; Tackx, 2018).

Social representations in the study of risks: a method.

The methodological approach we have chosen gives us access to the collective visions shared by the actors (Abric, 1994; Avry, 2012; Carter & Fuller, 2016; Kane, 2016). We access these representations by means of a method inspired by the one known as hierarchical evocation (Lo Monaco & Lheureux, 2007). This method consists of cross-referencing the frequency of occurrence of a response with an evaluation of the relationships between the network's actors and the territory's

risks. At the time of data analysis, a high frequency and concordance of evaluations make it possible to confirm, or not, the relationships described by the respondents (Butts, 2008). It should be noted that a methodology that uses social representations is not necessarily evaluative (Apostolidis et al., 2002; Moscovici, 1989). It describes the social representations of science or expertise on which risk management is based, traditions (inductive or deductive) and highlights the legitimacy factors that respondents have in this management (Casteigts, 2017). We draw on social representations in two ways. Firstly, by exploring the images of the network in which our respondents are situated and secondly, by the management links that unite the actors of this network to the different risks represented as part of the SAdK territory or as part of a territorialisation of risks and knowledge in socialization.

The study of social representations reveals the process of elaboration of images and the structure of collectively shared thought that emerges (information, phenomena and relations[4]) (Abric, 1994; Joffe, 2003; Moscovici, 1989). Social representations are "the conceptual entities inhabiting a symbolic space shared by the members of a group" (Lescano, 2013, 1). They form a set of functional elements articulated between them in which it is possible to see the modern equivalents of the myths and beliefs of traditional societies (Bonardi & Roussiau, 1999, p. 22). It is the social representations within the learning mechanisms of risk culture (e.g., reflecting mirror, role play, anticipation) that reveal the actors' socialization to risks. The SRs, with prevention, anticipation, risk preparedness, communication and emergency management, allow to highlight the integration of values, norms and roles related to prevention, risk preparedness and emergency management. These characteristics are the structuring elements of socialization, as defined in particular by Castra (Bolliet & Schmitt, 2008; Castra, 2013; Dubet & Martuccelli, 1996; Peterson et al., 2003). In our study, we highlight the

[4] Information sharing: updating or developing knowledge on new issues, e.g. on the presence and effects of genetically modified organisms (GMOs) in the environment; knowledge of phenomena: e.g. the emergence of social movements (Occupy, Black Lives Matter) or the occurrence of extreme weather events linked to climate change; development of relationships: between actors, or more simply between residents of the same village, of the same community.

influence of actors who are strongly socialized to the issue of risk management and emergency on the rest of their network.

The discourses constitute the primary material of our research and were collected with the help of the kitchen assembly. This survey technique enhances the acuity of the descriptions in the collected speeches and forms the social representations in the analysis. These discourses are collected from respondents in a social and physical context with which they are familiar and benefit from a ripple effect. The data (opinions and ideas) are processed by GEPHI, a visualization and network analysis software that deepens our understanding of the discourses and brings out social representations through the tools of network analysis and graph theories. The approach expressed in the article situates the actor within his network and environment and explores the relational dynamics that depend on them.

A method for accessing social representations of the network and risk management

The network of actors studied is characterized by its small size. There are 43 nodes and 61 relationships in the ANA part and 60 nodes and 50 relationships in the BpNA. The selection of respondents was based on meetings with members of the SAdK municipality and a snowball effect (Denscombe, 2017). This strategy enabled us to produce a list of citizen groups and organizations working in the SAdK territory. The boundaries of the network under study were defined through six (6) kitchen assemblies[5] that brought together twenty-eight respondents. These meetings took place between April and September 2019. They revealed the existing relationships between the citizen groups and the public, community, private, university, nonprofit and other actors (six nodes). This

[5] "The Kitchen Assembly is a technique for mobilizing actors (citizens, elected representatives, public sector representatives, etc.) [...]. This tool facilitates small group discussions on a specific issue in a friendly environment, such as the kitchen of one of the participants." (ROBVQ; https://robvq.qc.ca/guides_consultation_publique/ [French only])

characterization of the actors was carried out during the kitchen assembly meetings, although an initial identification was made by the municipality and the research team before the data collection. The criteria used to select the groups to be involved in the research were the relevance of the mission of these groups and their involvement in risk management (reflection, mobilization, governance). The inventory of the risks present in SAdK was carried out during the visit of a group of students from the University of Quebec in Rimouski as part of a fall 2018 integrated coastal zone management course. The survey was conducted door-to-door at all residences in the heart of the village. A list of seventeen risks was established. That list was used in our work to construct the BpNA.

Our methodological approach is inspired by the arc sampling design, which involves identifying the relationships to be evaluated and cross-referencing data from several sources (Butts, 2008). The open questionnaire developed is divided into two parts. The first part focuses on the structure of the relationships present in the network and takes into account their types, strengths and directions (Serrat, 2017). The second part focuses on the social representations of risk governance, which are the basis of the BpNA. The kitchen assembly format was beneficial in four ways: it allowed the creation of a climate of openness and trust; the settings in which the meetings were carried out were familiar to the respondents; the respondents were able to obtain answers to some of their questions; and lastly, it allowed the assembly to benefit from the group dynamic where each respondent completes the information put forward by the other respondents in the room (Fontan et al., 2013; Mias, 2003; Paillé & Mucchielli, 2012). Group discussions favour the emergence and definition of collective representations of the different themes discussed, as well as of the relationships that exist between the different actors of the network (Jedlowski, 1997; Lo Monaco & Lheureux, 2007; Negura, 2006). Nevertheless, researchers are aware that this method tends to undermine individual points of view and tends to impose organizational biases on the discussions. These biases are linked

to the social dynamics present within each of the groups questioned and are reflected in the ways in which respondents speak.

Visualizing with GEPHI, Results and Discussion

We use two types of visualization: ANA and BpNA. The global characteristics of the network (size, density) and the structure of the links (degrees and agglomeration) appear in the ANA, while the perceived risks on the territory and the spatialization of the sharing of the management of these risks are illustrated through the BpNA. The Force atlas 2 algorithm is used to make the projections in Figures 2, 3 and 5. This algorithm works well with small networks and the position of each node expresses the forces of attraction and repulsion at play in the network.

Thus, in Figure 2[6], we illustrate the undirected links to paint a general picture of the SAdK network. The diameter value of 4 corresponds to the maximum distance between two nodes in the graph (Table 2). The average path length is a measure that tells us how far we have to travel to reach all the nodes in the network. In this case, these two indicators show us a certain proximity between each of the actors. This demonstrates a connectivity of the network that favours inclusive management modes in which social representations could easily circulate. The size of the nodes in the graph is proportional to the degree, i.e., the number of relationships that each node maintains. The value of 2,837 for the average degree highlights a certain weakness in this aspect of the network. For example, the actors surrounding actor 9 have a degree of 1, pulling this average down. This statistic reveals the bridging role played by some actors (2, 9, 23, 27 and 34), increasing the average clustering coefficient. All these statistics allow us to define central and peripheral actors. Peripheral actors are characterized by a low degree and by their isolation, not being connected to the network or linked to

[6] In order to comply with our ethical guidelines, we have anonymized the identity of SAdK actors.

bridging actors. Central actors are those in the densest section of the graph and bordered by bridging actors.

Figure 2: Representation of the network of actors in Saint-André-de-Kamouraska.

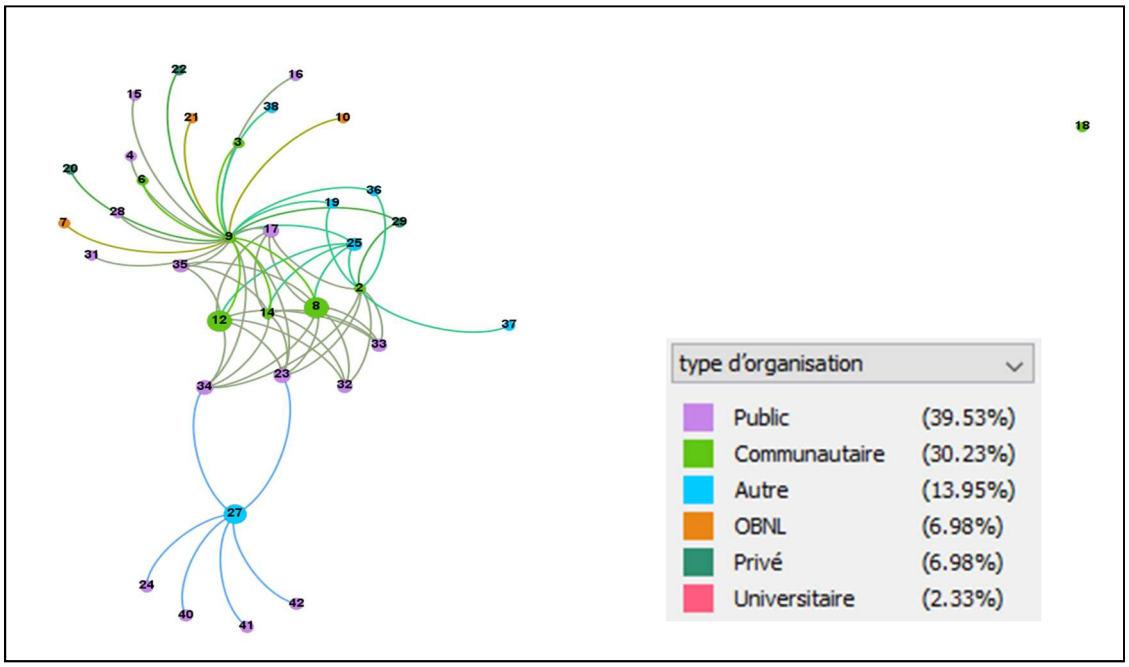


Table 2: Key statistics in Figure 2

Indicator	**Value**
Diameter	4
Average degree	2,837
Average path length	2,408
Average clustering coefficient	0.131

In figure 3, the links are presented in a hierarchy of actor satisfaction with the relationship (example question: " On a scale of 1 to 5, how satisfied are you of the relationship with this actor? "). This hierarchy demonstrates the data points where coordination, or the passing of information, is either facilitated or meets friction. The nodes' size is proportional their respective degree. This information is crucial for the assessment of governance modes, since it provides information about the qualities of governance modes. The use of solutions such as improving or consolidating relationships can increase the strength of the network.

Figure 3: Representation of the Network of Actors and their Level of Satisfaction Towards the Relationship

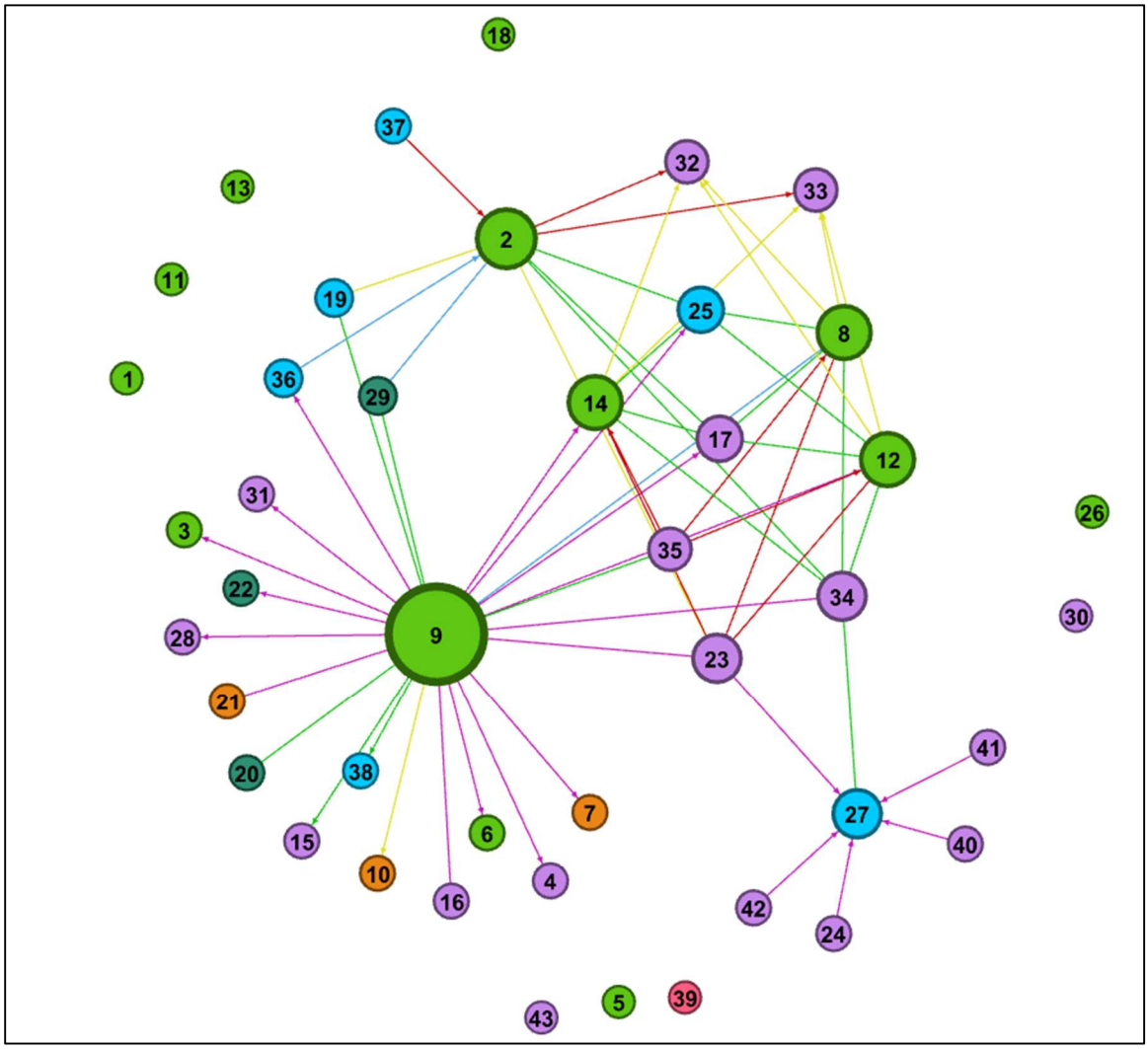


Table 3: Legend for the links shown in Figure 3.

Level of satisfaction towards the relationship		%
	1= Poor	14.75
	2= Low	0
	3= Average	14.75
	4= Strong	4.92
	5= High	31.15
	9= nil/no data	34.43

The visualization of the satisfaction towards the relationship is an example of the type of information used in a qualitative analysis of the network. Here we see a predominantly strong satisfaction (together, the combined ratings of 4 and 5 are equal to 36.07% of respondents). By superimposing these evaluations on the other indicators of the link's strength, frequency of contact, duration of the relationship, formal or informal nature and reasons for its existence (administrative, regulatory or financial), we are able to obtain a more detailed reading of the network's characteristics. This precision is notable in the search for the most appropriate paths to link actors together. For example, actor 12 is linked to actor 2 by a path that passes through actor 33, but whose satisfaction with the relationships is low. The graph shows that it would be advantageous to connect 12 to 2 via actor 17, for whom relationship satisfaction is high. In this way, we avoid potential relational pitfalls in the network.

With these two visualizations, we can see that the proximity of the actors is not as strong as the statistical data of the general ANA would suggest. In the SAdK network, central actors and bridging actors are needed in order to reach all actors. Thus, with the help of these two figures and the relational arrangements they highlight, the influence of some actors on others is demonstrated, as

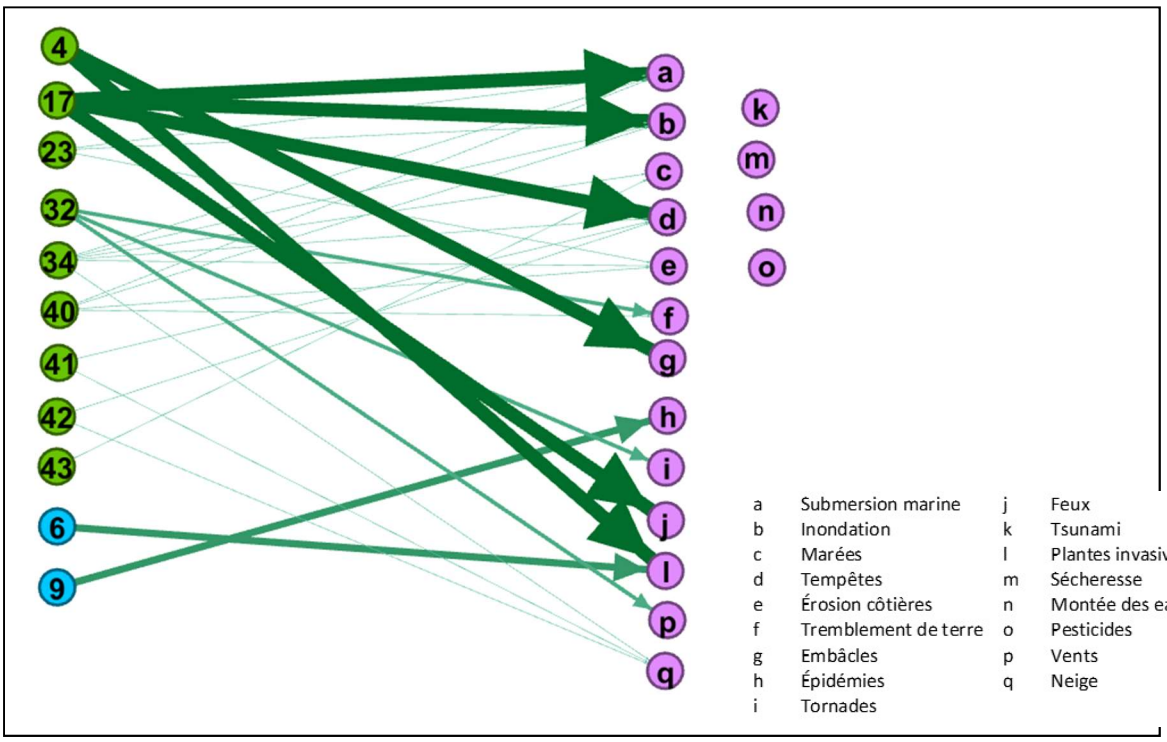
well as their potential to play the role of bridging actor in the transmission of knowledge of risks and their management. This transmission potential depends on the geodesic proximity of the actors and the quality of their relationships. For example, a potential inter-influence appears through the representation of the good quality and reciprocity of the relationship that links actors 8 and 9. The conceptualization that we propose allows us to deepen this reading and to extend it to the whole network. From then on, an initial overview of the actors' modes of socialization to risks and emergencies appears and allows the identification of patterns of dependence on the socialization of peripheral actors in relation to bridging or central actors.

To show the richness of a dynamic representation (figure 5) we must compare it to figure 4 which represents the links between actors and risks in a classical way. In Figure 4, the size of the links refers to the social representations of the management's quality (1=Poor; 2=Weak; 3=Average; 4=Strong; 5=High). The left-hand column is made up of nodes that represent the actors in the SAdK network. The right-hand column shows the risks. Each column is ordered alphanumerically. This first bipartite graph acts as a list. The degrees of the "risk" variables tell us how the network of actors deals with this variable. Actors who are not involved in the management of a risk do not appear in this figure. For example, thirty-two actors are absent from risk management and 11 are present. Note that some risks are left aside by the actors (tsunami, drought, rising sea levels and pesticide use). Other risks receive attention from one or more actors, but these relationships are represented very unfavourably. The risks related to tides, coastal erosion and snow fit this situation. Respondents rate the quality of management of the risks of flooding, storm, ice jam, fire and invasive plant species very favourably.

This first part of the bipartite analysis reveals the norms applied and the roles assumed by the actors in relation to certain risks. We can thus see which actor is socialized to which risk and in what way. Thus, actor 17 is the one who seems to be the most socialized to risks through his very favourable

links with 4 of them. Conversely, actor 43 seems to be poorly socialized to risks, having only one very weak link with the risk linked to tides. The actors absent from this figure would be even less socialized to risks. The fact that no mention is made of these actors and their link with one of the risks present in the SAdK territory demonstrates the social representation that our respondents have of these different actors. Thus, either the involvement of these actors in risk and emergency management is not significant or it is non-existent.

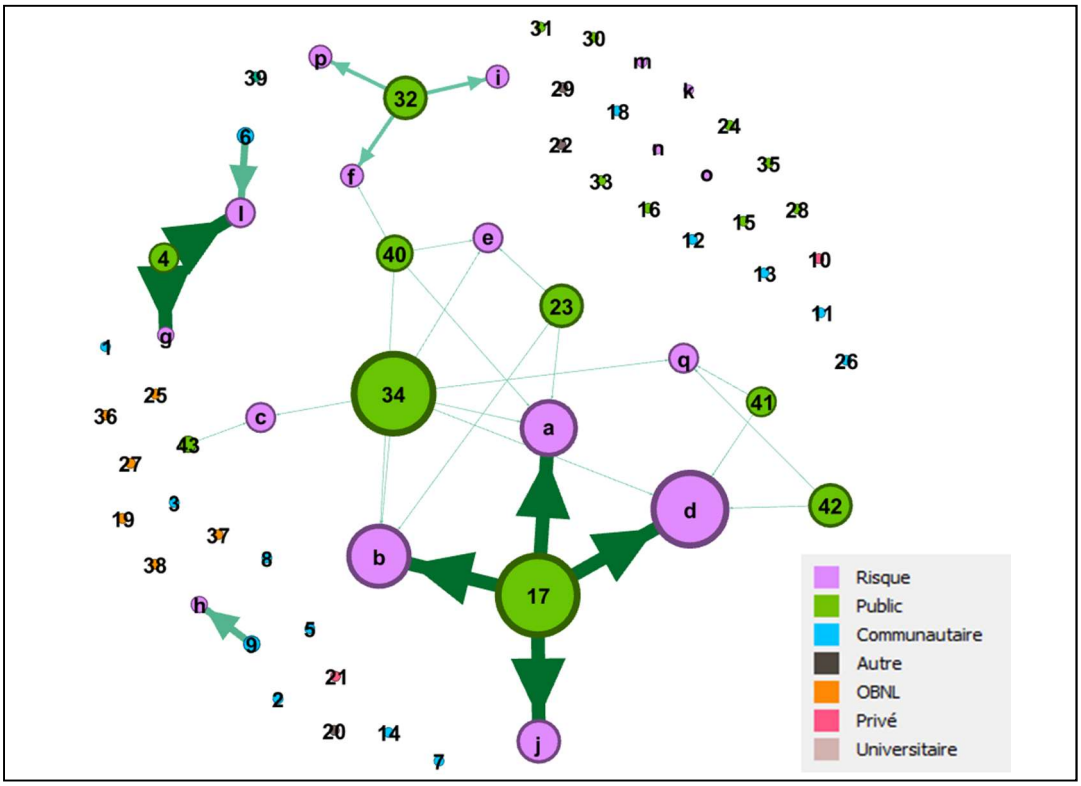
Figure 4: Bipartite actor-risk network.



In addition to the use of a classic figure (4), we propose the use of a dynamic figure of current and possible collaborations, based on the same data (figure 5). The colour and thickness of the arrow is equivalent to the strength of the link between actors and risks (1=very weak; 2=weak; 3=average; 4=strong; 5=very strong). Three distinct groups are identified: a main group (located in the centre) and two subgroups (North-West and South-West). The main characteristic of the two sub-groups is the presence of community actors. These are the only places where this type of actor is present in

the figure. The identification of these three groups makes it possible to put forward hypotheses concerning the possible emergence of virtuous dynamics in the network, or the possible integration of actors from civil society in the management of certain risks. The strong actors in the network can thus integrate actors whose link with the co-managed risk is weaker. With this figure, we graphically demonstrate a social representation expressed during the assemblies, i.e., the compartmentalization of responsibilities and weak collaboration between the different levels of management. As in the graphs produced for the ANA, a juxtaposition of the effect of the linkage variables provides a more comprehensive picture of risk management. In this case, we use the role of the relationship (regulation, monitoring, resources and information) as another qualitative variable.

Figure 5: Bipartite network; spatialization of risk management.



The BpNA provides a deeper understanding of the socialization to risk and emergency in the network. With the classic BpNA, we identify some actors whose risk management is better assessed.

We identify others who receive a better assessment of their risk management over a large number of risks. With dynamic BpNA, it is the working groups that are identified. These three groups are relevant to highlight as they give indications of possible "families" of actors who would share elements of a risk and emergency management culture. Through joint management of one or more risks, actors come to share values, norms and roles that contribute to the development of their own risk culture. The identification of these groups therefore contributes to the portrait of the risk and emergency socialization of SAdK actors.

Discussion

The relevance of using the ANA and BpNA in risk management is that these two tools allow us to go further than a simple statistical and qualitative description. For the managers, for example, the comparison of these two analyses provides information on the modes of governance at work in the territory and allows them to better position their actions. Thus, actors 17, 32 and 34 are those whose role is the most assertive in risk management. They are among the central actors in the network, but the relationships they develop with the other actors do not seem to be totally satisfactory. This mismatch between the relationships within the network and the risk management links demonstrates weaknesses in the coordination of the different actors' actions. The study of the bridging actors' role offers another demonstration of the qualities of the governance modes. Of these bridging actors, only actor 9 is involved in the management of the "epidemic" risk, without being in contact with the rest of the actors in the risk management network. The absence of the other bridging actors may reveal the weakness of the integration of peripheral actors in risk management, a management in silos or even a territorialisation of expertise and knowledge in the sense that Casteigts (2017) understands it. Moreover, actors 40, 41 and 42, who depend on bridging actor 27 to be in contact with the rest of the network, are involved in risk management, which is also dealt with by actors 17, 23, 32 and 34. This further illustration highlights actors who are involved in the management of the

same risk and who do not have a relationship (formal or informal) in the SAdK actors' network. Moreover, other actors are absent from the visualizations presented, with no links to the rest of the network. This is the case for certain ministerial actors whose absence is statistically noted and expressed in the discourse of the kitchen meetings participants.

These findings allow us to paint a picture of socialization to risk and emergency through three stages or features. The first feature highlights the links that unite the actors. These links are the basis for sharing norms, rules, behaviour and information, which are key elements of socialization to risk. The quality of risk management by the actors is the second feature revealed. This step makes it possible to evaluate the quality of the actors' socialization (anticipation, integration or communication). Finally, the third feature appears by grouping the actors by intervention "family" and reveals shared mandates. We thus reach the expression of this socialization.

But how does this data inform us about the network's risk and emergency governance capacity? And how is this relevant to managers? At the beginning of this article, we suggested that our conceptualization allows us to see the expression or absence of management norms. We believe that this is still the case, but with two conditions. First, the actors must have a minimal relationship in the ANA. Secondly, the same observation must be made through the BpNA. The fulfilment of these two conditions is necessary in order to have access to the expression of shared management norms. From then on, our conceptualization evaluates the risk management mobilized by each of the actors and it achieves this through SRs analysis. Here, the graph theory represents risk management based on the aggregation of this data, as well as their arrangement in GEPHI. What we notice then is that practically no couple or group of actors fulfills these two conditions. Only actors 34 and 17, who work together on the risks of marine submersion and storms, satisfactorily meet our criteria. Actors 23 and 34 only partially meet them, brought together by bridging actor 12. This interpretation highlights the need to examine in greater depth the question of the management

cultures found in the area under study. Indeed, it seems unlikely that actors working together on the same issues do not share any relationship that is minimally quantifiable. However, it is the social representations resulting from the discourse of the respondents, i.e., the socially conscious citizens of SAdK that are presented here. Nevertheless, it appears that little coordination exists between the different risk actors and that their common risk management does not seem to be perceived by our respondents.

Our results offer two important lines of thinking, each with its own implications. The first concerns the instrumentalization of local knowledge within science and the territorialisation of expertise. Knowledge of the network makes it possible to mobilize actors in order to respond to risk and emergency management needs. Our results have the potential to increase the efficiency of the implementation of measures, policies and information dissemination by clarifying existing knowledge (scientific and vernacular) of the expert's role. This responds to social representations of science that are related to their utility, potential for practical solutions and pragmatism (Brassard, 2002; Lescano, 2013). The second implication of our results concerns the intangibility and complexity of the social-ecological issues of risk management (Armitage et al., 2009; Ostrom, 2007; Pellaud, 2017). Our conceptualization materializes the complexity at play. It identifies spaces where the co-construction of knowledge and processes is possible between actors. Researchers, participants and managers with expertise can then better understand each other, develop trust and respect, identify the ways in which ideas emerge and, finally, stimulate collaboration in the network.

Another advantage of our approach based on the comparison of the ANA and the BpNA is its contribution to the critical and constructive reflection of governance. Beyond the numbering of actors in our model, we can position ministries, the MRC, municipal councillors and citizens whose work is compartmentalized by each actor's scales of intervention. This standardization of the legitimacy of actions reflects the historicity of actors' relations, specifies the context of scientific

knowledge emergence and institutionalizes the expert's role. This social historicity, or social representation, undoubtedly affects the possible paths of collaboration in the network, accentuates or diminishes the absence of an effective integration of categories of actors and the local population in the modes of risk governance. The flows of relations between actors shed new light on the modes of governance, allowing us to look at them from new angles and thus to target the characteristics and mechanisms of socialization in place or to be stimulated. These flows tell us who is playing the game of risk and emergency management and according to what rules.

The transformation of modes of governance requires an understanding of these modalities and the type of relationships between ministries, the MRC, municipal councillors and citizens. Our method is particularly effective when it comes to revealing the advantages, barriers and obstacles (role of bridging actors or peripheral status of certain actors) in the choice to use adaptive or transformative modes of governance. These advantages lie in the opportunities they offer to identify the places of decompartmentalization of scientific knowledge and expertise needed in the governance processes and consequently, in its capacity to guide collaboration in the network.

The reader should keep in mind that the ANA is a snapshot, a portrait of a moment, of the state of a network at a specific time. The SAdK actor network was most likely different in the past and will probably be different in the future. Nevertheless, addressing the flooding episode of 2010 has provided us with some evidence of the transformations experienced by the network. The analysis of this event highlights the lack of preparation of the municipality in the face of this risk. Links present at the time are found in our mapping. Actor 17, which is central today, was, in the opinion of our respondents, much less linked to the other actors in the network at the time. While some formal links between government institutions emerged or became stronger, the response to the 2010 submersion seems to have been provided mainly by actors who had informal links to each other and who were already very much linked to the municipal management apparatus. Thereafter, no other

major events disrupted the municipality. Therefore, it remains risky to assume the extent to which relational changes in the network influence its risk management capacity.

Conclusion

With this article we achieve three objectives. First, we reveal the key actors in the risk and emergency management network in SAdK. The statistical tools provided by graph theory and the network visualization software GEPHI allow us to quantitatively analyze the contribution of the actors in risk management. The use of social representations as a basis for unveiling the network allows us to identify these actors using qualitative indicators. Discourse analysis highlights our respondents' assessment of the actors' work. Our analysis indicates the perceived quality of management, the strength of the management link between actors and risks and the collaborative dynamics present in the network. Our results therefore highlight thirteen key actors in emergency and risk management in SAdK. The interpretation of these results allows us to achieve our second objective. We have indeed revealed the impact of actors on emergency and risk governance. This is complemented by the data provided by the BpNA, which depicts the sharing of risk management among the actors in the network. It allows us to offer avenues for improvement in the management relationships between actors and risks. By revealing the proximities between actors, this analysis opens the way to improving the collaborative dynamics present in the network. It puts forward a reflection on the compartmentalization of actors according to their type and on the sharing of responsibility for risk management. The third objective we pursued was to paint a picture of the socialization of actors to risks and emergencies, which we achieved by exploring the links between actors and risks and by sharing the modalities of these relations between the different actors. The absence of strong actor "families" emerged as an indicator of low risk socialization in SAdK.

The advantages of the approach for actors (scientists, managers or NGOs) are multiple. It allows an understanding of the local level (municipality, citizen groups, individuals) in all its complexity. It

allows the detection of proximities and points of connectivity between actors, which favours modes of governance adapted to the challenges of risk and emergency management (partnership, consultation, co-construction) and facilitates the circulation of social representations (regulations, norms, policies) in the network and the decompartmentalization of knowledge (scientific and local) from expertise. In the face of an apparent compartmentalization of responsibilities and deficient collaboration between actors from different management and territorial levels, this information opens the way to a critical reflection on the network's capacity to deal with risks and emergencies. The process brings out opportunities and spaces for in-depth improvement of risk and emergency management in SAdK. While the proximity of the actors and the small size of the network appear to be advantages, the compartmentalization of the actors by administrative level, the peripheral or central nature of certain actors, the bridging role played by some of them, the small number of quality collaborations and the absence of "families" of actors are data that make it possible to set up a reflection adapted to the SAdK context. This reflection is part of a desire for adaptive governance.

The experience and the materialization of a risk through an event such as the submersion of 2010 transforms the risk and emergency management network. These two facets of risk also transform the social representations of this management in the population. These findings constitute limitations to our research, as the SRs explored still seem to be affected by the 2010 event. We are not able to describe the historical trajectory of the network in the face of this event through the ANA and BpNA alone. This situation requires a better knowledge of the key actors identified in this article and a deeper understanding of the risk and emergency management cultures present in the network.

References

Abric, J.-C. (1994). *Pratiques sociales et représentations*. Presses Universitaires de France.

Aldunce, P., Beilin, R., Howden, M., & Handmer, J. (2015). Resilience for disaster risk management in a changing climate : Practitioners' frames and practices. *Global Environmental Change*, *30*, 1-11. https://doi.org/10.1016/j.gloenvcha.2014.10.010

Amat, C. B. (2014). Network analysis and visualization with Gephi. *REDES: Revista Hispana Para El Análisis de Redes Sociales*, *25*(1), 201-209. https://doi.org/10.5565/rev/redes.499

Apostolidis, T., Duveen, G., & Kalampalikis, N. (2002). Représentations et croyances. *Psychologie et société*, *5*, 7-12.

Armitage, D. R., Plummer, R., Berkes, F., Arthur, R. I., Charles, A. T., Davidson-Hunt, I. J., Diduck, A. P., Doubleday, N. C., Johnson, D. S., Marschke, M., McConney, P., Pinkerton, E. W., & Wollenberg, E. K. (2009). Adaptive co-management for social–ecological complexity. *Frontiers in Ecology and the Environment*, *7*(2), 95-102. https://doi.org/10.1890/070089

Avry, L. (2012). *Analyser les conflits territoriaux par les représentations spatiales : Une méthode cognitive par cartes mentales* [Phdthesis, Université Rennes 2]. https://tel.archives-ouvertes.fr/tel-00808779/document

Barnes, M., Bodin, Ö., Guerrero, A., McAllister, R., Alexander, S., & Robins, G. (2017). The social structural foundations of adaptation and transformation in social–ecological systems. *Ecology and Society*, *22*(4). https://doi.org/10.5751/ES-09769-220416

Beauguitte, L. (2013). *L'analyse des graphes bipartis*. *halshs-00794976*. https://halshs.archives-ouvertes.fr/halshs-

00794976/document#:~:text=Un%20graphe%20biparti%20(bipartite%20graph,2%2Dmode%20network)1.&text=Par%20ailleurs%2C%20si%20les%20relations,peuvent%20par%20contre%20%C3%AAtre%20valu%C3%A9es.

Berge, C. (2001). *The Theory of Graphs*. Courier Corporation.

Berkes, F., & Folke, C. (1998). Linking social and ecological systems for resilience and sustainability. In F. Berkes & C. Folke (Éds.), *Linking social and ecological systems : Management practices and mechanisms for building resilience*. Cambridge University Press.

Bolliet, D., & Schmitt, S. P. (2008). La socialisation. *Thème et débat*, 6.

Bonardi, C., & Roussiau, N. (1999). *Les représentations sociales*. Dunod.

Borgatti, S. P., Mehra, A., Brass, D. J., & Labianca, G. (2009). Network Analysis in the Social Sciences. *Science*, *323* (5916), 892-895. https://doi.org/10.1126/science.1165821

Bosomworth, K. (2018). A discursive–institutional perspective on transformative governance : A case from a fire management policy sector. *Environmental Policy and Governance*, *28*(6), 415-425. https://doi.org/10.1002/eet.1806

Brassard, M.-J. (2002). *La valorisation et la reconnaissance des savoirs collectifs locaux : Un outil de transformation sociale pour les petites communautés?* [Thèse de doctorat]. Université du Québec à Chicoutimi.

Brock, W. A., & Carpenter, S. R. (2007). Panaceas and diversification of environmental policy. *Proc Natl Acad Sci U S A*, *104*(39), 15206-15211. https://doi.org/10.1073/pnas.0702096104

Burton, I., Malone, E. L., & Huq, S. (2004). *United Nations Framework Convention for Climate Change.* (B. Lim & E. Spanger-Siegfried, Éds. ; UNDP). Cambridge University Press.

Butts, C. T. (2008). Social network analysis : A methodological introduction. *Asian Journal of Social Psychology*, *11*, 13-41.

Carrington, P. J., Scott, J., & Wasserman, S. (2005). *Models and Methods in Social Network Analysis*. Cambridge University Press. http://ebookcentral.proquest.com/lib/uqar-ebooks/detail.action?docID=228772

Carter, M. J., & Fuller, C. (2016). Symbols, meaning, and action : The past, present, and future of symbolic interactionism. *Current Sociology*, *64*(6), 931-961. https://doi.org/10.1177/0011392116638396

Castán Broto, V. (2017). Urban Governance and the Politics of Climate change. *World Development*, *93*, 1-15. https://doi.org/10.1016/j.worlddev.2016.12.031

Casteigts, M. (2017). Les enjeux de la territorialisation de l'expertise dans la société du risque. In F. Benchendikh, *Expert(ise) et action publique locale* (p. 131-148). LexisNexis.

Castra, M. (2013). Socialisation. *Sociologie*. https://journals.openedition.org/sociologie/1992

Chaffin, B. C., Garmestani, A. S., Gunderson, L. H., Benson, M. H., Angeler, D. G., Arnold, C. A. (Tony), Cosens, B., Craig, R. K., Ruhl, J. B., & Allen, C. R. (2016). Transformative Environmental Governance. *Annual Review of Environment and Resources*, *41*(1), 399-423. https://doi.org/10.1146/annurev-environ-110615-085817

Cherven, K. (2013). *Network Graph Analysis and Visualisation with Gephi. Visualize and analyse your data swiftly using dynamic networks graphs built with Gephi*. Packt Publishing.

Cherven, K. (2015). *Mastering Gephi Network Visualization. Produce advanced network graphs in Gephi and gain valuable insights into your network datasets*. Packt Publishing.

Ciplet, D., Adams, K. M., Weikmans, R., & Roberts, J. T. (2018). The Transformative Capability of Transparency in Global Environmental Governance. *Global Environmental Politics*, *18*(3), 130-150. https://doi.org/10.1162/glep_a_00472

Comtois, C., Lagimonière, L., Slack, B., & Vallée, D. (1993). Le rôle et la fonction des ports de petite et moyenne taille dans le système Saint-Laurent. *Cahiers de géographie du Québec*, *37*(100), 17-33. https://doi.org/10.7202/022319ar

Costanza, R. (2014). A theory of socio-ecological system change. *Journal of bioeconomic*, *16*, 39-44. https://doi.org/10.1007/s10818-013-9165-5

Culture et communications Québec. (2004). *Site du patrimoine du noyau paroissial de Saint-André—Répertoire du patrimoine culturel du Québec*. https://www.patrimoine-culturel.gouv.qc.ca/rpcq/detail.do?methode=consulter&id=93642&type=bien

Denscombe, M. (2017). *The Good Research Guide : For Small-Scale Social Research Projects*. McGraw-Hill Education (UK).

Dubet, F., & Martuccelli, D. (1996). Théories de la socialisation et définitions sociologiques de l'école. *Revue française de sociologie*, *37*(4), 511-535. https://doi.org/10.2307/3322131

Dubois, J.-M. M. (1993). *The Saint Lawrence River System, Atlantic Coast of Québec*. ASCE Library. https://cedb.asce.org/CEDBsearch/record.jsp?dockey=0083216

El-Sabh, M. I. 1939., & Silverberg, Norman. (1990). *Oceanography of a large-scale estuarine system : The St. Lawrence*. Springer-Verlag; WorldCat.org. https://bac-lac.on.worldcat.org/oclc/22184513

Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources*, *30*(1), 441-473. https://doi.org/10.1146/annurev.energy.30.050504.144511

Fontan, J.-M., Longtin, D., & René, J.-F. (2013). La recherche participative à l'aune de la mobilisation citoyenne : Une innovation sociale de rupture ou de continuité? *Nouvelles pratiques sociales*, *25*(2), 125-140. https://doi.org/10.7202/1020825ar

Fournier, J.-C. (2013). *Graphs Theory and Applications : With Exercises and Problems*. John Wiley & Sons.

Garmestani, A. S., Allen, C. R., & Cabezas, H. (2009). Panarchy, adaptive management and governance : Policy options for building resilience. *Nebraska Law Review*, *87*, 1036-1054.

Garnier, C., & Doise, W. (2002). Introduction. In C. Garnier & W. Doise, *Les représentations sociales. Balisage du domaine d'études* (p. 13-22). Éditions Nouvelles AMS.

George, P. (1986). Le système Grands Lacs–Saint-Laurent. *Annales de Géographie*, *95*(527), 121. WorldCat.org.

Gouvernement du Canada, P. et O. C. (2019, août 2). *Marées—Rivière-du-Loup*. https://www.marees.gc.ca/fra/station?type=0&date=2021%2F03%2F13&sid=3130&tz=EST&pres=1

Guillaume, J.-L., & Latapy, M. (2004). Bipartite structure of all complex networks. *Information Processing Letters*, *90*(5), 215-221. https://doi.org/10.1016/j.ipl.2004.03.007

Gunderson, L. (1999). Resilience, Flexibility and Adaptive Management——Antidotes for Spurious Certitude? *Conservation Ecology*, *3*(1). https://doi.org/10.5751/ES-00089-030107

Hatfield-Dodds, S., Nelson, R., & Cook, D. (2007). *Adaptative governance : An Introduction, and implications for public policy*. 13.

Hatvany, M. G. (2003). The Aboiteaux of Kamouraska : Tradition, Modernity, and Environmental Change in the Tidal Marshlands of Nineteenth and Early Twentieth Century Quebec. *North American Geographer*, *5* (1-12), 162-182.

Hatvany, M. G. (2009). *Paysages de marais : Quatre siècles de relations entre l'humain et les marais du Kamouraska*. Société historique de la Côte-du-Sud.

Holling, C. S. (1973). Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics*, *4*, 1-23.

Hölscher, K. (2019). *Transforming urban climate governance : Capacities for transformative climate governance*.

Jedlowski, P. (1997). Collective memories. Small-group Meeting on Collective Memory. *Proceedings*, 23-30.

Jessop, B. (1997). The governance of complexity and the complexity of governance : Preliminary remarks on some problems and limits of economic guidance. In A. Amin & J. Hausner (Éds.), *Beyond Markets and Hierarchy : Interactive Governance and Social Complexity* (p. 111-147). Edward Elgar.

Joffe, H. (2003). Risk : From perception to social representation. *British Journal of Social Psychology*, *42*(1), 55-73. https://doi.org/10.1348/014466603763276126

Jones, E. C. (2017). *Social Network Analysis of Disaster Response, Recovery, and Adaptation*. Elsevier Science. https://international-scholarvox-com.ezproxy.uqar.ca/catalog/book/docid/88835076

Kane, I. O. (2016). *Gouvernance intégrée du risque dans la perspective d'adaptation des communautés côtières aux changements climatiques : Une analyse empirique des représentations sociales de la résilience.* [PhD]. Paris-Saclay.

Lemieux, V. (1999). *Les réseaux d'acteurs sociaux*. Presses Universitaires de France.

Lemieux, V., & Ouimet, M. (2004). *L'analyse structurale des réseaux sociaux*. Les Presses de l'Université Laval.

Lescano, A. (2013). Stéréotypes, représentations sociales et blocs conceptuels. *Semen - Revue de sémio-linguistique des textes et discours*, *35*, 14.

Lo Monaco, G., & Lheureux, F. (2007). Représentations sociales. La théorie du noyau central et méthodes d'étude. *Revue Electronique de Psychologie Sociale, APSU*, *1*, 55-64.

Lovan, R. W., Murray, M., & Shaffer, R. (2004). Participatory Governance in a Changing World. In R. W. Lovan, M. Murray, & R. Shaffer (Éds.), *Participatory Governance. Planning, Conflict Mediation and Public Decision-Making in Civil Society* (p. 1-22). Ashgate.

Mercklé, P. (2011). *Sociologie des mouvements sociaux*. La Découverte.

Mias, C. (2003). Praticien-chercheur. Le problème de la double posture. In P.-M. Mesnier & P. Missotte, *La recherche-action : Une autre manière de chercher, se former, transformer* (p. 291-306). L'Harmattan.

Moscovici, S. (1989). Des représentations collectives aux représentations sociales. In G. Balandier, *Les représentations sociales* (p. 62-86). Presses Universitaires de France.

Municipalité de Saint-André-de-Kamouraska. (2012, novembre 15). La nouvelle digue de l'aboiteau du village et les grandes marées à venir. *L'Info de Saint-André*, 1-2.

Municipalité de Saint-André-de-Kamouraska. (2015, novembre 15). Inondation à Saint-André : C'était il y a déjà 5 ans… *L'Info de Saint-André*, 1-2.

Negura, L. (2006). L'analyse de contenu dans l'étude des représentations sociales. *SociologieS*, *1*, 26.

Newman, M. E. J. (2001). The structure of scientific collaboration networks. *Proceedings of the National Academy of Sciences*, *98*(2), 404-409. https://doi.org/10.1073/pnas.98.2.404

Olsson, P., Gunderson, L. H., Carpenter, S. R., Ryan, P., Lebel, L., Folke, C., & Holling, C. S. (2006). Shooting the Rapids : Navigating Transitions to Adaptive Governance of Social-Ecological Systems. *Ecology and Society*, *11*(1), 18.

Ostrom, E. (2007). A diagnostic approach for going beyond panaceas. *Proceedings of the National Academy of Sciences*, *104*(39), 15181-15187. https://doi.org/10.1073/pnas.0702288104

Paillé, P., & Mucchielli, A. (2012). *L'analyse qualitative en sciences humaines et sociales* (3ième). Armand Colin.

Pellaud, F. (2017). Changements climatiques et transition énergétique : Complexité, approche systémqiue et cartes conceptuelles. *Revue Francophone de Dévelopement Durable*, *mars*(9), 99-112.

Peterson, G. D., Cumming, G. S., & Carpenter, S. R. (2003). Scenario Planning : A Tool for Conservation in an Uncertain World. *Conservation Biology*, *17*(2), 358-366. https://doi.org/10.1046/j.1523-1739.2003.01491.x

Plante, S., Vasseur, L., & Santos Silva, J. (2018). Adaptation des communautés côtières aux effets des changements climatiques sous l'angle de la résilience : Lier la gouvernance locale au développement durable. *VertigO - la revue électronique en sciences de l'environnement*, *Volume 18 numéro 2*. https://doi.org/10.4000/vertigo.22079

Potapchuk, W. R., Jr, J. P. C., & Schechter, W. H. (1999). The Transformative Power of Governance. *National Civic Review*, *88*(3), 217-248. https://doi.org/10.1002/ncr.88307

Rhodes, R. (1997). *Understanding governance : Policy networks, governance, reflexivity and accountability*. pen University Press.

Rinck, F. (2010). L'analyse linguistique des enjeux de connaissance dans le discours scientifique. Un état des lieux. *Revue d'anthropologie des connaissances*, *4*(3), 427-450.

ROBVQ. (s. d.). *Boîte à outil sur la participation citoyenne. L'assemblée de cuisine.* Consulté 30 septembre 2021, à l'adresse https://robvq.qc.ca/guides_consultation_publique/

Scott, J. (1988). Social Network Analysis. *Sociology*, *22*(1), 109-127. https://doi.org/10.1177/0038038588022001007

Serrat, O. (2017). Social Network Analysis. In O. Serrat, *Knowledge Solutions* (p. 39-43). Springer Singapore. https://doi.org/10.1007/978-981-10-0983-9_9

Shoko, S., & Umetsu, C. (2014). *Social–Ecological Systems in Transition*.

Tackx, R. (2018). *Analyse de la structure communautaire des réseaux bipartis* [Sorbonne Université]. https://tel.archives-ouvertes.fr/tel-02966420

Thulasiraman, K., & Swamy, M. N. S. (2011). *Graphs : Theory and Algorithms*. John Wiley & Sons.

Walker, B., Holling, C. S., Carpenter, S. R., & Kinzig, A. P. (2004). Resilience, Adaptability and Transformability in Social-ecological Systems. *Ecology and Society*, *9*(2). https://doi.org/10.5751/ES-00650-090205

Watts, D. J., & Strogatz, S. H. (1998). Collective dynamics of "small-world" networks. *Nature*, *393* (6684), 440-442. https://doi.org/10.1038/30918