A collaborative governance framework for assessing risks to critical systems in a changing climate

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Introduction

The fall 2021 climate events in British Columbia raise questions about the resiliency of communities, but also of critical systems, with respect to the allocation of roads, telecommunications, drinking water, electricity, etc. The interdependence of these systems can quickly generate serious consequences for populations and socio-economic activities that local and regional authorities must manage. The diversity and number of stakeholders require these authorities to coordinate well. How then can the risks to which they are exposed be better assessed? How can we ensure coherence in the measures put in place in terms of planning, preparation and response?

The concepts and results presented in this article are the result of an action-research project carried out with the participation of numerous partners, particularly, but not exclusively, from municipal milieus in two regions of Quebec (Argenteuil and Brome-Missisquoi MRCs). This active collaboration with these regional partners has made it possible to propose an approach for implementing a collaborative governance framework combined with a risk assessment process. The tools and mechanisms associated with this approach will allow regional authorities to better understand the impact of climate change on the territory and to ensure consistency in the risk management actions of the various stakeholders.

Critical Systems and Collaborative Governance Framework

Also known as essential infrastructure or critical infrastructure, Essential Systems (ES) are large networks of interconnected infrastructure and equipment that provide resources that help maintain the health and well-being of the population. It also ensures the smooth functioning of social and economic activities by providing society with the resources essential to its daily activities (electricity, water, telecommunications, etc.). To provide these resources, ES use other resources that, in turn, come from other systems (Robert and Morabito, 2011). For example, to provide reliable telecommunications, the telecommunications network uses electricity, water, natural gas, etc. To provide electricity, the electrical grid uses telecommunications links, water, etc. Thus, there is a high level of interdependence within these infrastructures.

Each country defines and groups ES differently. Public Safety Canada (2018a) defines ES as "the processes, systems, facilities, technologies, networks, assets, and services that are essential to the health, safety, or economic well-being of Canadians and the effective functioning of government." This infrastructure provides services that are vital to the health, safety and well-being of the population and to ensuring an adequate economic environment. They are grouped into 10 broad categories: energy and utilities; communications and information technology; finance; health care; food; water; transportation; security; government; and manufacturing (SPC, 2018a).

In Quebec, the provincial public safety policy 2014-2024 (Ministère de la Sécurité publique du Québec, 2014) defines ES as the systems that ensure the production or provision of services or resources now necessary for the life and functioning of communities. These systems are also grouped into 10 sectors. They are identical with the exception of the manufacturing sector, which is replaced by a notion of key assets that represent importance to the community.

Considering the importance of SEs, the Government of Canada created the National Critical Infrastructure Strategy and Action Plan with the goal of implementing an all-hazards approach to increase the resilience of assets and systems (SPC, 2018b). It calls for cooperation among various municipal, provincial, and private stakeholders to engage in risk management actions.

ES management is carried out individually by public (e.g., local municipalities), parapublic (e.g., the Crown corporation Hydro-Québec), or private (e.g., Bell Canada or Rogers Communications) organizations. Each ES is responsible for the proper functioning of its network and there are no formal collaborative mechanisms for risk assessment or for identifying and managing interdependencies.

Locally, the main responsibilities of municipalities are to manage a territory in terms of development (e.g., uses, infrastructure, equipment) and services to the population (e.g., water, security). The provincial government also has an impact on the management of the territory not only through the legislative framework, but also because of the infrastructure under its responsibility (bridges, buildings, roads, etc.).

The complexity of inter-organizational relationships or interdependencies between ES shows that they could benefit from a governance framework that allows for the complexity of the relationships. The notion of a collaborative governance framework allows this to be taken into account.

Collaborative governance is composed of the processes, decision-making and management structures of a group of actors acting constructively across organizational boundaries with the goal of achieving a goal unattainable if the organization had acted alone. Collaborative governance thus assumes that this construction is achieved by a network of actors (Emerson et al., 2012). Collaborative governance regimes can not only be self-initiated, but can also be independently organized when policy challenges are complex or externally directed in the case of widespread policy challenges (Emerson and Nabatchi, 2015), which is the case, for example, in a climate change context. Ansell and Gash (2007) conceptualized a model of collaborative governance with starting conditions acting as key variables shaping the collaborative process. The starting conditions refer to the power or resource imbalances between stakeholders, the incentive to participate, and the history of conflict or cooperation between stakeholders. Specifically, in a well-defined territory, collaborative mechanisms need to provide temporal and spatial trade-offs that take into account the risk management plans of each ES, in order to guide the ability of municipal actors to act in the territory in accordance with the decisions made by elected officials (e.g., adoption of plans or policies, implementation of a project, issuance of permits). These decisions can be influenced by various constraints such as limited resources, legal obligations and the complexity of the legislative framework. However, municipalities can call on a variety of partners for operational, administrative, financial,

technical, mediation or expert support. Collaborative mechanisms must then make it possible to determine the tools that ensure that arbitrations are taken into account in territorial management.

Since stakeholders have repeatedly mentioned that they do not want to create new mechanisms to assess the risks of ES in a context of climate change at the regional scale, the proposed generic governance model is based on existing mechanisms. These are of four kinds:

1. Arbitration mechanisms such as the council of mayors and municipal councils.
2. Coordination mechanisms at the regional level.
3. Planning mechanisms such as the regional land use and development plan, the municipal emergency preparedness plan and the water master plan.
4. Mechanisms to support the determination of thresholds such as expertise and level of social acceptability.

In general, while the collaborative process may evolve in stages (Madden, 2018), many authors argue that it is more cyclical (Huxham, 2003; Ansell and Gash, 2007; Emerson and Nabatchi, 2015; Chandler, 2019) and must be built around five conditions that support collaboration, including:

1. Direct dialogue.
2. Building trust between actors.
3. Commitment to the process.
4. Shared understanding.
5. Production of intermediate results.

To promote the implementation of effective collaborative governance, it is necessary to know the issues related to ES on a territory and, first of all, to establish a portrait of the equipment and infrastructures located on the territory.

The portrait of Essential Systems in a territory

To identify and characterize the ES equipment and infrastructures on a given territory, a concept of key elements is used. A key element is an element on which the management, operation, exploitation and control activities of the organization that owns or manages an ES are based. If this element becomes unavailable, the operation or management of the ES will be disrupted or even interrupted.

Elements may also be identified that are not considered key to the operation or control of an ES. Indeed, some elements are traditionally associated with an ES, but do not provide a resource or service on the territory. These elements can be mapped if they represent a risk (e.g. a pipeline, a dam, etc.) or if they play an important socio-economic role for the region (e.g. a service center, etc.).

In order to produce such a portrait, the ES are characterized in eleven sectors presented in Table 1 below. They are taken directly from the Politique québécoise de sécurité civile 2014-2024 (Ministère de la Sécurité publique du Québec, 2014). The government activity sector has been adapted to the reality of regional and municipal stakeholders. An additional sector was added with the management of residual materials. This addition was made following discussions with regional partners. This represents a sector that is generally under regional authority and

whose activities are essential for health and the environment. For each of these sectors, resources or services provided on the territory are identified. For each of these sectors, resources or services provided on the territory are identified. To define the portrait of the ES, it is necessary to identify the key elements (buildings and equipment) of these ES and then the organizations that provide these resources or services on the territory.

Table 1: Characterization of Essential Systems

ES Sectors	***Resources and services provided by ES***
Municipal and regional activities	Executive governance and administration
Financial sector	Banking services
Public safety	Fire safety Emergency response Police service Border services
Grocers	Household foodstuffs
Energy	Electricity Natural gas Propane gas Petrol products
Telecommunication services	Fixed telecommunication Mobile telecommunication Radiocommunication and navigation Satellite communication Broadcast Media (television, radio, etc)
Water supply	General water supply Water regulation Water governance
Waste management	Waste water management Garbage collection and processing Snow removal from urban areas
Transport	Road network Railway network Maritime network Aviation Public transportation network
Health	Hospital services
Key assets	Management and protection of key assets

Each region or municipality must synthesize this portrait in its own way. Knowing that most of the information requested is known and already collected, it will be necessary to gather it specifically in this portrait. A methodological guide has been developed to help regional stakeholders establish such a portrait in their territory (Baril et al., 2020).

Figure 1 below presents the results of the portrait in the form of a map produced in one region of Quebec (Baril et al., 2020). All information was collected and organized from the

geographic information system usually used in order not to move or duplicate spatial data already stored. The data was then exported for use in Google Earth software to facilitate sharing of information to all stakeholders. In this figure, the colored areas correspond to municipal boundaries. Red areas correspond to high concentrations

From an operational point of view, this visual representation of ES allowed for the updating of outdated information, but also to highlight certain critical situations, such as the possible vulnerability of certain ES due to their proximity to other infrastructures or their isolation.

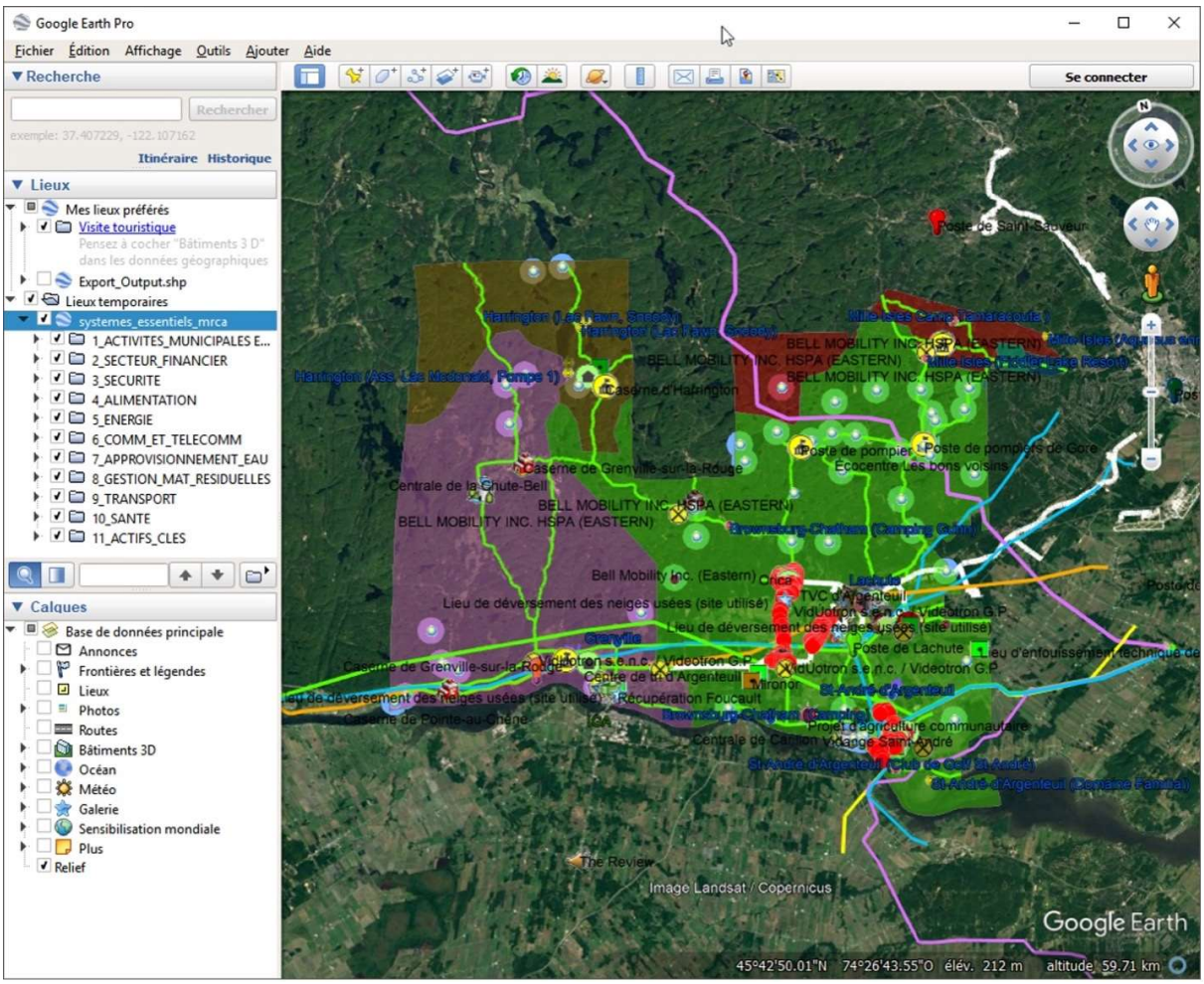

Figure 1: Example of a critical systems map (from Baril et al., 2020)

The development of this mapping satisfies the five conditions, which were previously identified, to support the implementation of the collaborative governance framework.

1. The development of an easily accessible Google Earth map makes it possible to create and develop a direct dialogue among all stakeholders.
2. The information contained in this mapping has been validated with the organizations concerned. For each geolocated ES, a contact person is identified. This person is the only one responsible for the shared information and for characterizing the vulnerabilities of the ES to the main climate hazards. This approach has allowed for the updating of databases, but also, and above all, favors the building of trust between actors.

3. It also ensures their commitment to the process, knowing that they will always be stakeholders in this mapping.
4. The vulnerability analyses that were carried out in the face of climate hazards allowed all stakeholders to work on similar hazards in the territory, thus ensuring a shared understanding of the issues related to interdependencies. This common understanding also allows them to put in place common disturbance management mechanisms for the ES affected at the same time by the same hazards.
5. Finally, all of these intermediate results have enabled the implementation of a collaborative governance framework.

As the frequency and intensity of climate change increases, one of the main challenges of this governance framework is that it endures over time. The fourth condition presented above is therefore important, as it ensures that ES managers achieve concrete results. It is therefore important to ensure that the work of assessing risks in the face of climate hazards allows for vulnerability analyses that are coherent with the challenges faced by ES managers.

Assessing the risks of essential systems to climate hazards

The challenge lies not only in the co-construction of a collaborative governance framework with the stakeholders concerned at the MRC level, but also in its institutionalization. In this regard, the stakeholders mentioned the importance of integrating it into the existing governance mechanisms on the territory and therefore not creating new ones. Moreover, even if it is possible to obtain a commitment to the process from ES managers, it appears that the resources that can be dedicated to risk assessment activities are very limited in organizations. Therefore, each climate situation under consideration needs to be appropriately focused, i.e., address common issues and be able to be analyzed in an efficient and collaborative manner due to limited resources. Work on the interdependence of ES (Robert et al., 2013) has demonstrated the importance of working on issues associated with common situations that generate disruptions, such as a water supply shutdown, a power outage, or high heat that can affect equipment. Despite the fact that each ES is managed differently, the global analysis of the mechanisms for managing disruptions will strengthen the shared understanding of the issues. Regional coordination mechanisms can then be identified to strengthen planning mechanisms for the management of these disruptions, but also for the crisis management mechanisms that may result from them.

Each ES owner or manager is responsible for the risk management process within their organization and for implementing measures to protect their equipment and maintain their operations. It appears from our study that a regional authority such as an MRC is well placed to assume a coordinating role in the implementation of a risk management process related to ES, but also in the validation of the coherence between the common protection and prevention measures that will be identified, planned and implemented.

In Quebec, the Regional County Municipalities (RCM) can play this role. These are bodies whose interventions are carried out in a collaborative context, since the council of the MRC is composed of the mayors (and certain representatives) of the local municipalities that make it up. Because of their organizational structure (representation of local municipalities) and their planning and intervention responsibilities (regional vision), MRCs are entities whose

governance is essentially based on interactions with several civic, community, governmental and paragovernmental actors in a context of collaboration and negotiation.

On a given territory, climatic hazards that affect a large number of ES are not very common. However, events related to the resource "water" and its use present problems that affect not only the health and safety of the population, but also the functioning of most of the ES in the territory. Work done in Quebec (Baril et al., 2020) has shown that drought situations that lead to significant decreases in water flows in rivers and decreases in water tables should be favored to begin the implementation of a collaborative governance framework. In the context of climate change, such an issue is particularly relevant, as it requires a longer-term vision. Moreover, since these are not current events, it also makes it more relevant to plan protective measures to better manage them when they occur.

The assessment of the risks to the ES involves the evaluation of their vulnerability to the climate hazard. This vulnerability is defined by the temporal margin of maneuver available to implement actions before the functioning of activities is significantly affected (Micouleau, 2016). To establish it, a manager must first understand and know the disruption and the consequences on his or her organization, incorporating internal anticipation and planning mechanisms. Analyses of all affected ES margins are performed to define points of vulnerability defined by short margins. The identification of these points of vulnerability will then require planning mechanisms for joint and collaborative management of the consequences on the territory.

From the portrait of the ES on the territory, as defined previously, the risk assessment follows a 6-step process.

1. Define a climatic situation to be studied and identify potential disturbances on the ES. Indeed, a climatic situation can be broken down into several effects. For example, a drought can generate water shortages, but can also be associated with high temperatures over long periods.
2. Establish a map of the climatic situation on the territory under study.
3. Compile the margins of maneuver of the ES for the previous disturbances.
4. Synthesize the information on the margins of maneuver and establish the points of vulnerability.
5. Map the points of vulnerability of the ES to the climate situation under study.
6. Couple the mapping results on the ES and the climate situation to establish the risks.

Figure 2 below presents an example of risk mapping for a specific area of a territory, for a climate situation of drought with temperature increases and heat waves.

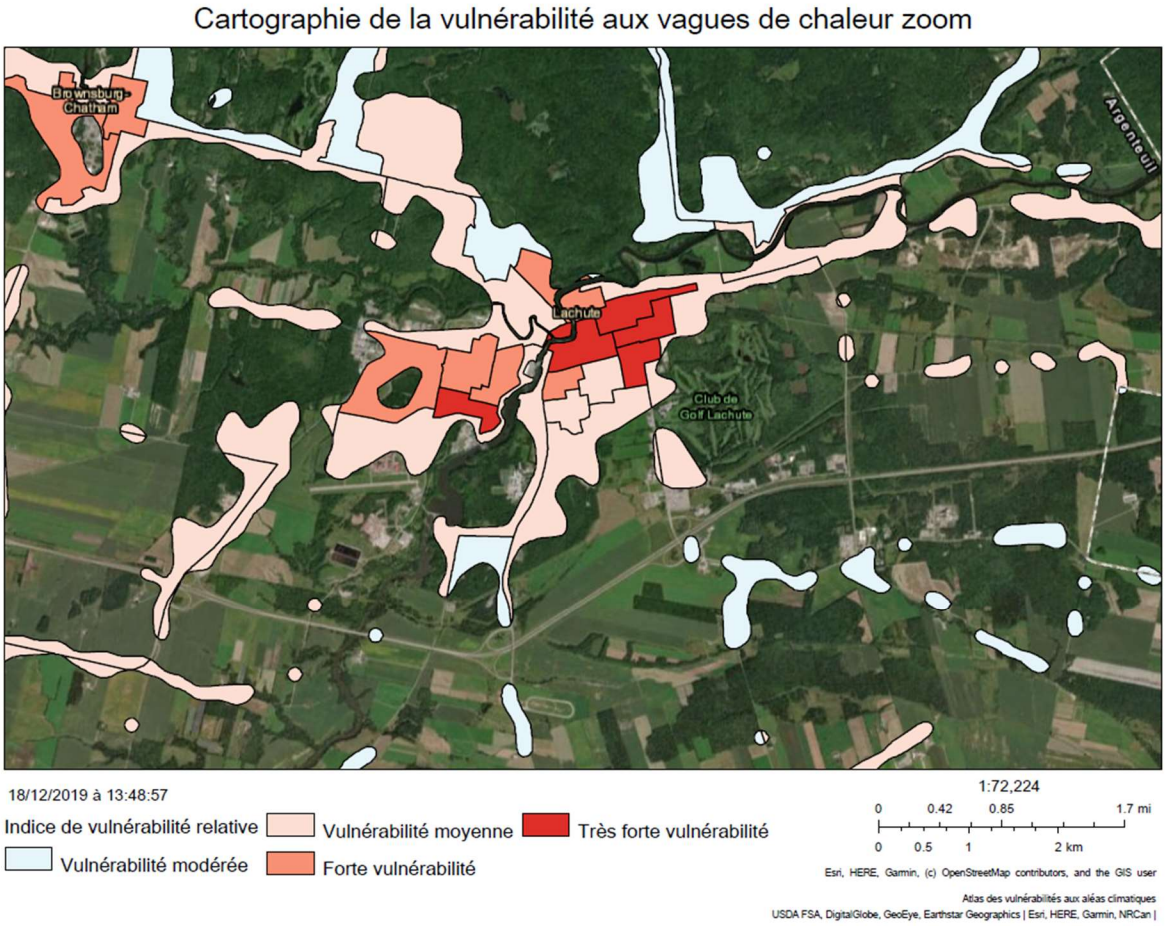

Figure 2: Example of risk mapping (from Baril et al., 2020)

In this example, the climate map used comes from the web atlas of the vulnerability of the Quebec population to climate hazards. This risk representation allows the vulnerabilities of the population to be grouped with those of the ES that provide resources for this same population.

Crisis management mechanisms

The combined representation of risks, such as the example in Figure 2, allows all stakeholders to reinforce their understanding of population safety issues. It allows regional authorities (MRCs in Quebec) to play a central role in the framework of collaborative governance by disseminating these cartographic representations, but also, and above all, by facilitating, framing and coordinating the multiple risk management mechanisms that result from them.

The managers and owners of the identified ES, based on the probabilities related to the available climate information, will be able to establish their own risk analyses and then carry out risk assessments according to their operational risk acceptability thresholds. Crisis management plans as well as internal plans for dealing with these risks will then be produced. The regional authorities will then have to ensure consistency in the crisis management measures of the various

SEs and ensure integration into the civil security plans drawn up by the civil security authorities. The protection and safety of the population on the territory will then be increased.

The implementation of such a collaborative governance framework at the regional level can allow the development of complementary risk management mechanisms. Among these, the following mechanisms have been identified:

Establishing a portrait of ES in the territory and mapping vulnerabilities will allow the development of a unified regional vulnerability index that can be integrated into three-year capital plans to plan infrastructure investments to reduce vulnerabilities.

Develop mechanisms for regional coordination and mobilization of resources for crisis management, linked to existing provincial and federal warning systems. Regional authorities have a leading role in establishing and maintaining these mechanisms.

Develop regional plans for mitigating the vulnerabilities of ES to major climate hazards. Regional planning schemes are possible tools, as is the development of preventive maintenance policies adapted to specific climatic situations. Specific regulations can also be adopted to support regional plans.

Develop mechanisms to exercise the civil security plans present in the territory to validate their adaptability to future climatic events related to climate change.

One of the important elements that also emerge from the operationalization of these mechanisms is adaptability. These mechanisms, as well as the tools, must be adapted to the context of each MRC in order to be better integrated into their operations. The level of maturity, as well as the available resources (both human and financial), do not allow for the same appropriation of results.

Another element is leadership. Leadership consists of the commitment of community decision-makers during all stages of the process. Responsibilities, objectives and the means to achieve them must be assigned at the outset. Communication and consultation are components of the process with the objective of improving the understanding of the risks and the process by all actors considering their various perspectives and ensuring that all participants understand the contributions and the mobilization procedures. It fosters trust between actors, the reduction of contradictory actions, the sharing of visions and objectives, the acceptability of the measures envisaged and the preparation of actors in the face of risks. It is therefore very important to clearly define the needs and actions that the MRC can implement. This will make it possible to exercise leadership that is mobilizing, unifying and inclusive, based on direct dialogue, confidence building, commitment, shared understanding and, above all, to provide intermediate results. This leadership will mobilize all ES and other stakeholders in the risk assessment process. This is a winning condition for a successful risk management process.

Conclusion

Climate change and its effects on ES and the public are well documented. Municipalities are the first to be affected and have a responsibility to manage the risks. However, municipalities are not the only owners of ES. They must work with the companies that own EM within their jurisdiction. Given their diversity (number of employees and budget), it becomes necessary to

consider how best to address this issue. The governance framework proposed in this article helps to address this issue.

The establishment of a portrait of the ES in a territory, through a regional authority, puts in place the conditions that promote collaboration between municipalities and ES. This portrait provides stakeholders with concrete tools to better appreciate the risks inherent to CCs on the territory and to better target their actions. The coherence that emerges from this risk assessment process is directly linked to improved territorial resilience. The various crisis management mechanisms that can be put in place will complement the actions already in place.

Finally, the leadership that the regional authority will exercise in the implementation of this framework dedicated to risk assessment will remain the element that will ensure the success of its implementation as well as its sustainability.

This article was originally submitted in French. See the French version for references

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