

## Urban Resilience: Short-term Recovery and Long-term Adaptation After the 2011 Floods in Saint-Jean-sur-Richelieu (Canada)

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### Abstract

Recent studies address resilience - specifically urban resilience - from the point of view of the factors that contribute to the development of adaptation mechanisms. They often stress the physical, economic, institutional and socio-cultural dimensions of resilience. However, these factors are often considered independent of one another and the relations between them and the projects' time phases and scales of intervention are largely underestimated. This research project proposes a framework that examines the variables constituting disaster resilience and the relationships between these variables. The framework is illustrated (and tested) with empirical results from the study of adaptation mechanisms and reactions developed after the 2011 floods that took place in Saint-Jean-sur-Richelieu in Canada. The research is supported by a detailed literature review on the subject, reports by local media and interviews with residents and local officials responsible for decision-making. The study finds that the actions carried out responded specifically to the emergency situation and benefited from a strong participation of the local government, provincial and local organisations. These actions ultimately mitigated imminent needs, but did not create sustainable resilience mechanisms to reduce the risks of future floods. There is an imbalance between efforts in emergency response and actions aimed at long-term risk reduction. It is concluded that an integration of the different factors of urban resilience, time scales and levels of intervention is required to produce more sustainable relationships between civil society, the city and the natural environment.

**Keywords:** Urban resilience, Emergency, Reconstruction, Risk, Canada, Floods.

### Introduction

Climate change is seen today as one of the most important urban challenges (Leichenko, 2011), and floods are one of its most visible consequences and one of the most common natural disasters in both developed and developing countries. This research examines these threats through the lens of urban resilience - which refers to the ability of a system, community or society exposed to hazards, to resist, absorb, adapt and recover from them effectively (UNISDR, 2009; Escalera and Ruiz, 2011). The study finds that the most recent contributions to urban resilience address the dimensions, scales and phases that need to be taken into consideration. However these are often considered separately and the relationships between them have been insufficiently explored. In response, this study aims at (a) analysing the mechanisms of adaptation and reaction carried out by institutions and individuals after the 2011 floods in Saint-Jean-sur-Richelieu, in Canada, and b) by doing so, examining the integration of the dimensions, scales and time phases that constitute urban resilience. In this way, the empirical and theoretical contributions of the study reinforce each

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other (the case study illustrates the analytical framework proposed here, but it also feeds its construction and analysis). In the following section, the theoretical framework of urban resilience is presented. The second section presents the methodology and the case study. In the third section, the results reveal the actions that contribute to urban resilience, which are then analysed in the discussion. The conclusions summarise the contributions of the study and present areas for future work.

## **A Framework of Urban Resilience**

Several authors argue that resilience is an attitude rather than a state, modeling the dynamics inherent to a socio-ecosystem from the point of view of the human protagonist (Escalera and Ruiz, 2011). There is a consensus also that planning for resilience after disasters includes considering short-term actions aimed at immediate recovery and developing long-term adaptation mechanisms aimed at reducing vulnerabilities (understood here as a progressive construction of weaknesses in the face of threats; Blaike et al., 1994; Hewitt, 1997). All of this requires the action of multiple civil society stakeholders, local and national governments, the private sector and the professional community (Jabareen, 2012). This research adopts the four dimensions of resilience identified by Leichenko (2011), but is also enriched by other approaches to the resilience concepts: (1) Urban ecological resilience, (2) Urban risk and disaster risk reduction, (3) Resilience of urban and regional economies, and (4) Urban management and institutions (Governance).

Urban ecological resilience emphasises traditional notions of ecosystem resilience and self-organisation in the face of uncertainty (Andersson, 2006; Barnett, 2001; Ernstson, 2010; Folke, 2006; Maru, 2010). The ecologists Walker and Salt (2006) describe resilience as the ability of a system to absorb changes and reorganise during the pressure of a new situation, retaining its function, structure and identity. In this approach, the city is understood as a system, where there is a close nature-society interaction at play - and often - at risk (Escalera and Ruiz, 2011).

Urban risk and disaster risk reduction put emphasis on improving the capacity of cities, infrastructure systems, urban populations and communities, to recover quickly and effectively from 'natural' and man-made hazards<sup>1</sup>. As such, resilience is considered a complementary concept to the theory of vulnerability (Pelling, 2003; Cutter et al., 2003) that focuses on risk reduction, efficient reconstruction strategies and adaptation to the environment. Risk reduction involves quantifying the resilience to hazards and assessing the resilience of urban infrastructure systems and built environments (Red Cross, 2012). It provides opportunities for investments by improving and modernising the infrastructure, refurbishing buildings for better efficiency and safety, and facilitating urban renewal and slum upgrading (UNISDR, 2010). Prioritising investments in cities, it is often argued, can help mitigate the impact of disturbances and reduce future risks.

Resilience of urban and regional economies takes into account the complexity, diversity and self-organisation of dynamic economic systems and industries. This dimension emphasises the role of power and politics to influence development (Rose, 2004; Simmie and Martin, 2010, Leichenko, 2011; Jabareen, 2012).

Urban management and institutions focuses on how institutional arrangements and governance mechanisms affect resilience. Local governments – it is often underscored - represent the institutional level that is closest to the communities and thus they should play

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<sup>1</sup>Blaike et al (1994) and Hewitt (1997) have argued that disasters are the result of the natural order of societies and not an interruption in societies, demonstrating that disasters are not in reality 'natural' but the cumulative result of social-based characteristics.

an immediate role in responding to crises and emergencies (UNISDR, 2012). They also provide essential services to citizens (health, education, transportation, water, etc.), which must be resilient to disasters. Furthermore, they are responsible for fulfilling various functions essential to reducing disaster risks in the long-term: land use planning, provision of public works and safety, provision of building permits and social services, etc. (UNISDR, 2010). It is asserted that a resilient city must have proper decision-making processes in the field of planning, including open dialogue, accountability and collaboration.

## A Holistic Approach to Post-Disaster Reconstruction

The four dimensions described above put emphasis on different aspects of the relationships between the societies, the built and the natural environment. However, there has been an increasing call for the systemic integration of the resilience variables (Howell and World Economic Forum, 2013; Martin-Breen and Anderies, 2011). Boshier (2010), for instance, proposes a holistic approach to post-disaster action in which physical vulnerabilities and natural hazards are confronted with socio-economic and political processes (see Fig. 1). He proposes fiscal constraints from the point of view of the way resources are distributed to reduce vulnerability, to whom and how, in relation to local levels of building capacity, so that technological solutions are available locally. He also emphasises appropriate technological solutions that incorporate traditional and community skills. Similarly, governance and political factors - he argues - must consider traditional forms of power within the community. This holistic focus is also claimed by Escalera and Ruiz (2011), who highlight the importance of taking into consideration multiple socio-cultural conditions - including local traditions, forms of organisation, social relations, creativity, learning ability, reorganisation and innovation.

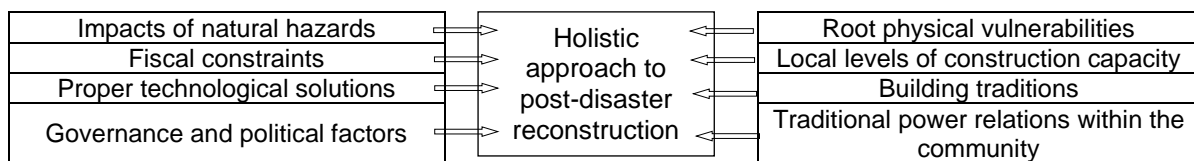


Figure 1: Components of a holistic approach to post-disaster reconstruction, according to Boshier (2010).

It can be argued that the four dimensions of resilience (Physical-Urban, Economic, Institutional and Socio-Cultural) are related to each other by a fifth dimension: communication and ties between stakeholders. In fact, UNISDR (2009) argues that communication and information are key factors in raising public awareness for the effective reduction of disaster risk. This includes development and dissemination of information through the media, educational campaigns, establishment of information centers, participatory actions, and early warning systems. Four key elements are often considered related to the dissemination of information: (a) increase of risk awareness, (b) monitoring, analysis and forecasting of threats, (c) communication or dissemination of alerts and warnings, and (d) development of local capacities to respond to the alerts received. With the aim of complementing the framework proposed by Leichenko (2011), we integrated the dimension of communication in our analytical framework of resilience (Table 1).

Table 1: Dimensions of urban resilience. Source: authors.

Dimension	Aspects emphasised	Authors who analyse them
Physical-Urban	<ul style="list-style-type: none"> <li>- City as a nature-society system</li> <li>- State of infrastructure and buildings</li> <li>- Appropriate technologies for reconstruction and</li> </ul>	Leichenko, 2011; Lizarralde, 2011; Red Cross, 2012; UNISDR, 2010; Walker and Salt,

	rehabilitation (physical vulnerabilities)	2006; Andersson, 2006; Barnett, 2001; Ernstson, 2010; Folke, 2006; Maru, 2010
Economic	<ul style="list-style-type: none"> <li>- Self-organisation of economies</li> <li>- Adaptation to economic turbulences</li> </ul>	Leichenko, 2011; Rose, 2004; Simmie and Martin, 2010; Jabareen, 2012
Institutional and governance	<ul style="list-style-type: none"> <li>- Institutional arrangements</li> <li>- Services rendered to the population: education, health, transport, communication, etc.</li> <li>- Urban development and land use planning</li> <li>- Public works</li> <li>- Security and building permits</li> </ul>	Leichenko, 2011; UNISDR, 2010; Jabareen, 2012; Djordjevic, 2011
Socio-cultural	<ul style="list-style-type: none"> <li>- Local traditions (ways of building, organisation of spaces)</li> <li>- Social relations</li> <li>- Level of education in perception and risk prevention</li> <li>- Existence of disadvantaged groups</li> </ul>	Escalera and Ruiz, 2011; UNISDR, 2009
Communication	<ul style="list-style-type: none"> <li>- Media and information</li> <li>- Early Warning Systems</li> </ul>	UNISDR, 2009

Besides these dimensions, there are also different scales at which resilience can be analysed. In fact, resilience can be achieved at the individual, family, community, city and national scales. These scales constantly interact with each other; for instance, community resilience can enhance or diminish family resilience, and vice versa. Arguably, resilience dimensions are not static, but evolve in time before, during and after the disaster. Physical destruction and loss of lives, for instance, influence people's attitudes towards risk in the immediate phase after disaster. Keeping in mind the dynamic nature of resilience dimensions, scales and phases, we propose a model that relates the different variables considered in a holistic assessment of resilience (Fig. 2). The model recognizes that the physical, economic, institutional, socio-cultural and communication dimensions happen at different scales and shape decision-making differently before, during and after the disaster. We will dwell on the advantages and limits of this framework in the section of discussion.

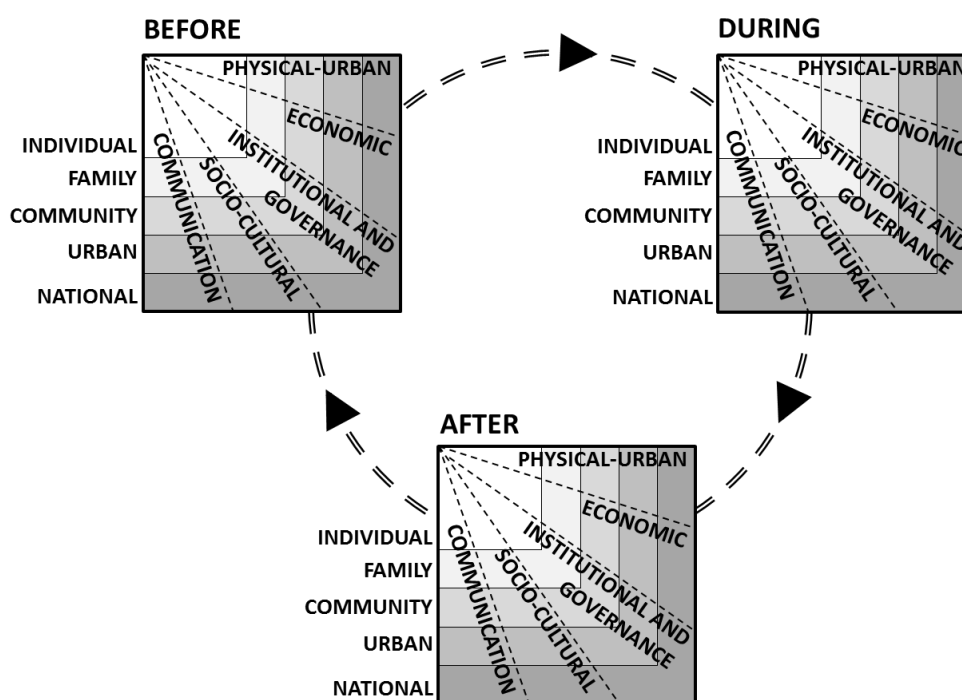


Figure 2: Model relating resilience dimensions, scales and phases.

## Research Methods

A detailed case study was conducted to collect and analyse the empirical evidence that simultaneously fed and was structured by the analytical framework presented above (Yin, 1984). The study proposed the following research question: What resilience mechanisms were implemented or developed after the 2011 floods in Saint-Jean-sur-Richelieu? Considering the action fields and the diversity of the stakeholders involved in the process, we examined both the mechanisms developed by the affected population and those implemented by the local government and community organizations. Initially, reports, printed documents and press releases were analysed (more than 65 documents were consulted). In total, three field visits were conducted. The first visit took place on May 30<sup>th</sup>, 2011, one week after the declaration of disaster, and the other two on October 4<sup>th</sup> and 18<sup>th</sup>, 2012. Photos of the settlement were taken during the three fieldwork visits to document changes to the structures and urban spaces and to report the technologies used in both private and public buildings. Likewise, diagrams were developed to analyse the relationships between and actions undertaken by different governmental institutions and organizations from the local to the federal level (Fig. 4). Subsequently, fifteen semi-directed interviews were conducted in order to recognize the mechanisms of adaptation and reaction undertaken by institutions and people in emergency and recovery (see Table 2). Local organisations were chosen after consulting reports and articles issued by the local and national press between May 3<sup>rd</sup>, 2011 and April 7<sup>th</sup>, 2012. This includes CTV Montreal News (Local Edition Montreal), The Canadian Press (Provincial Edition); CBC News (National Edition); QMI Agency (National Canadian Press); Radio-Canada.ca (Montreal Local Edition).

Key respondents were chosen in each organisation, notably officers with access to information and/or who had witnessed the 2011 floods. Appointments were arranged prior to the interviews to explain the objectives of the interviews and to ensure the willingness of the participants to provide accurate information. The interviews were held in two steps. The first one was largely structured in order to identify information on specific aspects previously identified by the researchers. In the second step, the interviewee could provide additional information and comments on aspects not previously considered by the study. Each interview took between 30 and 40 minutes. The data was then organised in tables according to the dimensions, scales and time phases proposed in the analytical framework.

Table 2: Summary of the interviews.

Unit	Interviewees	Objectives
Local Authorities and Organisations	<ul style="list-style-type: none"> <li>- The Municipality Deputy Mayor</li> <li>- A Civil Security Officer</li> <li>- A Director of the Fire Department</li> <li>- A Red Cross Volunteer</li> <li>- A Volunteer of the Assistance Center</li> </ul>	<ul style="list-style-type: none"> <li>- Understand the functioning of the public warning system and communication</li> <li>- Identify the emergency measures and responsiveness</li> <li>- Identify the role of organisations</li> <li>- Identify the sources of funding for the projects</li> <li>- Identify the measures and plans adopted to reduce future risks.</li> </ul>
Residents	<ul style="list-style-type: none"> <li>- Victims (10 interviews with local residents)</li> </ul>	<ul style="list-style-type: none"> <li>- Identify how plans are received and accepted by the population</li> <li>- Identify the extent to which the population was ready</li> <li>- Identify links with governmental and Non-Governmental Organisations</li> <li>- Identify funding sources</li> <li>- Identify measures of preparation</li> </ul>

## Results

Montérégie is an administrative region of the province of Quebec, situated on the south bank of the St. Lawrence River, on the Canadian border with the United States. It has a surface area of 11,131 square kilometers and a population of 1,442,433 inhabitants, most of them located near the St. Lawrence River. Its economy is based on agriculture and the production of goods and services. Saint Jean-sur Richelieu is a city in eastern Montérégie, located about 50 kilometers southeast of Montreal, in the west bank of the Richelieu River, at the northernmost navigable point of Lake Champlain, and has a population of 92,394 inhabitants. The region has a diversified industrial sector and land reserves to meet short and mid-term demands. However, it also has aging infrastructure and its housing stock is in poor condition. One of the most common causes of floods in Montérégie (and in Canada) is the accumulation of winter ice and snow, which is released in spring when temperatures rise above the freezing point. In the months of April and May 2011, the region of Montérégie was affected by the most important floods in the province's recent history: 3000 houses were reported flooded. The contamination of drinking water and odors caused by decomposing organic matter followed.

Although not all individuals behaved in the same way during the disaster, it can be said that there were similar patterns. These have been identified in those aimed at preserving the goods and those for the adaptation and mitigation of damages and threats. Differences in individual responses include the refusal of some families to evacuate, and their decision to stay in affected homes while protecting property. This can be considered an indicator of inadequate risk perception by residents living in an area historically affected by floods. Additional actions presented in tables 3 and 4, carried out at each scale (individual, family, community, urban, and national) address the resilience dimensions presented in the theoretical framework (physical-urban, economic, institutional and governance, socio-cultural, communication) (see Table 1).

Table 3: Resilience mechanisms deployed during the emergency phase.

Scale	Examples of actions	Objectives
Individual	<ul style="list-style-type: none"> <li>- Eliminate goods and objects that may provoke damages</li> <li>- Install sand bag barriers to prevent water from entering the houses</li> <li>- Persist living in the affected houses, avoid evacuation and protect assets</li> <li>- Filter or clean polluted water, or obtain bottled water from community aid centres</li> <li>- Follow instructions</li> </ul>	Protect individual material assets and reduce effects
Family	<ul style="list-style-type: none"> <li>- Evacuate houses and move to non-affected houses and hotels</li> <li>- Welcome and assist families whose homes were affected</li> <li>- Inform authorities about housing damage</li> <li>- Follow information and guidance provided by the authorities</li> <li>- Attend information meetings convened by the Government and Civil Security</li> <li>- Request and receive aid and compensation from the Government</li> <li>- (Note: Many families due to previous flood experience, procured pumps and electrical generators in advance and as a result, managed to remain in their houses)</li> </ul>	Reduce the effects of damages
Community	<ul style="list-style-type: none"> <li>- Provide information services, drinking water, showers, and snacks or food in care centres for floods victims</li> <li>- Fundraise for Disaster Relief (Red Cross).</li> <li>- Mobilise volunteers to work in community aid centres, fundraising, construction, manufacture and distribution of sandbags</li> <li>- Offer childcare services for clean-up volunteers</li> </ul>	Adapt to damages

Urban	<ul style="list-style-type: none"> <li>- Distribute 325,000 sandbags to families and install a sewage pumping system</li> <li>- Conduct a survey of damaged houses</li> <li>- Inspect technical conditions of the houses to ensure a safe return of victims</li> <li>- Patrol the area in boats</li> <li>- Provide public transport services via safe routes</li> <li>- Install waste collection containers</li> <li>- Provide counseling to flood victims</li> <li>- Conduct public meetings to disseminate information on measures to be taken</li> <li>- Issue updated news every half hour on local radio</li> <li>- Distribute daily bulletins house by house to tackle the lack of electricity</li> </ul>	Adapt to damages
Strategic / National	<ul style="list-style-type: none"> <li>- Distribute sandbags and mobilise armed forces for this work (place sandbags)</li> <li>- Provide financial aid to affected families.</li> <li>- Administer free vaccinations to victims and volunteers</li> </ul>	Adapt to damage

Table 4: Resilience mechanisms deployed during the recovery phase. Source: authors.

Scale	Examples of actions	Objectives
Individual	<ul style="list-style-type: none"> <li>- Rebuild houses on stilts without basement</li> <li>- Replace affected timber poles with moisture-resistant metal ones</li> <li>- Repair and renovate the affected houses</li> </ul>	Adapt to threats
Family	<ul style="list-style-type: none"> <li>- Host affected families during the reconstruction work of their homes</li> </ul>	Adapt to threats
Community	<ul style="list-style-type: none"> <li>- Coordinate volunteer work to clean up the city</li> <li>- Perform cleaning and sanitation activities in the affected areas</li> </ul>	Adapt to threats
Urban	<ul style="list-style-type: none"> <li>- Maintain and repair the city sewage network</li> <li>- Distribute reparation construction kits to affected families</li> <li>- Inspect projects to ensure their compliance with technical requirements and risk reduction criteria</li> <li>- Collect funds for reconstruction</li> <li>- Offer free construction permits to victims</li> </ul>	Adapt to threats; Reduce damage
Strategic / National	<ul style="list-style-type: none"> <li>- Award financial compensation to affected families</li> </ul>	Adapt to threats; Reduce damage

## A Network of Actions

The assessment of damages to private property was conducted by the Civil Security (Fig.4) and the assessment of damages to public infrastructure was conducted by the Municipality's department of Technical Services. At the onset of the floods, the Civil Security had not designed an alert system. The warning models were a responsibility of the Civil Security and relied on visual reference points measured every year according to the analysis of rainfall. The municipality distributed daily bulletins informing the public about what actions should be taken and providing precautions and general information. Small boats and amphibian cars belonging to the municipality were appointed for the evacuation of residents; community centres were equipped to provide information, clean water and immediate help. The

municipality's vehicles and small boats constantly collected information about what was happening in the city, and the city's planning department visited the most severely affected houses.

Health centres also participated in this process and, although there were no fatalities, it was necessary to offer psychological help to affected residents. The main source of funding for these measures, both in the emergency and the recovery, was the Ministry of Civil Security (70% of the costs were refunded by the Ministry and 30% were assumed by the municipality). The government undertook the task of reviewing the projects and providing financial assistance to them. However, this aid, according to several affected residents, was not sufficient to cover the expenses of reconstruction.

To clean the city, thousands of volunteers joined with local businesses that made their vehicles available for waste collection. After just two weekends, all the cleaning tasks were complete, and recovery efforts could focus on cleaning and repairing individual houses. The decision of whether to rebuild or repair was carried out using the criteria of provincial government inspectors (of the Civil Security), who, if necessary, ordered the demolition of the units. The resistance to moisture conditions and price were the main criteria for selecting the technologies and materials used in repairs and reconstruction (see fig. 3).



Figure 3: Adaptation mechanisms. Left: Strengthening in a house foundation. The original vertical support elements made of wood have been replaced by metallic ones resistant to moisture; Right: A newly built house rises from the ground level and does not have a basement, which is often vulnerable to floods.

Despite the support offered to victims, it was reported in July 2011 that hundreds of affected families were still waiting for financial aid. However, "The Government of Quebec set as deadline July 27<sup>th</sup> to deliver the first cheques promised as financial compensation to victims of the floods in Montérégie"<sup>2</sup>. A year and a half after the incident, there were 2,298 applications for financial assistance submitted to the government, there were 133 completely destroyed units and \$52.2 million paid to victims, including \$765,000 to 197 affected farmers. In May 2011, Canada's Minister of Foreign Affairs formally asked the International Joint Commission for Lake Management (which includes the United States and Canada), for an assessment of the costs of risk reduction in the region. The commission, if anything, provided an analysis of the flooding causes and pointed out that it was the third assessment

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<sup>2</sup> This was announced by the president of the organisation SOS Richelieu, Michel Fecteau, who explained that the government had already sent 380 cheques to cover 50% of the damage assessment of homeowners in the region. The agency had collected more than \$400,000, while the Red Cross collected about \$1.6 million to help families affected by the floods. In addition, a total of \$800,000 was collected in materials and products needed for the reconstruction of the region. Fecteau admitted that the amount collected would not be enough to solve the problems of the entire affected community. At the same time, a group of artists put on a show dedicated to the 800 families affected by the flood.



requested.<sup>3</sup> In fact, the river has exceeded the critical level of 30.48 m 27 times in 150 years; that is approximately one time every 5 years. This information underscored that flooding is an expected event in the Montérégie region, with a frequency that vividly remains in people's memories.

## **A Network of Stakeholders**

Figures 4 and 5 present the various stakeholders that participated in the emergency and recovery phases and the relationships between them. Fig.4 presents the roles assumed by each player, including the affected population. It shows that several actions were simultaneously required in the emergency phase, and thus an integrated intervention of different stakeholders was crucial. This integration and collaboration between stakeholders proved to be one of the most important strengths of the program. Other strengths included: (a) the government's willingness to provide funding; (b) the existence of a Government Act that regulates financial assistance in case of an actual or impending disaster, implemented and managed by the Ministry of Public Security; (c) the rapid mobilisation capacity of the Red Cross and local organisations; (d) the availability of construction materials and local small businesses to carry out reconstruction activities; and (e) the existence and performance capacity of the Civil Security's Government Operations Centers (GOC).

On the other hand, the program also met several challenges, which were underscored by experts, local residents and media. These include: (a) An insufficient alert system (notably communication between the Civil Security's Government Operations Centres -GOCs); (b) Prevalence of homes built with a basement and widespread use of timber structures; (c) Insufficient supervision of reconstructed homes and repairs; (d) Insufficient funding and government allowances to cover the entire loss of property; (e) Location of homes in areas prone to flooding; and (f) Lack of investment plans in the city's infrastructure to reduce flood risk. Of concern is that most of the actions undertaken concentrated on the houses' immediate reparation. In partially-affected houses, the damage was concentrated mainly in the basement, and actions taken to reduce their vulnerability included waterproofing work and replacing wooden supports with metal ones (fig. 3). Moreover, the houses that required complete reconstruction were most often rebuilt on the same site.

Up until February 2013, municipal plans did not yet include any engineering work to improve the city drainage system to tackle future flooding (a suggestion made by the Joint International Commission for Lake Management since 1939). Only isolated actions have been taken to maintain the existing infrastructure. The construction of a new canal to reduce floods is a competence of the Federal Government and it is subject to international agreements with the United States, which so far, have not been approved. The municipality has a limited budget for risk reduction plans and is forced to ask for compensation and relief efforts from the Provincial Government's Civil Security.

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<sup>3</sup> In 1939, a proposal was made to build a dam. For it to be effective, the canal should have been widened, but this was never done. In 1980, the International Mixed Commission of Administration of Lakes that United States and Canada share proposed to dig and expand the Richelieu River to a width equivalent to 82 Olympic pools - a 2.5 km wide canal. The cost was equivalent to \$12 million CAD in today's current rate. This plan was also never materialised.

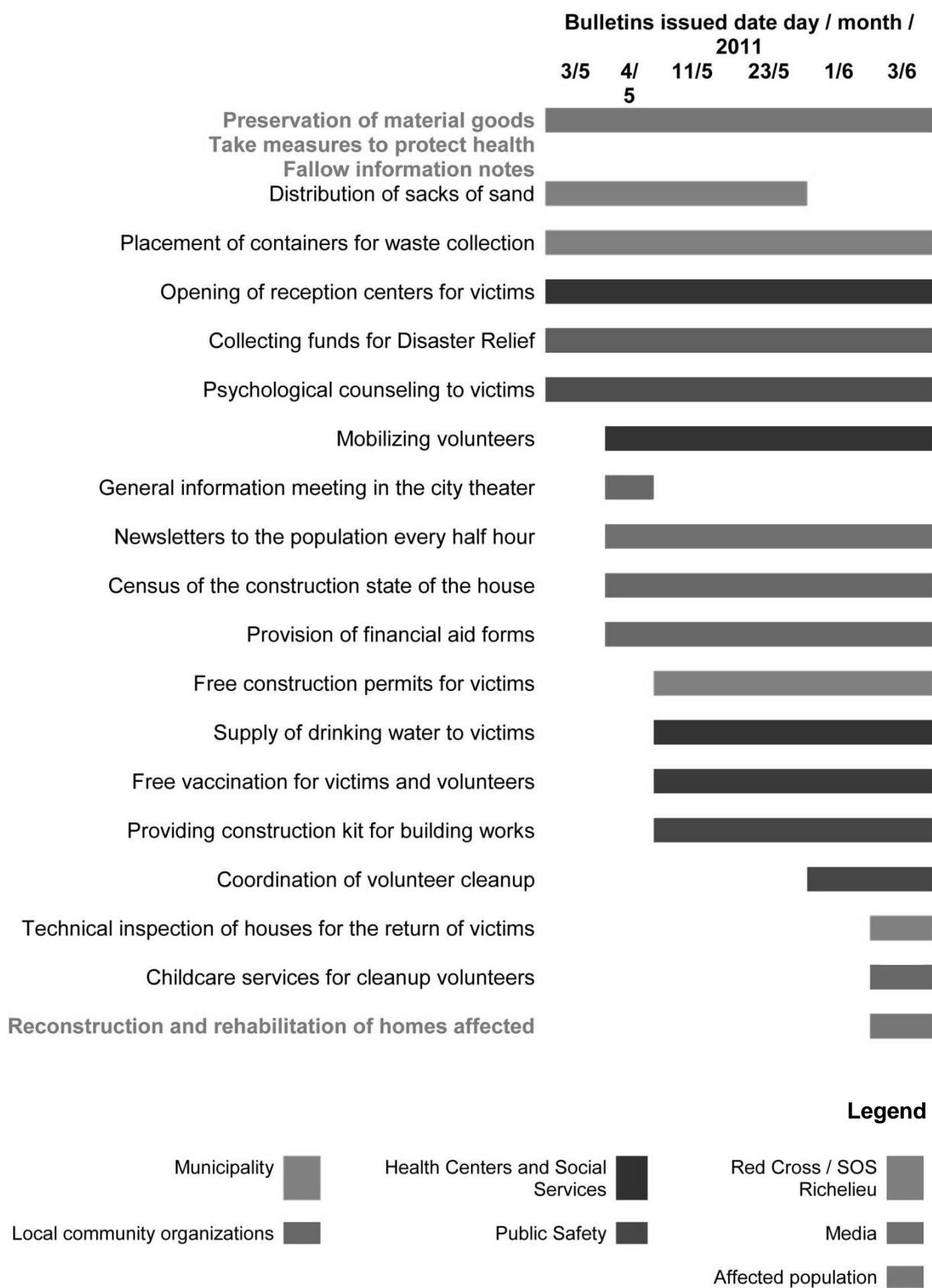


Figure 4: Stakeholders and actions undertaken during the emergency, according to official bulletins.

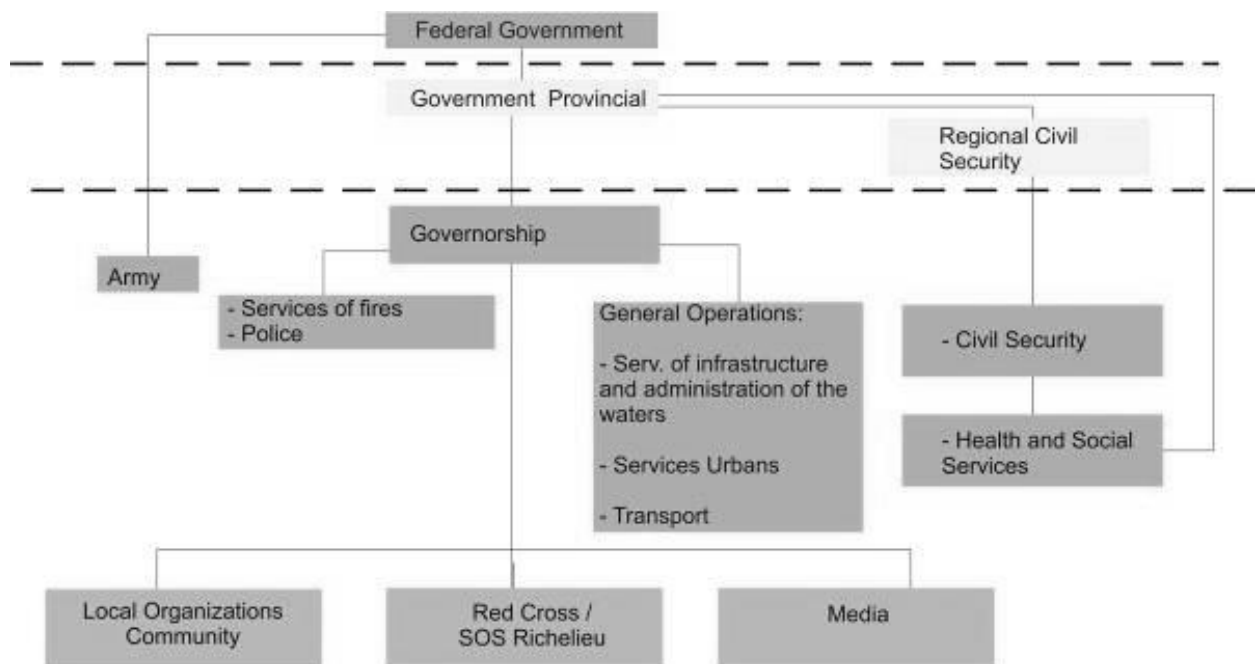


Figure 5: Diagram showing stakeholders' relationships and involvement during the 2011 post-flood interventions in Saint-Jean-sur-Richelieu.

## Discussion

Based on the dimensions identified by Leichenko (2011) and other publications mentioned in the previous sections, this study reveals the need for integrating the dimensions that influence urban resilience at different scales (individual, family, community, city and country) and during the three phases of disasters (before, during and after). According to recent literature in the field, achieving urban resilience requires more than taking measures to face the emergency phase; it includes undertaking strategic actions aimed at the development of long-term adaptation. These actions must concern multiple dimensions: physical-urban, economic, institutional and governance, socio-cultural and communication. In the case of floods in the Montérégie region, great emphasis has been put on measures that tackle the emergency phase and measures that solve the immediate effects of the disaster, but insufficient efforts are aimed at reducing future risks in the long term and at adapting structures and infrastructures to (already frequent) natural hazards. We shall now analyse some of the achievements and needs in each of the resilience dimensions considered in the conceptual framework.

- a. Physical-urban dimension: physical risk reduction was observed only in the repair and reconstruction of affected units. In this regard, physical vulnerability did decrease due to the repairs conducted in basements and exposed elements. In the case of new houses, they were built on the same site, although the new regulations do not approve the reconstruction of buildings in flood-prone areas. However, new homes without basements, built on stilts, and raised from the ground level, were most often proposed. There is still need for improvements in drainage systems to make the city more resilient to future events. Arguably, there is still an important risk of further flooding and losses. However, it must be highlighted that the local government and independent organisations remained functional during the disaster and provided support for disaster victims. In fact, the main functions of the city kept working, including waste collection, health, communication, transport, and provision of drinking water (albeit with temporary

adjustments). Under these circumstances, all organisations acted in a coordinated and collaborative manner, a fact that had a positive effect on the development of actions during the emergency phase.

- b. Economic Dimension: The local economy was not dramatically affected by the disaster. However, the disaster highlighted the fact that the municipality has a limited budget for risk reduction plans and that it depends on compensation and relief efforts from the provincial government.
- c. Institutions and governance dimension: the municipality and other organisations acted quickly after the floods. The municipal government was responsible for coordinating the delivery of essential services in the city and it efficiently delegated some of these responsibilities to the departments of urban planning and public works. However, investments were not focused on reducing future risks.
- d. Socio-cultural dimension: The level of education in the region is relatively high for Canadian standards. This was certainly an asset that contributed to the development of individual projects of renovation and retrofitting. However, there is insufficient awareness about the risks associated with living in proximity to the water. Despite the fact that floods are frequent in the region, residents underestimate the effects that floods can have in their houses and health.
- e. Communication and links between stakeholders dimension: One of the most important strengths of the program was the efficient communication and information means deployed during and after the disaster. This information was crucial for families, particularly in applying for financial aid and in responding to evacuation measures.

These results must be taken with sufficient prudence, considering the scope and methods used for the empirical analysis. In fact, the study was limited to the emergency and the recovery phases and it does not include a follow-up of the development of resilient measures over the medium or long-term. However, we are confident that they provide insightful information about the imbalances that can emerge between the immediate recovery and long-term adaptation strategies during post-disaster interventions. Additional studies could carry out a longitudinal analysis of the same program, analysing the development of resilience measures over time.

## Conclusions

This study proposes a conceptual framework for the study of urban resilience that builds on previous work and argues for a systems approach to resilience. In doing so, it integrates different dimensions and different scales of resilience during three key moments of time. In order to illustrate the analysis and feed the theoretical approach, the study examines the case of the post-flooding emergency and recovery phases of Canada's Montérégie region. The empirical study was based on interviews, analysis of printed information and on a literature review. The case study exemplifies that resilience measures do not always manage to balance emergency measures with long-term risk reduction ones. In fact, in the case study, it was found that post-disaster measures were aimed notably at reducing the immediate impacts of the floods, while less attention was given to creating infrastructure projects, enforcing legislation and educating the population for preventing future floods in the region. These findings have theoretical implications; the resilience analysis framework can be further used in additional cases studies and enriched by new studies. From a practical point of view, the results highlight the need for balancing immediate responses to urgent needs in the short-term and structural measures on the one hand, with long-term effects on adaptation to disaster risks, on the other hand. Stakeholders must work in an integrated manner to create decision-making mechanisms and structures that facilitate the development of long-term adaptation strategies at the individual, family, community, city and national levels. Decision-makers should note, however, that these mechanisms and strategies might evolve before, during and after the disaster with implications for the five

dimensions of resilience identified above. Academics and researchers must continue to explore the relationships between the different variables that influence resilience and – keeping in mind these relationships - they must develop units of measure for assessing of resilience.

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