Digital traces of climate risks. Assessing the communication impact of Paris resilience strategy.

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Digital Traces of Climate Risks

Assessing the Communication Impact of Paris Resilience Strategy

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Abstract

Climate pressures contribute to the complexity of urban systems that have multiple functions and interacting components. The concept of resilience introduces a holistic approach, embracing both the physical environmental (PE) and the socio-economic (SE) components of cities. 'Resilience thinking' involves overcoming fragmentation in risk management, by creating synergies among stakeholders. It is a challenge that illustrates the importance of the 'social construction of reality': a specific dimension of the city that corresponds to the perceptions and attitudes of the urban community regarding an issue or solution.

This thesis contributes to the current need to forge this link between the PE and SE components when studying climate-related risks in urban areas. More specifically, it attempts to answer the question: how can we analyse the role of communication in urban resilience?

With these premises in mind, the thesis proposes novel Resilience Communication Indicators (RCIs) that are a prerequisite to collecting meaningful data on stakeholders' views that can affect urban resilience. We designed and tested RCIs to investigate the communication processes that occur in the context of Paris region and local climate resilience strategies.

A first series of experiments are based on research methods that are usually adopted by SIA (Social Impact Assessment) experts. These experiments (press coverage monitoring and a questionnaire on an exhibition) were carried out in the framework of the communication strategy of Interreg NWE IVB RainGain (2012-2015), a European project on urban flood resilience.

Exploration techniques of unstructured big data (text mining and graph representation) were used for a second set of experiments. Four corpora of texts were extracted from the Web (with Europresse and Twitter Advanced Search) and analysed (with Gargantext, Gephi and Data Miner): tweets and press articles covering two major flood events in Paris (2016) and in Côte-d'Azur (2015); public authorities' documents on flood risk management in the Paris region (2003-2017).

The press monitoring highlighted that the RainGain communication activities and

two flood events in France and the Netherlands caused an increase of the number of news items on the project per month. The questionnaire brought out a discrepancy between the visitors' results and the control group results and it provided an approximate indication of the impact of the exhibition in terms of information dissemination and the RainGain project acceptance.

The experiments based on text mining and graph representation highlighted that in the press and on Twitter the peak of publications per day is determined by the date of the highest river discharge. Paris flood had more media visibility than the Côte-d'Azur flood, even though the second flood caused a higher number of victims. The press described the damages caused by the floods in both regions, but in the case of Paris the debate on various levers for flood risk management was more detailed. The tweet analysis called attention to the minor discussion on flood risk management solutions, if we compare it to the debate on the press. It also brought out that the most popular users belong to the press and public administration sectors. As for the analysis of public authorities' documents, it highlighted the recent emergence of the following themes: nature based solutions, integrated and multi–scale risk management, subsidiarity.

Both set of experiments showed that there can be correlations between a social factor and an environmental factor: indeed, we detected peaks in communication processes caused by meteorological events. The first series of experiments also proved that RainGain communication efforts resulted in a modest but positive effect on the respondents' awareness and support for a resilience project. The results of the second series of experiments showed that the press and Twitter made a chronicle of immediate flood consequences. In the case of the press, the higher visibility of Paris is probably due to the higher newsworthiness of the events occurring in the French capital and to the extremely high economic risks related to a flood event in the Paris region. The results of the tweet analysis can be explained by the fact that Twitter is typically used as an early warning system (i.e. to disseminate factual information on the time and location of a flood) and that in case of emergency the press and public institutions are considered as official and reliable sources of information. As for the results of the last experiment, these indicate that there is a slow transition towards the resilience paradigm in public authorities' strategies to cope with flood risk in Paris.

To conclude, this research enabled us to test relevant RCIs and analyse quantitative data on communication trends in the context of Paris region and local climate resilience strategies. The experiments showed that SIA techniques and big data exploration techniques complement each other. They also proved that interactions between communication processes and environmental processes can occur: detecting these correlations is the first step to integrate communication evaluation in a general urban resilience assessment.

We encountered experimental constraints that can be addressed with further research. For instance, some methodological limitations can be overcome by integrating SIA

techniques and big data exploration techniques. Most of the experiments were carried out in the Paris region, but can be easily implemented in other regions and with different time scales. We made an hypothesis on how the detected communication trends can affect urban resilience: this has to be validated by analysing potential correlations between communication trends and other resilience factors (e.g. the surface of regreened areas, the amount of insurance compensation, etc.) in the framework of a general resilience assessment.

Keywords: urban resilience, climate hazards, new media, resilience metrics, big data, graph representation.

RÉSUMÉ

Les pressions climatiques contribuent à la complexité des systèmes urbains, qui sont dotés de multiples fonctions et composantes en interaction. Le concept de résilience introduit une approche holistique qui englobe les composantes physico-environnementales (PE) et les composantes socioéconomiques (SE) de la ville. L'approche de la résilience consiste à surmonter la fragmentation dans la gestion des risques, en créant des synergies entre les acteurs. C'est un défi qui souligne l'importance de la construction sociale de la réalité : une dimension spécifique de la ville, qui correspond aux perceptions et aux attitudes de la communauté urbaine vis-à-vis d'un problème ou d'une solution.

Cette thèse contribue au besoin actuel de forger un lien entre les composantes PE et SE dans l'étude des risques urbains liés aux aléas du climat. En particulier, la thèse tente de répondre à la question suivante : comment analyser le rôle de la communication dans le développement de la résilience urbaine?

À partir de ces prémisses, cette thèse développe de nouveaux indicateurs de communication. Ces indicateurs ont été conçus et testés en région parisienne pour étudier les processus de communication qui caractérisent les stratégies locales de résilience aux risques climatiques.

Une première série d'expériences est basée sur des méthodes de recherche habituellement adoptées dans le domaine du SIA (Social Impact Assessment). Ces expériences (veille médiatique et questionnaire sur une exposition) ont été réalisées dans le cadre de la stratégie de communication d'Interreg NWE IVB RainGain (2012-2015), un projet européen sur la résilience aux inondations urbaines.

Des techniques d'exploration de big data non structurés (text mining avancé et représentation de graphes) ont été utilisées pour une deuxième série d'expériences. Quatre corpus de textes ont été extraits du Web (avec Europresse et Twitter Advanced Search) et analysés (avec Gargantext, Gephi et Data Miner) : des tweets et des articles de presse sur deux graves inondations à Paris (2016) et en Côte d'Azur. (2015); des documents institutionnels sur la gestion du risque de crue en région parisienne (2003-2017).

La veille médiatique a mis en évidence que les activités de communication du projet

RainGain et deux inondations en France et aux Pays-Bas ont entraîné une augmentation du nombre d'actualités par mois couvrant le projet. Le questionnaire a mis en évidence un écart entre les résultats des visiteurs de l'exposition et les résultats du groupe de contrôle et a fourni une indication approximative de l'impact de l'exposition en termes de diffusion d'information et d'acceptation du projet RainGain. Les expériences basées sur le text mining et la représentation de graphes ont montré que, dans la presse écrite et sur Twitter, le pic de publications par jour est déterminé par la date du plus haut débit du fleuve. La crue de la Seine a eu plus de visibilité médiatique que les inondations en Côte d'Azur, même si ce deuxième évènement a fait plus de victimes. La presse a décrit les dégâts causés par les inondations dans les deux régions, mais dans le cas de Paris, il y a eu débat plus détaillé sur les divers leviers de la gestion des risques d'inondation. L'analyse de tweet a permis d'observer que le débat sur les solutions de gestion des risques d'inondation a été très limité sur Twitter, si on le compare au débat dans la presse. Il en ressort également que les usagers de Twitter les plus «liké» et «retweeté» appartiennent aux secteurs de la presse et de l'administration publique. Quant à l'analyse des documents institutionnels, cette dernière expérience a mis en évidence l'émergence récente des thématiques suivantes : «nature-based solutions», gestion intégrée et multi-échelle des risques, subsidiarité.

Les deux séries d'expériences ont montré qu'il peut exister des corrélations entre un facteur social et un facteur environnemental : en effet, nous avons détecté des pics dans les processus de communication causés par des évènements météorologiques. La première série d'expériences a également prouvé que les actions de communication autour de RainGain ont influencé de manière positive, mais modérée, la sensibilisation et le soutien des personnes interrogées vis-à-vis d'un projet de développement de la résilience. Les résultats de la deuxième série d'expériences ont montré que la presse et Twitter ont fait une chronique des conséquences immédiates des inondations. Dans le cas de la presse, la visibilité accordée à Paris est probablement due à un intérêt journalistique pour tous les évènements qui surviennent dans la capitale française et, également, aux pertes économiques extrêmement élevées que peut provoquer une inondation en région parisienne. Les résultats de l'analyse de tweet peuvent s'expliquer par le fait que Twitter est généralement utilisé comme système d'alerte précoce (c.-à-d. pour diffuser des informations factuelles sur le moment et le lieu d'une inondation) et qu'en cas d'urgence, la presse et les institutions publiques sont considérées des sources d'information officielles et fiables. Quant à la dernière expérience, les résultats indiquent qu'une lente transition vers le paradigme de la résilience caractérise les stratégies de gestion du risque d'inondation mise en place en région parisinne par les autorités territoriales.

En conclusion, cette recherche nous a permis de tester des indicateurs de communication pertinents et d'analyser des données quantitatives sur des processus de communication dans le contexte de la région parisienne et des stratégies locales de résilience aux aléas du climat. Les expériences ont montré que les techniques SIA et les techniques d'exploration de big data se complètent. Ces expériences ont également prouvé que des interactions entre processus de communication et processus environnementaux peu-

vent se produire : la détection de ces corrélations est la première étape pour intégrer l'évaluation de la communication dans une évaluation générale de la résilience urbaine.

Les expériences menées étaient soumises à un certain nombre de contraintes qui pourraient être résolues à l'avenir. Par exemple, certaines contraintes méthodologiques peuvent être évitées en intégrant les techniques SIA et les techniques d'exploration de données volumineuses. La plupart des expériences ont été réalisées en région parisienne, mais celle-ci pourraient être répétées dans d'autres régions et à différentes échelles de temps. Nous avons fait des hypothèses sur la manière dont les variables de communication pourraient influencer la résilience urbaine : ces hypothèses doivent être validées en analysant les corrélations potentielles entre les variables de communication et d'autres facteurs de résilience (par exemple, la surface des zones reverdies, le montant des indemnités d'assurance-dommages, etc.), dans le cadre d'une évaluation générale de la résilience.

Mots clés : résilience urbaine, aléas climatiques, nouveaux médias, indicateurs de résilience, big data, représentation de graphes.

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CHAPTER 1

INTRODUCTION

From a distance, Mark Lombardi's beautiful, finely pencilled drawings look like star charts. Up close, however, one sees that his perfect circles and networks of arcing lines connect points labelled with names like Oliver North, George Bush, Bill Clinton... The airy, precise webs expanding up to four or five feet across suggest an evil order underlying apparent chaos (Heartney, 2003).

The American artist Mark Lombardi became famous for drawing 'narrative structures' as he called them: vast graphs representing links between politicians, businessmen, military men, crime figures, corporations and institutions. These historical diagrams were based on information that he drew from publicly available sources, mainly news stories from reputable media. He was able to synthesise mass of data into something meaningful without using any digital support: he stored his data on some 14 000 note cards, which are now part of the MoMA permanent collection. Beside their aesthetic quality, the artistic value of Lombardi's schematic drawings relies on their informative purpose: they were means to investigate the labyrinth of global networks and make readable complex underlying systems.

Cities are complex systems that have multiple functions and are located in a changing

geophysical environment. The concept of *resilience* introduces a holistic approach that meets the need to forge links between different urban dimensions: the physical environmental subsystems and socio-economic subsystems. This thesis aims at contributing to the current tendency of climate and environmental sciences to unify different disciplines by attempting to answer the question: how can we investigate the role of communication on urban resilience to climate risks? According to this research, exploration techniques of unstructured big data–such as graph representation of public documents–can contribute to the comprehension of a specific component of urban systems: the *social construction of reality* or, in other words, the perceptions and attitudes that different stakeholders may have regarding the same event, action or project.

The recent development of climate and environmental sciences is attributable to the fact that they confront complex systems where, physical environmental and socio-economic processes interact. In his 1973 seminal paper, the ecologist C.S. Holling stated that 'resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist' (Holling, 1973, p. 17). Since then, it progressively became necessary to move away from the dichotomy between social sciences and natural sciences and recognise that resilience relies both on physical ecological drivers and social-economic drivers. In this thesis we refer to this approach since it emphasises the human-in-nature perspective and provides a basis for measuring resilience. Indeed, defining resilience metrics is a necessary step to move from theory to implementation. Resilience indexes are helpful to identify objectives, compare the costs with the benefits of new activities, monitor change and adjust ongoing activities. Last but not least, resilience metrics are an information tool, aimed at ensuring transparency towards the stakeholders and facilitate their active engagement.

As the resilience approach involves apprehending the interactions among different components of a system, resilience implementation necessarily encourages new synergies among decision makers and different policy areas. It is a challenge that calls attention to an important component of urban systems: social networks, information flows, learning processes and other factors that affect the so-called 'social construction of reality'. The perceptions of a community towards an environmental action, project or policy are evaluated as part of 'Social Impact Assessment' (SIA), a methodology that aims at understanding the social effects of territory development interventions by focusing

on the human dimension of environments. According to this thesis, SIA practises, and in particular research on the social construction of reality, could benefit from recent developments in computer-aided exploration of unstructured big data, such as advanced text mining and graph representation.

In this framework, our research springs from the following questions: how can we analyse the role played by communication in cities coping with climate-related risks? With the goal of enriching current resilience assessment approaches, this thesis aims at:

- Outlining new indicators to monitor the role played by communication in urban resilience to weather extremes;
- Employing big data exploration techniques to comprehend the interactions between communication processes and other urban resilience drivers, as well as their space-time variability.

These overarching objectives are broken down into the following detailed objectives:

1. Reviewing different resilience assessment methods and identifying relevant principles for an adequate approach to measure urban resilience to weather extremes;
2. Outlining how Social Impact Assessment (SIA) is undertaken by SIA practitioners to reinforce balanced and informed decision-making;
3. Identifying Resilience Communication Indicators (RCI) that are tailored to the specific context of Paris region;
4. Testing these indicators through a set of experiments based on SIA research techniques and big data exploration techniques.

These research outcomes will be pursued through six chapters. Chapter 2 starts from comparing nine different methods to assess resilience that are adequate to urban areas facing weather hazards. This overview provides a state of the art of operational definitions of resilience and identifies best practices that can be considered as a frame to define new indicators. Some metrics addressing social construction of reality issues are examined in detail and a first insight is given on how the communication activities can be monitored as part of a resilience assessment.

The third chapter discusses the key role of social impacts in territorial development and outlines SIA practices, their scope and interest. The concept of *social construction of reality* is also explored, as well as the SIA methodological approach. Lastly, Paris and its resilience strategy are introduced as a challenging context where innovative monitoring methods would be helpful to understand the social dimension of the city and reduce negative social impacts.

In the last fifteen years a significant number of strategies were released by public authorities to cope with extreme weather in the Paris region. The fourth chapter presents a study on the communication activities proposed in twelve strategic documents released by local, national and international institutions from 2003 to 2017. This analysis resulted into the definition of communication variables that are relevant to investigate how the social construction of reality affects resilience in the specific context of Paris region. These variables are used as a basis to define indicators addressing the intensity and quality of communication processes, their space-time variability, the interplay with other resilience drivers, and the underlying socio-semantic networks. Some of these indicators were tested through the experiments that constitute the empirical part (Chap. 5, 6, and 7) of this thesis.

The following chapter presents the experiments that were undertaken in the framework of the Interreg NWE IVB RainGain project, a project on flood resilience implemented in the Paris region, as well as in three other cities of North-Western Europe. The result of various communication activities (press relations, an exhibition, a promotional video and a workshop) was analysed through SIA techniques: media monitoring, a questionnaire and interviews. Communication results were analysed in both qualitative and quantitative terms. Quantity was considered as corresponding to the communication frequency and audience size. Communication quality was assessed in terms of interpretation of scientific information and risk perception. One of the experiments explores the evolution of the press incidence over time and the correlations with weather hazards.

The experiments presented in Chap. 6 and 7 aim at testing indicators that appraise socio-semantics networks and participatory communication. Big data exploration techniques, and in particular advanced text mining and graph representation, were adopted as research techniques to explore four corpora of Web communication data. In Chap. 6, we examine digital media contents that were published during and shortly after two

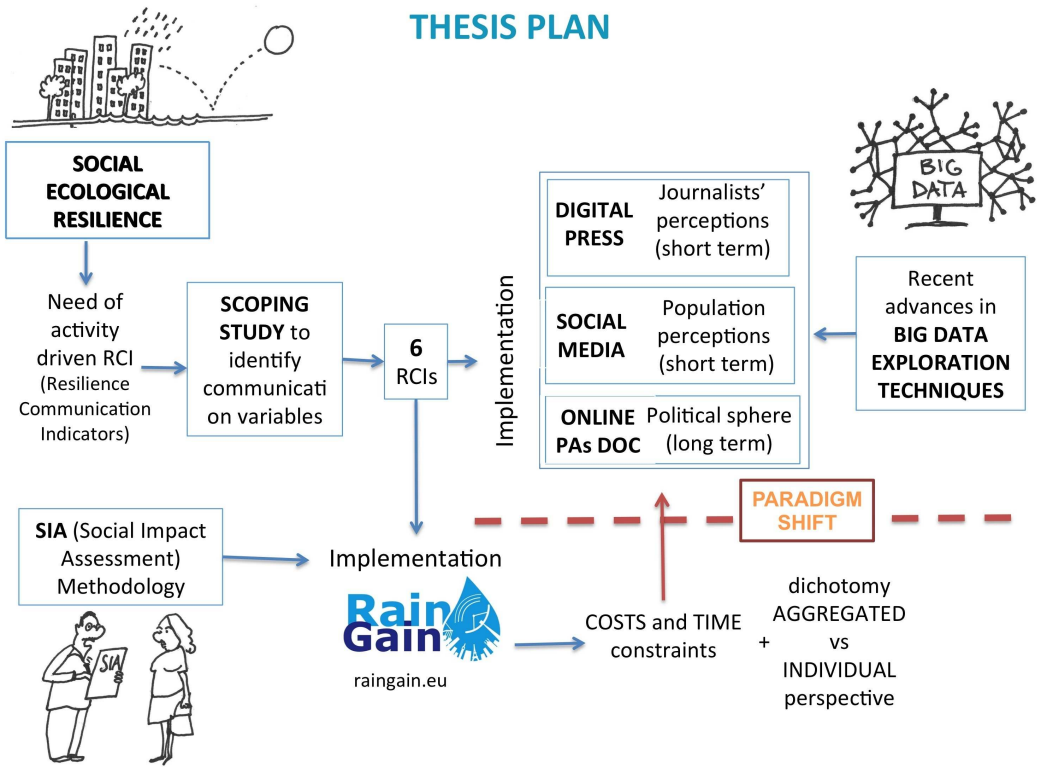
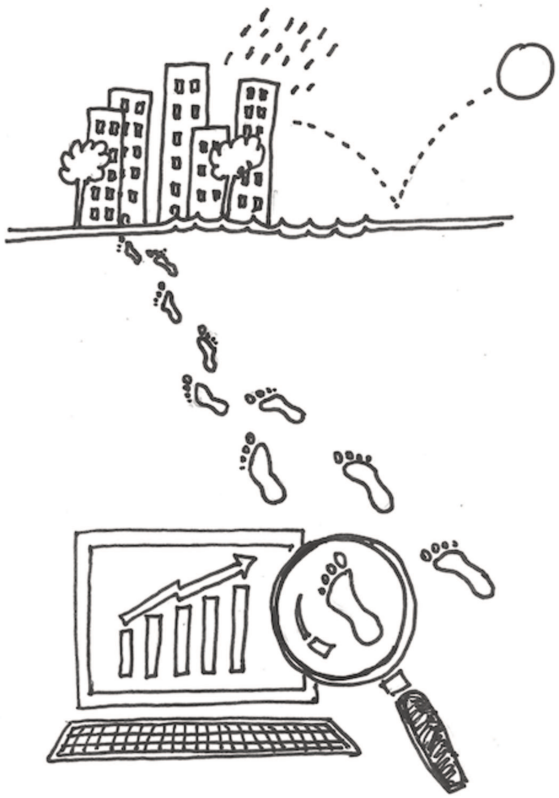


FIGURE 1.1. The research plan followed in this thesis.

flood events: the flood event that hit Côte d'Azur in October 2015 and the Seine River flood of June 2016. In Chap. 7, we consider a longer time period (2003–2017) and we analyse digital documents that were published by public authorities.

The analysis of the four corpora involved an iteration between manual and automated extraction of hundreds of key terms, graph representations based on measures of semantic proximity between key terms (conditional distance or distributional distance), automated cluster visualisation (computed by Louvain algorithm). Visual observation of the graph coupled with quantitative analysis enabled us to detect topics and actors, frequent co-occurrence links and clusters that characterise each corpus. Through a comparison of the four corpora, it was also possible to observe how these patterns change over time and in the context of different flood-prone urban areas.



CHAPTER 2

URBAN RESILIENCE TO EXTREME WEATHER: FROM THEORY TO PRACTICE

Cities are complex systems, with multiple functions and interacting components, where climate pressures contribute to their complexity (Ruth and Coelho, 2007). The socio-economic and physical environmental dimensions are two urban subsystems that are traditionally studied by researchers from different disciplines. This dichotomy was brought into question by notions such as the 'social-ecological resilience' (Folke, 2006). In this thesis, we refer to the social-ecological resilience, as a theoretical frame to comprehend the role of communication in urban resilience. This approach involves analysing the complex interactions between the physical environmental drivers and socio-economic drivers of resilience, the latter including communication processes. Indeed, social networks, information, communication and learning capacities of urban communities influence urban resilience. Furthermore, the social-ecological resilience approach involves the definition of quantitative resilience metrics.

After outlining the concept of *resilience* in Sect. 2.1 and of *social–ecological resilience* in Sect. 2.2, we discuss the worth of resilience quantitative metrics. Sect. 2.3 and 2.4 present examples of resilience assessment methods to that can be implemented in cities coping with extreme weather. We then outline, in Sect. 2.5, good practices to define relevant indicators. In Sect. 2.6 we examine those resilience indicators that address communication processes and we observe that this social factor is not sufficiently explored

in the literature.

2.1 The concept of resilience

Defining the concept of *resilience* is necessary to identify the aim of resilience strategies and assess the progress towards those objectives. Different approaches to resilience appeared in a variety of academic and operational fields across the 20^{th} and 21^{st} centuries: from material sciences, engineering and construction, computer networking, to psychology, economy and ecology.

The notion of resilience was introduced in ecology between the 1960s and early 1970s. The early interpretation of resilience was rather concerned by the capacity to absorb a stress and to continue maintaining the function of a system that is assumed to be stable. 'Engineering resilience' – as Holling (1996) and Folke (2006) refer to – influenced mainstream ecology and environmental management that were dominated by a single equilibrium view. This approach can be applied to understand the behaviour of linear systems (or non-linear systems that are so close to a stable equilibrium that a linear approximation is acceptable). The focus is on resisting to change and disturbance and on preserving the functions and constancy of a system. The system is presumed to be within or close to a unique, constant, predictable state.

The 'social-ecological resilience' perspective, as it called by Folke (2006), departed from the mainstream interpretation of resilience. This new approach points at renewal, reorganisation, innovation, development and adaptation after disturbance as important capacities in a resilient system (Gunderson and Holling, 2002; Berkes et al., 2003; Adger, 2006, Folke et al., 2010).

Holling (1973) is one of the pioneers who applied the concept of resilience to ecosystems, with a perspective that is totally different from the *engineering resilience*. Indeed, Holling considers ecosystems as complex systems with multiple basins of attraction. A perturbation can move a system over a threshold. Beyond this threshold, the system leaves the basin of attraction of its original state to reach the basin of attraction of a new state.

Folke (2006) identifies a sequence of three concepts, across the literature, that address

Table 2.1: A sequence of resilience concepts, from the narrowest interpretation to the broader social–ecological perspective (Folke, 2006).

Resilience concepts	**Characteristics**	**Focus on**	**Context**
Engineering resilience	Return time, efficiency	Recovery, constancy	Vicinity of a stable equilibrium
Ecological resilience, social resilience	Buffer capacity, withstand shock, maintain function	Persistence, robustness	Multiple equilibriums, stability landscapes
Social-ecological resilience	Interplay disturbance and reorganisation, sustaining and developing	Adaptive capacity, transformability, learning	Innovation

the topic of resilience. The first narrowest concept is 'engineering resilience' that relies on the efficiency and time that are needed to return to a stable equilibrium, after a shock. The 'ecological resilience' and 'social resilience' are two wider concepts, where resilience corresponds to buffer capacity, withstanding shocks, while maintaining functions. According to this definition, multiple equilibriums (or stability landscapes) exist for one system. 'Social-ecological resilience' is the widest concept according to Folke's view: resilience relies on a system capacity to sustain and develop, through the interplay between disturbance and reorganisation. These dynamics are shaped through interactions between different time and space scales.

2.2 Social-ecological resilience

This section thoroughly outlines the social-ecological resilience approach for two main reasons:

- It emphasises the human-in-nature perspective, by considering interactions and interdependence between the socio-economic and physical environmental subsystems;

- It provides measurable definitions of resilience that are a basis to develop and implement resilience metrics.

According to this approach, resilience can be defined as the 'the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks' (Walker et al., 2004, p. 2).

The social-ecological resilience perspective puts the accent on thresholds, uncertainty, non-linear dynamics, interplay between gradual change and rapid change (Walker and Meyers, 2004) and on interactions of these dynamics throughout spatial and temporal scales (Gunderson and Holling, 2002). Systems have multiple domains of attraction, that are unstable equilibriums, and the transition from one attractor to another can be sharp or gradual. Because of the complexity of systems, that continuously evolve and are characterised by multiple interactions across scales, the trajectory followed by a system after a perturbation is uncertain: it can be better described with terms such as 'renewal', 'regeneration' and 'reorganisation' rather than 'recovery' (Bellwood et al., 2004). For the same reason, Carpenter (2003) prefers the terms 'regimes' or 'attractors' rather than 'stable states' or 'equilibriums'.

System dynamics are described with the 'adaptive cycle metaphor' (Gunderson and Holling, 2002). This heuristic model entails four development phases that are triggered by discontinuous processes and events. This model emphasises the coexistence and complementarity of stable periods:

- The 'exploitation' or 'r phase' identifies a period of exponential change;
- The 'conservation' or 'K phase' describes a period of stasis and rigidity. And unstable periods:
- The 'release' or 'omega phase' corresponds to a period of collapse, creative destruction and readjustments;
- The 'a phase' corresponds to a period of renewal and reorganisation;

Instead of focusing on stability, as the conventional earlier approaches to resilience, the adaptive cycle metaphor highlights that disturbance is a component of the development process.

These dynamics can be observed at different spatial and temporal scales. The interactions across scales are described by a model, named 'panarchy' (Gunderson and Holling, 2002), of nested adaptive renewal cycles. This model illustrates how a transition from

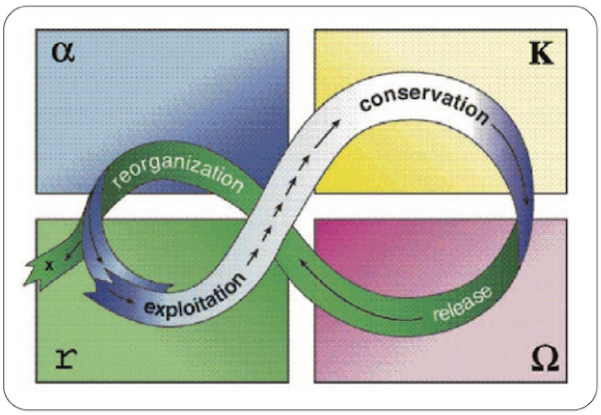


FIGURE 2.1. The adaptive cycle (Gunderson and Holling, 2002).

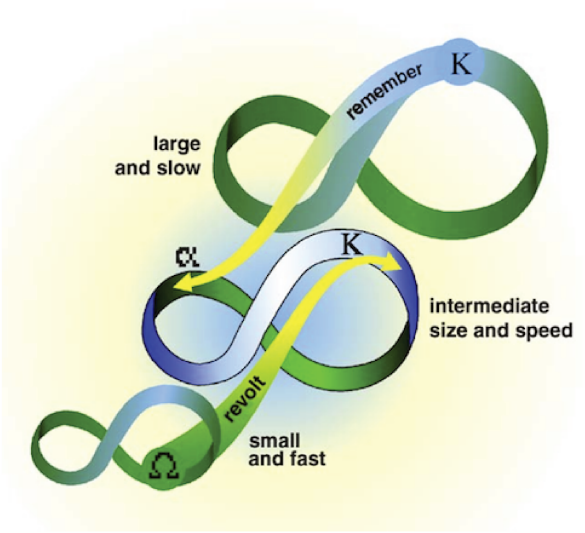


FIGURE 2.2. The panarchy diagram shows cross-scale interactions (Folke, 2006, modified from Gunderson and Holling, 2002).

one phase to another can trigger other transitions at different spatial or temporal scales.

2.3 Implementing social-ecological resilience

Going beyond theory and implementing resilience requires resilience metrics: such indexes enable decision makers to compare the costs of resilience enhancement actions with the economic, environmental, social, and sanitary costs of non-action. Resilience metrics also help to set up clear objectives at the beginning of a project, to evaluate and

improve management capacities, to increase transparency and stakeholder involvement during and after a project. According to Carpenter et al. (2001), quantitative definitions and resilience metrics are necessary to test hypotheses on the dynamics of systems. An operational and measurable definition of resilience should be consistent with the theoretical definition, and the same definition should be applicable to different systems and enable cross-system comparisons.

Carpenter et al. (2001, p. 766) agree with the interpretation of Holling (1973; 1996) and they state that resilience is 'the magnitude of disturbance that can be tolerated before a social-ecological system moves to a different region of state space controlled by a different set of processes'. According to this definition resilience relies on three features of a system:

1. How much change a system can tolerate while maintaining the same functions and structure (or, in other words, while remaining in the same basin of attraction);

2. The capacity of self-organisation;

3. Learning capacity and adaptability (adaptability is understood as defined by Gunderson (2000), i.e. a learning response to a stress).

In the same paper, the authors also explain that resistance is complementary to resilience: both need to be considered when assessing long-term persistence of a system.

Adaptability is a characteristic of social-ecological systems that is also mentioned by Folke et al. (2010, p. 1). The authors consider 'adaptability' as part of resilience and define it as 'the capacity to adjust responses to changing external drivers and internal processes and thereby allow for development along the current trajectory (stability domain)'. Adaptability of social-ecological systems should be addressed to understand their dynamics and development, as well as 'transformability', another characteristic that is interrelated to resilience. Transformability is defined as 'the capacity to cross thresholds into new development trajectories'. Transformation is necessary to resilience since 'transformational change at smaller scales enables resilience at larger scales'.

Another important step to assess resilience is to identify the disturbance and the system, exposed to the stress, we are interested in. This is necessary to define the spatial, social and temporal scales of the system. However, the question 'resilience of what, to

what?' (Carpenter et al., 2001) shouldn't lead to focus on 'specified resilience' only, but also to consider 'general resilience' that takes into account all parts of a system and all kinds of shocks and stresses, also new ones.

Specified resilience entails the risk of enhancing resilience of specific components of a system to specific shocks, while weakening resilience in other ways (Cifdaloz et al., 2010). The 'Highly Optimised Tolerance' theory (Carson and Doyle, 2000) shows that systems that become highly resistant to frequent types of stresses become vulnerable to infrequent shocks. Hence, fostering specified resilience doesn't necessarily avoid regime shifts. Transformability of systems should always be considered.

Systems are complex in time and space (Schertzer and Lovejoy, 2004). This is presumably the source of the important gaps between theories and applied metrics of resilience. Indeed, operational resilience metrics are usually defined with the help of semi-quantitative indicators that are applied to variables aggregated up to the outer scale of the system, not across the various spatial scales of the system. It is worth mentioning that Tchiguirinskaia et al. (2014) shows that multifractals can be used to define both resilience and its metrics across space-time scales.

In this review we are particularly interested in the city resilience to extreme weather. However the emphasis on this topic doesn't prevent from considering possible interplay across spatial scales and between floods and other kinds of shocks.

As it is highlighted by Leichenko (2011), the majority of urban resilience studies refer to climate change, considered as one of the pressures that cities face. However, climate-related stresses and shocks happen in combination with other kinds of disturbances, such as environmental, economic, and political pressures. Hence, urban resilience to climate risks necessarily involves the development of resilience to a larger variety of pressures that mutually influence each other.

By the 2000s increasing attention among academics, as well as practitioners, is devoted to the implementation of resilience. Putting the concept of social-ecological resilience into practice involves relevant changes in policy and decision-making. Folke (2006) discusses how policies, following the social-ecological approach, aim to adaptation (Berkes et al., 2003; Smit and Wandel, 2006), rather than controlling change. For in-

stance, if we consider urban resilience to climate change, the focus would be on adapting and mitigating climate change, rather than controlling it.

Leichenko (2011) proposes an interesting analysis of the topics that are addressed in urban resilience studies. The author traces the origins of four topic areas: urban ecological resilience; urban hazards and disaster risk reduction; resilience of urban regional economies; promotion of resilience through urban governance and institutions. Each study area puts the accent on different aspects of urban resilience and on different components of the cities. Nevertheless, there is a consensus on two points: 1) the need to develop urban resilience to a wider range of risks in order to prepare cities to climate change; 2) climate resilience should be enhanced together with urban development and sustainability. According to Leichenko (2011, p. 166), resilience shouldn't be equated to 'reducing vulnerability' or 'enhancing adaptive capacity' and reflection is needed on how to apply the concept in urban areas.

According to the social-ecological resilience perspective, learning how to manage through change is considered a key capacity of individuals and groups to face uncertainty and surprise (Carpenter and Gunderson, 2001; Berkes et al., 2003; Peterson et al., 2003; Kinzig et al., 2003). Hence, citizens are considered as active actors, which emphasise the need to apply the principle of subsidiarity, i.e. to decentralise risk management, encourage citizen participation and share responsibilities (Tanguy, 2015).

Resilience recently became very popular among practitioners in the field of disaster risk management (Keating et al., 2014). A variety of definitions of disaster resilience is proposed by academics, development agencies and NGOs, and multilateral institutions to provide a common basis for resilience implementation. Emergency responders and NGO introduced resilience thinking in their work with individuals and communities, after a disaster. The concept of resilience was also employed in regional and national policies, especially after the Hyogo Conference in 2005[1]. This was a turning point in the UN strategy to reduce natural disasters that has brought the resilience concept in the global arena.

The resilience assessment techniques presented in the next section are extremely

[1]In January 2005, the "Hyogo Framework for Action 2005-2015: Building Resilience of Nations and Communities to Disasters" (UN/ISDR, 2007) was adopted by 168 States during the World Conference on Disaster Reduction in Kobe, Hyogo (Japan, 18-22 January 2005).

heterogeneous in terms of the concept of resilience they refer to, the system and disturbances they consider, the selection of indicators and variables, the degree of the on-site implementation. These examples of resilience indicators include six cases of resilience indicators that are adequate to urban areas (Sect. 2.4.1 DRSC, 2.4.2 MAES, 2.4.3 AIRT, 2.4.6 100RC, 2.4.7 RA, 2.4.8 DROP-BRIC) and three other cases that specifically concern indicators of urban flood resilience (2.4.4 SMARTeST, 2.4.5 4Rs-5Cs, 2.4.9 UNR). Their main characteristics are summarised and compared in the matrix in Appendix A, while the next section discuss in more depth these features.

2.4 Methods and metrics that are suitable to assessing flood resilience in urban areas

This section offers examples of resilience indicators adopted in different areas: from the academic field to the proposals by multilateral organisations, foundations, and private companies. There is much to be learned from experiences of design and implementation of methods to assess resilience, from qualitative analysis to quantitative metrics.

In 2010, the United Nations secretariat of the International Strategy for Disaster Reduction launched the campaign 'Making Cities Resilient' [2]. Following the adoption of the 'Sendai Framework for Disaster Reduction' (UN/ISDR, 2015), the goals and priorities of the campaign were updated, as well as the resilience assessment tool dedicated to cities: the *Disaster Resilience Scorecard for Cities* (DRSC) (UN/ISDR, 2017). This methodology is aimed at monitoring the implementation of the Sendai Framework at local government level.

2.4.1 Disaster Resilience Scorecard for Cities (DRSC)

Approach to Resilience. According to the United Nations secretariat of the International Strategy for Disaster Reduction (UN ISDR) resilience is 'the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions'[a].

[a] unisdr.org/we/inform/terminology

[2] unisdr.org/campaign/resilientcities/

However, we should note that the 'Sendai Framework for Disaster Reduction' (UN/ISDR, 2015) puts the accent on 'disaster risk reduction' as a main outcome. Nevertheless, resilience is still considered a necessary goal to achieve the outcome of disaster risk and loss reduction. Furthermore, one of the four priorities of the Sendai Framework is 'Investing in disaster risk reduction for resilience' (UN/ISDR, 2015, p. 18).

Assessment Framework. The UN ISDR monitors the progress towards the Sendai targets at local government level, in the framework of the 'Making Cities Resilient' campaign (www.unisdr.org/campaign/resilientcities/). A guide for municipalities presents the 'Disaster Resilience Scorecard for Cities' (DRSC) (UN/ISDR, 2017). This assessment method springs from the following 'Ten Essentials for Making Cities Resilient' (UN/ISDR, 2017, p. 4):

1. 'Organise for disaster resilience;
2. Identify, understand and use current and future risk scenarios;
3. Strengthen financial capability for resilience;
4. Pursue resilient urban development and design;
5. Safeguard natural buffers to enhance the protective functions offered by natural capital;
6. Strengthen institutional capacity for resilience;
7. Understand and strengthen societal capacity for resilience;
8. Increase infrastructure resilience;
9. Ensure effective disaster response;
10. Expedite recovery and build back better.'

Each Essential is aligned to one of the Sendai targets. In this way, local assessment can be compared to national and global assessments. A list of key questions are used as indicators to monitor the progress towards these Essentials. The scorecard offers two levels of assessment: a preliminary evaluation that includes 47 questions/indicators with a graduated 3-point scale; the detailed evaluation requires stakeholders' involvement and includes 117 questions/indicators with a 0–5 score.

Implementation. It is foreseen that the methodology will be implemented in 4,300 cities participating in the 'Making Cities Resilient' campaign.

The DRSC methodology has a high international relevance and institutional legitimacy. An interesting point is the importance given to stakeholder involvement in the assessment process. However, it should be noted that there are discrepancies between the DRSC approach and the social-ecological resilience perspective. Indeed, the DRSC points at disaster reduction, rather than at resilience as an overall objective. Furthermore, seven out of the ten Essentials concern social and economic drivers of resilience, while only three refer to the physical and environmental subsystems.

The *Mapping and Assessment of Ecosystems and their Services* (MAES) framework, outlined by the European Union (Maes et al., 2018), goes quite the opposite way. The list of indicators for urban ecosystems focus on the physical and environmental dimensions of a city. Indeed this document springs from the 'Target 2' of the EU 'Biodiversity Strategy to 2020' (European Commission, 2011, p. 12) that is to 'maintain and restore ecosystems and their services' in Europe. According to the MAES framework, ecosystem services rely on high ecosystem quantity and quality that are necessary to ensure their resilience.

Nevertheless, the relation between ecosystems and the socio-economic systems is not disregarded: according to the Biodiversity Strategy, ecosystem services increase well-being and have an economic value. The MAES framework specifies that, in urban areas, good living conditions for humans contribute to establish if urban ecosystems are in good condition. The relation between ecosystems and socio-economic systems also arises from the fact that human activities are considered as the drivers of change. Other relevant aspects of the MAES framework are that all the indicators are quantifiable, they are scalable from a local to a global scale, and enable detection of change over time. Experts with particular knowledge in urban areas were involved in defining indicators. EU Member States, other scientific experts and the EC environmental policy units were asked to verify that indicators are policy relevant.

2.4.2 Mapping and Assessment of Ecosystems and their Services framework (MAES)

Approach to Resilience. In the 2018 MAES report (Maes et al., 2018, p. 15), resilience is defined as 'the capacity of a social-ecological system to absorb or withstand perturbations and other stressors, such that the system remains within the same regime, essentially maintaining its structure and functions'.

However, the focus is, in the first instance, on environmental subsystems. Indeed, the objective of the assessment framework is to map and assess ecosystems. High ecosystem quality and quantity are necessary to maintain their resilience and their capacity to provide services. The link between the environmental system and the socio-economic system is made explicit when the report mentions that 'healthy ecosystems are the fundamental basis for a resilient society and a sustainable economy' (p. 8). 'When this capacity is used, ecosystem services flow from ecosystems to humans and deliver benefits. When use exceeds capacity, ecosystems are used in an unsustainable way and degrade' (p. 15).

Assessment Framework. The MAES framework includes indicators for environmental pressures (e.g. new built up areas) and ecosystems condition (e.g. urban temperature). This assessment method aims at identifying the links that exist between pressures, conditions and services (e.g. sustainable food production) and inform a broad range of policies related to the use or protection of natural resources (see Fig. 3). For instance, policies that intend to improve human well-being could use this framework to assess the positive impact of reducing a specific pressure on an ecosystem service provision.

All the MAES indicators consider the correlations between ecosystems and socio-economic systems are quantifiable and spatially explicit. The framework was conceived to assess ecosystems at EU level, but it is also scalable to national and regional level.

Part of the assessment framework is dedicated to urban ecosystems that are considered as essential for human well-being, since most people live in urban areas. According to a report focusing on urban ecosystems (Maes et al., 2016, p. 69): 'Urban ecosystems are considered in good condition if the living conditions for humans and urban biodiversity are good. This means, among others, good quality of air and water, a sustainable supply of ecosystem services, species and habitats of community interest in good conservation status and a high level of urban species diversity.' Some of the indicators for urban ecosystems measure the exposure of the population to an environmental pressure, such as the percentage of the population exposed to noise. These indicators tackle societal challenges and are a clear example of how ecosystem condition can concretely affect people's lives. Urban ecosystem assessment can be adapted to three different spatial scales (regional, metropolitan and urban scale) according to the policy questions, the socio-ecological processes that are investigated and the available data and indicators.

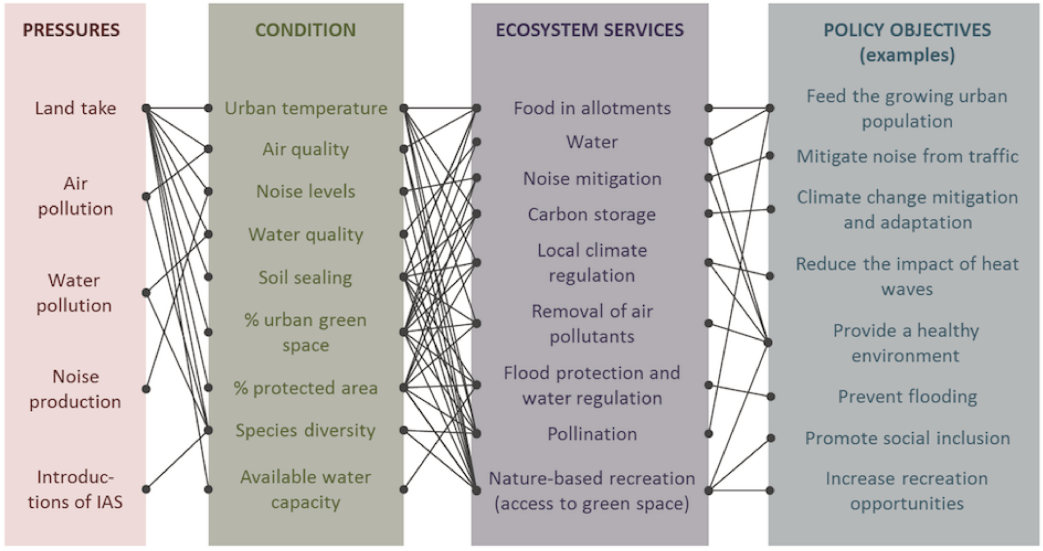


FIGURE 2.3. Synthesis of the links between pressures condition and ecosystem services in urban ecosystems (Maes et al., 2018).

Implementation. The MAES assessment framework was designed on the basis of a wide array of case studies. These pilot sites provided examples of how mapping and assessment can assist policy making and implementation in the European Union. Experts from these pilots were involved through surveys and workshops to select a final set of indicators. Urban case studies include ten pilots in Portugal (Cascais, Oeiras, Lisbon), Italy (Padua, Trento, Rome), the Netherlands (Utrecht), Poland (Poznań), Spain (Barcelona) and Norway (Oslo).

Stakeholder participation in the evaluation process is a key aspect of three other assessment methods: the *Integrated Analysis of Territorial Resilience*, the *SMARTeST Indicators of Success*, and the *Four R's – Five C's* approach. The last two are specifically designed for flood resilience.

The *Integrated Analysis of Territorial Resilience* (AIRT) was developed by the French Ministry of Ecology, Sustainable Development and Energy (MEDDE). The AIRT led to the analysis of twelve pilot sites affected by disasters to provide recommendations to local communities on how to enhance resilience, adaptation and recovery of the territory.

With a perspective that is in line with the social-ecological resilience approach, the MEDDE emphasises resilience as a key goal (Tanguy, 2015). Indeed, 'developing sus-

tainable and resilient territories' is one of the axes of the French 'National Strategy of Ecological Transition for Sustainable Development' (MEDDE, 2015, p. 6).

2.4.3 Integrated Analysis of Territorial Resilience (AIRT)

Approach to Resilience. This assessment framework points at resilience as a leading objective, since 'developing sustainable and resilient territories' is one of the axes of the French 'National Strategy of Ecological Transition for Sustainable Development' (MEDDE, 2015), adopted by the French government in February 2015. The chosen perspective conforms to the social-ecological resilience approach. Resilience is considered as the capacity of a system (or a territory) to reach a new equilibrium after a strong perturbation. The new equilibrium can be different from the state of the system before the perturbation. Indeed resilience also relies on the ability to innovate, reorganise, and adapt to new potential system states (Tanguy, 2015).

Assessment Framework. The implementation of AIRT consisted of two phases. The first stage was dedicated to data collection in the pilot sites: over 60 interviews were conducted with elected officials, managers of national and local technical services, network operators, civil protection service, associations, private companies.
During the second phase of the implementation, three working groups met to discuss about the three following topics: 1) 'The citizen at the heart of resilience'; 2) 'The territory of resilience'; 3) 'Enhancing resilience: the integration factor in public policies.'

Implementation The assessment was implemented in four groups of pilot sites:

- Seven sites that in the past were affected by a natural or technological disaster (Somme 2001, AZF 2001, Aquila 2009, Argens 2010) or where a specific security intervention was performed (Evac'Agglo Grenoble 2010, Evac'Agglo Metz 2011, RESAU2 Drôme – Ardèche 2009).
- Sites where a confirmed risk is being monitored (cliff blocks breaking in Rhône-Alpes Region, and in Normandie region).

- The Paris region that could be affected by a potential Seine River flood as the one that occurred in 1910;
- The Charente-Maritime region that was hit by Xynthia storm.

Four corresponding reports are available on the 'Wikihydro' Web platform (wikhydro.developpement-durable.gouv.fr), together with the proceedings of a seminar, held on the 5th of February 2013, which outline the results of the interviews.

The implementation of AIRT included a first phase of data collection in the pilot sites, based on over 60 interviews with the stakeholders. During the second phase, three working groups met to discuss about: the role of the citizen, the space scale to be considered, how to integrate different policy areas.

The *SMARTeST Indicators of Success* and the *Indicators for post-implementation assessment* are key steps of the 'Implementation Strategies for Flood Resilience (FRe)' (Tourbier, 2013). These indicators were designed as part of Smarter Resilience, Tools, Technologies and Systems (SMARTeST), a European FP7 research project aimed to develop, test and integrate new small-scale solutions for urban flood resilience. According to this approach, the degree of flood resilience in a city can be measured with four subindexes corresponding to four different dimensions of an urban system (spatial planning, structural planning, social planning and risk management). A peculiarity is that the weight of each sub-index is not pre-defined, but it is considered as a critical aspect to be discussed with the stakeholders.

2.4.4 SMARTeST indicators of success (SMARTeST)

Approach to Resilience. According to the 'SMARTeST glossary' (FP7 SMARTeST project, 2011, p. 22) resilience is 'the ability of a system/community/society/defence to react to and recover from the damaging effect of realised hazards'. 'Flood resilience' should be distinguished from 'flood control' and 'flood defence', which involve a cost-benefit analysis that usually ignores adverse environmental impacts. Flood resilience is a more complex concept since it considers multiple levels of planning that correspond to different components of an urban system:

- 'Spatial planning', i.e. land use and run-off management.

- 'Structural planning', it involves government responsibilities, as well as actions from private owners, transport authorities, utility companies, and other stakeholders.
- 'Risk management', it relies on availability of flood insurance and public access to information on how to reduce flood risk.
- 'Social planning', it entails flood warning, emergency planning, stakeholders' involvement, education and dialogue between decision makers and stakeholders.

Furthermore, Tourbier (2012) considers that 'flood resilience' is a more precise notion than 'sustainable development'. Indeed, it is possible to identify performance measures for each one of the four urban dimensions.

Assessment Framework. 'SMARTeST indicators of success for project guidance' (Tourbier, 2013) are aimed to guide project design, and adjust the project while it is carried out. Clear project goals should be outlined since the beginning, so that it is possible to monitor the progress towards these goals.
'Indicators for post-implementation assessment' should entail evaluation of the 'effects' (i.e. the project outcomes), of 'effectiveness' (i.e. achieved goals and measures), of 'efficiency' (i.e. use of resources).
Both categories of indicators, for project guidance or post-implementation assessment, are defined on the basis of four levels of resilience. These correspond to the four planning levels listed above: 'spatial-ecological flood resilience', 'structural flood resilience', 'flood risk resilience', 'social flood resilience'.

Implementation. Indicators of success for project guidance are based on all the four resilience levels, but different rating weights can be attributed to each of them by using the 'Weighted Sum Method'. According to this method, different ratings are assigned, as a percentage, to different categories (corresponding to one of the four resilience levels), the sum of all the ratings should be equal to 100%.
The post-implementation assessment evaluates the degree of achievement for each category, i.e. if each criterion is fully met, partially met or not achieved.

The Four R's – Five C's (4Rs-5Cs) approach was designed to measure flood resilience at community level. The method is outlined in the white paper 'Operationalising Resilience Against Natural Disaster Risk' (Keating et al., 2014; 2017) – one of the key documents of the multi-year research programme Zurich Flood Resilience Alliance led by

the Zurich Insurance Group. A community is here described as a system with multiple interacting dimensions: the 'five community capitals' or '5 C's' that include the 'Human', 'Social', 'Physical', 'Natural', and 'Financial' capitals. The resilience of the city relies on four key characteristics that are called the '4 R's' ('Robustness', 'Redundancy', 'Resourcefulness', 'Rapidity'). A notable aspect of this approach is the use of a mobile app in the pilot sites. This interactive web tool is aimed at involving the community members in the assessment campaigns.

2.4.5 A 'Four R's – Five C's' framework to assess community flood resilience (4R-5C)

Approach to Resilience. Keating et al. (2014) agree with the social-ecological resilience perspective. Indeed, they consider communities as part of complex adaptive systems that are dynamic and have natural and social subsystems with strong interactions. Following the hazards research perspective, they propose a definition of resilience that points at the 'community well-being' and 'development' as the main objectives of resilience strategies. Their interpretation also highlights the importance of considering 'current risks', 'potential risks', and 'potential risk changes'. The authors define disaster resilience as 'the ability of a system, community or society to pursue its social, ecological and economic development and growth objectives, while managing its disaster risk over time in a mutually reinforcing way'. According to the authors, the resilience of complex dynamic systems relies on the 'four R properties' outlined by MCEER (2006):

1. 'Robustness', defined as the 'ability to withstand a shock';
2. 'Redundancy', or 'functional diversity';
3. 'Resourcefulness', corresponding to the 'ability to mobilise when threatened';
4. 'Rapidity', defined as 'ability to contain losses and recover in a timely manner'.

Assessment Framework. This assessment methodology is built upon the 'four R properties' and considers the social, human, financial, physical and natural components of a system as 'five community capitals'.
According to the definition by DFID (1999), the five capitals (or five Cs) are:

1. 'Physical capital', 'things produced by economic activity from other capitals, such as infrastructure, equipment, improvements in crops, livestock, etc.';
2. 'Financial capital', 'level, variability, and diversity of income sources and access to other financial resources that contribute to wealth';
3. 'Human capital', 'education, skills, health';
4. 'Social capital', 'social relationships and networks, bonds aiding cooperative action, links facilitating exchange of/and access to ideas and resources';
5. 'Natural capital', 'natural resource base, including land productivity and actions to sustain it, as well as water and other resources that sustain livelihoods'.

These five capitals are monitored, over time, through 88 indicators named 'sources of resilience'. The indicators are graded on a scale of A to D that enables a 'semi-quantitative assessment of qualitative properties' (Keating et al., 2017). Furthermore, each indicator is classified as related to a specific capital and to one of the R properties. It should be noted that, according to the authors, two communities, with similar capital values, can be differently affected by a flood if they have different resilience properties.
Each indicator is also categorised by theme ('education', 'life and health', 'assets and livelihoods', 'governance', 'natural environment', 'energy', 'food', 'transport and communication', 'waste', 'water'), context ('community level' vs 'enabling environment'), and phase of the Disaster Risk Management cycle ('prospective risk reduction', 'corrective risk reduction', 'crisis preparedness', 'coping'). Thanks to this categorisation the same indicators are used to perform different types of analysis.
The method also includes 29 indicators, named 'outcome measures', that are monitored when a flood occurs. These measures are categorised by 'theme' and 'context'. They are aimed at evaluating the effectiveness of the resilience resources.

Implementation. A mobile data collection and a web-based application were set up to involve stakeholders in data collection and analysis for the assessment. In November 2015, 20 staff members, from six NGOs, were trained to implement the method in 75 communities in eight different countries.

The concept of a system with multiple interacting components is also employed by *100 Resilient Cities* (100RC) (www.100resilientcities.org; The Rockefeller Foundation and ARUP, 2015), a network of cities, founded by the Rockefeller Foundation. The network

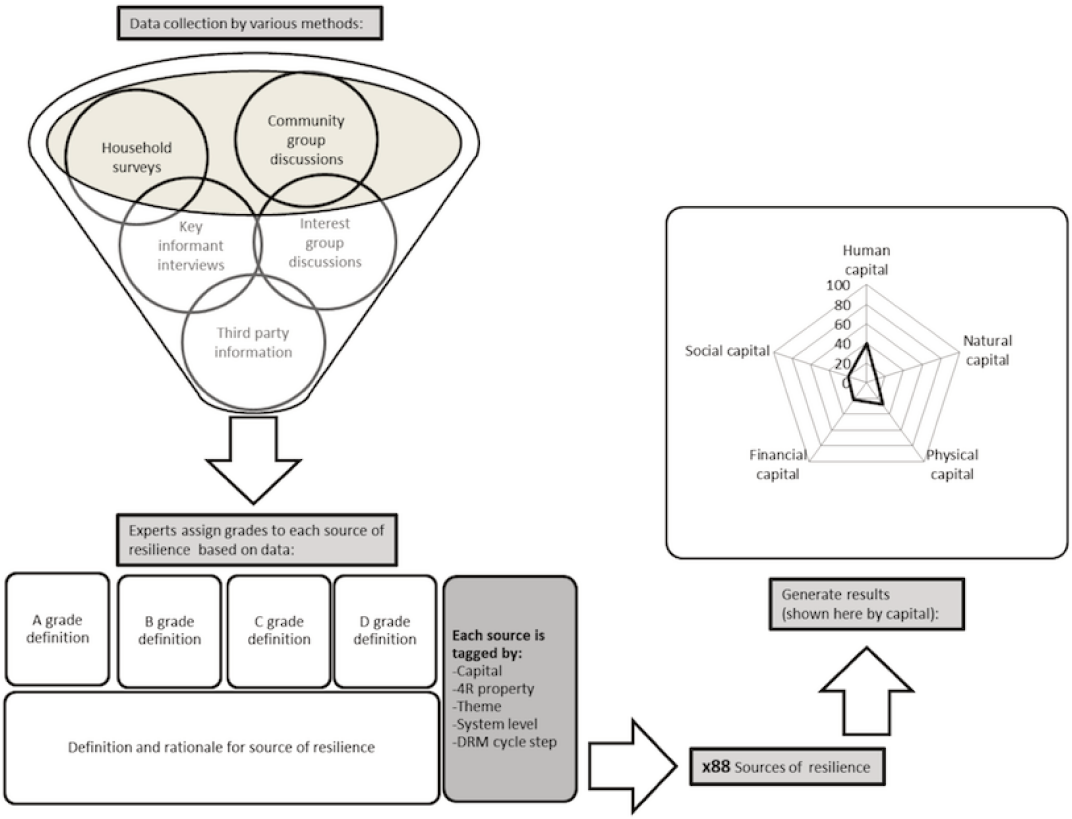


FIGURE 2.4. Zurich Flood Resilience Measurement Framework implementation process (Keating et al., 2017).

aims at supporting cities in coping with natural, social and economic shocks and stresses. City Resilience Index (The Rockefeller Foundation and Arup, 2017) are used as a basis for assessing and improving investment and planning decisions. Similarly to the 4Rs-5Cs approach, also 100RC relates urban resilience to other key characteristics: reflective, resourceful, inclusive, integrated, robust, redundant, flexible. As in the previous example, also 100RC provides a Web tool to facilitate data collection and assessment.

2.4.6 100 Resilient Cities network and the City Resilient Framework (100RC)

Approach to Resilience. 'Urban resilience is the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kind of chronic stresses and acute shocks they experience' (www.100resilientcities.org).

This definition answers the question 'resilience of what?' by focusing on urban systems, intended as complex systems with multiple components. Furthermore, it looks at city development as a key goal. The complementary question 'resilience to what?' is answered by broadening the attention to a wide range of perturbations. Both chronic stresses (e.g. high unemployment, inefficient public transports, food and water scarcity, endemic violence, etc.) and acute shocks (e.g. earthquakes, flood, disease outbreaks, terrorist attacks, etc.) are considered.

Assessment Framework. The City Resilient Framework – developed by ARUP and the Rockefeller Foundation (2015) for the 100 Resilient Cities network – outlines a conceptual basis to investigate the components of an urban system and the resilience drivers. This is a tool designed for city managers to enable them to evaluate city resilience, determine the weaknesses, as well as the needed interventions to enhance resilience. This assessment framework identifies seven key qualities that resilient cities should have:

1. 'Flexible', willingness and ability to adopt alternative strategies in response to changing circumstances;
2. 'Redundant', spare capacity that is purposively created to accommodate disruption;
3. 'Robust', well conceived, constructed, and managed systems;
4. 'Resourceful', recognising alternative ways to use resources;
5. 'Reflective', using past experience to inform future decisions;
6. 'Inclusive', prioritising broad consultation to create a sense of shared ownership in decision-making;
7. 'Integrated', bringing together a range of distinct systems and institutions.

The city is described as a complex system entailing four dimensions with 12 related goals and 52 resilience indicators:

- 'Health and well-being', the health and well-being of everyone living and working in the city;
- 'Economy and society', the social and financial systems that enable urban populations to live peacefully and act collectively;

- 'Infrastructure and environment', the way in which manmade and natural infrastructure provides critical services and protect urban citizens;
- 'Leadership and strategy', effective leadership, empowered stakeholders, and integrated planning (The Rockefeller Foundation and ARUP, 2015).

Each indicator is analysed through the prism of the seven qualities of a resilient city (as it is illustrated by the 'Resilience Wheel', Fig. 5) and with a selection of 156 quantitative metrics and 156 qualitative metrics (The Rockefeller Foundation and ARUP, 2017). A web platform was developed to support city governments and their partners in collecting and analysing data (cityresilienceindex.org).

Implementation. Cities that join 100 Resilient Cities network obtain resources to develop 'a roadmap to resilience' (100resilientcities.org). The offer entails a support to carry out a 'City Resilience Strategy' that consists in a six to nine-month process, aimed to identify resilience issues and possible actions to enhance resilience. The 'City Resilience Strategy' is based on the City Resilient Framework described above. The strategy was implemented by the network members, for example by New Orleans that is one of the pilot cities.

The use of quantitative variables in resilience assessment presents several advantages: numeric data can be used for statistical analysis and consequently to generalise a finding, they facilitate comparison across different space-time scales, detection of correlations between variables, automated data collection and analysis. Examples of quantitative variables are presented in four cases of resilience assessment methods: the above mentioned DRSC and 100RC – where quantitative variables are combined with qualitative evaluation – and *MAES framework* (MAES), the *Resilience Alliance* (RA) approach, the *Baseline Resilience Indicators for Communities* (DROP-BRIC), and the *Performance Indicators to assess Urban Networks Resilience* (UNR).

Resilience Alliance (RA) (Resilience Alliance, 2010) is an international, multidisciplinary research organisation that develops guidelines and principles to assess resilience of social-ecological systems and to implement sustainable development strategies. RA outlines an assessment framework that is absolutely consistent with the social-ecological approach. Indeed, the RA evaluation method includes specific and general resilience, as well as multiple space and time interacting scales. For each quantitative variable a threshold should be identified, as well as the effects if the threshold is crossed.

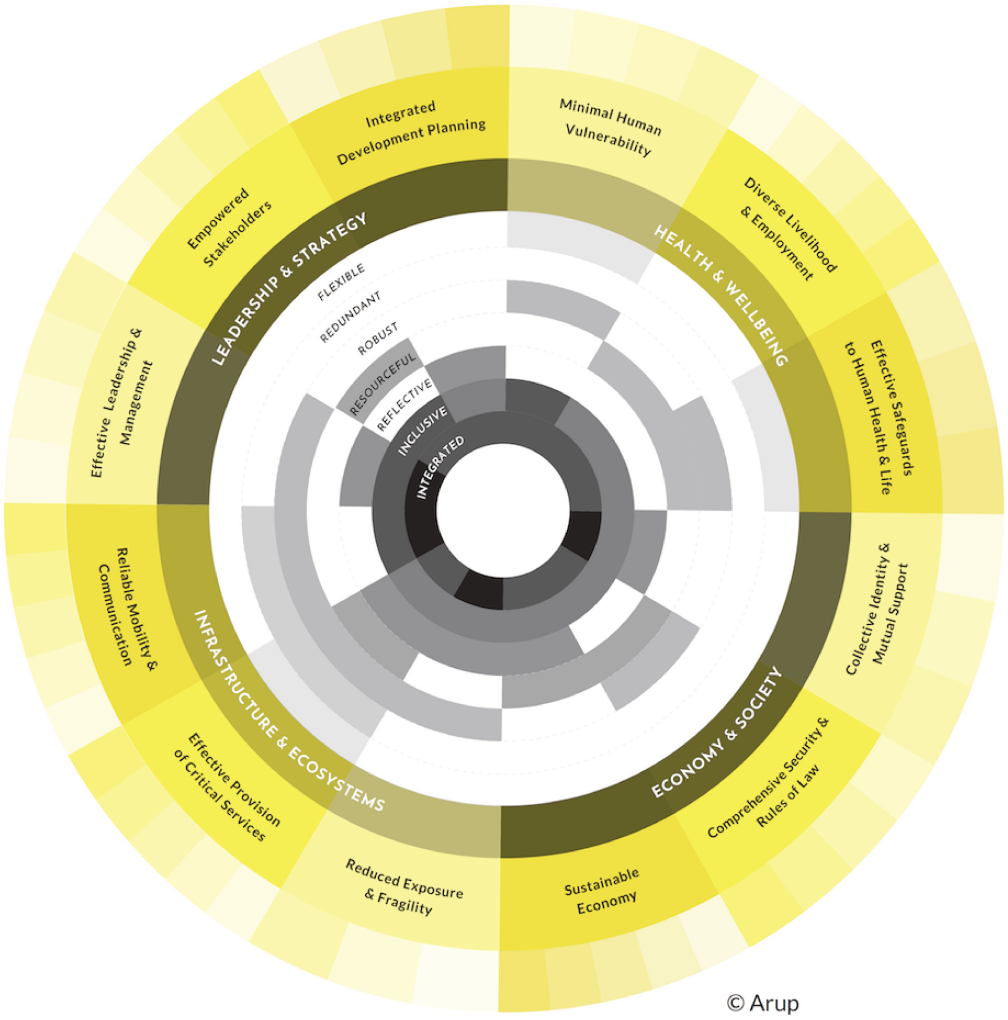


FIGURE 2.5. The Resilience Wheel illustrating the City Resilience Framework (The Rockefeller Foundation and ARUP, 2014).

2.4.7 Resilience Alliance assessment (RA)

Approach to Resilience. The conceptual framework outlined by RA accurately adheres to the social-ecological approach described in Sect. 2.2. Resilience is defined as 'the capacity of a system to absorb disturbances and reorganise while undergoing change so as to retain essentially the same function, structure, identity and feedbacks' (Resilience Alliance, 2010, p. 51). The approach adopted by RA takes into account social and ecological components of a system and their interplay. It considers specific as well as general resilience and the related uncertainties.

The adaptive cycle metaphor and the panarchy model (see Sect. 2.2) are used to describe system dynamics and incorporate continuous change and cross-scale interactions.

Assessment Framework. The first step in the assessment process is to define the focal system by identifying the main issues and by answering the question: 'resilience of what to what?" However, these are soft boundaries, since multiple space and time scales are also considered.
The dynamics of the system are then described by identifying the different phases of the adaptive cycle, across the selected time lapse. One or more key variables must be chosen as indicators of changes that occur from phase to phase.
The past, current, and potential future states of the system are then identified, together with the drivers (and related variables if available) that push the system to cross a threshold and transit to a new state. The threshold is located and the consequences of threshold crossing are assessed, as well as the degree of reversibility. It is finally highlighted if dynamics of larger-scale systems or smaller-scale subsystems (and the related driving variables) can cause or prevent changes in the focal system.
In order not to focus only on a specific disturbance (specified resilience) but consider a wider range of potential shocks and stresses, five qualities that confer general resilience to a system are evaluated: 'diversity', 'openness', 'reserves' (both ecological and social), 'tightness of feedbacks', 'modularity'.
The last step is an analysis of the governance system to understand power relations and conflicts among stakeholders, and how they influence resilience. In particular, the adaptive governance and institutions and social networks are assessed as two key characteristics.

Implementation. The assessment framework designed by Resilience Alliance was implemented in 13 different projects and locations all over the world, such as: urban areas in Sweden and in Ethiopia, the Brazilian Amazon, Biosphere Reserves in Ontario, forests and coastal areas in Alaska, rice terraces of Bali, river catchment areas in Australia.
Details on each project, the background needs, the objectives and outcomes are available on www.resalliance.org.
None of these projects concerns urban flood resilience, but the Practitioner's Workbook (Resilience Alliance, 2010) refers to flood risk case studies, such as Hurricane Katrina in New Orleans or water management in the Florida Everglades.

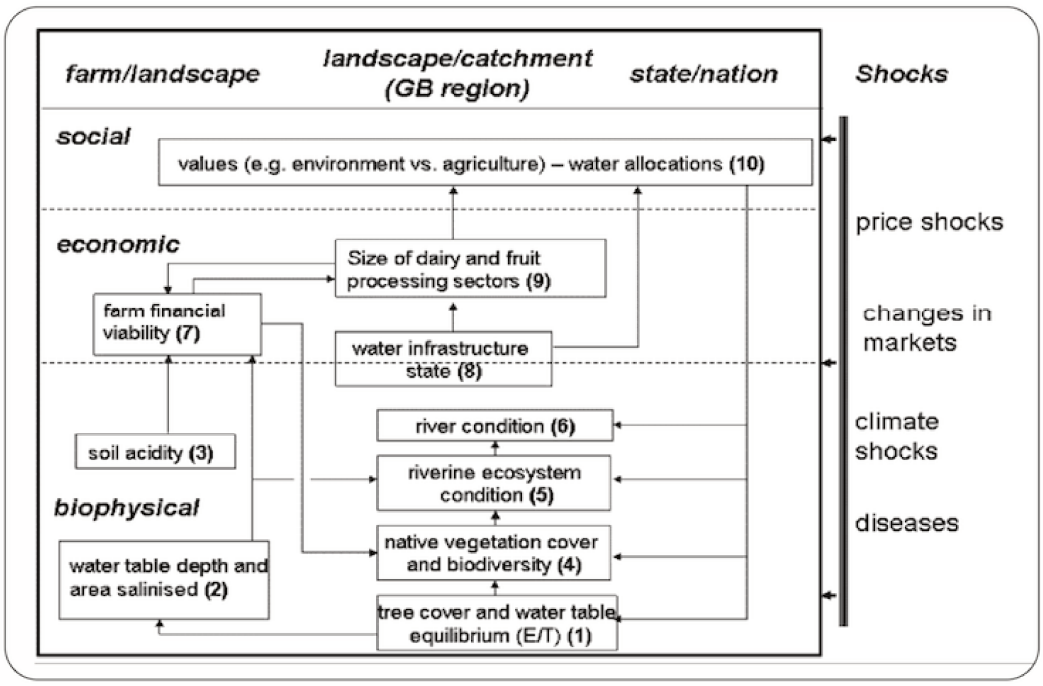


FIGURE 2.6. A 'thresholds and interactions diagram' presenting ten variables with thresholds in the Goulburn-Broken region (Australia) (Resilience Alliance, 2010).

The *Disaster Resilience Of Place model* and the *Baseline Resilience Indicators for Communities* (DROP-BRIC) are defined by Cutter et al. (2008; 2010; 2014). The authors focus on resilience to natural hazards at community level and on the relationship between resilience and vulnerability. The model is a conceptual basis to identify resilience indicators that can be used with different spatial scales. Similarly to the SMARTeST proposal, the DROP-BRIC approach defines a composite resilience index, with subindexes corresponding to different dimensions of the urban system. However, unlike SMARTeST, Cutter exclusively considers quantitative variables, and he defines a method to normalise different ranges of values to a unique scale.

2.4.8 Disaster Resilience Of Place model and the Baseline Resilience Indicators for Communities (DROP-BRIC)

Approach to Resilience Cutter et al. (2008) focus on social systems and considers resilience as an antecedent condition, as well as a process.

The authors state that 'resilience is the ability of a social system to respond and recover from disasters and includes those inherent conditions that allow the system to absorb impacts and cope with an event, as well as post-event, adaptive processes that facilitate the ability of the social system to reorganise, change, and learn in response to a threat' (p. 599).
They outline a model aimed to describe the relationship between resilience and social vulnerability and to be used as a conceptual basis to assess community resilience to natural hazards. The 'DROP model' considers the interplay among the social system, the built environment and the natural system. In particular, the authors put the accent on the relevance of the 'sustainability' concept that establishes a link between the resilience of a community and the state of the environment and its resources.

Assessment Framework. The 'baseline resilience indicators for communities' identified by Cutter et al. (2014) are based on six resilience dimensions: 'environmental resilience', 'social resilience', 'economic resilience', 'institutional resilience', 'infrastructure/housing resilience', and 'community capital'. Those variables that are relevant, robust and representative are selected and aggregated to obtain a composite indicator measuring disaster resilience.
Once the quantitative raw data are collected, they are converted (in percentages, differences, averages, or rates) for comparison. The data are then normalised to a unique range of values between zero (the worst rank) and one (the best rank). An average score per each 'resilience subindex' is calculated. It is then summed up to the score of the other five subindexes to obtain a 'composite resilience score' that ranges from 0 to 6.

Implementation. This methodology was implemented to assess the community resilience to disasters in the United States (Cutter et al., 2014). Resilience scores were calculated in 3108 counties and compared through a spatial representation of disaster resilience index (Fig. 7), a spatial representation of subindexes, and through a ranking table.

Another method to normalise different ranges of values corresponding to different quantitative variables is described by Lhomme et al. (2013a) who define *Performance Indicators to Assess Urban Networks Resilience* (UNR) as a basis to evaluate urban resilience to flood risks. The authors aggregate three subindexes, corresponding to three different resilience capacities: absorption, resistance and recovery.

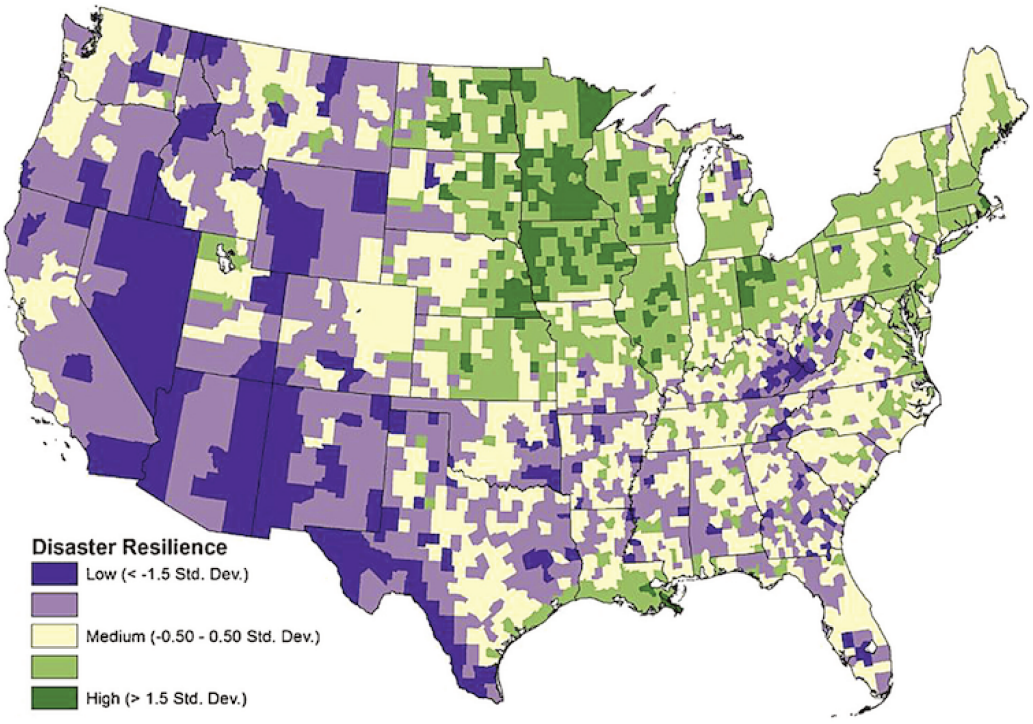


Fig. 1. Disaster resilience index for the contiguous United States, 2010.

FIGURE 2.7. Disaster resilience index for the contiguous United States, 2010 (Cutter et al., 2014).

2.4.9 Performance Indicators to Assess Urban Networks Resilience (UNR)

Approach to Resilience Lhomme et al. (2010, p. 487) provide a definition of resilience that is tailored for research on urban networks (e.g. power grid networks, the internet, pipelines, sewage systems, roads) and flood risk: resilience is defined as 'the ability of a city to absorb disturbance and recover its functions after a disturbance'. According to this approach, resilience is based on two characteristics: 'absorption capacity' and 'recovery capacity'.

Another important aspect is that the city is considered as a complex and open system. It is complex since it entails multiple interacting components, such as networks, companies, population, and public infrastructure. It is open because urban areas have important external connections: for instance, with the countryside, or with other cities through product exchange. During a flood, a major external input is meteorology that affects external and internal connections in the city. The authors outline a systemic view that doesn't only focus on flood-prone areas.

Assessment Framework. According to Lhomme et al. (2013b), technical networks are the main entrance point of floods and of related risks in urban areas. For example, heavy rainfall can overload the sewerage system and cause a flood. Since technical networks are interdependent, a malfunction of the sewerage system can compromise other networks, such as transport networks, with consequences on all the other components of a city. This example illustrates how crucial technical networks are for urban resilience.
The assessment approach outlined by Lhomme et al. (2013a, p. 224) is based on resilience indicators related to three 'capacities':

- 'Absorption capacity', defined as 'the ability of a network to redistribute flows towards undamaged parts of the network when this network is partly damaged'. It can be assessed by measuring the redundancy of the network.
- 'Recovery capacity', defined as 'the ability to restore damaged components'. It corresponds to the time required to restore damaged components.
- The above two capacities are strongly dependent on 'resistance capacity' that 'analyses dysfunctions induced by damaged components and takes into account interdependencies among networks'.

The aggregation of these three assessments provides a 'network resilience indicator'. Once the acceptable resilience thresholds are established, urban areas with non-resilient networks can be identified. According to Lhomme et al. (2010), the urban areas with non-resilient networks can be defined as non-resilient. If the number of non-resilient areas in a city is high, the city is non-resilient.

Implementation. A Web-GIS prototype was developed and tested in two pilot sites: in Orléans (France) with a focus on the road network redundancy (Lhomme et al., 2013a), and in Dublin (Ireland) with a focus on the sewage system recovery capacity (Lhomme et al., 2013b). The WebSGIS prototype computes an automated analysis of flood resilience based on indicators that are specific to each kind of network.

2.5 Guiding principles to assess urban resilience to weather extremes

Different methodologies to assess resilience were proposed by academics and practitioners. This chapter gives an overview of the high variety of methods to assess resilience.

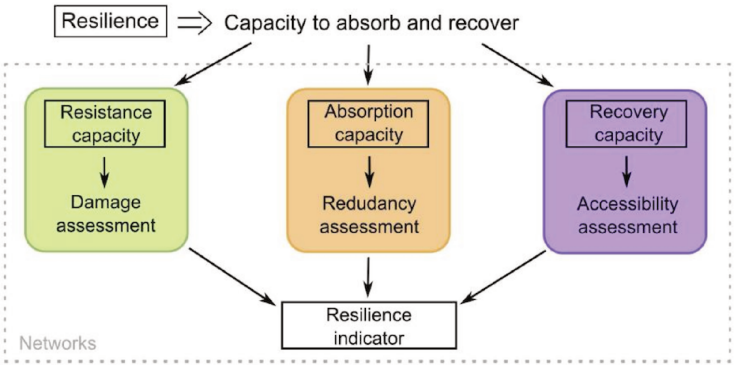


FIGURE 2.8. Strategy to assess network resilience (Lhomme et al., 2013a).

The definition of resilience differs, as well as the focus on a certain space scale and on specific stresses and shocks, and the choice of specific variables and metrics. Furthermore, some assessment methods were largely implemented in various pilot sites, while other frameworks are in an early stage of the implementation. This heterogeneity is evident in the matrix (see Appendix A) that sums up and compares the main features of the assessment methods presented in the Sect. 2.3 and 2.4. Each approach has its notable points of interest, and this review is a useful basis to identify relevant resilience indicators for urban areas. On the basis of the features highlighted in the previous section, we can establish that relevant resilience indicators, for cities coping with extreme weather, should:

- Refer to a definition of resilience that is consistent with the social-ecological resilience approach (see Sect. 2.2);
- Define a general composite index of resilience that can be easily used for spatial distribution representations and rankings (see Sect. 2.4.8 DROP-BRIC);
- When defining subindexes, consider:
  - More than two components of urban systems (see Sect. 2.4.6 100RC, 2.4.4 SMARTeST, 2.4.5 4Rs-5Cs, 2.4.8 DROP-BRIC);
  - Interactions among different components (see Sect. 2.4.2 MAES, Sect. 2.4.7 RA);
  - Specific resilience and general resilience (see Sect. 2.4.7 RA);

  - Multiple spatial and temporal scales (see Sect. 2.4.2 MAES, 2.4.7 RA, 2.4.8 DROP-BRIC);
  - System properties that are associated to resilience (see Sect. 2.4.5 4Rs-5Cs, 2.4.6 100RC, 2.4.7 RA, 2.4.9 UNR);
  - What is the weight of each sub-index (see 2.4.4 SMARTeST).

- Select quantitative variables (see Sect. 2.4.1 DRSC, 2.4.2 MAES, 2.4.7 RA, 2.4.8 DROP-BRIC, 2.4.9 UNR) since numeric data can be used for statistical analysis, facilitate inter-comparison and benchmarking, automated data collection and analysis;
- Identify for each variable a corresponding threshold and what happens if the threshold is crossed in terms of adaptive cycle phase change and system state change, and in terms of interactions with other thresholds (see Sect. 2.4.7 RA);
- Define a method to normalise different value ranges in a unique scale (see Sect. 2.4.8 DROP-BRIC, 2.4.9 UNR);
- Develop an interactive web tool for automated data analysis (see Sect. 2.4.1 DRSC, 2.4.5 4Rs-5Cs, 2.4.6 100RC, 2.4.9 UNR);
- Involve stakeholders in the assessment process from the selection of variables, to the collection and analysis of data (see 2.4.1 DRSC, 2.4.2 MAES, 2.4.3 AIRT, 2.4.4 SMARTeST, 2.4.5 4Rs-5Cs).

2.6 Communication indicators in the literature on resilience assessment techniques

This section explores how the resilience assessment methods, presented in Sect. 2.3 and 2.4, take into account the role played by communication. The concept of 'communication' is used in a broad sense here. The indicators examined in this section concern communication processes and communication infrastructure, communication among institutional actors and with their stakeholders (that include citizens), top-down communication, as well as two-way dialogue. These indicators also address other social factors that strongly affect communication, such as 'population stability' and 'language competency' (Sect. 2.4.8 DROP-BRIC).

The matrix in Appendix B presents a selection of indicators organised in seven columns that correspond to the resilience assessments methods previously presented (except for the MAES and UNR methods that don't refer communication processes). The matrix also includes seven lines, corresponding to seven resilience drivers that are relevant from a communication perspective: 1) early-warning systems, 2) institutional transparency and relations, 3) public outreach, 4) public engagement, 5) education, 6) training, 7) communication infrastructure. Surprisingly, the matrix highlights that a minority of assessment methods considers early warning systems (Sect. 2.4.1 DRSC, 2.4.4 SMARTeST, 2.4.5 4Rs-5Cs), public outreach (Sect. 2.4.1 DRSC, 2.4.4 SMARTeST, 2.4.6 100RC) and training (Sect. 2.4.1 DRSC, 2.4.5 4Rs-5CS, 2.4.8 DROP BRIC). Education and communication infrastructure are evaluated in the framework of a bigger number of assessment techniques (Sect. 2.4.1 DRSC, 2.4.5 4Rs-5CS, 2.4.6 100RC, 2.4.8 DROP BRIC). Public engagement and institutional relations/transparency are the most prominent groups of indicators, with six out of seven methods referring to these topics. Both themes are related to decentralisation of risk management that, according to Tanguy (2015), is a necessary condition to implement social-ecological resilience.

The matrix confirms that subsidiarity is gaining importance in resilience implementation, as well as in recent assessment practices. Indeed, until a few years ago, the citizens were considered as passive actors in risk management policies, to be protected and compensated for the damages (Tanguy and Charreyron-Perchet, 2013). According to Tanguy (2015), citizens' engagement is a hard challenge because the collective memory of a disaster is very limited: after a disaster the victims prefer oblivion, especially in those regions where these events have a low frequency.

As mentioned in Sect. 2.3 and 2.4, various recent methods (Sect. 2.4.1 DRSC, 2.4.2 MAES, 2.4.3 AIRT, 2.4.4 SMARTeST, 2.4.5 4Rs-5Cs) exploit resilience evaluation campaigns as an opportunity to develop stakeholder active involvement. An example is the Iterative Risk Management (IRM), a methodology proposed by Zurich Resilience Flood Alliance to merge expert risk analysis with stakeholder perspectives, in the framework of the 4Rs-5Cs (Sect. 2.4.5) assessments. The community is involved in assessing performance and potential risks, and in identifying and implementing solutions to enhance the four Rs. The IRM approach is considered a key tool to cope with risk management problems such as 'lack of robust data, long time scales, uncertainty in future conditions, operationalization and quantification' (Keating et al., 2014, p. 8). Public engagement is

enhanced through the user-friendly mobile app and the Web platform that facilitate data collection and automated analysis.

2.7 Conclusions

A relevant number of indicators, among those listed in Appendix B, monitor communication in terms of presence/absence of efforts, frequency of activities, and audience size. Other indicators consider the effectiveness of these activities and their positive impact in terms of awareness, knowledge, preparedness, response, coordination. However, none of these indicators explore the complex socio-semantic dynamics that contribute to the 'social construction of reality', a concept that will be discussed in the next chapter.

The aim of our study goes beyond a description of the state of communication processes and infrastructure in an urban area exposed to risks. We propose a dynamic perspective with alternative resilience communication indicators. These novel metrics are tailored to appraise how specific communication activities contribute to achieving local resilience goals. These indicators require a rich and detailed selection of communication variables that are activity driven, i.e. they enable detection of resilience changes, that occur even in a brief time, and the causes related to a past or ongoing communication activity.

The concept of resilience introduces a holistic approach that is a reply to a spreading need to forge links between different urban dimensions when coping with climate pressure and urban sprawl consequences. Chapter 3 provides an overview of Social Impact Assessment (SIA), a method designed for project managers that are asked to take into account the social dimension in territorial development projects. From Chap. 4 to Chap. 7, we present our research results on alternative resilience communication indicators that can contribute to the progress of current resilience assessment practices. More specifically, in Chap. 4 we identify a range of variables to be used as communication indicators. These indicators are designed on the basis of the guidance criteria discussed in Sect. 2.5. Furthermore, they address the content quality and the socio-semantic networks that underlie communication, beside its frequency, effectiveness and benefits. In Chap. 5, 6, 7, we finally present various experiments that are aimed to test some of these communication indicators.


SIA

CHAPTER 3

Social Impact Assessment

Assessment of social impacts has gained importance in territorial development practice and research, including the studies on urban flood resilience. For example, a study undertaken by ten Veldhuis (2011) highlights how assessing flood damages from a societal perspective rather than an economic perspective determines different order of priorities in infrastructure protection.

Adverse social impacts can reduce the intended benefits of a project, and can threaten its viability if they are severe enough. In some other cases, the diverse impacts may mutually counterbalance each other, by furthermore strengthening and amplifying the social resilience.

Social Impact Assessment (SIA) is an approach aimed to monitor and better take into account the social variables in territorial development projects. The proposed concepts and methods are an interesting formula to better appraise the interplay between the social factors and other urban resilience drivers. For the purpose of this thesis, the following aspect of the SIA perspective is particularly relevant: evaluating the impact of stakeholder perceptions and attitudes that are defined as the 'social construction of reality' (Inter-organisational Committee on Guidelines and Principles for Social Assessment, 1994, p. 113).

This chapter outlines how Social Impact Assessment (SIA) is undertaken by SIA practitioners to reinforce taking balanced and informed decisions. In particular, it will be discussed why social impacts are a key feature of territorial development, and what the main steps are in performing social impact assessments as a collaborative process. The

next section intends to summarise the main typologies of social impacts, one of which is the social construction of reality.

3.1 Concept of Social Impacts and their typology

The Inter-organisational Committee on Guidelines and Principles for Social Assessment (1994, p. 107) defined social impacts as 'the consequences to human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another, organise to meet their needs, and generally cope as members of society'. According to this definition, social impacts are the 'people impacts' of development actions. This definition includes social-psychological changes, for example to people values, attitudes and perceptions of themselves and their community and environment.

The main types of social impact that occur as a result of these action-induced changes can be grouped into five overlapping categories (Glasson, 2000):

- *Lifestyle impacts* – on the way people behave and relate to family, friends and cohorts on a day-to-day basis;
- *Cultural impacts* – on shared customs, obligations, values, language, religious belief and other elements which make a social or ethnic group distinct;
- *Community impacts* – on infrastructure, services, voluntary organisations, activity networks and cohesion;
- *Amenity/quality of life impacts* – on sense of place, aesthetics and heritage, perception of belonging, security and aspirations for the future;
- *Health impacts* – on mental, physical and social well-being, although these aspects are also the subject of health impact assessment.

However, these types should be carefully reviewed for their relevance in a given situation and/or country, for example to development goals or to basic needs for food, water and shelter. In addition, many of the impacts listed are not easily measurable, and require analysis of a number of variables. For this reason, basic dimensions of social change are used as a reference point to be adapted, for defining impacts and means of mitigating them in a specific context where a specific action is implemented. The key

characteristics and variables (see Table 3.1 in Sect. 3.3) that are often correlated with adverse social impacts, the so-called causes of social impacts, include:

- *Demographic change*– e.g. size and composition of the resident population, influx of temporary work force or new recreational users of the area such as tourists that disrupt the cohesion of a small, stable community;
- *Economic change*– e.g. new patterns of employment/income, real estate speculation that marginalise long term, older residents;
- *Environmental change*– e.g. air and water quality, alterations to land use, natural habitat and hydrological regime that can misplace the subsistence or livelihood in resource-dependent communities;
- *Institutional change*– e.g. law and administration in the structure of local government or traditional leadership, zoning by-laws or land tenure that reduces access or control and leads to disempowerment or impoverishment of the established population.

Social impacts can be a significant aspect of many types of actions, and not only proposals for large-scale development. Like environmental impacts, social impacts can vary in desirability, ranging from the desirable to the adverse. The referents of action-induced social change include intensity or severity (a dimension that is defined differently in different project settings), probability, importance, etc. They also vary in scale with the setting and the characteristics of the community affected, including small remote communities. It is also important to consider how social impacts may vary in accordance with different stages of an action life cycle.

Furthermore, humans are affected by changes in the distinctly human environment, including those associated with the phenomenon known as the social construction of reality. The social construction of reality is characteristic of all social groups. Persons not familiar with the social sciences are often tempted to treat social constructions as mere perceptions or emotions, to be distinguished from reality. Such a separation is not so easy to accomplish. In the case of proposed actions that involve controversy, attitudes and perceptions toward a proposed policy change are one of the variables that must be considered in determining the significance of impacts. There are two important factual reasons for this. First, positions taken by all sides in a given controversy are

likely to be shaped by differing perceptions of the policy or action. Therefore one set of perceptions can be accepted while another one is excluded, even when the decision isn't scientifically defensible. Second, a simple dismissal of the expressed concerns as being merely imagined or perceived, may raise the level of hostility to the whole action and will stand in the way of a successful resolution of the problem.

It is important to consider the social equity or distribution of impacts across different communities: a particular attention should be devoted to the impacts on vulnerable segments of the human population. Examples include the poor, the elderly, adolescents, the unemployed, and women; members of the minority and/or other groups that are culturally or politically distinctive; or value-based groups for whom a given community, region, or use of the biophysical environment is particularly important.

Last, but not the least observation is that, just like environmental impacts, some social impacts can be of short duration, while others can last a lifetime; and some communities 'return to normal' quite quickly once a source of disruption is removed, while others do not. This common aspect of social and environmental impacts establishes a direct link with the concept of 'resilience'. Similarly, there are differences in the degree to which environmental and social impacts are likely to be cumulative, at one extreme, or mutually counterbalancing, at the other.

The key points on social impacts briefly discussed in this section are that:

- Social and natural environment impacts are interconnected and should be assessed together;
- Social Impact Assessment (SIA, see Sect. 3.2) is concerned with the human consequences of proposed actions, identifying all significant social impacts that arise in this context;
- Some of the most important aspects of social impacts involve the meanings, perceptions, or social significance of the action-induced changes;
- Combined assessment of social and environmental impacts is an entry point to the integrated impact assessment in support of sustainability aims of maintaining natural capital and building human capital of the resilient society.

3.2 Field of Social Impact Assessment (SIA)

Social Impact Assessment (SIA) focus on the human dimension of environments, and is used to identify and then to analyse the impacts of a proposed action on individuals, those who benefits and who loses, in order to mitigate the adverse effects and enhance the positive effects of that action. SIA can help to ensure that the needs and voices of diverse groups and people in a community are taken into account. It also provides a framework to manage social change.

To predict what the probable impact of proposed actions will be, SIA seeks to understand the past behaviour and life conditions of individuals and communities affected by this type of actions. It aims to identify probable undesirable action-induced social effects before they occur in order to make recommendations for mitigation. When social impacts can be measured and understood, recommendations for mitigating actions can be made and the issues of alternative plans and alternative impacts can be raised. Hence, Social Impact Assessment is a field of research, planning and management of social changes or consequences (positive and negative, intended and unintended) arising from various actions, i.e. policies, plans, programmes and projects (Taylor et al., 1998). It is one of the tools in the toolbox of integrated environmental management that focuses on the human element of development interventions. However, the human element cannot be examined and assessed in isolation of the biophysical and economic dimensions that, together with the social dimension, contribute to attaining sustainability, i.e. all three dimensions that constitute the environment must be examined and assessed in an integrated manner.

While still there is no widely agreed definition of SIA, it is reasonably well understood as a process of incremental information gathering, involving multiple, inter-related disciplines, to enable analysis and assessment, with the purpose of defining new actions, either to remedy negative impacts or to enhance benefits. Social Impact Assessments deal with action-specific impacts on communities and people directly affected by proposed actions. Social Impact Assessments are seldom applied on a wider scale, for example, on a national scale. In such cases, development proponents usually commission SIA as part of Economic Assessments aimed to understand and evaluate wider economic and societal benefits that may accrue from a proposed action.

Social Impact Assessment covers multiple disciplines in an integrated manner: an-

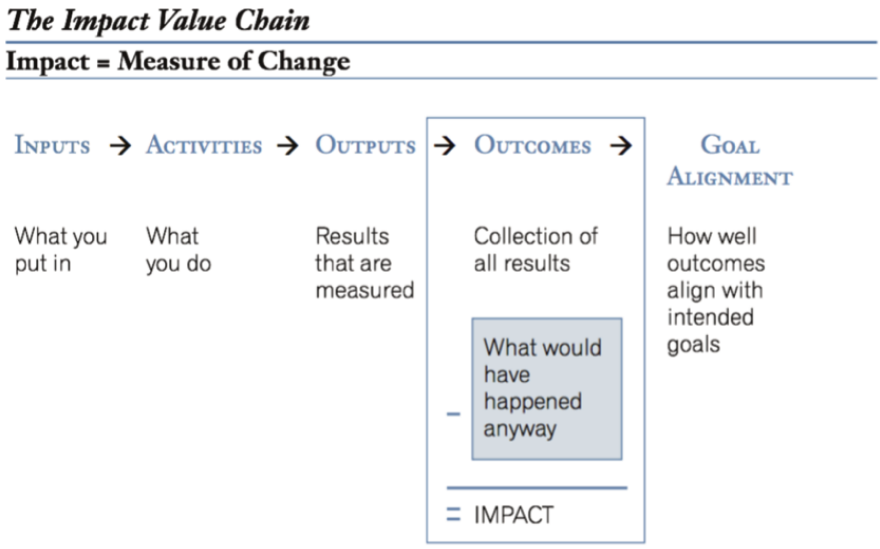


FIGURE 3.1. The impact value chain (The Goldman Sachs Foundation and The Rockefeller Foundation, 2003).

thropology, sociology, gender studies, psychology, economics, political science. SIA often runs in close association with public participation. Therefore, by its nature, it requires public awareness raising, a dialogue approach.

3.3 Role and scope of SIA

Conflicts between economic development and natural resources can be the cause of social problems. Economic losses and social costs from environmental degradation can occur long after the economic action-induced benefits have been realised. The proposed actions, like development projects, can provide economic benefits and better living environment, but they can also affect local people adversely. The principal role of Social Impact Assessment (SIA) is to help in understanding such impacts. The impact value chain of development projects and role of SIA is illustrated in the Fig. 3.1: the output is any measurable results from an organisation activities, while the outcome refers to the changes in attitudes, behaviours, knowledge, skills, status, or level of functioning that are a consequence of the activities result and can be monitored through SIA.

Social Impact Assessment (SIA) essentially involves characterising the existing state of the key social aspects (see Tables 3.1 and 3.2), forecasting how they may change if a

Table 3.1: Key social aspects.

KEY SOCIAL ASPECTS
Organisation of the community, social and cultural institutions and beliefs.
The way people cope with life through their economy, social systems, and cultural values.
The way people use the natural environment, for subsistence, recreation, spiritual activities, cultural activities, and so forth.
The way people use environment for shelter, making livelihoods, industry, worship, recreation, gathering together, etc.
A group values and beliefs about appropriate ways to live, family and extra-family relationships, status relationships, means of expression, and other expressions of the community.
Preservation of the community identity.
The aesthetics and cultural character of a community or neighbourhood and its ambience.
Art, music, dance, language arts, crafts, and other expressive aspects of culture.

Table 3.2: Common questions involved in SIA.

EXAMPLES OF COMMON QUESTIONS
Who are the stakeholders of the project/proposed action?
Are project objectives consistent with stakeholders' needs, interests and capacity?
What institutional arrangements are needed for participation and project delivery? What will be the impact of the project or programme on the various stakeholders, especially women and vulnerable groups?
Are there plans to mitigate adverse impacts?
What social and cultural factors affect the ability of stakeholders to participate or benefit from the proposed policy or project?
Are there plans to build capacity at appropriate levels?
What social risks might affect project or programme success?

given action or alternative is implemented, and developing means of mitigating changes that are likely to be adverse from the point of view of an affected population. SIA can be defined in terms of efforts to assess or estimate, in advance, the social consequences that are likely to follow specific policy actions (including programmes/projects and the adoption of new policies), giving particular attention to the mitigation of adverse or unintended aspects. It is a process that provides a framework for prioritising, gathering, analysing, and incorporating social information and participation into the design and delivery of development interventions (Rietbergen-McCracken and Narayan 1998). The SIA ensures that the development interventions: (i) are informed about and take into account the key relevant social issues; and (ii) incorporate a participation strategy for involving a wide range of stakeholders.

The scope of SIA evolved over time and nowadays differs from country to country:

1. *SIA was conducted mostly under Environmental Impact Assessment (EIA) legislation and procedure*–Over the past few decades, the direct link between EIA and SIA constitutes the basic modelling frame, which assumes that impacts on the social environment resemble biophysical impacts in several ways. Indeed, the term environment is defined broadly to include 'social', 'cultural', and other human dimensions. Hence, the Environmental Impact Assessment legislation and procedures was used to provide a framework for the field of Social Impact Assessment. In this context, SIA approach follows approximately the steps of the EIA process, while it focuses on the impact of proposed actions on people.

2. *SIA was initially limited to environmentally related changes*– The projects with important and 'everyday' social impacts include perceived health risks and loss of amenity (e.g. landfill and hazardous waste disposal sites nearby inhabited areas) or lifestyle disruption resulting from relocation (e.g. dams and reservoirs that are constructed close to residential areas). Often, in EIA, most attention is focused on such a high-profile issues, notably for projects which displace people and affect vulnerable ethnic minorities. These matters are unquestionably important internationally, not infrequently raising issues of human rights and social justice (see case example below). In particular, involuntary resettlement has extreme social impacts, which in many cases warrant separate and specific studies. However, these issues are a relatively small subset of the overall social impacts associated with development projects.

3. *Larger range of social impacts are now considered*– For example the key role played by social networks and information flows (see examples in Ch. 4).

4. *SIA is further developed as a separate process*– For example, the World Bank promotes broadly based SIA (see examples in Sect. 3.4) to understand and manage social change processes. This framework covers the full scope of social considerations, including poverty alleviation, gender balance, governance and institutions, and equity, rights and justice issues. Many SIA practitioners endorse such an overarching approach, beyond what is possible in the context of EIA. However, there is not yet a common understanding of its scope, boundaries and content of what is also called social appraisal or human impact assessment. Furthermore, the correlations between social impacts and biophysical impacts are not at stake.

5. *Focus is on social issues of sustainable development, poverty alleviation and justice*– Such as in the case of Paris Resilience Strategy supported by the 100 RC network (see Sect. 3.8).

6. *Scope of SIA differs from country to country, depending on each government jurisdictional arrangement*– The consideration of social impacts is triggered by and, in some cases limited to, environmentally related changes. These can be particularly important in developing countries where large numbers of people are dependent on local natural resources for their subsistence and livelihood. In other cases, once an EIA is required for a proposal, major effects on the human environment can be considered in their own right. These can include potential changes to the population, lifestyle, cultural traditions, community dynamics, and quality of life and well-being. In other cases, for example the City of Paris and the other members of the 100 Resilient Cities network (see Chap. 2), the assessment process is more comprehensive and considers several interacting dimensions such as 'environment and infrastructure', 'health and well-being', 'leadership and strategy', 'economy and society' (The Rockefeller Foundation and ARUP, 2015, p. 7).

3.4 Review of the methodological frameworks, data sources and tools

International agencies such as the World Bank (www.worldbank.org/socialanalysis) classify the existing SIA methodologies into five (overlapping) classes: analytical, com-

Table 3.3: Five principal sources of information used by SIA experts.

SIA SOURCES OF INFORMATION
Detailed data from the sponsoring agency on the proposed action/project.
Records of previous experience with similar actions, e.g. as evidenced in other SIA reports.
Census and vital statistics on the area/population affected; documents and secondary sources that document baseline conditions and trends.
Field research, including interviews, meetings and other contact means.
Surveys of the general population (subject to available funds).

munity–based, observation and interviews, participatory, and workshop-based. However, there are sharp differences among SIA experts on the methodological frameworks that should be applied to assess social impacts. A number of orientations can be identified. Notably, there is a polarisation between the economic and environmental sciences approach, which emphasises prediction of change (with vs without the project), and the social and political sciences approach, where SIA is oriented toward community development and empowerment. Some SIA practitioners consider social impacts to be only 'as experienced' (e.g. stress, disruption, hunger) and differentiate these from the causal processes (e.g. overcrowding, infrastructure pressure, poverty).

In practice, all these methodological differences may not be so apparent, being merged by regulation requirements and implementation procedures that give emphasis to the management of social impacts. Furthermore, both schools of SIA draw on five principal sources of information, as summarised in Table 3.3. However, not all SIA practitioners would agree with the classification of impacts as proposed in Sect. 3.1, and not all of the impacts listed are necessarily considered as part of assessment practice.

The basic social dimensions that can be measured that reflect fundamental and important characteristics of a community result in the following Table 3.4 of key SIA variables that also evolved over time (see Inter-organisational Committee on Guidelines and Principles for Social Impact Assessment, 1994 and Impact Assessment and Project

Appraisal, 2003).

Studied over time, these characteristics give us insight on how social structure will be altered when change occurs. Then in accordance with Fig. 3.1, the output could be any measurable results from an organisation's activities (e.g. number of people placed into employment or number of youth served). And the outcomes would be the specific changes in attitudes, behaviours, knowledge, skills, status, or level of functioning that are a consequence of the activities result. (e.g. household income or access to education).

Social Impact Assessment uses any of the tools of social sciences, programme evaluation, or business practice to determine the social impact of an intervention, programme, organisation, or company. Very often, these make use of workshop-based methods and participatory assessment methods (see Table 3.5). For example, the World Bank tool kit is a particular approach to SIA that is implemented in the context of developing countries. It emphasises the importance of these interactive methods, which can be used to collect baseline information, to build a profile of the existing social situation and to gain an understanding of how a proposal might affect a community. Some of the methods engage stakeholders directly in the process of predicting impacts. For example, participatory and community-based approaches involve affected local people in estimating how their lifestyles are likely to alter as a result of projected changes. However, these estimates should be corroborated, especially if there is no local experience of the kinds of impacts expected.

Much of the analytical work in SIA centres on prediction of potential change in key social variables as established in the scoping phase. Scoping is indispensable because it focuses the study on key issues. Depending on the scope, SIA may use different tools and techniques. Fig. 3.2 gives an illustration of the scoping process. This can help to address the problem of incomplete data, as well as compare and highlight any variations in information derived from different sources. Generally, an integrated approach, which combines a number of methods, will provide the most composite and reliable prediction of impacts and identification of suitable measures to mitigate and manage them. In practice, however, this is not always possible, and often not more than two or three SIA tools will be used. At a minimum, the prediction of social impacts should be based on:

- *Understanding of the affected population* – how are people likely to respond to and be affected by a given proposal?

Table 3.4: Key SIA variables and their evolution from 1994 to 2003 (Inter-organisational Committee on Guidelines and Principles for Social Impact Assessment, 1994; The Goldman Sachs Foundation and The Rockefeller Foundation, 2003).

SIA VARIABLES (1994)	**SIA VARIABLES (2003)**
1. Population Characteristics	**1. Demographic factors**
Population change, ethnic and racial distribution, relocated populations, influx/outflows of temporary workers, seasonal residents, tourists, etc.	Number of people, location, population density, age, etc.
2.Community and Institutional Structures	**2. Socio-economic determinants**
Voluntary associations, interest group activity, size and structure of local government, historical experience with change, employment/income characteristics and equity, local/regional/national linkages, industrial/commercial diversity, presence of planning and zoning activity, etc.	Factors affecting income and productivity, such as risk aversion of the poorest groups, land tenure, access to productive inputs and markets, family composition, kinship relations, and access to labour opportunities and migration, etc.
3. Political and Social Resources	**3. Socio-political context**
Distribution of power and authority, identification of stakeholders, interested and affected publics, leadership capability and characteristics, etc.	Implementing agencies' development goals, priorities, commitment to project objectives, control over resources, experience, and relationship with other stakeholder groups, etc.
4. Individual and Family Changes	**4. Social organisation**
Perception of risk/health/safety, displacement/relocation concerns, trust in political and social institutions, residential stability, density of acquaintanceship, attitudes toward policy/project, family and friendship networks, concerns about social well-being, etc.	Organisation and capacity at the household and community levels affecting participation in local level institutions as well as access to services and information, etc.
5. Community Resources	**5. Needs and values**
Change in community infrastructure, land use patterns, effects on cultural and historical resources, etc.	Stakeholder attitudes and values determining whether development interventions are needed and wanted, appropriate incentives for change and capacity of stakeholders to manage the process of change, etc.

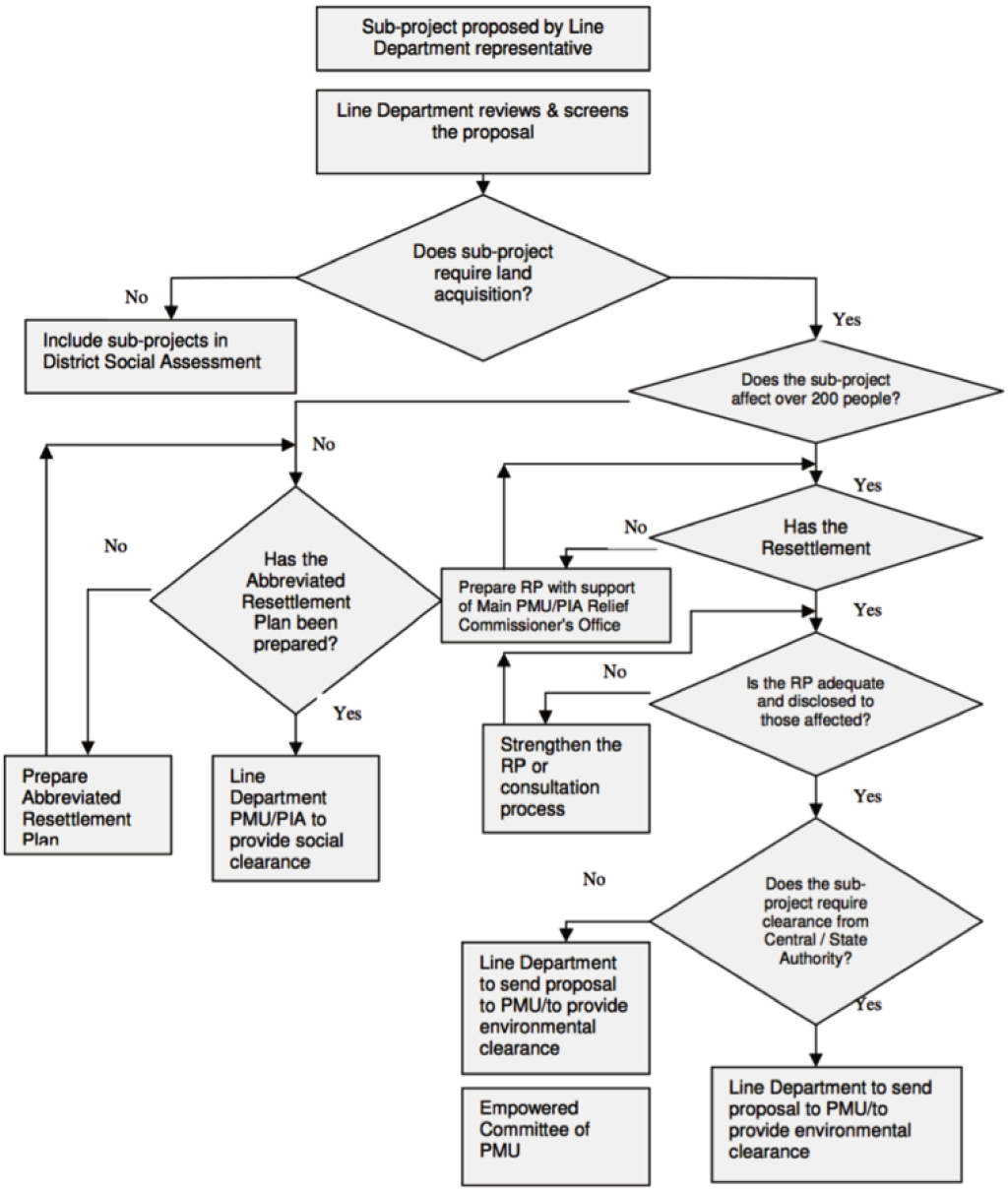


FIGURE 3.2. Example of scoping algorithm for social impacts from Emergency Tsunami Reconstruction Project, the Government of Tamil Nadu and Pondicherry (www.worldbank.org/socialanalysis).

Table 3.5: Two principal interactive methods that are generally used for profiling of social situations.

INTERACTIVE METHOD	**DESCRIPTION**
Workshop-based methods	Collaborative decision elaboration often takes place in the context of stakeholder workshops, which bring stakeholders together to assess issues and design development projects collaboratively. A trained facilitator guides stakeholders through a series of activities to promote mutual learning and shared problem solving.
Participatory assessment methods: Participatory Rural Appraisal (PRA)/Associative strengths, Resourcefulness, Action-planning, and Responsibility (SARAR)/Beneficiary Assessment (BA)	Social assessments can also be informed by field visits to communities and other local-level stakeholders to learn about their perspectives and priorities. Such methodologies provide tools for collaborating with local people in analysis and planning, and contribute to the development of action plans and participation strategies.

- *Comparison with similar cases* – what is the experience with the effects of proposed actions on similar communities elsewhere?

- *Appropriate expertise and knowledge base* – was the analysis undertook by an experienced SIA practitioner using suitable methods and tools?

Methods of predicting the future impacts are at the heart of the SIA process. Forecasted impacts are the difference in the human environment between the future with the project and a future without the project. Different methods exist to predict probable social impacts. For instance, the comparative method (Table 3.6) involves examining similar communities that experienced similar policies or projects in the past. This method also permits a restudy of the impacted community in the future to assess the actual impact, and verify if forecasts matched with outcomes. Care must be taken to ensure the quality and transparency of methods and data, and to provide for a critical review. Table 3.6 recapitulates some of the methods for analysing and predicting social impacts (Taylor et

al., 1998; The Goldman Sachs Foundation and The Rockefeller Foundation, 2003).

One way to capture the complex dynamic quality of social impacts is to metaphorically take a series of snapshots over time as the development event or policy change unfolds and fill in what happened in between. Ideally, information about the community or geographic area of study is available both before and after the event to help in measurement. Social impacts then become the changes taking place between the two measurements points. The social assessor attempts to forecast the change associated with proposed activity, based on research and information accumulated from comparative studies of similar situations. A strength of the comparative SIA model is that with appropriate data sources (those which can be collected frequently) it allows for an interpretation of dynamic events and can provide monitoring of short-term impacts. This kind of frequent monitoring provides a continual source of evaluation that is useful base for forecasts of social impacts.

As underlined by Rietberg-McCracken and Narayan (1998), SIA is an iterative process that has to be organised in a phased manner in several stages. Although, the major involved stages and followed steps in conducting SIA are logically sequential, they often overlap in practice. According to the Inter-organisational Committee on Guidelines and Principles for Social Impact Assessment (1994), the SIA involves undertaking various actions in the following major stages:

1. *Public involvement* – to develop and implement an effective public involvement plan to involve all interested and affected stakeholders is the vital first step. This involves identifying the target population that will either benefit or be adversely affected by the project. A wide range of public participation techniques (see Table 3.5) should be used to collect information about public response to a proposed action. This first step is vital as the public participation programme develops throughout the implementation and monitoring;

2. *Identification of alternatives* – to describe the proposed action and reasonable alternatives to it, including the no action alternative. During this stage, the proposed action is described in detail so as to identify the data requirements needed for the proponent to make a preliminary assessment. The project alternatives, including no project option, should be identified and their suitability can be examined on

Table 3.6: Principal methods for analysing and predicting social impacts.

PREDICTIVE METHOD	**DESCRIPTION**
Comparative method	This method examines how an affected community responded to change in the past, or the impact on other communities that underwent a similar action. The present is compared to the future with the proposed action. Based on past research and experiences in similar cases, determination of significance is made based on the comparative data presented.
Trend extrapolations	This method takes existing trends and simply projecting current trends, such as population change or employment, into the future. This method assumes that what happened in the past is likely to happen in the future, with or without modifying the rate of change.
Population multiplier methods	In this method, extrapolated increases in population size designate coefficients for the change in other variables, such as employment and housing units, infrastructure or service needs.
Statistical significance means	It involves calculations to determine probabilistic differences between situations with and without the proposed action. A social assessor could employ comparative statistical methods to determine statistical significance for appropriate SIA variables.
Scenarios	These refer to logical-imaginations based on construction of hypothetical futures through a process of theoretical modelling the assumptions about the SIA variables in question. Scenarios include exercises to develop the likely, alternative or preferred future of a community or society. Scenarios can be used to compare different outcomes (e.g., best versus worst case).
Consulting experts	Use of expert knowledge such as researchers, professional consultants, local authorities, or knowledgeable citizens. Such persons familiar with the study area could be asked to present scenarios and assess the significant implications for the proposed action.
Calculation of 'futures forgone'	A number of methods were formulated to determine what options would be lost irrevocably as a result of a plan or proposed action. For instance, the wetlands mitigation strategy and its impact on the local ecosystem constitutes such an example.

the basis of the information on the project, area of influence and social issues (see Tables 3.1 and 3.2), and in consultation with the stakeholders;

3. *Profiling of baseline conditions* – to document the relevant human environment/area of influence of the proposal and the existing social conditions and trends (using the characteristics and variables described in Table 3.1, 3.2 and 3.5);

4. *Scoping* – to identify and prioritise the range of likely social impacts through a variety of means, including discussion or interviews with potentially affected stakeholders. The principal methods to be used by experts are reviews of the existing social science literature, public surveys and public participation techniques;

5. *Projection of estimated effects* – to analyse and predict the probable impacts of the proposal and the alternatives against baseline conditions (with vs without the action). This involves investigating the probable social impacts in terms of (i) predicted conditions without the actions (baseline condition) and (ii) predicted conditions with the actions and the predicted impacts. Investigation of the probable impacts involves different techniques and five major sources of information (see Table 3.3);

6. *Prediction and evaluation of responses to impacts* – to determine the significance of the identified social impacts to those who will be affected. Projecting the impacts through analysis is an important and also a difficult task, but the responses of affected parties frequently will have higher order significance impacts. After the direct impacts are estimated, the assessor must next estimate how the affected public would respond in attitude and actions. The actions of affected public can be estimated using comparable cases and interviews with those affected about what they expect to do. Again, this involves targeted public participation;

7. *Estimation of indirect and cumulative impacts* – to identify the subsequent, flow-on effects of the proposal, including the second/third order impacts and their incremental impacts when added to other past, present and foreseeable current activities. Secondary or indirect impacts are those caused by the primary or direct impacts; they often occur much later, both in time and geographic distance, than primary impacts;

8. *Changes to alternatives* – to recommend new or changed alternatives and estimate or project their consequences for affected and interested stakeholders. Each alternative or modification to the proposed action should be assessed separately. The

estimation methods described in the previous step apply here but usually on a more modest scale;

9. *Mitigation* – to develop and implement a mitigation plan, in order of preference to firstly avoid, secondly minimise and thirdly compensate for adverse impacts. If the predicted impact is minimal and can be managed, mitigation measures must be put in place. These could be in the form of modification of the specific event in the project, operation and redesign of the project or policy or compensation for the impact by providing substitute facilities, resources and opportunities;

10. *Monitoring* – to develop and implement a monitoring programme to identify deviations from the proposed action and any important unanticipated impacts. This should track project and programme development and compare real impacts with projected ones. It should spell out (to the degree possible) the nature and extent of additional steps that should take place when unanticipated impacts or those larger than the projections occur.

3.5 Benefits of SIA

SIA practice is rewarding for the local community and stakeholders, as well as for the project managers since it facilitates the achievement of the project goals, furthermore, it is a valuable experience for future project proposals. However, in practice, SIA implementation and follow-ups are not always undertaken systematically. Very often SIA cannot be grounded in the context of comparable projects. This situation constrains SIA practice, while the major benefits of undertaking a systematic SIA are well known (see Table 3.7).

In many cases, these benefits of SIA are not anticipated or expected by the different parties involved in the process. For example:

- Developers may focus only on the short-term costs of the SIA, see it as a process that may be appropriated by proponents, or consider the risk of early disclosure prevails over any potential benefit of conducting the study;
- Governments or decision makers may not support transparency of the decision-making process;
- Communities may not consider the SIA process as neutral, but rather as bending the objections.

Table 3.7: Six major SIA-induced benefits.

BENEFITS	ACTIONS	COMMENTS
Reduced impact on people.	- Identifying and prioritising social issues associated with the project; - Mitigating negative impact on communities or individuals.	Identification of mitigation measures is an integral element of SIA.
Enhanced benefits for those affected.	Identifying necessary measures.	E.g. Job training packages.
Avoided delays and obstructions.	Gaining development approval.	Social impact management seriously help to gain project acceptance.
Lowered costs by timely actions.	Addressing social impacts and mitigation measures at an early stage.	This helps to avoid costly errors and remedial actions imposed at a later stage by regulatory agencies.
Improved community and stakeholder relationships.	- Identifying project stakeholders; - Building the trust and cooperation between community and stakeholders.	Experience showed that SIA can help to allay fear and concern and build a basis of trust and cooperation that is necessary for the successful implementation of the project.
Improved future proposals.	Providing information that adds value to existing projects and helps to design future ones.	SIA acts as a precautionary measure and avoids costly errors in the future.

The importance of social impact assessment and its application in specific projects can be understood clearly by some of the examples of SIA good practices or application case studies, as discussed in the next section.

3.6 Examples of SIA good practices

This section draws from the guidelines for SIA prepared by the Inter-organisational Committee on Guidelines and Principles for Social Impact Assessment (1994). In Appendix C we outline the principles that guide the concepts, the process, and the method of conducting social impact assessment. These principles are based on the expert judgement

of widely varied professionals to ensure sound scientific enquiry and are based on the best practices established in the field over the last decades.

When conducting SIA, the following factors and considerations can assist in implementing and amplifying the principles of good practices:

- *Identifying trends* – when gathering baseline data on an affected community, it is important to situate the profile or 'snap shot' in a dynamic context by identifying the changes that are occurring already from non-project sources;
- *Taking account of initial response to project announcement* – support or opposition may be an impact itself or an indicator of the likely degree of community cohesion or conflict over social issues;
- *Qualifying data sufficiency and reliability* – where SIA is hampered by a lack of adequate data, it is better to be cautious in reporting any potentially significant impacts (e.g. stating that it cannot be ruled out with confidence rather than concluding it is not proven);
- *Predicting key issues* – it is better to be roughly correct on the matters that count, rather than quantifying the impacts that can be counted;
- *Team building* – experienced social scientists need to be an integral part of the project team to predict these key issues and establish linkages to environmental and economic impacts. Often, team building must address cultural style as well as disciplinary differences, for example when relating project planning timetable, on the one hand, and the norms and traditions of an affected community on the other.

Analysing impact equity (#2 among the good practice principles outlined in Table 3.8), i.e., who gains and who loses from a proposal, is central to the SIA process. Normally, emphasis will be given to identifying and mitigating adverse impacts. These impacts should be specified and reported for each group that is likely to be differently affected. Successively, appropriate mitigation measures should be taken to ensure each group brunt is not borne disproportionately. In this regard, particular attention is given to highlight adverse impacts on people who are sensitive or vulnerable, for example by reason of age, gender, ethnicity, caste, poverty or other factors. This enforces five particular deeds of good practice in analysing impact equity (see Table 3.8).

Table 3.8: Good practice in analysing impact equity.

FIVE DEEDS ANALYSING IMPACT EQUITY
1. Predict adverse impacts.
2. Specify for each group.
3. Explain reasons for variations.
4. Highlight impacts on vulnerable groups.
5. Guard against representational bias.

Impact equity can be effectively assessed only if an attempt is made to minimise any bias and take full account of the consequences for disadvantaged and marginalised groups. SIA practitioners guard against the following biases:

- *Spatial bias* – information gathering focuses on accessible locations and overlooks remote or nomadic tribes;
- *Seasonal bias* – a SIA may be carried out at a time when it is difficult to gain a representative information on an affected community, for example during harvest time or hunting season;
- *Personal bias* – consultation and interviews may be dictated by cultural traditions or power structures, for example limited to political leaders, elderly people or men; and
- *Professional bias* – lack of interaction between disciplinary specialists may result in important links between the biophysical context and society being omitted.

As can be seen, considerable guidance is now available on SIA good practices, both generally applicable and with specific reference to EIA procedures, established by countries or international agencies such as the World Bank. The good practice principles outlined in Table 3.8 were prepared by leading SIA practitioners, mainly from the USA. However, they are sufficiently generic to become a measure of international acceptance. Most importantly, perhaps, the principles and main steps of the SIA process indicate how common issues of SIA practice, such as data limitations, can be addressed.

Table 3.9: Good practice in impact mitigation and management.

TEN DEEDS IN IMPACT MITIGATION AND MANAGEMENT
1. Identify mitigation measures for each impact.
2. Customise them to the different groups affected.
3. Give priority to avoiding social impacts.
4. Then minimise social impacts as far as practicable.
5. Use compensation as a last resort.
6. Ensure impacts are not borne disproportionately by one group.
7. Ensure no one should be worse off than before.
8. Treat relocation/resettlement as a very special case.
9. Improve livelihoods of those displaced.
10. Enhance benefits for local people through job training and development packages.

Some other SIA practitioners refined this framework to meet their particular purposes. For example, an IAIA (International Association for Impact Assessment) project developed International Guidelines and Principles for Social Impact Assessment (www.iaia.org). For example, this project identifies principles relating to the integration of biophysical and social impacts that:

- Recognise that all environmental impacts are experienced in human terms;
- Extrapolate all biophysical changes to their implications for people;
- Take account of the implications of seasonality for people and their activities.

Ideally, an interdisciplinary approach should be taken to integrate SIA and EIA studies. At a minimum, the information on social and environmental impacts should be synthesised into a coherent impact statement. When a SIA is conducted as a separate

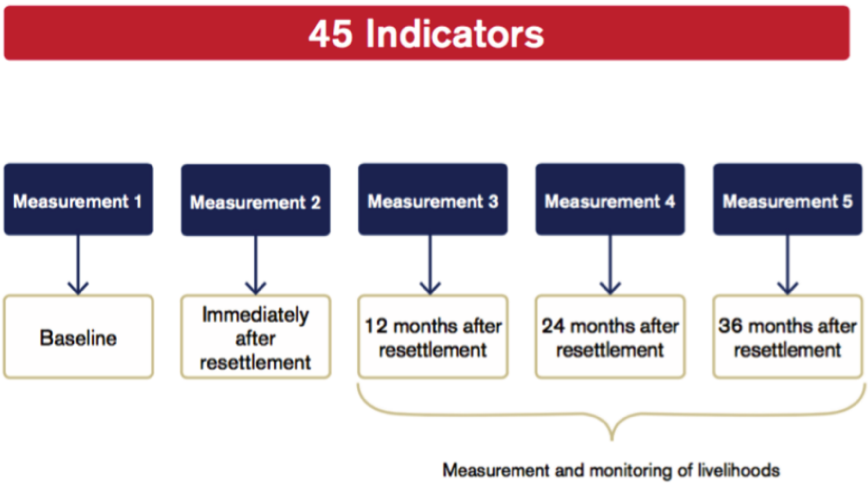


FIGURE 3.3. Schematic illustration on employment of 45 indicators that were measured over a three-year period in order to assess the baseline and monitor the impact of an action on livelihoods after 12, 24 and 36 months (Anglo American, 2003).

study or is a major component in its own right, it should be conducted with reference to the EIA process (and vice-versa) and key findings should be cross-referenced.

The handbook on *Anglo American SEAT TOOLBOX, Socio-Economic Assessment Toolbox Version 3* and the publication *Goldman Sachs Foundation and The Rockefeller Foundation SIA. A Discussion Among Grantmaker* are both dated 2003, and together constitute an interesting example of a complexity in the process of coexistence among well-established and widely applicable tools, on one side, and newly emerged needs on another one. For instance, the *SEAT TOOLBOX* gives an example when 45 indicators, across the nine dimensions, were measured over a three-year period, in order to assess the baseline and monitor the impact at different time scales (see Fig. 3.3). Then the handbook outlines, for the same project, the changes to livelihoods and the effectiveness of the economic development, which gives an illustrative example of the monitoring of the indicators score in the context of a resettlement process (see Fig. 3.4). However, while the overall process illustrated by these two figures is easily transportable to a variety of circumstances within different scientific fields, the indicators themselves require being the situation-tuned. As underlined in T*he Goldman Sachs Foundation and The Rockefeller Foundation SIA* (2003, p. 4), this creates situations when, e.g., 'the social enterprise field as a whole finds itself burdened by significant misalignments in goals,

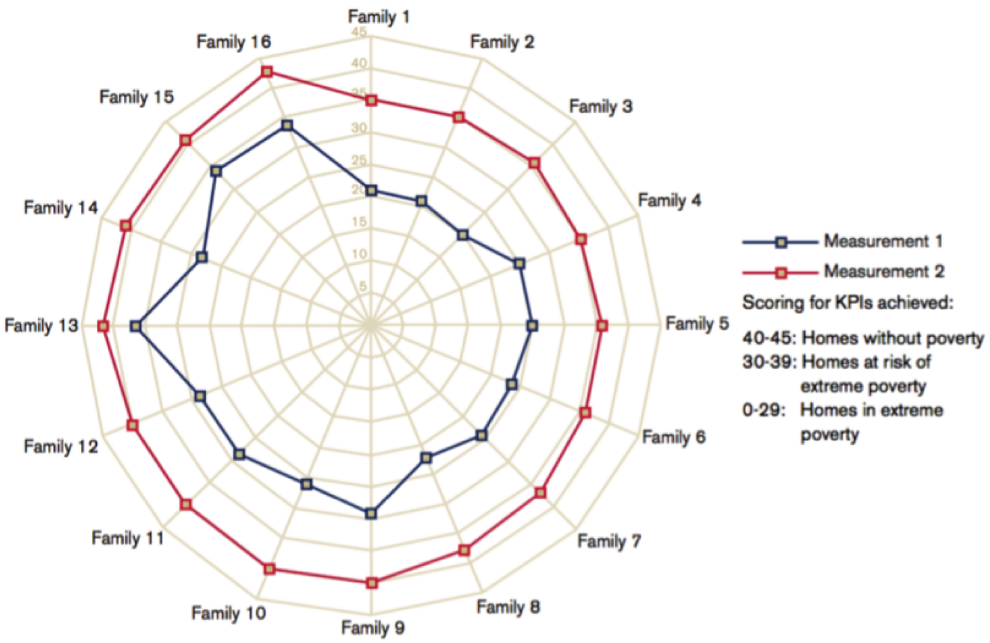


FIGURE 3.4. An illustrative example of the monitoring of the changes made to livelihoods and the effectiveness of a better distributed economic development, being quantified by indicators (Anglo American, 2003).

methodologies, and strategy. Funders have different theories of change, goals, metrics, and reporting requirements... The field as a whole lacks common vocabulary.'

In a presentation by the Ministry of Ecology, Sustainable Development held (MEDDE, 2015, p. 2) the ancient idea that 'what we measure remains to guide us toward sustainable development' is strongly underlined. The need to go beyond GDP metrics is introduced with the quote 'GDP measures everything except that which makes life worthwhile' (Robert F. Kennedy, 1968). In particular, Fig. 3.5 illustrates the multi-dimensional aspect of the notion 'quality of life' in France, while Fig. 3.6 confirms that happiness of the population is not always proportional to GDP. Overall, these three documents highlight persisting need for selecting key indicators that better address the relevant social changes. It is in this spirit that this research aims to define (in Chap. 4) and test (see Chap. 5, 6 and 7) new relevant indicators that can help understand key social changes related to social construction of reality and more specifically to communication.

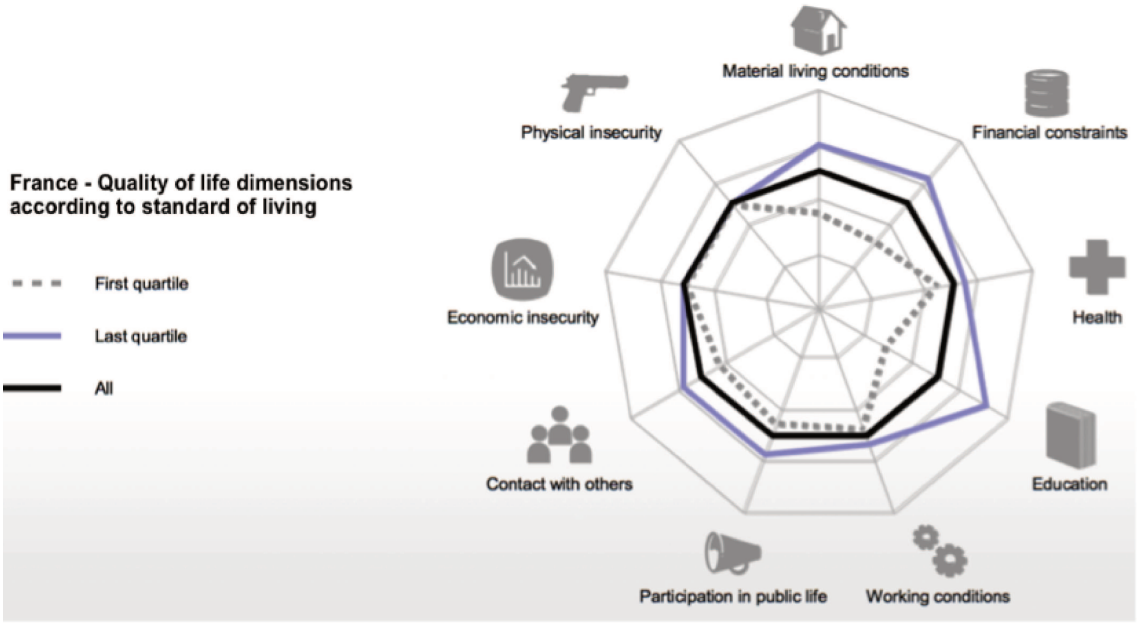


FIGURE 3.5. Illustration of the multi-dimensional aspect of the notion 'Quality of life' in France (MEDDE, 2015).

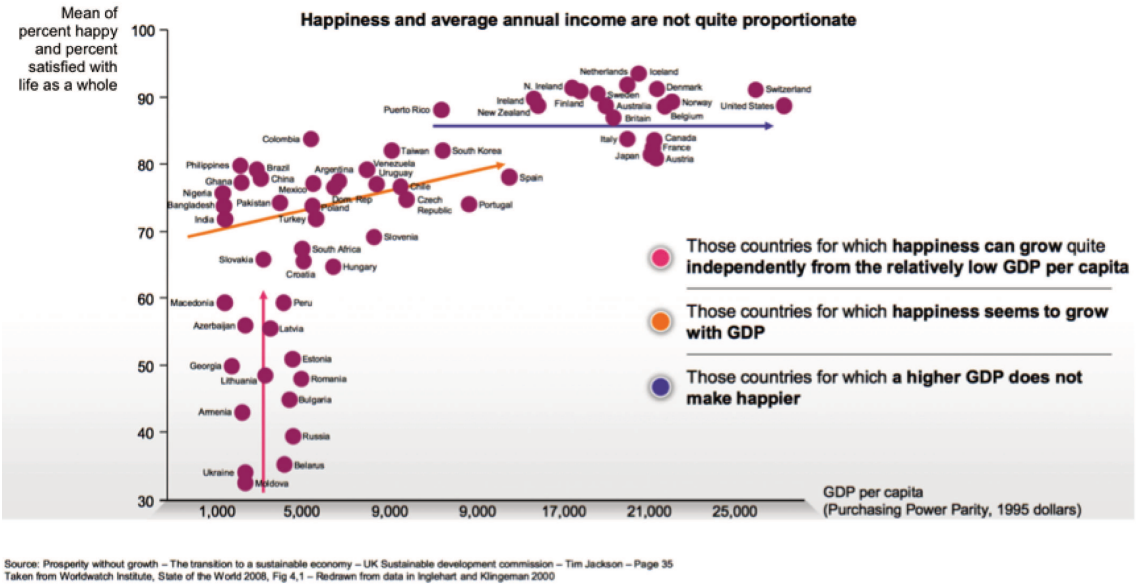


FIGURE 3.6. Graph of Happiness of population vs. GDP (MEDDE, 2015).

3.7 SIA glossary

Main source: Rockefeller Foundation Double Bottom Line Project (Clark et al., 2004).

Baseline means a geographical and time line to start the assessment.

Community and Institutional Structures mean the size, structure, and level of organisation of a local government including linkages to the larger political systems. They also include historical and present patterns of employment and industrial diversification, the size and level of activity of voluntary associations, religious organisations and interest groups, and finally, how these institutions relate to each other.

Community Resources include patterns of natural resource and land use; the availability of housing and community services, including health, police and fire protection and sanitation facilities. A key to the continuity and survival of human communities are their historical and cultural resources. Possible changes for indigenous people and religious subcultures are also considered under this collection of variables.

Credibility is the extent to which the desired approach will be sufficiently rigorous and thorough to provide measures that are credible to the social science, academic, and public policy communities.

Cumulative Impacts are those impacts resulting from the incremental impacts of an action added to other past, present, and reasonably foreseeable future actions regardless of who undertakes them.

Feasibility is the extent to which measurement tools will be useful and applicable in the strenuous environment of a growing venture. Feasibility could be (also) defined in terms of financial costs, person hours, and cultural compatibility with measurement.

Impact is the difference between the outcome for a sample exposed to an enterprise's activities and the outcome that would have occurred without the intervention (e.g. venture, organisation, or investment).

Individual and Family Changes refer to factors which influence the daily life of the individuals and families, including attitudes, perceptions, family characteristics and friendship networks. These changes range from attitudes toward the policy to an alteration in family and friendship networks to perceptions of risk, health, and safety.

Outcomes are specific changes in attitudes, behaviours, knowledge, skills, status, or level of functioning that result from enterprise activities, such as finding a job, avoiding getting sick, or reducing emissions by a certain amount.

Outputs are measurable results from an organisation's activities, e.g. units of housing, number of people placed into employment, number of youth served, etc.

Political and Social Resources refer to the distribution of power and authority, the interested and affected publics, the leadership capability and capacity within the community or region.

Population Characteristics mean present population features and expected change, ethnic and racial diversity, and influxes and outflows of temporary residents as well as the arrival of seasonal or leisure residents.

Social Impact Assessment (SIA) means using any of the tools of social science, programme evaluation, or business practice to determine the social outputs, outcomes, or impact of an intervention, programme, organisation, or company.

Social Return is the monetised impact, minus costs, of an intervention, programme, organisation, or company.

Social Return on Investment (SROI) is the ratio of social returns to investment, calculated according to the specific methodology used by organisations such as the Roberts Enterprise Development Fund (REDF), the Global Social Venture Competition (GSVC), or by economists. This includes monetising predicted future outputs and sometimes outcomes.

Theory of Change is the understanding by stakeholders of exactly how an enterprise will generate social impacts. It highlights the causal relationship between actions, short-

term outcomes, and long-term outcomes. Another term for this is 'logic model'.

3.8 Specific challenges in mitigating social impacts within the Paris-R100 context

The *City Resilient Framework* is a tool designed by The Rockefeller Foundation and ARUP (2015) for the cities joining the 100 Resilient Cities Network. As it is extensively outlined in Chap. 2, this tool provides the guidelines to assess four components of the urban system ('environment and infrastructure', 'health and well-being' 'leadership and strategy', 'economy and society'). These components overlap with the five social impact categories presented in Sect. 3.1, plus the biophysical dimension that is also taken into account.

The City Resilient Framework is being implemented by the City of Paris since 2015 under the supervision of the Chief Resilient Officer, Sébastien Maire. With the support of 100 RC network, Paris addresses with a unique strategy several issues that are at stake: e.g. terrorist attacks, flood risk, heat waves, air pollution, immigrants and refugees fleeing, housing demand, social inclusion.

Remarks from Michael Berkowitz, President of 100 Resilient Cities (100resilientcities.org, 2016)

For centuries, the world has looked to Paris to be inspired. As the birthplace of many revolutions – in the arts, politics, philosophy and urbanism – it is only appropriate that Paris will also be at the vanguard of the next revolution: the resilience revolution.

This revolution is our shared response to the greatest human challenges of our time – including globalisation, urbanisation and climate change. Globalisation means that now more than ever what happens in one city affects others around the world – whether it's flooding disrupting interconnected supply lines, a disease epidemic or economic contagion. Urbanisation and changing demographics mean that cities face even greater pressures not just on the delivery of basic services, but also creating a shared identity among those who have deep roots and those who are just beginning to plant their own.

And we know that the effects of climate change and sea level rise threaten entire cities – on coastlines, in river deltas and on high plains exposing billions of people to significant risk from floods, droughts and rising tides. These 21st-century challenges require 21st century solutions. For example, with COP21, the world reached the most important international agreement on climate in history. But while climate change is indeed a major risk accelerating the need for resilience thinking, it is far from the only one.

When the city of Paris applied to become part of the 100 Resilient Cities network in 2014, its application focused on the city's vulnerability to flooding and heat waves. Given the risk the Seine poses and the legacy of the tragic 2003 heat waves, these priorities were appropriate focuses of Paris's application. Over the course of the year 2015, the world watched as the horrific events of Charlie Hebdo and Nov. 13 unfolded. These attacks, along with waves of immigrants and refugees fleeing conflict in search of a better life, have rightly focused attention on inclusive cities and a discussion about what it means to be French, Parisian, European.

What resilience thinking asks us to do is to have those two conversations together. To ask ourselves how we can solve for the environmental challenges – around climate change, heat waves, air pollution and flooding – at the same time as we think about how to plan for and integrate new migrant populations.

How does that apply to the context here in Paris? Well, imagine if we were to solve Paris exposure to flood risk not just by asking where to build new flood walls, but by asking how we can also improve public safety and social inclusion through green space in flood-prone areas. Imagine if we were to ask how Paris past infrastructure decisions, including the segregation of the city core from its outer suburbs by the Boulevard Périphérique, has contributed to social isolation and lack of economic opportunity in Les Banlieues. And how, through green, inclusive public space, we could address both environmental threats and social cohesion at the same time.

The Paris metropolitan region will spend billions in the coming years to implement the vision from COP21. Imagine if an inclusion screen were placed on those investments, mandating that each decision needed to account for building a more inclusive society, city, and region. This is the power of resilience thinking, what we refer to as 'the resilience dividend'. Addressing multiple challenges with one intervention.

This is what excites me most about this partnership: Paris has the opportunity to become a world-class exporter of best practices for tackling climate-related threats while achieving social integration even for the poorest and most vulnerable. With efforts to build a smarter, more inclusive Paris – we see resilience as the umbrella that ties all of these initiatives together. Paris has been inspiring the world for centuries with some of the most brilliant minds and thought leaders across the disciplines. This city is well known as a leading urban innovator. We want to build upon these endeavours and honour their contribution to work across sectors and departments to tell Paris unique resilience story, and to share the lessons you developed here with his growing network of colleagues all across the world.

3.9 Conclusions

As Berkowitz mentions, one of the main aims of 'resilience thinking' is to facilitate synergies between different policies. This approach involves overcoming fragmentation in risk management by creating constructive interactions among decision makers.

It is a challenge that illustrates a key aspect of SIA: the social construction of reality, i.e. meanings, perceptions, social significance that different stakeholders may have regarding the same action or project (see Sect. 3.1). The convergence or divergence of stakeholders' views is a major determinant of a project or action success. Monitoring the stakeholders' social construction of reality merits special attention: some concrete examples will be presented in Chap. 5, 6, 7.

Identifying key communication indicators and variables is the necessary basis to collect relevant data on stakeholder attitudes and analyse the role of communication in urban resilience. Next chapter presents a study undertaken in Paris to identify relevant Resilience Communication Indicators.

CHAPTER 4

Resilience Communication Indicators for the Paris region

The city of Paris joined in 2015 100 Resilient Cities, a network created by the Rockefeller Foundation in 2013 that nowadays counts 100 member cities – such as London, New York, Bangkok and Rio de Janeiro – and 1000 other applicants from all over the world. Since its accession to the network, Paris is committed to a 'Resilience Strategy', a process of global development that will enhance its efforts to become more resilient to unpredictable shock (e.g. terrorism, the centennial Seine River flood or epidemics) as well as to chronic crises such as unemployment and housing crisis. A keystone of the Resilience Strategy is to create, with a financial support from the Rockefeller Foundation, a Senior Resilient Officer position in each member city. These officers have the task of innovating local policies and develop international collaborations, strengthen funding programmes and reduce vulnerabilities of all the urban community, especially low-incomes citizens, with the general goal of enhancing the city resilience to shocks and stresses. Furthermore, Paris municipality decided to devote 10% of its budget to resilience efforts, as an extension of the commitment that Paris made during COP21 and as an innovative way to plan, mitigate, and adapt in the context of climate change.

The Resilience Strategy is one of the latest proposals that were developed to cope with extreme weather in Paris. Before that, other risk management plans were designed and implemented since 2003. As it is discussed in this chapter, an integrated approach to

risks progressively emerged. At the same time, citizen engagement and communication activities gained importance. The analysis of strategic documents, released by public authorities, can give useful insights on some of the key social aspects outlined in Chap. 3, in particular on the social construction of reality (defined in Sect. 3.2). Similarly to what SIA experts do during the scoping phase, in this section we identify communication variables that are relevant to comprehend the role of stakeholders' perceptions in urban resilience.

These variables draw on an analysis of 12 strategies, developed by local national and international institutions to cope with flood risk in Paris. The variables are then used to outline what we define as Resilience Communication Indicators (RCIs). The study consists in the following steps:

- Identifying communication activities proposed in the public authorities' documents, and specifying the communication context, objectives and target audiences;
- Detecting communication variables that are tailored to the context, objectives, audiences, activities of each communication strategy (outlined through the previous step);
- Establishing what are recurrent communication variables that can be exploited as relevant indicators to analyse the role of communication in urban resilience.

As discussed in Chap. 2, metrics of communication intensity, its effectiveness and benefits are already employed in the framework of various resilience assessment approaches. Conversely, exploring communication with accuracy, in terms of message interpretation and socio-semantic networks and in relation to specific communication activities, is not practised in this field. In this section, we propose a new approach to communication assessment that, at the same time, is activity-driven, considers the guidance for resilience indicators (outlined in Chap. 2) and addresses the complex dynamics that result into the social construction of reality.

The meaning construction by the audience and its behavioural change were investigated by researchers in the fields of risk communication and of public understanding of science. The first series of works explore the impact of risk communication on the audience perceptions and behaviour. Rohrmann (1992) and Lundgren and McMakin (2004) discuss the importance of evaluating the success of risk communication strategies.

Other authors (e.g. Terpstra et al., 2009; Maidl and Buchecker, 2015) evaluate the impact of specific risk communication activities such as interactive workshops, focus groups and one-way communication.

The second set of studies describe different approaches and techniques to evaluate science outreach. Godin and Gingras (2000), Bauer (2008), and Neresini and Pellegrini (2008) discuss the methodological principles of science outreach assessments. Examples of evaluation experiments are described by Scheufele et al. (2005), who designed a national telephone survey on nanotechnology, and by Wagoner and Jensen (2015), who assessed adolescents' learning at the zoo by combining questionnaire data with responses with detailed verbally administered questions.

Our research specifically investigates resilience communication: the definition of "resilience" is discussed in Chap. 2; "communication" is understood here as a one-way, or two-way, exchange of information, involving also an audience of non-scientists and exploiting different possible media (writing on the press or on the Web, face-to-face speaking, creating an exhibition, filming...). Nevertheless, the above-mentioned literature provides helpful hints for this study. As highlighted by Neresini and Pellegrini, the evaluation of a communication activity presupposes that the communication goal is taken into account. For instance, assessing a communication campaign aimed at disseminating information on flood resilience is different from assessing a campaign that promotes public engagement in flood resilience strategies. Since this research focus on communication indicators, we assume that communication activities–planned and implemented in the framework of a resilience strategy or project–enhance resilience if they contribute to achieving the strategy or project goals.

The communication objectives are strongly related to the target audience. Before going into the details of the analysis, a slight digression is necessary to recall the concept of *target audience*, a key aspect of communication strategies. Identifying the target population – that will benefit or will be negatively affected by an action or a project – is an important stage of social impact assessment, as it is put forward in Chap. 3. Profiling the target population is essential to select relevant indicators and variables during the SIA scoping phase. When a project includes a communication plan, the target population will be defined as the target audience. The next section provides some insights on how to define the target audience of a communication project aimed to enhance resilience.

4.1 Communicating on resilience: who is the audience?

This section presents some examples of audiences selected as target populations of communication strategies aimed at enhancing resilience (see Table 4.1). Target audiences (i.e. groups to which communications are addressed) may widely vary depending on the communication goals that, in turn, derive from the project objectives. Defining the target audience is a crucial phase of a communication plan that will influence the strategy efficiency, especially when selecting messages, communication means, time and locations. Quite often communication strategies refer to the 'general public' as a target. Though, an accurate audience profiling enables tailored communication activities that are directed where a real need exists, and where results can be detected.

Reef Resilience (www.reefresilience.org) and London Resilience Partnership (Ingleby, 2014) are two examples of resilience strategies that attach importance to an accurate definition of target audiences. In both cases detailed guidelines to define target groups are proposed as part of the communication strategy.

4.1.1 Reef Resilience

Reef Resilience – a partnership led by The Nature Conservancy, aimed at supporting coral reef managers and practitioners – presents guidelines on how to identify target audiences in a resilience communication strategy. Eleven key questions are proposed to identify the potential audiences (see Table 4.2).

According to the guide, a distinction should be made between *primary* and *secondary audiences* by answering the following queries: 'What specific action or behaviour needs to be changed to address the objectives or solve the issue at hand?'; 'Which audience best helps to meet the specific strategy goals?'; 'Is the audience persuadable?' (www.reefresilience.org). Indeed it happens that a target group (e.g. the inhabitants of a city) can be reached only through an intermediary audience (e.g. journalists of local media). These intermediaries are considered a secondary audience. When the target groups are selected, audience research provides insights on:

- Who is the audience and what they do?
- What is their perception of an issue?

Table 4.1: Comparison of different approaches to target profiling in resilience communication activities.

PROJECT	CRITERIA TO DEFINE THE AUDIENCE	TARGET AUDIENCES
Reef Resilience	- Risk causes; - Interest for resilience enhancement; - Positive or negative influence on the rest of the community; - Benefits and disadvantages of resilience enhancement; - Uses of natural resources at risk.	
London Resilience Partnership	The impact that an incident has on groups of people.	- People directly affected by the emergency; - Local people, friends and relatives; - Wider audience.
CEPRI	Awareness and involvement in flood issues.	- Participants; - Early adopters; - Early majority; - Late majority; - Obstinate sceptics.
CASA	- Capacity to interpret the information as expected and use it; - The impact that an incident has on groups of people.	- Linguistic groups; - Minorities; - Communities at various levels of risk.
TOMACS	- Capacity to interpret the information as expected and use it; - The impact that an incident has on groups of people.	- Fire brigades; - Public transport companies; - Residents of at-risk urban areas.
RainGain	Degree of awareness and type of operational involvement in urban flood resilience management.	- Politicians; - Policy and decision makers for Urban water management at national, regional and local level; - Local and regional government entities; - Water authorities and water utilities; - Weather services; - Inhabitants of flood-prone areas; - Partners of other projects.
Wikiresilience	Degree of awareness and kind of involvement in resilience issues.	- Citizens; - Local associations; - Public authorities; - Practitioners from the private or public sector; - Researchers, teachers, students, institutes.

Table 4.2: Eleven questions that can help determine target audiences (reefresilience.org).

ELEVEN KEY QUESTIONS TO IDENTIFY THE TARGET AUDIENCES
1. Who is causing the problem?
2. How are they causing it?
3. What other audiences might be interested or relate to the project message or goal?
4. Which audiences have the most political influence?
5. Which audiences have the most social influence?
6. Who shares information in this particular location? Who has the most influence on this particular audience?
7. Who will be most positively affected by the project/management actions?
8. Who has the potential to be negatively affected by the project/management actions?
9. Who will be involved in the implementation of the project?
10.Who usually causes confusion or trouble when information is distributed to the public or the key audience?
11.Who is directly involved in using and/or taking resources from the reef?

- What are their preferred methods to get informed, and motivation/barriers to it?

A variety of research techniques are available: from qualitative methods (e.g. open-ended questionnaires, unstructured interviews, focus groups, observations) to quantitative methods (that are necessary for statistical analysis), or a combination of the two. Audience research can be performed not only to plan a communication strategy but also to assess the progress made during and after the implementation.

4.1.2 London Resilience Partnership

Choosing and understanding the target audience is even more challenging in urban areas, especially metropolis, where the density and diversity of the population are higher. *London Resilience Partnership* – a coalition of organisations including emergency services, local authorities and central government, health organisations, transport and utility companies, business representatives – focuses on incident response and recovery, therefore on communicating 'prior to a known potential incident, during an emergency and after an emergency' (Ingleby, 2014, p. 4). Hence the selected target audiences are those people that are directly or indirectly concerned by an incident. Audience profiling is therefore preformed on the basis of the impact that an incident has on various groups of people (see Table 4.3).

4.1.3 CEPRI

A very different approach is proposed by CEPRI (European Centre on Risk Prevention) in the guide 'Rising awareness among the population at risk from flooding' (CEPRI, 2011) that explains how to communicate during standard periods, flood periods, post-flood periods and recovery periods.

According to the guide, target groups should be identified on the basis of their awareness and involvement in flood issues. Distinct phases of a communication plan should be dedicated to each of the following target groups:

- *Participants*, strongly involved people who are very interested in new information. They are a minority;
- *Early adopters*, people who think that benefits worth the cost and are likely to get involved. They represent a bigger portion of the population;

Table 4.3: Types of audiences (Ingleby, 2014).

Those directly affected by the emergency (including casualties).	GROUP A: Survivors – those in the immediate vicinity of the incident who were directly affected (including casualties).
Those directly affected by the emergency (including casualties).	GROUP B: Those close by who may need to take action to avoid further harm.
Local people, friends and relatives.	GROUP C: Those in the area who may be disrupted by the consequences of an emergency and the clean-up process.
Local people, friends and relatives.	GROUP D: Those who are related to, or know people who are, or might be, affected.
Wider audience.	GROUP E: People who are not affected by the incident, but are interested in it, or concerned or alarmed about wider implications.
Wider audience	GROUP F: The media.

- *Early majority*, weakly involved people who are ready to make the minimum investment. They represent a relevant percentage;
- *Late majority*, they resist getting involved and deny security issues. They represent a relevant percentage;
- *Obstinate sceptics*, people who are against any change of behaviour. They represent a minority.

4.1.4 TOMACS, CASA and RainGain

When communication goals correspond to disseminating complex information, target groups are defined on the basis of their capacity to interpret the information as expected and use it to make better decisions, and on the basis of the relevance that information has for them. This is the case of *TOMACS* (Tokyo Metropolitan Area Convection Study for Extreme Weather Resilient Cities), *CASA* (Collaborative Adaptive Sensing of the Atmosphere) and *RainGain* (Interreg NWE IVB RainGain), three research programmes aimed at developing high resolution weather observations, now casts and warnings and at enhancing city resilience to weather extremes. The weather information has to be

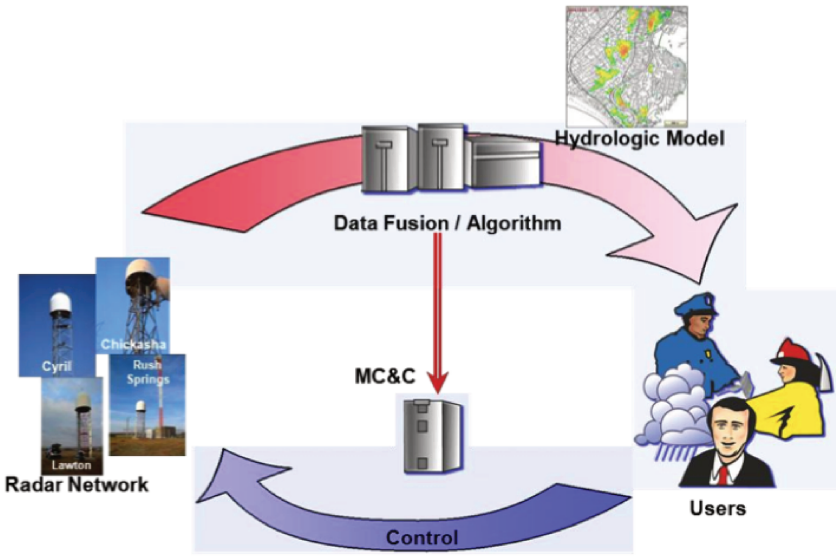


FIGURE 4.1. The CASA centre collects feedback from different groups of target audiences (or information users) in order to adapt weather information to their background knowledge capacities and on the basis of the relevance that information has for them (V. Chandrasekar et al., 2012).

adapted to different audiences, including fire brigades, public transport companies, residents of at-risk urban areas (Tsuyoshi et al., 2015), different linguistic groups, minorities (such as the elderly, women and the disabled) (Donner et al., 2012). Social experiments were performed in the framework of TOMACS (Tsuyoshi et al., 2015) to collect feedback from the end users, while social networks, especially Twitter (Chandrasekar et al., 2015), are being used by the CASA Centre to monitor user satisfaction (Fig. 4.1).

At the time of writing this thesis, RainGain research on dissemination of weather information was at an early stage of development. Nevertheless a comprehensive communication campaign was carried out since 2012, over four years, as it is further detailed in Chap. 5. The aim of the campaign was to raise awareness on the project and develop a network of future users of weather data and related flood prediction services. The following target audiences were defined on the basis of their degree of awareness and their role in flood resilience management: politicians, policy and decision makers in the field of urban water management (at local, national and international level), local and regional government entities, water authorities and water utilities, weather services, inhabitants of flood-prone areas, partners of other projects.

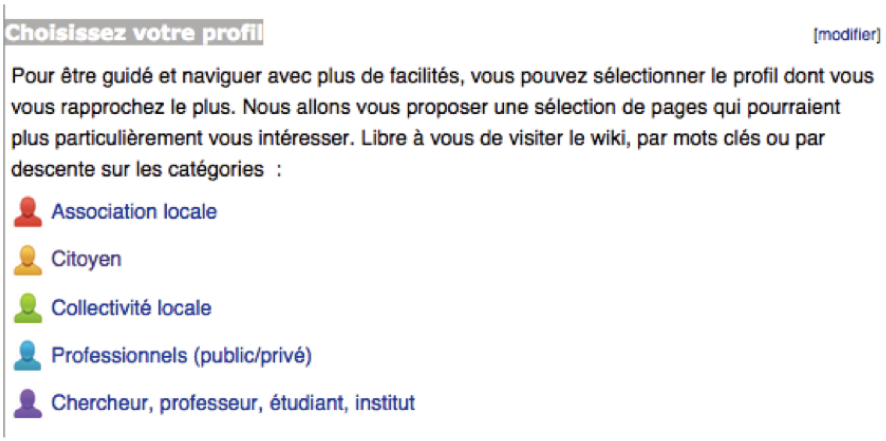


FIGURE 4.2. By clicking on one of the five corresponding icons the navigation experience is adapted to the user profile (http://wikiresilience.developpement-durable.gouv.fr/).

4.1.5 Wikiresilience

Active involvement, consultation, and empowerment of stakeholders are often considered a must in resilience development. Especially today, with an international turn toward fiscal austerity, public expenditures are limited and public authorities tend to distribute responsibilities for risk management to local communities. For this reason, participatory communication is a frequent approach in resilience projects. For instance, *Wikiresilience* (wikiresilience.developpement-durable.gouv.fr) is a web tool aimed at developing resilience through participatory communication. This interactive tool was created by the French Ministry of Ecology, Sustainable Development and Energy to collect and share information on resilience development, knowledge and practices from all over France. Five groups of users were identified: 1) *Citizens*; 2) *Local associations*; 3) *Public authorities*; 4) *Practitioners from the private or public sector*; 5) *Researchers, teachers, students, institutes*. By clicking on one of the five corresponding icons (see Fig. 4.2), the navigation experience is adapted to the user profile.

4.2 Analysis of 12 communication strategies implemented by public authorities to cope with flood risk in Paris

Identifying key communication indicators and variables is a necessary basis to collect relevant data on the audience perceptions and monitor their evolution before, during and after a project or action. An example of identification of communication variables is the following study undertaken in Paris. The aim of the study is to identify the sources of data that can be used to analyse the impact of public authorities' [1] communication activities on the population perception of flood risk and resilience. We examined twelve plans, strategies, charts and reports developed by public authorities from 2003 to 2017, with the aim of strengthening Paris food resilience. We focused on the communication activities described in these documents and we extracted information on the communication context, communication objectives, target audiences and communication means. On the basis of this information, relevant communication variables are proposed. A matrix, in Appendix D, summarises and compares these results.

4.2.1 Plan de Prévention des Risques D'inondation Du Département de Paris (Direction Régionale de l'Urbanisme du Logement et de l'Équipement d'Île-de-France, 2003)

- Communication objectives

  To provide information on flood risks in the city Paris so that individuals and activities, located in flood-prone areas, **behave in a responsible manner** by keeping themselves informed and by taking appropriate action in response to flood risk.

- Target audiences

  1. **Inhabitants**;

[1] The documents were released by the following local and national authorities, an international agency and an international network: the Municipality of Paris, Île-de-France region, Seine-Normandie Agency on Water, the Territorial Public Authority of the Seine-Grands-Lacs Basin, the Ministry of the Interior, the Ministry of the Environment, the OECD, 100 Resilient Cities.

2. **Workers**;
3. **People** being **hospitalised**;
4. **Owners of products** that are **dangerous for the environment** in Paris flood-prone areas.

- Communication activities

  The PPRI includes a series of **maps** describing flood risks and related impacts in the city of Paris.

- Observations on potential communication variables

  A communication assessment should monitor: are the **maps easily accessible** to the different target audiences? What is the **number of consultations** for each group? Are they **interpreted as expected** by the different groups. The assessment should track if **expected action** is taken as a consequence of information dissemination.

4.2.2 Paris: Dossier Départemental des Risques Majeurs (Préfecture de Police, 2009)

- Communication context

  1. Because of the high population density in Paris, the **time of reaction** to an extreme event and the time of **information dissemination** are extremely **important**.
  2. Paris **attracts** and **spreads through** its networks–including **information networks–the consequences of an extreme event** occurring in Paris or in other departments of the Île-de-France region.
  3. There is an extreme **increase** of the number of **phone calls** when an emergency occurs.

- Communication objectives

  1. To **involve the citizens** by developing their risk awareness;

2. To **unite Paris with the first ring of departments** surrounding it (the so-called 'petite couronne') through a global and common emergency management approach defined by the ORSEC plan.

- Target audiences

  Paris population.

- Communication activities

1. The City of Paris informs its citizens through the **DICRIM** (Dossier d'Information Communale sur les Risques Majeurs).
2. National and local **early warning system**.
3. Risk information and indications on how to behave are spread through national and local radio broadcasters.
4. **DDRM** includes **information on how to behave** in case of flood risk.
5. **Plan Seine**.
6. A **PPRI** (Plan de Prévention du Risque d'Inondation) dedicated to **urban planning** in the city Paris.
7. A **PPRI** dedicated to the RATP network is aimed to **protect the metro** and **RER** lines located in the flood-prone areas of Paris.
8. An **ORSEC** plan aimed to **organise rescue** and **relief efforts** in case of a Seine River flood.
9. A **'shedding' system** is used by the fire brigade to respond first to the demands for help concerning the most severe accidents, especially those that require a rescue of victims.
10. Météo France sets up a **weather warning map** to forecasts weather extremes and to undertake adapted responses.

- Observations on potential communication variables

1. A communication assessment should monitor: are the **documents** and **maps are easily accessible** to the different target audiences? What is the **number of consultations** for each group? Are these **interpreted as expected** by the different groups? The assessment should track if **expected action** is taken as a consequence of information dissemination.

2. Radio news impact could be assessed by **measuring the news item frequency**, the **audience size**, by **profiling** the audience, by monitoring how each news item is **interpreted** by the audience and if **expected action** is taken as a consequence of information dissemination.
3. The 'shedding' system could be assessed by measuring the **number of victims** and **damages**.

4.2.3 Document d'Information Communal sur les Risques (Mairie de Paris, 2009)

- Communication objectives

  Help everyone to **develop a culture of civil security**, by teaching and updating day by day.

- Target audiences

  Paris population.

- Communication activities

  1. **Indications for public servants** are included in the **PCS** (Plan Communal de Sauvegarde) of the City of Paris and specific information sheets of the municipality department.
  2. **Early warning systems** using **sirens**, vehicles with **speakers**, outdoor **LED panels**, automated mass **phone calls, radio and TV broadcasters, the Internet**.
  3. **National warning system** using the sirens of the national warning network.
  4. The Regional Direction for the Environment (**DIREN** of Île-de-France) and **Météo France produces twice a day information notes** and **flood warning maps**.
  5. Paris PPRI includes **maps of flood-prone areas**, indications about the **rules and actions** that are aimed to reduce flood vulnerability; PPRI is used as a basis to define the regulation of the Local Urban Plan.
  6. **Citizens are recommended to**:
     - **Prepare a Family Safety Plan** in order to be active participants to risk management and to facilitate rescue and other emergency actions;

  - Before an extreme weather events, citizens are asked **to gather information** at the municipal district office or at the prefecture about the risks concerning their own house and on **warning levels, weather forecasts**, public authorities **recommendations** and follow them;
  - If a warning is launched, citizens are asked to **keep** themselves **updated** by listening to the **radio** about the risk, how to behave, and if it is necessary to evacuate; they are also asked to **follow the recommendations of the security agents**;
  - **After the end** of the warning, citizens are asked to **inform public authorities of any danger** that they might notice;

- Observations on potential communication variables

1. Assessment should monitor: are the documents and **maps easily accessible** to the different target audiences? Are these **interpreted as expected**? What is the **rate of consultation** for each group? Are they well interpreted by the different groups? The assessment should track if **expected action** is taken as a consequence of information dissemination.
2. Different means to disseminate warning messages could be assessed by measuring the **time of message transfer and audience response**, the **audience size**, and if **expected action** is taken as a response.
3. The outcomes of the recommendations addressed to the citizens could be assessed by verifying the **number of readerships** of the DICR document, **how many readers read and memorised** these recommendations, and if **expected action** is taken as a response: how many families prepared a plan, if requests for information rates and radio audience rates increased, if citizens communications towards public authorities on existing dangers increased, if phone calls rates decreased, if public response to authorities instructions improved.

4.2.4 ORSEC - Plan Familial de Mise en Sûreté (P. Oumraou, P. Arrondeau, M. Rousselon, 2010)

- Communication objectives

1. To **inform families** about risks, warning systems, how to behave as a response to risks, location of safe havens.
2. To **enhance individual responsibility and autonomy**.
3. To **guide families** in establishing their own safety plan.

- Target audiences

  Families in France.

- Communication activities

1. The guide recalls the **local sources of information** that are public and are available online (**www.risques.gouv.fr**) and in any prefecture or municipality office: the **'Dossier Départemental des Risques Majeurs'** describes local risks; the **'Plan Communal de Sauveguarde'** beside presenting the risks, describes safeguarding measures, and recommended behaviours; risks reports that should be provided for any property transaction (rent or sale).
2. The guide includes **a CD** with indications **on recommended behaviour** 'J'apprends à me protéger'.
3. The guide recalls what are the **early warning systems** implemented by the public authorities and private operators, and how to recognise their signal: the National **Sirens** Network, the dam sirens, automated phone calls and **SMS**, **loudspeakers** carried by vehicles, local **radio** broadcasters, other warning methods such as **church bells** and **door-to-door visits** are used by some municipalities.

- Observations on potential communication variables

1. The impact of the guide could be assessed by monitoring the **number of readers**, the **number of family plans produced**, the **readers' capacity of preparation and response** to risks, if families' **request for assistance** during an emergency is reduced.
2. It should also be assessed if the dissemination of the guide caused an **increase of the website unique visitors** and of the number of visitors **who consulted risk reports** in the prefectures and municipalities offices.

4.2.5 Stratégie Nationale de Gestion des Risques d'Inondation (MEDDE, 2014)

- Communication context

  1. Prevention capacity and risk awareness are not homogeneous among the French population. Hence, there are **inequalities in the manner in which people is facing risk** in flood-prone areas.
  2. Citizens are not aware of high variability in natural systems functioning because of a **widespread vision of the society as technologically advanced together with a weak risk perception**.

- Communication objectives

  1. **Developing a risk culture and informing** citizens to enable them to ensure their own safety when possible. This objective includes the following goals:
     - **Preventive information** on flood risk;
     - Ensuring **early warning**;
     - **Training** on safe behaviours.
  2. Concrete, **operational information** and **crisis simulations** are essential to engage all citizens.
  3. **Improving public awareness raising**, spreading and systematically ensuring it, not only during the post-crisis period.

- Target audiences

  1. **Public authorities**;
  2. **Inhabitants**;
  3. **Businesses**;
  4. **Public institutions** located **in flood-prone areas.**

- Communication activities

  1. This strategy is the result of a **consultation with the public** (during six months) and **stakeholders** (local authorities, EPBT, associations. . .) (during four months).

2. **Concrete** and widely **accessible actions are needed**, supported by all public institutions (including national education) through all information means.
3. The following **tools** are aimed at **getting prepared** to go through and to manage post crisis:
   - 'Plan Communal de Sauvegarde' (**PCS**) is an operational safety plan established by each mayor for the local population to inform them about the local risks and the early warning system. The plan includes simulation exercises;
   - **Cartography of potential flood-prone areas**, with different flood scenarios;
   - 'Plans de Continuité d'Activité', **Continuity Plans** of businesses and other activities;
   - 'Plans de Mise en Sûreté Familiale', **Family Safety Plans**;
   - Plan for **Safety and Promotion of Cultural Heritage**.
4. The following tools are dedicated to **preventive information** and they contribute to the risk culture, even though their implementation is currently heterogeneous:
   - 'Dossier Départemental des Risques Majeurs' (DDRM), **department report on major risks**;
   - 'Document d'Information Communal sur les Risques Majeurs' (DICRIM), **municipality information document** on major risks;
   - 'Information des Acquéreurs et Locataires' (IAL), **information for property purchasers and tenants**.
5. **Developing new flood information tools** for decision makers.
6. With **PAPI** ('Plan d'Action et Prévention des Inondations') and **PSR** ('Plan Submersions Rapides') calls, **over 60 flood resilience projects** were labeled as pursuing several objectives, including **promoting risk knowledge and culture**. PSR includes among the objectives to improve population warning and information systems.

- Observations on potential communication variables

1. According to the document:

- **A long-term evaluation** (up to 20–30 years) **is planned**. A **quantitative assessment** of current and future performances will be undertaken:
- **100% of PCS should be produced by 2018** by the municipalities that are compelled to do it since 2013 or before.

2. What could be improved:
   - A communication assessment should monitor: **are the plans** (PCS, 'Plan de Continuité d'Activité', 'Plan de Mise en Sûreté Familiale', plan for safety and promotion of cultural heritage, PAPI, PSR), **maps and public documents** (DDRM, DICRIM, IAL) **easily accessible** to the different target audiences? Are these intepreted as expected? What is the **number of consultations** for each group? Are these **interpreted as expected**by the different groups? The assessment should track if **expected action** is taken as a consequence of information dissemination.
   - It should be also monitored **if new communication tools are developed** and implemented. How to evaluate their efficiency depends on the type of communication means and contents.

4.2.6 PAPI de la Seine et de la Marne (EPBT SGL, 2014)

- Communication context

1. Although **Greater Paris** is the French region with the highest number of inhabitants living in flood-prone areas, its **population** is not aware or **underestimates flood risk** in terms of exposure, direct and indirect vulnerability, and recurrence. The inhabitants of Paris, as well as the managers of public facilities and buildings, disregard the Seine River, the uncertainties related to a river flood, the scale of the possible impacts.
2. Conversely, **emergency managers in Île-de-France have an outstanding knowledge of data concerning flood impacts** in the region and the issues at stake in such a densely urbanised area (e.g. ORSEC strategy, PCS local initiatives for emergency planning).

- Communication objectives

To **develop flood risk awareness and culture**, to **enhance emergency management preparedness**, in order to keep a good quality of life in the river basin.

This is one of the three key objectives of the document and the first of seven axes of the PAPIs national guidelines.

- Target audiences

  1. The **inhabitants**;
  2. The **educational community**;
  3. **Property managers**, social landlords;
  4. **Industries**;
  5. **Local public services**;
  6. **Local authorities** located in the Seine upstream Basin (Paris, Hauts-de-Seine, Seine-Saint-Denis, Val-de-Marne).
  7. The focus is **especially on: the population of flood-prone areas** (about 850 000 inhabitants, 630 000 (11,5%) workers, 56 700 (9,5%) public and private institutions, 350 health facilities), emergency managers, managers of facilities, buildings and infrastructure that are essential to maintain a fully functioning territory, public and private planners, local authorities' technicians.
  8. **Also the rest of the population** is taken into consideration since they can be affected by flood impacts on urban networks: electricity (1,2 million EDF subscribers), transports (56% of RATP lines), drinking water (2,9 millions of consumers) and wastewater.

- Communication activities

  39 awareness raising activities are planned with a dedicated budget of 6.5 M€HT. Any activity is based on general collective orientations but it is **tailored to the local needs** and features of each department (Paris, Hauts-de-Seine, Seine-Saint-Denis, Val-de-Marne):

  1. **Creating and developing a resource centre** dedicated to floods in the upstream Seine River Basin;
  2. **Creating**, adapting and **maintaining three smartphone applications**;
  3. **Visualising flood-prone areas through 3D** augmented reality **technology**;
  4. Organising the **information on social networks** in case of floods;

5. **Providing documents and workshops to support training** programmes for technicians from local authorities and planners, so that flood risk is better taken into account in the region development projects;
6. **Promoting other activities** to be tailored according **to different target audiences and different communication tools** (videos, cultural projects, reports, multimedia, brochures, signposting of past floods height).

- Observations on potential communication variables

1. The **number and profile of visitors** in the resource centre should be monitored, as well as how the **information is interpreted and used**, especially to what degree flood **risk culture and emergency response improve**.
2. Smartphone **applications** can be used to automatically collect data on their users profile, behaviour and location. It should be assessed if and how web interactive communication **affects flood risk perception and emergency response** of the users and of the local authority providing the web contents.
3. **Perceptions** and **skills** of the technicians and planners should be monitored **after the workshops**.
4. Any traditional and multimedia communication tool (from signposting to 3D augmented reality) should be evaluated in terms of **audience size, audience profile**, and its impact on the **audience perceptions and behaviour**.

4.2.7 OECD Review of the Seine Basin, Île-de-France Resilience to Major Floods (OECD, 2014)

- Communication context

1. **'Citizens' and decision makers' risk perception is very low** while vulnerability remains high and even increases in some places. (. . .) The level of information and the degree of awareness of a major flood risk for citizens are insufficient in view of the extent of the danger. There wasn't any significant flood for almost 60 years, and the impacts of low frequency events of 10 to 30 years ago have nearly disappeared thanks to the upstream dam reservoirs. As a consequence, the flood risk tends to fade from collective memory. On the other hand, the collective insurance cover provided by the Cat-Nat insurance

regime, while presenting many advantages, can create a moral hazard by giving citizens, firms, and decision makers the impression that, come what may, they will be compensated for their damage: this does not lead to increased risk awareness or to initiative to try to set up preventive measures' (p. 15). 'The lack of any (recent) significant flood event (. . .) tends to reduce awareness and does not motivate stakeholders to structure a financial approach to prevention challenges' (p. 21).

'French risk regulations make procedures to inform or consult the stakeholders mandatory. However, they **do not institute quantified objectives for risk awareness**. Their effectiveness and their implementation are quite low and variable depending on the various local authorities' level of commitment. (. . .) Overall, it would appear that the public decision makers' failure to communicate on the subject is a major factor limiting the development of a culture of risk. This reveals a low awareness of the risk since flooding continues to be considered unlikely' (p. 15).

2. 'In recent years, **awareness increased in companies** but is still variable. Large companies in a certain number of sectors (energy, transport, water, telecommunications, banking) became aware of this risk through their participation in work on crisis management, through the regulation on business continuity for vital sectors or through local initiatives run by the business districts of the Chamber of Commerce. Once businesses become aware of the issue they demand access to accurate information on the risk, both with regard to the precise water levels and the interruption of critical networks. On the other hand, **smaller companies or other sectors have only a very limited awareness of the risk**. There are very few activities intended for them in this field, as well as towards essential stakeholders for resilience development such as those in engineering, urban planning or architecture. Ultimately, the differences in the degree of awareness and commitment between the various sectors and the various stakeholders hamper the development of a genuinely shared culture of safety' (pp. 15–16).

- Communication objectives

Reinforcing the 'risk culture' among citizens, decision makers and companies and stressing the benefits of greater resilience is essential 'as the memory of

historical floods disappears' (p. 15) and because 'it is a condition for action at any level' (p. 14). How?

1. **Developing risk awareness** as a base to create the culture of risk.
2. Enhancing the **appropriation of the river culture** and strengthening its link with the risk culture in a multi-dimensional perspective.
3. **Enhancing public engagement** and participation in decision-making in order to 'enable increased responsibility and accountability of the various stakeholders' (p. 11).

- Target audiences

1. **Citizens** (local populations upstream);
2. Companies and particularly the **SMEs**;
3. **Decision makers** (stakeholders in engineering, urban planning or architecture, prevention and crisis management stakeholders, insurance sector).

- Communication activities

1. **Consultation of citizens** and other stakeholders should be encouraged, similarly to what was done in the framework La Bassée Storage project: a consultation of local populations upstream through a large and transparent public debate.
2. **Innovative communication approaches**, which are not regulatory for raising citizens' awareness, have a good response from the population (exhibitions, work in schools, 3D films).

- Observations on potential communication variables

1. According to the document:
   - According to the OECD there is a contradiction in French risk regulations that 'make procedures to inform or consult the stakeholders mandatory' but do not identify effective **'quantified objectives for risk awareness'**. The result is that the effectiveness and implementation of information, consultation and risk awareness procedures 'are quite low and variable depending on the various local authorities' level of commitment'.

2. What could be improved:
   - Since the context analysis is very detailed, an assessment could be aimed at comparing the context features, **before and after a communication activity**, especially in terms of **risk culture, river culture and stakeholders accountability** and responsibility.
   - A **consultation** process should include monitoring the **participants' number and profile**, the **interactions** between decision makers and stakeholders, of the **collective meaning construction, behaviours**.
   - Concerning innovative, **non-regulatory communication activities**, continuity and **consistency with collective resilience goals** should be carefully monitored. Different communication techniques will provide different kinds of data that can be used to assess the audience response.

4.2.8 Plan de Gestion des Risques d'inondation 2016-2021. Bassin Seine Normandie (DRIEE, 2015) and Stratégie Locale de Gestion des Risques d'Inondation — TRI «Métropole Francilienne» (DRIEE, SGZDS de Paris, 2016)

- Communication context

  1. **Maintaining and developing risk culture** is necessary to successful flood risk management. Flood events didn't occur in the Seine Basin since several decennials. However, flood risk persists and shouldn't be forgotten.
  2. According to the regulation, **flood risk information** is managed at multiple governance levels: mayors are responsible for public information at the municipality scale.

- Communication objectives

  1. Developing **preventive information**, **communication and risk culture** at the Seine-Normandie Basin scale.
  2. Keeping alive **memory about flood risk** and learn to live with an awareness of that.

     These general goals lead to the following specific objectives:
     - **Integrating** flood **risk** as part of the **culture** of each territory,

  - **Engaging all stakeholders** in reinforcing it;
  - Pushing the communication efforts beyond the regulatory obligations, by using **new information means** so that as many citizens as possible are reached;
  - **Informing about the impact of** environmental changes on flood risks, especially about the local and global consequences of **human activity**;
  - **Raising mayors' awareness** on the importance of information on flood risks and ensuring the good conditions that **facilitate mayors' communication** towards the local population;
  - **Informing industries** about flood resilience solutions in order **to involve** them in flood prevention management;
  - **Sharing information** on vulnerability reduction **with project managers**;
  - Developing the offer of flood risk **training**, especially on vulnerability reduction, territorial resilience, hazard management, crisis management, risk culture.

- Target audiences

  1. **Citizens**.
  2. **Industry**, business, agriculture sectors, consular chambers.
  3. **Urban planners**, architects.
  4. School **pupils**.
  5. **Policy makers, decision makers and project developers** (especially those in charge of urban planning and economic development).
  6. The government, local **authorities**, mayors.
  7. **Social** and **economic actors** having an impact on flood risk.

- Communication activities

  1. Risk Prevention Plans (**PPR**, 'Plans de Prévention des Risques').
  2. The basin territorial public authorities (EPTB, 'Établissements Publics Territoriaux de Bassin') have to design and promote **training** and **communication tools on vulnerability reduction** (especially for project developers and consular chambers).

3. According to the regulation, the mayors must inform citizens about the local risks and the corresponding safety measures. **Municipalities are compelled to undertake the following activities:**
   - Identifying **past flood river levels** and highlights them with **signage**;
   - Developing and implement Municipalities' Information Documents on Major Risks (**DICRIM**, 'Documents d'Information Communaux sur les Risques Majeurs') and Municipalities' Safety Plans (**PCS**, 'Plans Communaux de Sauvegarde'):
   - An **inventory of existing PCS and DICRIM** in the Seine-Normandie Basin will be made by 2021. This inventory will be made available to the public through public authorities **websites**;
   - **PCS and DICRIM** should be **updated** every time the Department prefect transfers the Department Report on Major Risks (DDRM, 'Dossier Départemental des Risques Majeurs') to the flood-prone municipalities. This occurs after a flood event or after a new mayor election.
   - Providing, once every two years, **updates to the population** on flood risks characteristics and risk management measures through **public meetings** or other communication means;
   - **Website** contents **and leaflets** addressed to the citizens are developed by those government services in charge of flood risk management (prefectures, DDT-M, DREAL, DRIEE);
   - Local Strategies for Flood-Prone Territories ('Stratégies Locales des TRI'), Action Programmes for Flood Prevention (PAPI, 'Programmes d'Actions pour la Prévention des Inondations'), Development Plans for Water Management (SAGE, 'Schémas d'Aménagement et de Gestion des Eaux') include a communication plan for flood-prone areas. The main target audience is the general public but it can also be tailored for network managers, industries, social landlords, architects, project developers, etc. The **communication plan describes**:
     * **Flood risk** (risk level, vulnerable areas, types of vulnerabilities) and its **impacts** in each territory;
     * **Risk management measures** at territorial level;
     * **Individual measures**.

4. Any communication programme on climate change supported by a public funding has to include **information on climate change impacts** on flood risks.
5. Any communication plan on water and natural risk should include **information and training on the advantages of wetlands and floodplains** for a territory.
6. Disseminating **information towards the economic actors through the consular chambers**.
7. **Training** of school pupils, decision makers, industries: public institutions dedicated to professional training (IFORE, CVRH, CNFPT, engineering schools, universities. . .) should develop a training offer that is **tailored** to the issues of the Seine-Normandie Basin.
8. The government, local authorities, other **public institutions** and the associations **should collaborate to educational programmes** on water and risks aimed to increase citizens' responsibility (especially youths).
9. **Pedagogical programmes and cultural events dedicated to** the topic of **water environments** conservation **should include information** and communication activities **on flood risks**.
10. **These recommendations translate into local activities** that are **tailored to the needs** and capacities of **15 Flood-Prone Territories (TRI)** in the Seine-Normandie Basin: Auxerre, Troyes, Meaux, Châlons-en-Champagne, Saint-Dizier, Creil, Compiègne, Chauny-Tergnier-La Fère, Île-de-France, Rouen-Louviers-Austreberthe, Évreux, Le Havre, Dieppe, Cherbourg-Octeville, Caen-Dives-Ouistreham.
11. In the case of the Île-de-France-Region, concrete activities are not described. There is a reference to the **Local Strategy for Flood Risk Management in Île-de-France** (DRIEE, SGZDS de Paris, 2016). This **strategy outlines the following communication activities**:
    - Creating a **resource centre** to centralise and share **technical information** on flood risk and hazards;
    - Creating a **strategic communication plan tailored to local culture** and aimed to develop risk and river culture;
    - Undertaking **awareness raising and training activities**, especially addressed to **school pupils**;

- Providing necessary information to local authorities through the **resource centre** and the Department Report on Major Risks (**DDRM**, Dossier Départemental sur les Risques Majeurs). This will enable local authorities to adequately inform the **local population**;
- Developing and providing **training on hazard data**;
- Promoting the installation of **flood river level signage**;
- Developing and implementing **awareness raising and training activities** that are tailored to different public and private **decision makers**.

12. For each Flood-Prone Territory (TRI), the following **maps** are available online: maps of flood-prone areas, describing different types of hazards and different events frequencies, maps of associated risks. Related reports, consultation summaries and a map visualisation tool accompany these maps. For the Île-de-France region, the maps are available on the following website: driee.ile-de-france.developpement-durable.gouv.fr

• Observations on potential communication variables

1. According to the document:
   - **An evaluation of the plan is planned in 2021** to inform citizens about the results and any related issues, to verify the consistence of the plan with other policies and possible synergies. A set of **evaluation questions and indicators** was identified.
   - Concerning the **communication strategy, the evaluation question is 'Does the plan facilitate risk culture development?'**, the quantitative indicators are the **implementation rates of PCS and DICRIM**. **Other quantitative indicators or qualitative analysis could be developed during the plan implementation**, in order to complete the assessment of communication, awareness raising, and training activities.
   - In the case of the **Île-de-France-Region**, the Local Strategy for Flood Risk management includes among its objectives:
     * **Assessing local risk culture**;
     * **Widespread communication assessment procedures**.
2. What could be improved:
   - A communication assessment should monitor: are the **plans** (PPR, PCS), maps and public documents (DICRIM) **easily accessible** to the different

target audiences? Are these interpreted as expected? What is the **number of consultations** for each group? Are these **interpreted as expected** by the different groups? The assessment should track if **expected action** is taken as a consequence of information dissemination.

- **Signage** of past river flood level should be evaluated in terms of **audience size**, **audience profile**, and its impact on the **audience perceptions and behaviour**.
- **Perceptions and skills** of the trainees or students should be monitored **after the training** or educational programmes.
- **Public meetings** could be assessed in terms of **participants' number and profile**, **the quality of interaction** between the facilitators and the participants, **collective meaning construction**, **change of behaviours**.
- Concerning the **web pages and leaflets**, a quantitative assessment (**number** of web pages and intranet **visitors**, **visits duration**, **number of distributed leaflets**) and qualitative assessment (target audiences' **interpretation** of the disseminated messages and response in terms of **behaviour**, **attitudes** and **risk culture**) should be foreseen.
- **The number** and **profile of visitors** in the **resource centre** should be monitored, as well as how the **information is interpreted and used**, especially to what degree flood risk culture and emergency response evolve.
- The monitoring could also cover the communication activities planned by other organisations (EPBT, municipalities and other local authorities, consular chambers) or other programmes and strategies mentioned in the document (TRI Local Strategies, climate change communication projects, water and natural risk communication plans). Different communication techniques will provide different kind of data that can be used to assess the audience response.

4.2.9 Plan Climat Énergie – Stratégie d'Adaptation (Mairie de Paris, Direction des Espaces Verts et de l'Environnement, Agence d'Écologie Urbaine, 2015)

- Communication objectives

The main goals are to **protect the inhabitants** of Paris, **raise awareness and enhance involvement of stakeholders**. These broad goals are broken down into specific objectives:

1. **Improving the information system and safety instructions** addressed to the population during an extreme weather event;
2. **Maintaining population access to communication** and telecommunication **networks**;
3. **Better taking into account stakeholders behaviours and expectations** and how these evolve;
4. **Raising awareness and enhancing active involvement** of Paris citizens and other stakeholders to develop sustainable urban lifestyles and urban planning that are compatible with the challenges of climate change and resources decline: new reflexes when constructing and using a building, carrying out shared territorial diagnosis in order to involve the inhabitants in the evolution of their neighbourhood (including climate evolution), broadly increasing awareness on the consequences of climate change and what are the means to adapt to it.
5. **Encouraging solidarity** with the vulnerable citizens by developing a solidarity network among neighbours in case of weather extremes so that everybody has access to information and stay safe.

- Target audiences

1. **Paris inhabitants**;
2. **Workers in Paris**;
3. **Paris visitors**;
4. **Local economic actors**;
5. **Civil society**;
6. Special efforts are dedicated to children, young persons, elderly persons, and other **vulnerable citizens**.

- Communication activities

1. External and internal **information and warning systems**, both implemented during normal and crisis situations, will be set up to develop a culture of risk;
2. Organisation of **awareness raising events** such as Plouf75;
3. Information **dissemination through the media** (TV and radio broadcasters);
4. Development of **multilingual instructions**;
5. **Dissemination** of awareness raising or warning messages **through the public transports infrastructures, social networks and SMS**;
6. Design and public dissemination of a **Paris map** where all the relevant locations are identified;
7. **Communication systems focused on guaranteeing people and activities safety**;
8. The **'Participatory budget'** and the **'Greening licence'** as two tools aimed to encourage the inhabitants to actively transform Paris; other active involvement activities on the topics of environment, sustainable development, and climate such as the **Paris Climate Action** Chart for the local economic actors.
9. **Use of traditional communication means** (brochures, information and awareness raising campaigns, participatory systems) **as well as new communication means** (contests, social media, nudge marketing);
10. **Activities addressed to the youth** will be carried out by the City of Paris Network for Environmental and Sustainable Development Education.
11. **Solidarity systems** in case of emergency due to climate extremes such as the **CHALEX file**.

- Observations on potential communication variables

1. Quantitative assessment (**rate of attendance** of each target audience to the events and participatory activities, **number of press articles, press readership and TV/radio audience**) and qualitative assessment (target audience **interpretation** of the disseminated messages and **response** in terms of **behaviour, attitudes and risk culture**) should be performed for each communication activity.

2. During an emergency, accessibility to communication and information infrastructure, **rate of assistance requests** should be monitored.
3. **Public engagement activities** could be assessed in terms of **participants' number and profile**, the **quality of interaction** between decision makers and stakeholders, collective **meaning construction**, **implementation**.

4.2.10 Plan Communal de Sauvegarde de Paris (Mairie de Paris, Préfecture de Police, 2015)

- Communication context

1. **A flood in the city of Paris could cause considerable damages**, due to several aggravating factors: the high population density (21 583 inhabitants/km on a surface of 105,3 km), the importance of tourism (with 29 millions of tourists per year), a high concentration of economic and institutional activities.
2. 350 000 people live in flood-prone areas and **850 000 people could suffer because of flood consequences**.
3. The **social diversity** of the population and the **frequency of street demonstrations and strikes** (about 6000 per year) make crisis management more complex.

- Communication objectives

To **raise awareness, develop a shared risk culture**, inform, warn, **provide security instructions** so that every citizen becomes an active actor and ensures its own safety (as it is mentioned by the law n° 2004-811 of August 13, 2004) by behaving in a responsible manner when facing a risk.

1. **Any citizen should keep himself informed before** a flood event (on the risks and security instructions) **and during** a flood event.
2. **Public information will improve the municipality capacity of response to risks** and it will contribute to preventing crisis and better protect the population, the properties and the environment.

- Target audiences

1. The **inhabitants**;
2. **Tourists**;
3. **Institutions**;
4. **Industries, businesses**;
5. Social landlords, **property manager**;
6. **Boat owners** in Paris.
7. Special efforts are dedicated to **vulnerable people**: people over the age of 75, children and infants, ill and disabled people.
8. Inhabitants and activities in Hauts-de-Seine, Seine-Saint-Denis, Val-de-Marne, Seine-et-Marne, Yvelines, Essonne and Val-d'Oise since **an extreme event in one of these departments might have an impact on the Paris area**.

- Communication activities

  During normal situations:

1. The document recalls that **each family should prepare** a family security plan **(PFMS)** and **follow the dedicated guide**. The guide also mentions that families should keep themselves informed through different means: by listening to the news on radio and TV broadcasters (France Bleu 107.1 and regional TV), by paying attention to loudspeakers of ground or aerial vehicles and to sirens, Paris Municipality website, mobile application 'Paris à la seconde', signposts. Phone calls should be avoided, except for calls to the emergency services.
2. The PCS document includes **maps** that identify flood-prone areas in Paris.
3. In accordance with the art. L125.2 of the Environmental Code, the City of Paris is committed to informing the population through **campaigns on extreme weather events**.
4. Every year the City of Paris plans assistance and **support measures for** the most **vulnerable** citizens: e.g. the **CHALEX file** lists all the persons that wish to be included in the heat waves monitoring programme; in the framework of the annual **'Commerçants Solidaires'** programme, the Civilian Security provides information documents on the heat waves to the merchants, who will distribute the information to old, ill, disabled, or isolated people.

5. In accordance with the Law on Modernisation of the Civilian Security (13/08/2004), the City of Paris wrote and published the Municipality Information Document on Major Risks (document d'information communal sur les risques majeurs, **DICRIM**) that informs the citizens about the major risks in Paris and the prevention measures implemented by the Municipality, and the security instructions that each person should follow. The document is available online (Paris.fr) and in each district hall.
6. **The magazines of the City of Paris** ('à Paris' for the inhabitants of Paris is published every three months with 1 150 000 copies and it is mostly distributed in the mailboxes; 'Mission Capitale' for the Municipality officers) provides information on prevention tools and procedures and on the correct behaviours in case of risks.
7. **The websitesof the City of Paris**: 'Paris.fr' (100 000 pages, 4 500 000 visits/months, 15 millions viewed pages/month, 80 contributors) includes pages that are dedicated to major risks; 'Intraparis' (the intranet platform for the Municipality officers) provides regular information on major risks, with specific pages in the Prevention and Protection Direction sections, as well as in all the other Directions and City Districts sections.
8. **Electronic Information Displays**: 173 electronic displays are installed in Paris to disseminate simple operational information and refers to 'Paris.fr' or a telephone number for further details.
9. 'Paris à la seconde' is **a mobile application** that provides real-time information on any event occurring in Paris (demonstrations, weather warnings, pollution warnings, traffic information. . .); information is provided with push notifications, and local information for each district can be selected.
10. Information is also disseminated through **social networks**: Facebook ('Paris' page has 2,6 millions 'Likes', including 100 853 'likes' from Paris inhabitants), Twitter ('@Paris' account has 2,6 millions followers, a new account @Parisinondation was created in 2014); Foursquare (16 300 followers), Instagram ('Paris-maville' has 154 000 followers). A new Twitter account, '@Parisinondation', was created in 2014. It is entirely dedicated to flood risk in Paris. These accounts are managed together with 'Paris.fr' website in the framework of a unique information strategy.
11. **Public meetings**: the Prevention and Protection Direction (Crisis Manage-

ment Unit) attends various events and conferences on the topic of risk management, meetings with property managers, social landlords, chambers of commerce, public meetings in the district halls.

12. The **Civilian Security** of the City of Paris contributes to disseminating preventive information.
13. The **Operational Monitoring Centre** and the **Information and Communication Direction** constantly **monitor the media** to collect as soon as possible, any useful information on a potential threat.

During crisis:

1. The **Operational Monitoring Centre manages any warning** (from the reception, to the processing and dissemination). The origin of a warning can be: Paris inhabitants (phone calls to 3975), the municipality policy makers and officers, the French government.
2. A population warning is launched in case of a severe upcoming incident. A **visual or sound signal** is transmitted to catch the population attention and to distract them from their daily activities. The following warnings and information will aim to support the population by providing instructions on how to behave to actively contribute to their own protection. The Police Commissioner and the General Secretariat of the Île-de-France Defence and Security Zone are in charge of launching a warning, inform the City of Paris of the warning launch, choose which means of warning and information will be used, define the messages that will be disseminated. Once a warning is launched by the Police Commissioner, the City of Paris will contribute to disseminate it to the population as soon as possible, as widely as possible, and as effectively as possible (in a precise manner, to the right target audiences). According to the type of risk, the level of danger, the number of people to be reached, time constraints, **different warning means** will be used:
   - The **sirens** of the National Warning System: the same signal is used all over France and it means that the population should reach a safe location, wait for rescue, quit cars, avoid phone calls, do not pick the children up from school, avoid windows, do not light fires;
   - The City of Paris **electronic information displays, websites, intranet, social networks, mobile applications**: these tools provide factual and

precise information in case of warning, with these information means it is possible to tailor the information for each district, constantly update it, collect messages from the population and provide answers, they are a good alternative to phone calls. A specific website was designed for emergencies and is hidden during normal situations and ready to be published in case of warning. These communication tools are managed by the Communication Division of the Crisis Central Cell, under the coordination of DICOM (the Communication Direction of the City of Paris), the Cell is also in charge of monitoring the media and analysing the population messages.

- The **Civilian Protection** ('Réserve Solidaire de Paris') contributes to inform the population about local risks.

- Observations on potential communication variables

1. Quantitative assessment (**alarm frequency** and **spatial range**, number of **false alarms**, **rates of attendance** of each target audience to the events, **population reached by the civilian protection, number of press articles, media audience**, institutional magazine readerships, number of **web pages** and intranet **visitors**, visit duration, **number of e-mails**, number of social media followers, forwarded posts and comments, **number of application users**, **profile of visitors/users/followers** when available, **number of phone calls...**);
2. And qualitative assessment (target audience **interpretation** of the disseminated messages and response in terms of **behaviour, attitudes and risk culture**) should be performed for each communication activity and each target audience.

4.2.11 CPIER Plan Seine (DRIEE/DBSN, 2015)

- Communication context

CPIER Plan **follows the Seine River Plan** for 2007–2013 and is **based on** several **State-Region contracts**.

- Communication objectives

1. **Raise awareness and promote the actions** that were **implemented** in the Seine River Basin, as well as the knowledge that was developed.
2. Engage the stakeholders by keeping alive and **developing a risk culture**.

- Target audiences

  The **stakeholders of the Seine River Basin**.

- Communication activities

  Create a **shared information site** connecting the river basin stakeholders.

- Observations on potential communication variables

  A communication assessment would focus on **who and how many are the stakeholders**, the **frequency and quality of information sharing**, **who and how is benefiting from this information**.

4.2.12 Paris Resilience Strategy (Mairie de Paris and 100 Resilient Cities, 2017)

- Communication context

  1. Risk management in France leaves little place to citizen involvement. Though, **the terrorist attacks of November 2015 showed that the inhabitants can have a key role in facing an emergency**.
  2. Paris should **exploit the opportunities offered by the new technologies** in the field of robotics, artificial intelligence and big data to develop high quality services, while **guaranteeing citizens' interests and conservation of resources**.

- Communication objectives

  1. **Strengthen the risk culture** among Paris inhabitants and create a **culture of action and solidarity**, so that the citizens get familiar with the concept of resilience, get involved and act for a resilient city;
  2. **Facilitate citizens' initiatives** and more in general their active involvement;
  3. **Inform and train the population to cope with risk**;

4. Invite the **population** to get **involved in the innovation of urban areas** and in the development and implementation of public policies;
5. **Encourage the citizens and local organisations to initiate**, implement, co-fund **resilient solutions**;
6. **Prepare everyone** to face daily **stresses** as well as occasional **shocks**;
7. Improve crisis communication thanks to **new technologies**;
8. **Enhance solidarity**, goodwill, inclusion and social cohesion among neighbours, across different territories and generations;
9. **Connect the citizens** that are willing to **help vulnerable people**;
10. **Reinforce networking and cooperation** in the neighbourhood as well as at wider levels, i.e. across different territories (e.g.different municipalities, urban areas and rural areas);
11. **Develop the network with other cities** and 100RC private partners;
12. **Paris aims at becoming a leader city** among the municipalities that are developing a resilience strategy, especially concerning terrorism, climate change, air pollution, refugees and migrants.

- Target audiences

1. The **inhabitants of Île-de-France region and Seine River Basin** (beyond inner Paris);
2. **Vulnerable individuals**;
3. **Neighbourhood networks**;
4. **Local authorities**;
5. **Businesses, companies**;
6. **Farmers**;
7. **Associations**;
8. **Research institutions**;
9. **Land planners**;
10. **Developers**;
11. **Network operators, service providers**;

12. **Dealers, logisticians**;
13. **Landlords**;
14. **Restaurant managers**;
15. **Cultural actors**;
16. The **civilian security**;
17. The **fire brigade**.

- Communication activities

1. **Regular consultations of partners, citizens and economic actors** to jointly design resilience solutions, the action plans and manage them;
2. Consultation of citizens will be aimed at improving regulation as well as in designing and implementing small scale measures such as urban events, temporary occupations, street furniture, greening, urban agriculture, rainwater collection, compost. **Citizens will be supported to design and implement these solutions** through dedicated maps, advisory services, collaborative funding and public incentives;
3. **Exchanges at international level**, compare the experience of different cities, jointly develop resilience solutions;
4. **Workshops for citizens** to become prepared for risks and develop solidarity actions;
5. **A citizens' solidarity network** will be created to support public authorities' interventions on a daily basis as well as during major crisis: these citizens will be trained on first aid, life-saving actions, crisis management; they will practise awareness raising; they will also be trained to crowdsource mapping methods;
6. A **centre** dedicated to information, research and training **on resilience**: it will be open source and addressed to multiple audiences;
7. An **interactive map** on urban resilience challenges: it will gather crowdsourcing data and will merge it with information risk prevention and management. It will be a public, reliable, free, privacy-respectful service for data management. An event will promote this tool and crowdsourcing mapping methods;

8. **Pedagogical tools and videos on terrorism** risks will be designed for school teachers and parents.
9. A **communication campaign will promote psychological support** services open to everybody with a specific programme for schools;
10. An **interactive platform** gathering information **on social practices and association activities** with a dedicated interactive map;
11. The inhabitants of the Paris region will be involved in local urban mobility plans through the **Forum Métropolitain du Grand Paris** (FMGP).

- Observations on potential communication variables

  A communication assessment could be aimed to compare the following trends, before and after a communication activity:

  1. The **perception of risk**, **security** and **existing solutions** of different audiences;
  2. **Number of citizens involved** in the City of Paris public engagement programmes;
  3. Target audience response to risk in terms **responsible behaviour and solidarity actions**;
  4. Rate of **requests for assistance** during an emergency (number of phone calls) and **profile of rescue seekers**;
  5. **Number of participants** to workshops and meetings, **number of visitors and active users** of the interactive map and platform, **number of members** of the citizens' solidarity network;
  6. **Number of international meetings and attendance**, number of **solutions developed with international partners**, number of solutions developed, **implemented** and managed by **citizens**...
  7. The communication assessment should be **integrated in a wider resilience assessment**:
     - The 2017 resilience strategy aims at defining resilience indicators (considering biodiversity, social inclusion, climate change adaptation, costs of none-adaptation...) to identify investment and purchase priorities, define the specifications for concession agreements and delegation of public service provision.

4.3 General remarks on the communication objectives, audiences and activities

As it is summarised in Fig. 4.3, the review of strategic documents on Paris flood resilience call attention on the evolution of public authorities' communication objectives, selected target audiences and activities.

4.3.1 The emergence of an integrated approach to risk management

Concerning the objectives, while most of the analysed documents focus on the Seine River flood resilience, a markedly integrated approach to risk management appears only in three recent documents: *'Plan Climat Énergie de Paris'* (Mairie de Paris, Direction des Espaces Verts et de l'Environnement, Agence d'Écologie Urbaine, 2015), PGRI[2] (DRIEE, 2015) and *Paris Resilience Strategy* (Mairie de Paris and 100 Resilient Cities, 2017). *'Plan Climat Énergie'* outlines a communication strategy addressing all climate risks and promoting long-term resilience solutions (sustainable urban lifestyle and urban planning), instead of only focusing on emergency management. *PGRI* draws attention to the importance of integrating information on flood risks with information on other natural risks, water environments, climate change, as well as on human activity impacts. *Paris Resilience Strategy* presents as its keystone the so-called 'resilience thinking', i.e. creating synergies among different policy areas that address a range of urban risks (e.g. flood risk, heat waves, housing crisis, terrorist attacks) that appear as distinct but are in fact interrelated.

[2]The following abbreviations will be employed to refer to some of the strategic documents released by the public authorities: 'PPRI' stands for 'Plan de Prévention des Risques d'Inondation' (Flood Risk Prevention Plan), 'DICR' stands for 'Document d'Information Communal sur les Risques' ('Municipality Risk Information Document'), 'DDRM' stands for 'Dossier Départemental des Risques Majeurs' ('Department File on Major Risks'), 'PFMS' stands for 'Plan Familial de mise en Sûreté' ('Security Family Plan'), SGRI stands for 'Stratégie Nationale de Gestion du Risque d'Inondation' (National Strategy for Flood Risk Management), 'PAPI' stands for 'Programme d'Action de Prévention des Inondations' (Action Plan for Flood Prevention), 'OECD' stands for Organisation for Economic Cooperation and Development, 'PGRI' stands for 'Plan de Gestion du Risque d'Inondation' (Flood risk management plan), 'PCS stands for Plan Communal de Sauvegarde (Safeguard Municipality Plan), 'CPIER' stands for 'Contrat de Plan Interrégional entre l'État et les Régions' (Interregional Plan Contract between the State and the Regions).

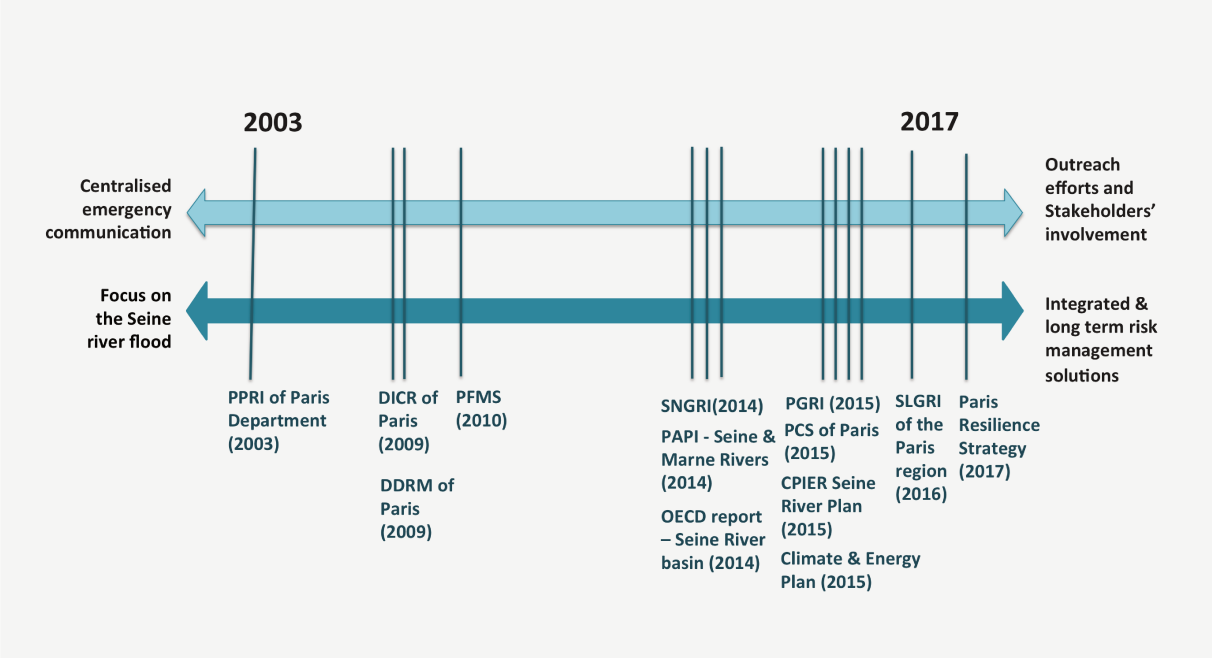


FIGURE 4.3. Evolution over time of public authorities' approaches to communication on flood resilience issue in the Paris region.

4.3.2 From centralised communication to public outreach and citizen engagement

Another manifest trend – that becomes evident from the analysis of the objectives, audiences and the activities – is a centralised approach to risk communication in the early documents that is progressively replaced by a more decentralised approach. Indeed, in recent years, public outreach and participatory communication (public consultation and engagement) grew in importance, while the documents published before 2014 present top-down communication strategies. In the documents dated from 2003 to 2010, the communication objectives are defined with a generic statement that recalls the public authorities' legal obligation to provide information, as well as citizens' duty to keep themselves informed and act responsibly. The target audience is usually generically defined as 'Paris population' except for the *'PPRI du Département de Paris'* (Direction régionale de l'urbanisme du logement et de l'équipement d'Île-de-France, 2003) that identifies several subgroups. The action plans are mostly centred on emergency management and prioritise communication flows in one direction (from the public authorities to the population). The first attempt to provide the citizens with a tool to get actively involved is the *'Plan*

Familial de Mise en Sûreté' (P. Oumraou, P. Arrondeau, M. Rousselon, 2010), a guide for designing a family safety plan. In this last example the citizen role is merely executive though. It is only in the latest documents that consultation and public involvement in the decision-making process are envisaged.

4.3.2.1 Developing risk culture becomes a priority

In the documents published from 2014 to 2016 the objectives are consistent with the goals defined in the earlier plans. However, they are defined more in detail, the associated target audiences are better profiled and there is a reflection on how to facilitate information dissemination and citizens' active role with innovative activities. *SNGRI* (MEDDE, 2014) is a strategy developed in consultation with the public and stakeholders. Furthermore it introduces for the first time the objective of developing a 'risk culture'. This concept is indicative of a more pedagogical approach to risk information and a broader view of risk resilience that doesn't only focus on the emergency period.

The *'PAPI de la Seine et de la Marne'* (EPBT SGL, 2014) also refers to developing a risk culture as one of the main objectives. The communication plan envisages top-down communication activities, but there is a remarkable effort to introduce new communication techniques (with the support of a devoted budget) and to facilitate the access of different target audiences to information. Furthermore, the aim of the programme is to reinforce the consistence of the actions (including communication activities) undertaken by different local authorities in the Seine and Marne River Basin.

The *OECD Review of Seine Basin Resilience to Major Floods* (OECD, 2014) also considers risk culture development as an objective. Enhancing participation is presented as a second key objective, with corresponding recommendations for concrete activities such as consultation of citizens.

4.3.2.2 Stakeholders become active actors of resilience

Like most of the recent documents, *PGRI* identifies risk culture development as one of its main goals. Moreover, the document defines the profile of the target audiences and recommends new information tools as a way to improve information, beyond the regulatory obligations. The document mentions the need to actively involve industries and other actors that have an impact on flood risk. A specific feature is that *PGRI* aims

to engage local authorities and other public institutions in order to ensure a common and consistent communication strategy and create synergies in the Seine Normandie Basin.

'Plan Climat Énergie' associates the goal of raising awareness with the goal of involving stakeholders. These goals are broken down into specific objectives, which result in a rich mix of top-down and bottom-up communication activities.

Similarly, in the *CPIER Plan Seine* (DRIEE/DBSN, 2015) the objectives of raising awareness and engage stakeholders translate into a two-way communication activity. The target audience is not well profiled as in the other recent plans.

'Plan communal de Sauvegarde' (PCS) (Mairie de Paris, Préfecture de Police, 2015) has some analogies with the early security plans as well as with the last strategic documents. Like in the older plans, the PCS objectives evoke the duty of every citizen to ensure its own safety. However, there is also a reference to the importance of supporting a culture of risk, as in other recent documents. Similarly to the early documents, the PCS communication plan focuses on emergency preparedness and management. For this reason the plan mainly includes top-down communication activities, while stakeholder consultation is not foreseen. However, the detailed description of the communication objectives, target audiences and activities reveals the value placed on facilitating communication access.

Consultation of stakeholders since the beginning of risk management planning is a key aspect in the *Paris Resilience Strategy*. Furthermore, particular attention is devoted to vulnerable target audiences. One of the novelties introduced by this strategy is to encourage actions involving collaboration and solidarity among different stakeholders. Interactive web tools and workshops are dedicated to this objective.

As it is discussed above, in the last years risk communication plans are more accurate in terms of definition of precise goals, target audiences profiling, and description of concrete activities. However, among the reviewed documents, only three recent ones refer to communication monitoring and identify related indicators. The evaluation strategy, outlined in these documents, resulted in an assessment campaign that is discussed in the next section.

4.4 Example of assessment of flood risk perception and communication evaluation in Île-de-France region

References to communication evaluation and metrics appear in recent strategic documents. The OECD review (OECD, 2014, p. 15) evokes the need to define 'quantified objectives for risk awareness'. The *National Strategy for Flood Risk Management* (MEDDE, 2014) foresees long-term evaluation of the current and future performances. A list of quantified objectives is defined. The only quantified objective relating to communication activities is: '100% of PCS should be produced by 2018 by the municipalities that are compelled to do it since 2013 or before' (p. 11). Communication evaluation is then recalled and further developed in the *PGRI–Bassin Seine-Normandie* (DRIEE, 2015) and in the *SLGRI – Paris region TRI* (DRIEE and SGZD de Paris, 2016).

According to the first document, a result evaluation is planned in 2021 and a range of qualitative questions and quantitative indicators are listed. The evaluation question for the communication strategy is 'Does the plan facilitate risk culture development?' (p. 142); the main communication indicators are the implementation rates of PCS and DICRIM. Nevertheless the plan evokes the possibility to add new questions and indicators.

The *SLGRI* includes among its objectives 'assessing risk culture' (p. 59) and 'widespreading communication assessment procedures' (p. 60). These general objectives were translated into concrete activities with an update of the *'PAPI de la Seine et de la Marne'* in December 2016 and the organisation of a work group ('Atelier PAPI') dedicated to awareness raising and training on flood risks (EPBT SGL, 2 February 2016). An assessment plan, focusing on local risk culture and information, was led by EPBT Seine-Grands-Lacs (EPBT SGL, 28 February 2017).

The employed methodologies correspond to those adopted by SIA specialists to monitor the social construction of reality in a community. Indeed, the assessment is based on literature reviews, the outputs of past information campaigns, individual interviews, questionnaires, focus groups (Figure 4.4). As it will be discussed in the next chapters, analysis of social perceptions and communication processes could benefit of recent advances in exploration of unstructured big data. Indeed these techniques can be helpful to

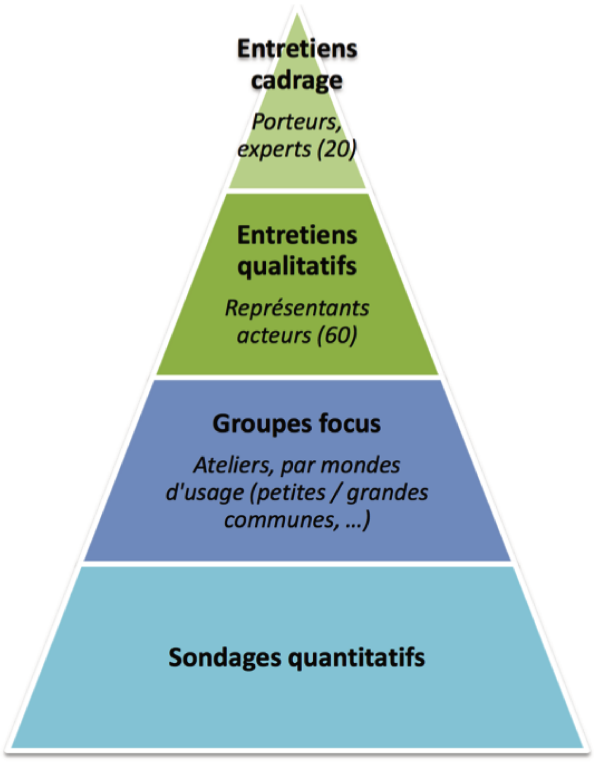


FIGURE 4.4. Assessment plan on flood risk perception and information in Île-de-France region (EPBT SGL, 28 February 2017).

overcome some of the constraints of traditional research techniques used by SIA experts. The next section outlines general criteria to define relevant RCIs and variables. These criteria were used as a base to design the experiments presented in Chap. 5, 6 and 7.

4.5 General guiding criteria for RCIs

Relevant communication variables are identified during the 'scoping phase' (see Chap. 3), likewise other key social variables. As it is exemplified in Sect. 4.2, communication variables and RCIs can be defined on the basis of the project communication context, objectives, target audiences and available cultural contents (produced through communication activities). RCIs should be tailored to the project and context specificities, however we can outline six recurring categories of variables. The categories (listed below) can serve as guiding criteria to include relevant RCIs in a wider urban resilience assessment. Collected data should provide information on the following six key aspects of communication processes that are essential to analyse the role of social construction of reality

(defined in Chap. 3) in urban resilience:

1. ***Intensity***: number of tweets, retweets, followers, comments, attendees, website unique visitors, visit duration, number of press articles, readerships, etc. Each rate can be broken down by different sub–groups of audiences. High exposure to a message is a necessary but not sufficient condition to raise urban community's awareness of local resilience issues and solutions, and possibly gain their support for a resilience project.

2. ***Quality*** (Did it reach the adequate target audience? Does public perceptions and response match with what was expected?): number of distributed messages that are consistent with the campaign key messages, percentage of the target audience who interpreted as expected the messages, percentage of the audience whose perceptions evolved through the campaign, percentage of the target audience that took action to contribute to the campaign goal achievement. Each rate can be broken down by different sub–groups of audiences. If the audience doesn't interpret a message as it was planned, a communication activity can have no effects, or negative effects, on public awareness and on the outcomes of a resilience project.

3. ***Participatory communication***: percentage of the target audience who contributed to disseminating information, percentage of citizen information that contributed to changing risk management. Data on public engagement can be easily collected in the case of projects involving the use of social media (Grandi and Neri, 2014; Topping and Illingworth, 2016) or mobile app for 'citizen science' (Keating et al., 2014; Koole et al., 2015). This type of communication can strongly support the implementation of the subsidiarity principle that, according to Tanguy (2015) is necessary to enhance resilience (see Chap. 2).

4. ***Comparison***: to observe how communication trends change over time, in different locations and from one segment of the population to the other. Observing variability in communication processes is a preliminary step to detecting possible correlations with resilience evolution.

5. ***The interplay with other resilience drivers***: examples of correlations between communication and other urban system components are a) policy makers that were influenced by the media coverage of a flood (e.g. a debate on insurance issues or alarm dysfunction); b) an information campaign that contributed to decreasing damages and injuries; c) a new transport connection that increased

the attendance rate and variety of participants to a conference. This criterion establishes the connection between RCIs and other resilience indicators and to integrate communication assessment in a wider resilience assessment framework.

6. ***Socio-semantic networks***: metrics on the social relations and information distribution. This type of analysis can provide quantitative data on the quality of information that is exchanged in an urban community and on the social actors who drive and contribute to this exchange. These social actors are potential influential persons or organisations who can strongly affect communication processes with consequences on public awareness of resilience issues and solutions or, more specifically, on the implementation of a resilience project. The importance of the quality of information, from a urban resilience perspective, is discussed under §2.

4.6 Conclusions

The review of public authorities' strategies shows a growing effort along the past ten years to facilitate access to information, encourage citizen participation and to share responsibilities with the population. This trend does not only result from a political will to apply the principle of subsidiarity and decentralise risk management (Tanguy, 2015), it also springs from a growing awareness among public institutions of the social construction of the reality as a key social factor. Therefore, the communication between public authorities and citizens, especially a two-way dialogue, is becoming a keystone of resilience strategies since it facilitates mutual understanding, shared goal identification and cooperation.

More and more frequently resilience projects include a communication strategy or focus on communication activities. SNGRI (MEDDE, 2014) and PGRI (DRIEE, 2015) open the path to more comprehensive communication evaluation and the RCIs, outlined in this chapter, can contribute to progress in this direction. The validity of the proposed metrics was tested through experimentations that constitute the empirical part this thesis. A first set of experiments (Chap. 5) were implemented in the operational context of the RainGain communication campaign and are based on SIA research methods (third party sources, questionnaire, interviews). The second set of experiments (Chap. 6 and 7) exploit recent advances in big data exploration techniques, more specifically advanced text mining and graph representation.

CHAPTER 5

THE RAINGAIN PROJECT: ASSESSING THE IMPACT OF COMMUNICATION DURING A PROJECT ON URBAN FLOOD RESILIENCE

The HM&Co (Hydrology Meteorology and Complexity) laboratory of École des Ponts ParisTech and TU Delft (Delft University of Technology) collaborated in several research projects aimed at enhancing urban resilience to extreme weather. These projects also involved developing and strengthening a network of stakeholders through dissemination and public engagement activities. HMCo and TU Delft strove in this direction by first being involved in the participatory workshops addressed to the stakeholders of the FP7 SMARTeST project. After this first experience, they launched a four–year long communication strategy in the framework of the Interreg NWE IVB RainGain project. The main communication objective was 'to disseminate and make available the tools and methodologies developed in the project, so that its target groups are informed, educated, involved and mobilised so that vulnerability to urban pluvial flooding is reduced and resilience is enhanced' (Interreg NWE IVB RainGain, 2011, p. 2).

The frequency of communication activities and their impact, in terms of audience size, were monitored since the beginning of the communication plan. This enabled the RainGain project team to adjust the communication activities during the project implementation when problems were revealed. Indeed, precise target values were established as part of the communication strategy, in agreement with the European Commission

evaluators in charge of the Interreg NWE IVB funding programme. During the execution of the plan, the project partners and the funding programme staff periodically compared the target values to the attained values, in order to appraise if sufficient efforts and resources were devoted to specific activities (Fig. 5.1). The design of the experiments, the data collection and the analysis of the results were carried out through a participatory process, involving the international project team (the communication officer, the scientists and the practitioners), as well as external staff (from the EC Interreg Programme, École des Ponts and Terre et Avenir association) who provided a third party advise.

This chapter presents three experiments that were executed in the framework of the RainGain communication strategy. The research methods employed in these evaluations are three SIA techniques (see Chap. 3): press monitoring (i.e. third party sources), questionnaire and interviews. Each experiment takes into account some of the six guiding criteria listed in Chap. 4. More specifically, the first experiment 'Media coverage monitoring' explores the intensity of communication (criterion 1), it compares different time periods (criterion 4) and highlights the correlations between communication and another resilience driver, i.e. a meteorological event (criterion 5). The second experiment 'Questionnaire administered to the visitors of an exhibition' explores the quality of communication (criterion 2) and compares different sub–groups of audiences (criterion 4). The third experiment 'Interviews' is aimed at providing data for preliminary research and support monitoring of RCIs.

5.1 Media coverage monitoring

Among the communication values that were monitored during the RainGain project, the media coverage reached remarkable results that far surpassed the target values. The data presented in this section were collected from different sources:

- Feedback from the Communication Department of École des Ponts that constantly monitors, through L'Argus de la Presse (argus-presse.fr), if the media mention 'École des Ponts';

- Research on Google News (news.google.com) of press news items that include the key–word 'RainGain';

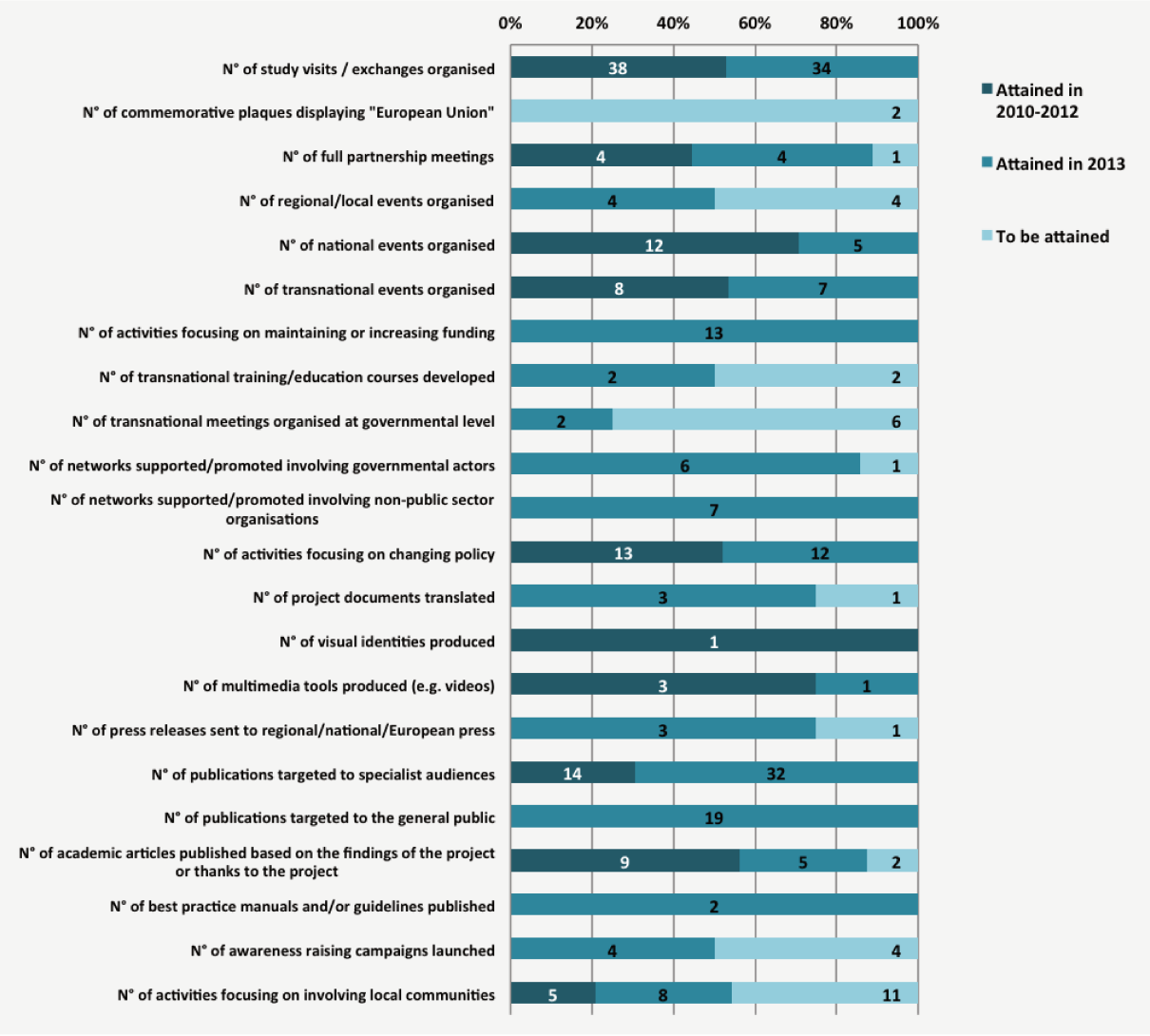


FIGURE 5.1. Monitoring of the frequency of the RainGain communication activities in 2013. During the execution of the RainGain communication plan, the target values (to be attained by the end of the project) were periodically compared with the attained values.

- Feedback from the researchers that were interviewed by the press on the RainGain project;
- Data on the audience size of printed press were collected on each newspaper website.

From July 2011 to December 2015, we counted a total number of 65 news items on the RainGain project, published by the French, Dutch and Belgian press. These news items include 29 articles on printed press, six TV reports, five radio reports, 25 Web news items and Web TV reports.

Figure 5.2 shows that during specific months the number of news items rapidly increased. Two kinds of events occurred when the increase rate was high:

- The RainGain communication activities (a press release in March 2013 and two conferences in October 2013 and May 2015). These are social and endogenous causes of news items rate increase, since they are the outcome of the work of the project team;
- Flood events in The Netherlands (October 2013) and in France (October 2015) that are environmental and exogenous causes. The impact of a flood event on media coverage is an example of correlation between an environmental factor and a social factor.

Data on the number of press articles were compared to the data on the newspaper audience size. We refer to audience size as the readership that was estimated by the newspaper editor or by companies specialised in media measurement. These estimates are not precise as measurements of immediate audience (i.e. a public who is face–to–face with the speaker), but provide an approximate metric of the potential dissemination of a news item. Figure 5.3 displays a comparison between the temporal evolution of the cumulative number of articles and the cumulative audience size of printed press. The difference between the two cumulative curves is variable. Indeed, different newspapers have different impacts in terms of audience size. Hence, the impact of an article is variable according to the newspaper that publishes it. This is particularly true when we compare the impact of a local newspaper to the impact of a national newspaper. The audience size is also variable in the case of TV, radio and digital press.

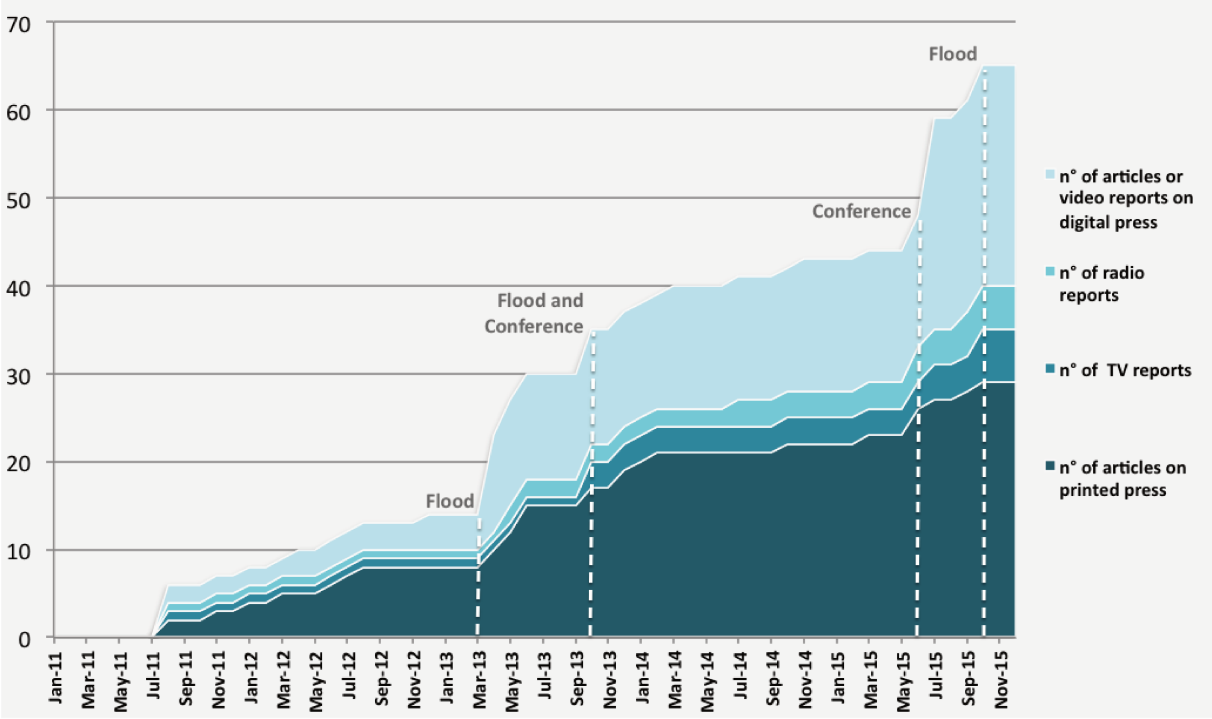


FIGURE 5.2. Cumulative number of news items (printed press, digital press, TV and radio) concerning the RainGain project and published from July 2011 to November 2015. The number of news items rapidly raised during specific events: 1) dissemination of a press release on the project (March 2013); 2) a flood event in The Netherlands, followed by a project conference in France (October 2013); organisation of an international scientific conference related to the project (May–June 2015); 3) a flood event in South-Eastern France (October 2015).

The frequency of press articles and the audience size are two RCIs (Resilience Communication Indicators) that provide an estimation of the population that was reached. This is an essential step to evaluate the communication effects on citizen perceptions and urban community resilience. Indeed, media visibility is a necessary but not sufficient condition to raise awareness among a relevant portion of stakeholders and gain their support for a flood resilience project like RainGain. The RCIs employed in this experiment provide insights also on how the resonance of a message evolves over time (Fig. 5.2 and 5.3) and on possible correlations with other resilience drivers (e.g. a meteorological event, as it is shown in Fig. 5.1). With respect to the resilience goals of the project, the experiment showed that attention of the media on urban flood–prone areas and on emerging scientific and technological solutions was gained thanks to press relations. We

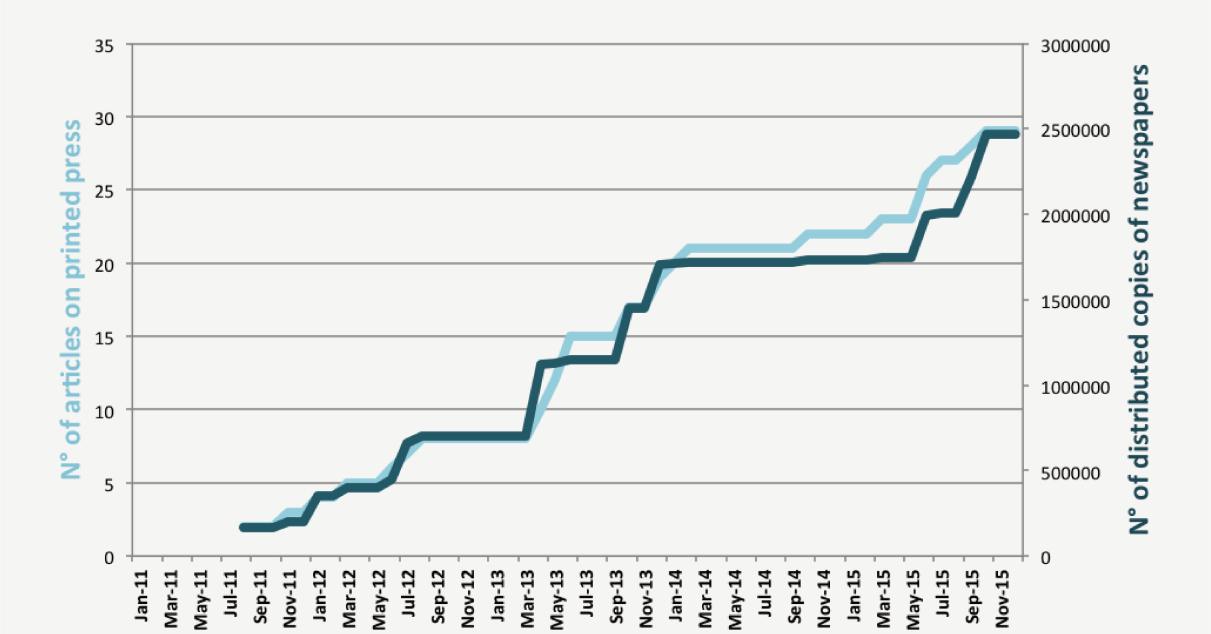


FIGURE 5.3. A comparison between the temporal evolution of the cumulative number of articles and the cumulative audience size of printed press. The differences between the two cumulative curves are due to the fact that different newspapers have different impacts in terms of audience size, hence the impact of an article is variable according to the newspaper that publishes it. In order to highlight this variability we overlapped the first and the last values of the two curves.

finally should observe that an aggregated analysis of press news items doesn't give any insight on the communication contents.

5.2 Questionnaire administered to the visitors of an exhibition

The experiment presented in this section illustrates how RCIs based on a questionnaire can capture if the audience perceived a message as expected. Even if a communication activity reaches a wide public, when the audience doesn't interpret a message as it was expected, there could be no consequences, or negative consequences, on public awareness and on the outcomes of a flood resilience project. Questionnaire questions, such as those presented in this experiment, provide variables (e.g. frequency of expected answers, frequency of high risk perception) that can be used as RCIs to assess the respondent

interpretationa ans perception.

An exhibition dedicated to the RainGain project was held at École des Ponts in April–May 2014. It included five panels (84 cm x 120 cm) with texts and images on the project and the weather radar that was going to be installed beside the school, at the end of 2014. The subject of the exhibition was very technical: only professionals in the field of weather forecasts and flood risk management are knowledgeable about it and have access to other sources of information on the topic. The questionnaire were distributed to the workers and students of the school one month after the end of the exhibition. The questionnaire aimed at exploring if the displayed information was interpreted as expected, if it was memorised after several weeks, and if it changed the visitors' perception of RainGain (Persoz, 2014). 37 respondents were recruited on a voluntary basis among the 513 workers and 827 students of École des Ponts (all domiciled in the Paris region). They were invited through internal mailing to complete an online questionnaire (see Appendix E, for a detailed list of the questions). The sample was expected to be small, since no monetary incentive was provided for answering the questionnaire and there was no examiner who could individually reach each potential respondent to solicit his answers. We were also aware that questionnaires give limited insights on the cognitive processes that shape individual and social perceptions. However, rather than obtaining results that can be generalised to a wider population, our main objective was to test if quantitative research can be employed to explore how a message is perceived and interpreted. Indeed, this method and the research technique presented in the previous experiment have a common characteristic: they provide numerical data that are adequate to integrate communication assessment in a wider urban resilience assessment.

The questionnaire included questions on the professional background of the respondents. On the basis of these questions six experts were excluded from the sample, in order to obtain a relative homogeneity in terms of background knowledge. As a result, the final sample consisted in 31 respondents (see Appendix E for demographic data). Other questions were aimed at identifying through which source of information the respondents learnt about the project. On the basis of these questions the sample was divided in four subsets: 1) 13 visitors to the exhibition; 2) five visitors who also read the brochure distributed at the exhibition; 3) six respondents who had only access to informal information (from word of mouth[1]); 4) 12 participants who never heard about

[1]We use the term 'from word of mouth' to refer to information that was passed from person to person –

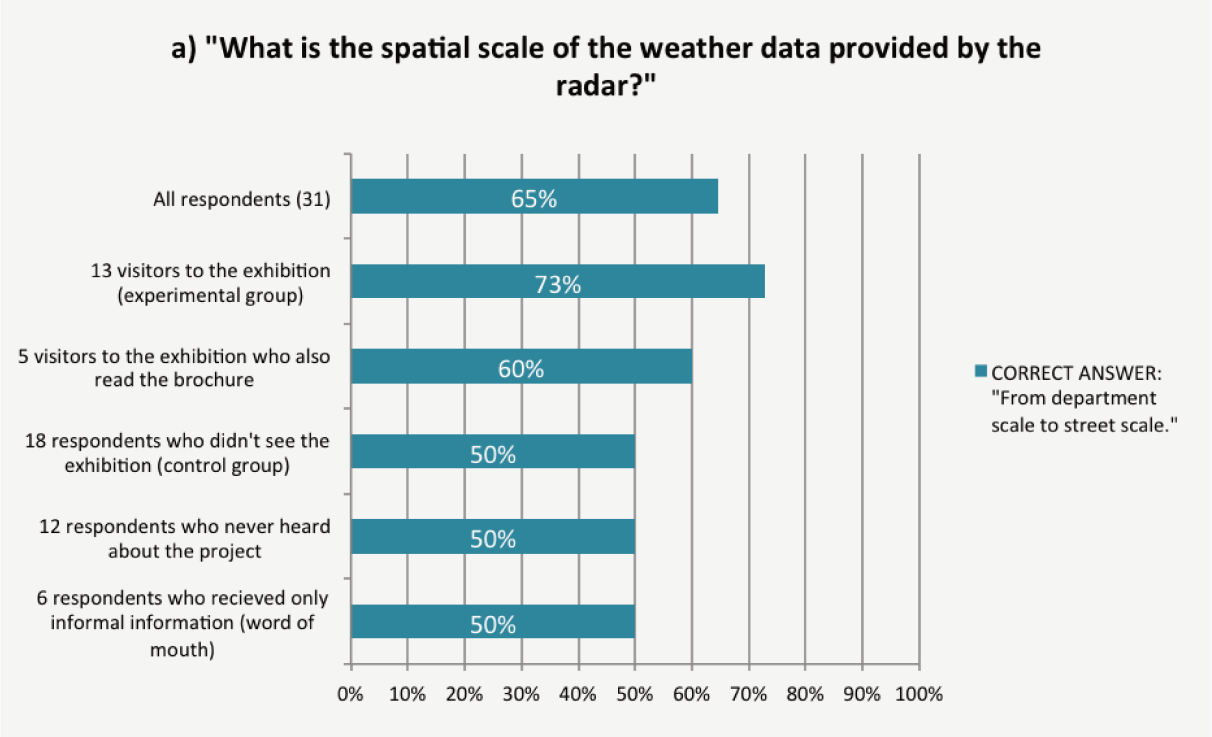


FIGURE 5.4. The answers to the questionnaire question a) on the RainGain exhibition held in April-May 2014.100% corresponds to the total number of respondents included in each subset: 31 respondents in the first row, 13 respondents in the second row, 5 respondents in the third row, and so on.

the project. In order to perform a comparative experiment, the first subset was considered as the experimental group with 13 respondents, while the third and fourth subsets were considered as the control group with 18 respondents. We used the Fisher's Exact test to compare the answers by the experimental group with those of the control group.

Figure 5.4 shows that the number of respondents who visited the exhibition and ticked the correct option for the question 'What is the spatial scale of the weather data provided by the radar?' is 23% higher than in the control group. As it appears in Fig. 5.5, the wrong responses to the question 'What are the advantages of X band weather radars compared to C band and S band radars?' are 20% less frequent among the exhibition visitors. According to the results presented in Fig. 5.6, the number of respondents who visited the exhibition and provided a wrong response to the question 'Why is it important

working or studying at the school – by oral and informal communication.

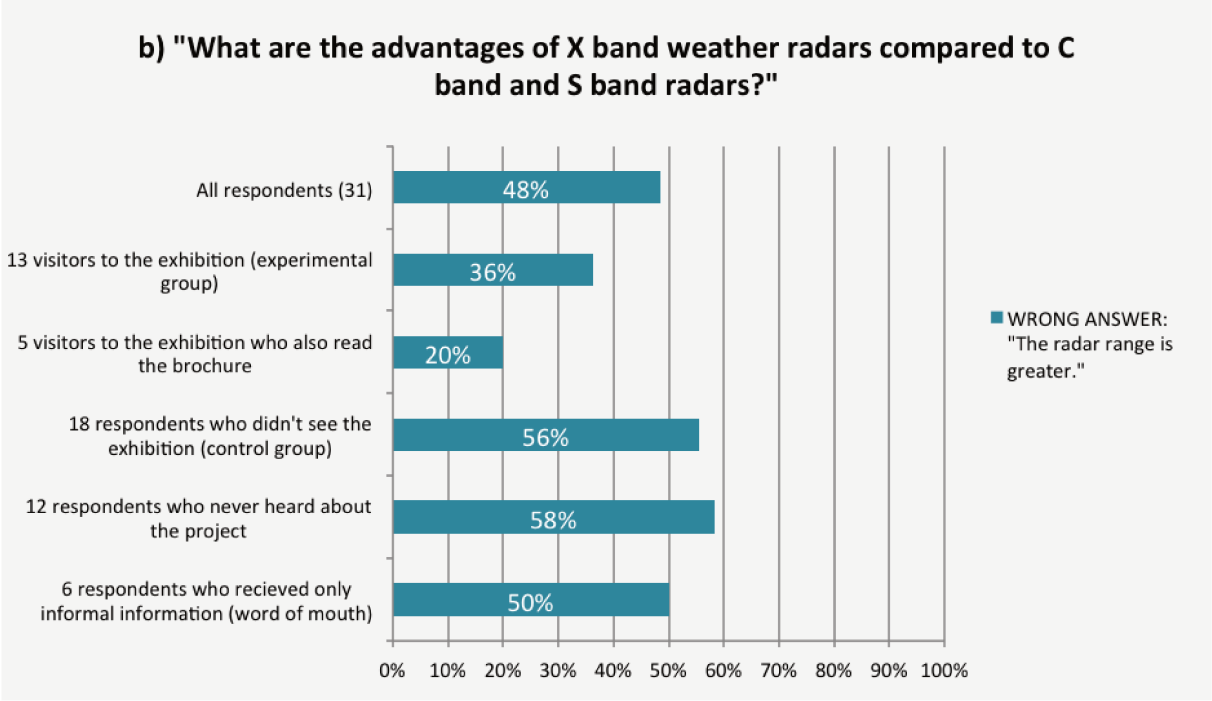


FIGURE 5.5. The answers to the questionnaire question b) on the RainGain exhibition held in April–May 2014. 100% corresponds to the total number of respondents included in each subset.

to measure precipitations at small scale?' is 15% lower than in the control group. The discrepancy between the visitors' results and the control group results is between 15% and 23% and it provides an approximate indication of the impact of the exhibition in terms of information dissemination and expected interpretation.

An unexpected result concerns the answers by the respondents who read the brochure at the exhibition in Fig. 5.4 and 5.6. In Fig. 5.4 the rate of correct answers by the respondents who read the brochure is lower (60%) than in the experimental group (73%). Figure 5.6 shows that the rate of wrong answers by the respondents who read the brochures is surprisingly high (40%): it is close to the rate of wrong answers by the respondents who never heard about the project (42%). We could assume that the respondents, who picked the brochure, spent little time reading the exhibition panels or that there was a problem with of the brochure information (e.g. it was not enough clear, didactic and suitable for the general public).

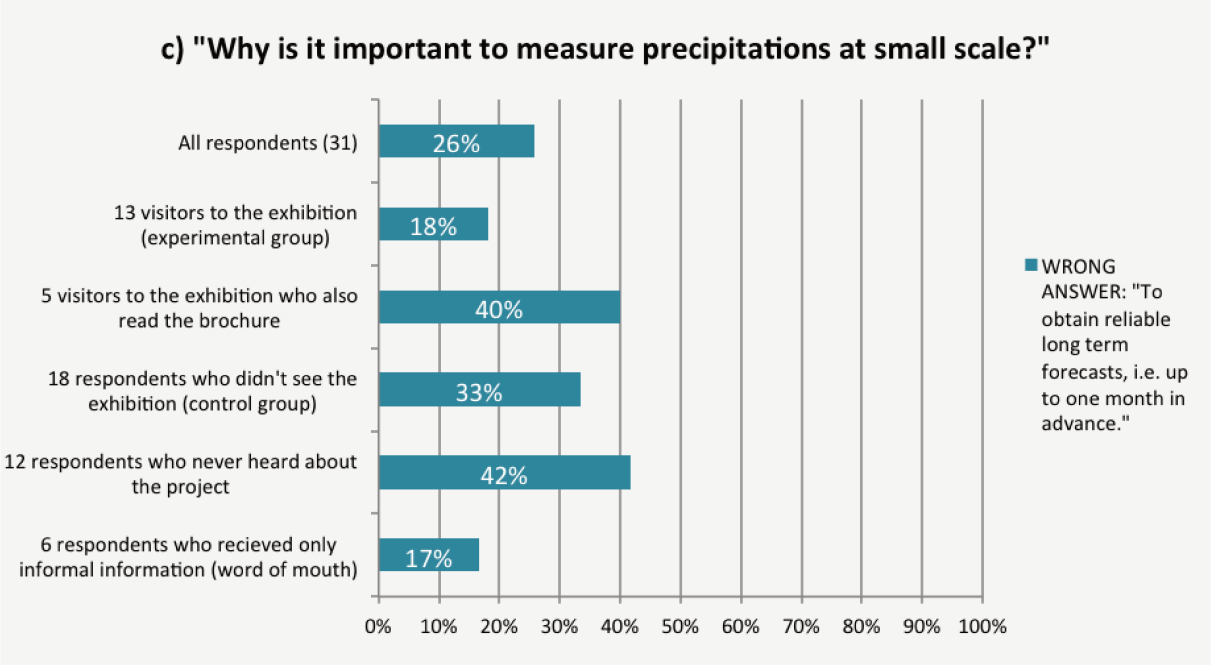


FIGURE 5.6. The answers to the questionnaire question c) on the RainGain exhibition held in April–May 2014. 100% corresponds to the total number of respondents included in each subset.

Figure 5.6 highlights another interesting result: the lowest rate of wrong answers corresponds to the group of respondents who didn't attend the exhibition but heard about the project from word of mouth. We can suppose that face–to–face communication can strongly reinforce transmission of highly technical information.

To sum up, the answer rates, displayed in Fig. 5.4, 5.5 and 5.6, show that the exhibition had a modest positive effect on the respondents' awareness about a flood resilience project, the background environmental issues and the solutions being developed. We suppose that this effect was reinforced by word of mouth communication, but was also weakened by the brochure.

Figure 5.7 presents the answers to a questionnaire question aimed at evaluating the risk perception and project acceptance of the respondents who visited the exhibition. The results show that the exhibition and the brochure, i.e. formal and official information, helped to reassure the respondents on security issues and encouraged them to support the implementation of the flood resilience project. Word of mouth communication didn't

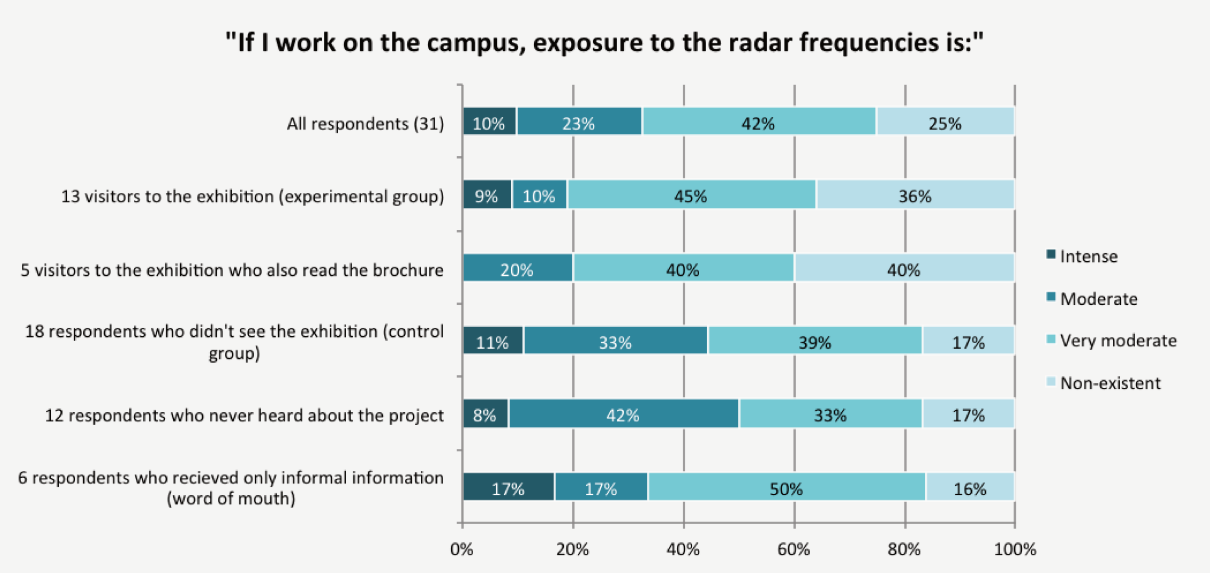


FIGURE 5.7. Answers to a questionnaire question evaluating the risk perception of the visitors after the RainGain exhibition. 100% corresponds to the total number of respondents included in each subset: 31 respondents in the first row, 13 respondents in the second row, 5 respondents in the third row, and so on.

have such a positive effect as formal information, but neither did it compromise the achievement of the project goals.

The Fisher Exact test [2] was applied to the results of the four questions: *p–values* aren't significant, as these are always greater than 0.05 (the conventionally accepted significance level). Hence, the test confirms that, because of the small size of the sample, the differences between the answers by the experimental group and of the control group aren't statistically significant.

[2]We computed a 2x2 contingency table, for each questionnaire question, with the frequencies of: a) the correct answers by the experimental group; b) the correct answers by the control group; c) the wrong answers by the experimental group; d) the wrong answers by the control group. We then applied the Fisher's Exact test because in all the 2x2 contingency tables at least one value is N 5. The test uses the following formula where the 'a,' 'b,' 'c' and 'd' are the individual frequencies of the 2X2 contingency table, and 'N' is the total frequency:

p= ((a + b) ! (c + d) ! (a + c) ! (b + d) !) / a ! b ! c ! d ! N !

5.3 Interviews

While questionnaires with close–ended questions make possible a quantification of the results, interviews can reveal more insights on the reactions and reasoning of the respondents. These research techniques don't provide quantitative variables that can be used as RCIs. Nevertheless, this is a helpful evaluation method to be adopted for exploratory studies or to validate the results of a questionnaire. Two assessments based on open–ended questions were conducted during the RainGain project in relation to outreach activities.

One of the achievements of RainGain was the inauguration of a new high–resolution weather radar at École des Ponts during the international conference 'Researchers water managers preparing cities for a changing climate' (8 and 9 June 2015). The promotion of this event involved a wide range of outreach activities and means. One of the promotional contents, which were produced on this occasion, is a short video (Mulard et al., 2015). It shows the installation of the radar, highlights the importance of this device in terms of research and innovation and invites the audience to attend the conference. The video is mainly addressed to the students and workers of École des Ponts, since the school is located in front of the radar site. Jeanine Courtot, the manager of the school café and a charismatic and well-known figure on the campus, was involved as the speaker of the video. While the video was broadcast on YouTube and on the school screens, two women and two men were interviewed (they were all university students, aged between 20 and 23 years and domiciled in the Paris region). The questions (Table 5.1, see Appendix F for details on the design process) aimed to appraise what kind of information the audience expected, how they interpreted the video contents, and how they reacted to the interview questions. The respondents were selected from the list of students invited to the conference and they participated in the interview on a voluntary basis.

The video was appreciated by the respondents who found it 'catchy' thanks to its dynamic pacing and the charisma of the speaker. They also found interesting the images of the radar installation. However, the respondents, who were all engineering school students, expected more information about the radar functioning and its concrete applications. They were curious about the extent of the implementation of the project ('Is the radar already operational?', 'How many new radars will be installed in Europe?', 'You should include a map with the pilot sites in the video.') and the radar functioning

Table 5.1: Questions to the audience of the video 'Jeanine presents the radar' (Mulard, 2015).

QUESTIONS ON THE VIDEO
a. What was unclear in the video and why?
b. Which aspects of the project would you like to learn more about?
c. What are the strengths and weaknesses of this video?

('Does the radar provide predictions of the rainfall volume?', 'It would have been nice to see some radar images.'). They also wondered about the researchers and engineers that operate the radar, the services that can be developed with these new weather data ('Is it used only for weather forecasts?', 'Is it possible to use it for Roland-Garros?'). These results will be used to design new questionnaires addressed to students from an engineering school. In particular, it appears relevant to include questions that make the link with their professional interests and that are accurately tailored to their background knowledge.

A similar assessment, based on three open-ended questions (Table 5.2, see Appendix F for details on the design process and the respondents' answers), was undertaken in November 2015 to evaluate the impact of a workshop dedicated to RainGain (held during the Provin Climate Forum). The respondents were all the participants of the workshop: 18 pupils, ten girls and eight boys, all aged between eight and nine years and resident in the Paris region, who had been invited by the forum organisers. We chose the snapshot interviews (Fogg Rogers et al., 2015) as an investigation method since it is an alternative technique that is appropriate for a young audience and the context of a forum. The assessment highlighted that the audience enjoyed and well remembered a manual activity on rainfall observation where they were active participants. It also revealed that the third question was not interpreted as expected. Its purpose was to assess how the communication contents were perceived, but the respondents interpreted it as a question testing their learning capacities. This result suggests that the questions addressed to a young audience should be formulated in such a way that the respondents don't feel like they are being examined.

Table 5.2: Questions to the participants of the RainGain workshop, conceived and held by Auguste Gires in the framework of the Provin Forum (November 2015).

QUESTIONS ON THE WORKSHOP
a.What did you like in this workshop?
b.What did you learn that you didn't know before?
c.Is there anything you didn't understand or you would like to learn more about?

5.4 Conclusions

The experiments carried out during the RainGain project were an opportunity to test valuable RCIs with the support of SIA techniques. These techniques are widely used, but the RCIs are a novel concept and have characteristics that are different from usual resilience indicators related to communication processes. At this stage of the research, we are cautious in generalising the validity of the following conclusions that are the result of few experiments applied to limited samples and with volunteer respondents (who induce a self-selection bias).

With respect to the resilience goals of RainGain, the first experiment showed that awareness raised among the media (of North-Western Europe) and their audience on local urban flood issues and on emerging scientific and technological solutions thanks to press relations. The results of the questionnaire showed that the exhibition and the brochure contributed to reassuring the respondents on security issues and encouraged them to support the implementation of the flood resilience project. The impact in terms of information dissemination and expected interpretation are positive but modest.

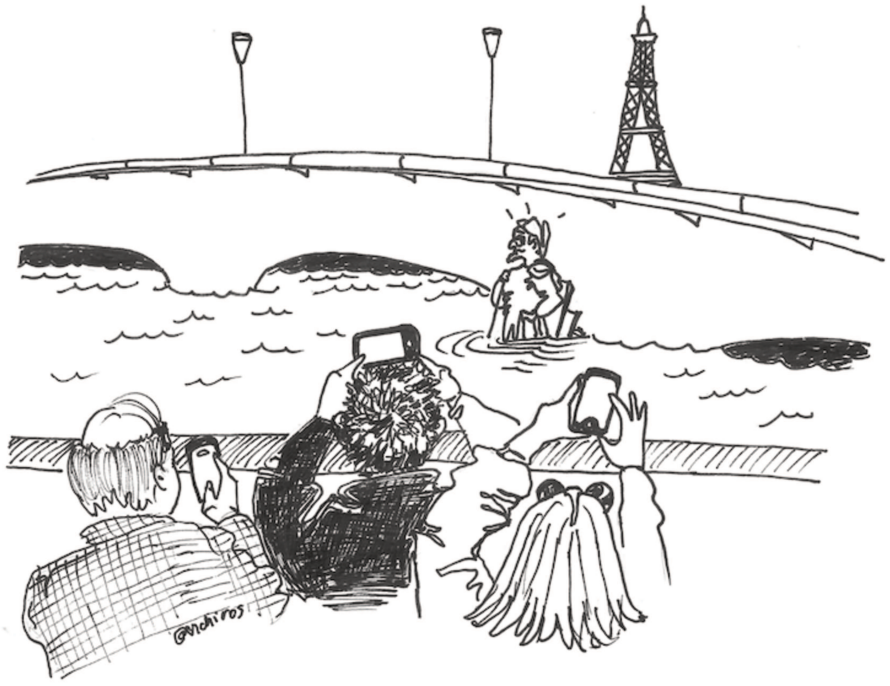
The media monitoring experiment highlights that news item frequency and audience size are two RCIs that are necessary to identify the population that was reached. Furthermore, it shows that a correlation between a physical environmental process (a flood event) and a social process (press communication) can be quantified. It would be significant to analyse the contents that spread through press news items: for instance, if the representation of scientific innovation by the press is positive or negative and which correlations exist between the concepts of innovation and resilient cities. Computer–assisted text mining tools are a possible methodological path to be followed.

Such big data exploration techniques would also be helpful to overcome time and cost constraints that were encountered with the questionnaire experiment, the results of which should be validated with a larger sample. However, thanks to this experiment it was possible to: 1) design RCIs aimed at evaluating how a message was perceived and interpreted by a non-specialist audience; 2) test their implementation in the operational context of a resilience communication campaign; 3) compare the experimental group response with the control group response in order to normalise the response ratings to different questions.

Qualitative assessment methods, such as interviews, are helpful to move beyond an aggregated analysis and to zoom into an individual perspective. Nevertheless, for the purposes of this research, qualitative research methods seem adequate for preliminary studies or result validation of quantitative studies. For instance, the interview outcomes could be used to develop the content of the questionnaire and ensure that questions are formulated in an appropriate fashion.

The SIA methods tested through these three experiments appear to be complementary and endorse the following conclusions: assessment aimed to investigate the role played by communication in urban resilience cannot rely on a unique technique and quantitative analysis is paramount in this context. In fact, data in numerical form are necessary to investigate the interplay between the communication processes and other resilience drivers, such as meteorological events. Investigating these interactions is a necessary basis to integrate communication indicators in a wider urban resilience assessment.

As a follow-up to these experiments, we investigated the the socio-semantic patterns that characterise the Web. In a resilience assessment perspective, the advantage of digital communication datasets is that these enable extraction of numerical data on social relations. Moreover, as it will be thoroughly discussed in the next chapter, thanks to computer-aided exploration techniques it is possible to both consider the global trend and the individual behaviour.



CHAPTER 6

CLIMATE RISKS AND DIGITAL MEDIA: FOLLOWING WEB TRAILS TO INVESTIGATE URBAN COMMUNITY RESILIENCE

Nowadays when extreme weather affects an urban area, huge amounts of digital data are spontaneously produced by the population on the Internet. These digital trails can provide an insight on the interactions existing between climate-related risks and the social perception of these risks. According to this thesis, big data exploration techniques, and more specifically advanced text mining and graph representation, can be exploited to monitor these interactions that can influence public awareness of resilience issues and solutions and can affect the outcomes of a resilience project. The experiments presented in this chapter show that digital research techniques can be used to monitor the six RCIs (Resilience Communication Indicators) outlined in Chap. 4: intensity and quality of communications, their interplay with other resilience drivers, their space and time variability, participatory communication, and socio-semantic networks. Furthermore, these techniques make possible to overcome some of the limits of SIA research methods that were encountered in the experimentations presented in Chap. 5: e.g. the cost and time constraints, a dichotomy between aggregate and individual level data.

After an overview of related research works (Sect. 6.1), we discuss the advantages and constraints of big data exploration techniques (Sect. 6.2). In Sect. 6.3, 6.4 and 6.5,

we describe three experiments that are aimed at appraising how digital media represent urban resilience during extreme weather and in the following weeks.

6.1 Related works

Analysis of big data corpora drawn from digital texts was employed in two research fields related to communication on climate risks. A series of studies analyse and compare the existing controversies on climate change in the spheres of science and digital media, and their evolution. Other research works investigate the use of social media during crisis due to natural hazards.

Several studies use digital datasets to explore the state of the scientific debate on climate change. Anderegg et al. (2010) analyse scientific publications and citation data to evaluate the distribution and resonance of dissenting and agreeing researchers with the theory of anthropogenic climate change. Bjurström and Polk (2011) highlight that references to economists and earth scientists in the International Panel on Climate Change Third Assessment Report are dominant. Li et al. (2011) look at the frequency of relevant keywords, such as 'holoceene' 'temperature' 'drought' 'precipitation', in scientific papers on climate change. Other research works investigate the climate change controversy on the Web. Niederer (2013) presents an analysis of the hyperlink connections (based on 'Issue Crawler') and of online visibility (based on 'Google Search' top results); similarly, Rogers and Marres (2000) examine interlinking and key frequent quotations.

In recent years, graph representation was employed to highlight the most relevant connections among key issues in the climate change debate. The Climate Tweetoscope (tweetoscope.iscpif.fr; Chavalarias, 2015) is an interactive visualisation tool based on automated co-word analysis that illustrates the key climate change issues and compares their prevalence in the scientific literature with their popularity on Twitter (twitter.com). The website climaps.eu (EU FP7 project EMAPS, 2011–2014) is an online atlas that gathers maps and data on the climate adaptation debate. One of the 'Issue stories' published on the website identifies four main approaches to climate change in the digital media: 'scepticism', 'mitigation', 'adaptation', 'conflict'. For each of the four approaches, the reports present Twitter metrics (number of tweets, number of users, number of redirecting URLs, top ten hashtags, top ten mentioned users, top ten active users, top ten hosts, most linked URLs, most retweeted tweets). The prevalence of each approach is

also investigated through Google search results and through an analysis of the websites of organisations working on climate change. Graph representation is used to illustrate the co-occurrence of hashtags in the same tweets and the popular book titles suggested by Amazon when people search for books on climate change.

With the emergence of Web 2.0 technologies, public authorities and citizens are increasingly using Twitter during natural disasters as a two-way early warning and information channel. According to Bruns and Liang (2012), Twitter is particularly suitable for crisis communication, indeed its 'flat and flexible communicative structures' (p. 2) enable any visitor to access public tweets: users who are not yet followers of the account, that disseminates the information on a crisis event, or even visitors that are not registered on Twitter. Furthermore, hashtags (keywords preceded by the symbol ") enable any visitor to search for tweets on a specific topic. Such communicative structure facilitates fast, large-scale collection and dissemination of information. Various types of metrics were used in research to analyse datasets of tweets covering an extreme weather event:

- The spatial and temporal distribution of tweets (Palen et al., 2010; Morss et al., 2017);
- The behaviour of Twitter users in terms of the number of tweets per user, replies, retweets, URL tweets, new users, low active users (Hughes and Palen, 2009; Starbird and Palen, 2010);
- Graph representations of the interactions among Twitter users based on replies, retweets (Bruns et al., 2012; Kogan et al. 2015);
- Distribution of salient topics and salient words (Kireyev et al., 2009; Vieweg et al. 2010; Bruns et al., 2012; St. Denis et al., 2014; Morss et al., 2017).

Several recent studies that are markedly oriented towards operational purposes, such as improving the emergency information and response services, present custom-made research tools that integrate scientific data from meteorological sensors (such as rain gauges and weather radars) with social media data on extreme weather events (Lanfranchi et al., 2014; Gaitan et al., 2014; Koole et al., 2015; J.C. Chacon-Hurtado, 2017). These ICT platforms collect information from the inhabitants of an area exposed to climate-related risks through dedicated smartphone app or through mainstream social

media platforms such as Twitter or Flickr.

The originality of our approach lies in the fact that it is framed in the context of research on urban resilience assessment. For this reason, it aims at contributing to the comprehension of the interactions that exist among different urban resilience drivers. With a quantitative analysis of digital communication patterns it is possible to explore how communication trends and other resilience drivers (e.g. an environmental factor) mutually influence each other. When these correlations exist, they are a necessary basis to understand how social perception of climate risks affects urban resilience.

Besides examining these methodological challenges, we also intend to contribute to the comprehension of the social perception of city resilience to climate risks, through digital media. We present an analysis of three datasets in Sect. 6.3, 6.4 and 6.5: the press articles covering the June 2016 Seine River flood; the press articles covering the October 2015 Côte d'Azur flood; the tweets on the 2016 Seine River flood. We detected the thematic subsets and connections among topics and actors that constitute online socio-semantic networks. We also compare the three datasets and reflect on how the debate changes over time, in different urban areas and in different media contexts.

6.2 Advantages and constraints of digital media analysis based on advanced text mining and graph representation

6.2.1 Method

Stakeholders' perception of a controversial issue is a community characteristic (and a social impact when change occurs) that can be analysed through surveys, meetings and interviews. Surveys provide information on population attitudes at aggregated level, while interviews and meetings (e.g. focus groups) provide insights about how and why particular attitudes are developed at individual level or at small-group level. However, big data exploration techniques make possible to get beyond the dichotomy between the aggregated structure and the individual component when studying social connections (Latour, 2012). The following examples of analysis of digital texts illustrate how these methods provide insight both on the aggregated and individual level of web

communication data. Indeed, thanks to an automated big data exploration tool such as Gargantext (Chavalarias and Delanoe, gargantext.org, 2017), it is possible to quickly navigate through huge masses of digital texts and following the connections among cultural contents (e.g. articles, blog posts, tweets), key issues, and the names of public figures or organisations.

The Internet age led to an increasing access to big digital datasets and, in the early 2000s, to the development of network analysis (Leydesdorff and Milojevic, 2012). Network analysis is employed in a wide range of scientific fields such as physics, computer science, biology, ecology, logistics and social sciences. Networks (or graphs) are simplified abstract representations of systems, such as text databases, that are meant to facilitate a smart navigation in the analysed systems. A network or graph is a collection of interconnected objects. The objects are called 'nodes' (or 'vertices') and the connections are called 'edges' (or 'links') (Newman, 2010). The analysis of the graph leads to the comprehension of its single objects (i.e. nodes), the interactions (i.e. edges) among those components and the pattern of interactions (i.e. graph).

Graph representation techniques applied to text databases were partly derived from and introduced in the field of scientometrics. Hess (1997, p. 75) defines scientometrics as the 'quantitative study of science, communication in science, and science policy'. Scientometrics study texts as empirical units of an analysis based on quantitative data. According to Chavalarias and Cointet (2008, p. 39), one of the main goals of these studies is 'the development of information systems that may help to browse the outstanding mass of scientific papers published worldwide every day'. This research approach was indeed developed in the field of science and technology studies, but it also expanded to domains dealing with other digital documents than scientific publications (Leydesdorff and Milojevic, 2012): webpages, blogs, online press, administrative documents, etc.

Scientometrics aim to reveal the internal structure of cultural domains by analysing data extracted from digital texts: authors, sources, documents, citations, links, references, terms, etc. A multitude of methods were developed to automatically map these data. One of these methods, employed by Gargantext, is 'co-word analysis', a technique to map the semantic structure in a database that exploits the statistics on the frequency of co-occurrences between two terms. These statistics can be then used to compute graph representations through clustering algorithms, such as the Louvain modularity (for a

definition see Table 6.1).

With Gargantext it is possible to extract, automatically as well as manually, a list of key terms from a corpus of texts. A first list of terms is automatically extracted by Gargantext algorithms on the basis of their occurrence, compared to other occurrences that characterise all Gargantext database corpora, as well as on the basis of the co-occurrences that characterise the specific corpus. This list can be manually modified: enriched with other terms extracted from the corpus, reduced, some terms can be merged in sub-lists. Then, graph representations are computed on the basis of two possible semantic proximity measures between one term of the list with another: conditional distance or distributional distance. In a co-occurrence graph based on distributional distance, an edge exists between two nodes representing key terms when these key terms have a similar co-occurrence profile with all the terms of the maps: for example two synonyms will probably be connected. Co-occurrence graphs based on conditional proximity, such as the graphs presented in this chapter, illustrate which key terms co-occur in the same meaning unit (e.g. a press article or a social media post) and with what probability (iscpif.fr/gargantext/your-first-map/).

Gargantext computes non-directed graph representations, i.e. these graph have no directed edges. The graph representations remain stable even when few documents are deleted from the corpus or few nodes are removed from the graph. The nodes are assembled in cohesive subsets through a clustering algorithm, more specifically through the Louvain modularity. The degree of each node (i.e.the number of edges incident connected to the node) can be displayed through Gargantext graph visualisation engine. Gargantext graphs are weighted, a value (called the "weight" of the edge) from 0 to 1 is assigned to each edge of the graph and it indicates the probability that two terms co-occur.

6.2.2 Data

Online press articles and social media posts are second-hand data. Indeed, as it is discussed by Venturini et al. (2014), the researcher cannot directly control the production of these data and he should question himself about their production context and process. For instance, the publication of press articles follows a set of journalistic values, the so-called *newsworthiness*, that determine if and how much a story is important for a media outlet and its audience. An example of news value is ‘the greater the drama, the greater its prominence in conversation’ (Boyd et al., 2008, p. 17): this kind of news, that

Table 6.1: Glossary of graph theory terms.

TECHNICAL TERM	DEFINITION
Graph (or Network)	A system of nodes linked in pairs by edges. A graph can be directed, if the edges have an orientation, or undirected, if the edges don't have an orientation.
Node (or Vertex)	One of the two fundamental units (together with edges) of which graphs are formed.
Edge	One of the two fundamental units (together with vertices) out of which graphs are constructed. Each edge has two nodes to which it is attached (i.e. its endpoints). Edges can be directed or undirected.
Node degree	The number of edges incident connected to the node.
Weighted graph	A graph in which each edge is given a numerical weight.
Edge weight	In the specific case of Gargantext graphs, it is a value from 0 to 1 that is assigned to each edge of the graph and indicates the probability that two terms co-occur.
Graph clusters	A cohesive subset of nodes.
Louvain algorithm	The Louvain method for community detection is used to maximise the network modularity. A network with high modularity has dense edges between the nodes within modules and sparse edges between nodes belonging to different modules. The modularity maximisation involves two stages: first the small clusters are detected, then the nodes that belong to the same cluster are aggregated and a new network is produced whose nodes are the clusters. These operations are repeated until a maximum of modularity is reached and a clusters hierarchy is built.
Conditional distance	Co-occurrence graphs based on conditional proximity, such as the graphs presented in this chapter, illustrate which key terms co-occur in the same meaning unit (e.g. a press article or a social media post) and with what probability.
Distributional distance	In a co-occurrence graph based on distributional distance, an edge exists between two nodes representing key terms when these keyterms have a similar co-occurrence profile with all the terms of the maps: for example two synonyms will probably be connected.

is expected to get their audience talking, is considered more worthy than others. These values are translated in a hierarchy of information that will guide news programming. In the case of social media, the problem of the digital divide (i.e. Internet access, skills and usage inequality) leads the researcher to consider the socio-demographic characteristics of social media users. For example, when analysing tweets, it should be taken into account that in France the population over 45 years is not well represented by a sample of Twitter users, while the population with a university degree is overrepresented. Indeed, in France in 2017, 16% of Twitter users were over 45 years old and 40% of the users had a university degree (excluding BTS) (blogdumoderateur.com)[1]. According to Venturini (2014, p. 4) 'digital traces are not natural items but artefacts created in a specific environment and with specific objectives'. However, this doesn't reduce their value, since their publication process can be a source of information on the social construction of reality, for instance the media representation of climate-related threats. Even though digital communications make possible a more direct observation of social phenomena, these data need to be contextualised and interpreted.

The Seine River flood that occurred in June 2016 was picked as a case study because of its prominent media impact. According to a search of French press articles on Europresse (europresse.com), on the 3rd of June 2016 the press coverage of this flood event reached a peak of 310 articles published in one day (corresponding to 29 437 terms, as illustrated by Fig. 6.1 a). This is a remarkable figure considering that the same French media published 591 articles, in one day, on Trump's victory on the 8th of November 2016. Media visibility influences public opinion, hence stakeholders' attitudes towards risks and disasters, and related resilience policies or projects[2]. Therefore this flood event is worth exploring from the urban resilience perspective.

On the 3rd and 4th of October 2015 extreme rainfall caused river floods in the Alpes-Maritimes Department. Cannes, Antibes, Vallauris, Biot and Mandelieu-la-Napoule were the most affected municipalities. The press coverage of this flood event was more limited

[1]According to the French National Institute of Statistics and Economic Studies (insee.fr), in 2017, in France, 20,9% of the population between 25 and 65 years old had a university degree (obtained after more than two years of university studies) and 41% of the population was over 45 years old.

[2]Media contribute to our perception of reality (including risks and disasters) through selection and omission of information. For example the UK government reassurance campaign contributed to spread the mad cow disease, which resulted in millions of animals being destroyed and the deaths of 226 people. Furthermore, humans respond more forcefully to emotional appeals than to facts like in the case of the Indian Tsunami earthquake (2004): images and stories from tourists and the extreme language used by the media led to a higher donors' response compared to other disasters with more victims.

(286 articles over five months) in comparison to the Seine River flood (761 articles over five months), even though the first flood took a huge toll on human life with 20 deaths. This is probably due to the higher newsworthiness that events in the French capital have in comparison to those occurring in the rest of the country. Another reason is that the economic risks related to a flood event in Paris region are extremely high (OECD, 2014). In fact, it is a densely populated area that represents a third of the national economy. where company headquarters, national and international institutions are located; Furthermore, it is an important transportation node and one of the first tourist destinations in the world.

As mentioned above, the press select and prioritise the news items, hence it defines the prominent topics and their organisation in thematic clusters. In this way, editors and journalists obviously influence the public perception of an extreme weather event, even though a two-way relationship exists between the press and the audience. This bond has been progressively fading since access to information has hugely increased in terms of variety and quantity. This trend is the consequence of different factors, among others the development of public relations by non-journalistic organisations and the pervasive role of the Web sphere (Bucchi, 2013; Trench, 2008). In this context, a corpus of texts published on a social media deserves to be analysed and compared to the press article corpora. In this way, it is possible to gain insight into the public perception of a flood event, beyond the borders of the journalistic arena. The third dataset analysed in this chapter is a corpus of tweets covering to the Seine River of June 2016. The choice to focus on Twitter is due to its increasing important role during natural disasters, as mentioned in Sect. 6.1.

6.3 Press coverage of Seine River flood in 2016

A corpus of 761 articles were first selected through Europresse archives on the basis of the following criteria: French press articles published from 15/05/2016 to 15/10/2016, with a title including the terms ‘crue’ or ‘inond*’ and ‘Seine’ or ‘Ile-de-France’ or ‘Paris’ or ‘Région Parisienne’. In this way we obtained a selection of articles in which the main topic was the 2016 Seine River flood. The corpus was then analysed through the open source software Gargantext.

6.3.1 Aggregated analysis

A first histogram was created to illustrate the intensity of press coverage in terms of the number of terms per day and how it evolved over one month (see Fig. 6.1 a). Due to a very high inflow of publications in few days, the information in Fig. 6.1a is presented in a semi-log plot to make the information clearer. The press coverage peak was reached on the 3rd of June 2016: on the same day the Seine River discharge was highest.

The following step of the analysis consisted in selecting terms that correspond to a range of 'flood risk management solutions' (see Table 6.1). 'Flood risk management solutions' is understood here in a large sense, as any kind of solution that is implemented to reduce flood damages. 316 key terms have been extracted from two corpora of articles: the corpus of articles covering the 2016 Seine River flood and the corpus of articles covering the 2015 Côte d'Azur flood. For each corpus, a first list was automatically established by Gargantext algorithms. These lists were then manually refined on the basis of the relevance of each term (as a solution aimed to cope with a flood event) and finally merged. The resulting list was used to analyse the occurrence and co-occurrence of the key terms in each corpus, except for the terms with less than five occurrences that were not considered in order to highlight the most frequent terms.

As shown in Fig. 6.1a, the key terms list was used to compare the total number of terms per day with the number of key terms per day referring to the topic of flood risk management solutions. The comparison between the overall corpus with the sub-group of key terms (referring to flood risk management solutions) was necessary to monitor how the quality of the contents evolved over time. The portion of flood risk management solutions key terms varies between 0% and 10%. Further insights can be obtained through a comparison with other histograms, based on different corpora of texts. Figure 6.1b shows a similar histogram based on press articles covering the 2018 Seine River flood (21/01/2018–20/02/2018). In this case, the portion of key terms referring to flood risk management solutions is reduced, since it varies between 0% and 5%. A comparison with two other corpora (a corpus of articles covering a flood event in a different location and a corpus of tweets) will be presented in the next sections.

FIGURE 6.1. Comparison between the total number of terms per day (light-blue) and the number of terms per day referring to flood risk management solutions (dark-blue) in a semi-log plot. The histograms are based on four different text corpora: press articles on the 2016 Seine River flood for Fig. 6.1.a, press articles on the 2018 Seine River flood for Fig. 6.1.b, tweets on the 2016 Seine River flood for Fig. 6.1.c, press articles on the Alpes-Maritimes flood for Fig.6.1.d.

Table 6.2: Key terms related to flood risk management solutions. The terms were extracted from the articles on the 2016 Seine River flood and the 2015 Côte d'Azur flood. The list was automatically created by Gargantext algorithms. Afterwards it was manually refined on the basis of the relevance of the terms.

KEY TERMS RELATED TO FLOOD RISK MANAGEMENT SOLUTIONS
adaptation, adapter, adapté, adaptations, adaptées, alerte, alertes, alerte générale crue, alerte orange, alertes orange, vigilance orange, alerter, alerte rouge, anticiper, assurance, assuré, assurée, assurés, assurances, barrages, barrage, barrer, barrer l'accès, barrières, barrières étanches, barrière, barrières en inox, aquabarrières, aquabarrière, aqua-barrière, aqua-barrières, barrières anti-crue, bassin de rétention, bassins de rétention, bassins d'orage, casier, expérimental, casiers, réservoir, casier, réservoirs, réservoir, casier-pilote, batardeaux, batardeau, bulletin, bulletins, capteurs, stations de mesures, courantomètres hydroacoustiques, équipements de mesure, courantomètres hydroacoustiques, station hydrométrique, capteur, cellule de crise, centrale de crise, constat, constats, coupés, coupez, coupées, coupée, barrées, coupé, culture du risqué, débat public, dépanneuses, dépanneuse, désimperméabilisation, désimperméabilisations, végétalisation, diagnostics, diagnostic, digues, digue, données, dons, écluse, écluses, école fermée, écoles fermées, entretien des cours d'eau, espaces verts, espace vert, estimations, estimation, état de catastrophe naturelle, cat nat, plan d'aide, solidarité financière, dispositifs de soutien, classement en catastrophe naturelle, fonds d'indemnisation des catastrophes naturelles, garantie de catastrophe naturelle, procédure de catastrophe naturelle, système de solidarité, fonds de solidarité, étude, études, évacuation, évacuations, évacuées, évacuer, évacuation préventive, évacuations préventives, évaluent, évaluation, évalue, évaluations, fonds exceptionnel de soutien, former, gestion des milieux aquatiques et prévention des inondations, hébergement, hébergées, centre d'hébergement d'urgence, centre d'accueil, centres d'hébergement d'urgence, refuge, héberger, relogées, relogés, relogée, relogé, structures d'accueil, héberge, hébergements, relogement, information, informés, renseignements, informée, informer, informations, informé, interdiction, interdite, interdictions, interdit, interrompu, suspension totale, arrêtés, interrompue, arête, interrompus, arrêté, la bassée, bassée, lacs réservoirs, lacs-réservoirs, lacs de rétention, lacs de stockage, lac-réservoir, retenues des grands lacs, lacréservoir, lacs de retenue, lac réservoir, lacs artificiels, quatre grands lacs, lacs-réservoir, lidar, mémoire, mémoires, mesure de sécurité, consignes de sécurité, règles générales de sécurité, mesures préventives, mesure préventive, mettre en sécurité, mis en sécurité, mise en sécurité, modélisation, modèles, modéliser, murer, obturer, muret, murettes, murets, nouvelles zones endiguées, nouvel ouvrage, oeuvres stockées, parpaings, plan communal, plan communal de sauvegarde, pcs, plans communaux, plans communaux de sauvegarde, plan crue, plans de prévention, plans de prévention des risques, plan de prévention, dispositifs de prévention, plans de préventions des risques naturels, plans de préventions du risque d'inondations, ppr, pprn, stratégies de prévention, programmes d'actions de prévention des inondations, plans de prévention du risque inondation, ppri, plans de protection, plan de protection, plaques, pompes, pompes de relevage, pompage, pompe, pompant, possibles évacuations, précaution, précautions, première zone pilote, préparation, préparer, préparatifs, préparés, prévenir, prévention, préventive, préventives, titre préventif, prévisions, prévoit, prévision, prévoir, prise de conscience, prendre conscience, conscientiser, conscientisation, protection, protections, recherche, recherches, reconstruction, régulation, régulateur, relevés, relevé, relevés automatiques, mesures de débit, renforcer, renforcé, renfort, renforts, réparations, reconstruire, réhabilitation, réparation, repères, repère, restrictions, restriction, retour d'expérience, sauvetage, sauvetages, scénario, secouru, secourue, sécuriser, sensibilisation, réveillé les consciences, sensibilisations, conscience du risque, sensibilisant, service de prévention vigicrues, simulation, simulateur, simulations, site vigiecrues, solidarité, solidaires, solidarités, solution technique, soutien financier, financer, aides financières, fonds, rembourser, indemnisés, indemniser, fonds d'urgence, subventions, dédommagements, remboursements, indemnisations, moyens financiers, fond, financement, indemnisation, remboursement, dédommager, indemnisé, crédit, aide financière, subvention, financements, finances, indemnisées, stocker, stockages, stockage, stockant, suivi, surveillance, surveillances, surveiller, surveille, surveillée, vanne, vannes, vigicrues, vigicrue, vigiecrues, vigilance jaune, vigilance rouge, volets en acier

6.3.2 Graph representation

After analysing the key terms frequency in an aggregated manner, the second step of the analysis was aimed at representing a socio-semantic network. Graph representation can be used to detect the connections that exist among different topics, public figures and organisations. An adjusted version of the terms list, referring to flood risk management solutions, was used to compute it. Indeed, new key terms corresponding to public figures and organisations, involved in flood risk management, as well as affected infrastructure and properties were added to the initial list. Furthermore, synonyms ('habitants' and 'riverains'), declensions of terms (e.g. 'scientifique' and 'scientifiques') and equivalent

forms (e.g. 'Établissement Public Seine Grands Lacs' and 'EPTB Seine Grands Lacs') were merged. Once the terms list was refined, a graph with 254 nodes and 445 edges (Fig. 6.2) was generated on the basis of the semantic proximity measure called conditional distance, i.e. the probability that two terms co-occur in the same document. The node degree measures the number of node edges, in other words, how many other key terms (or nodes) each key term (or node) co-occurs with. Each subset or 'cluster' corresponds to a group of key topics and key actors that frequently appear in the same article. With Gargantext it is possible to zoom in and out the graph, move around, select a node and highlight its connections.

6.3.3 Visual observation of the graph

Similarly to the graph representation presented by Venturini et al. (2014), a first analysis of the results can be based on visual observation of the graph. By navigating the graph, it is possible to observe nodes with high degree, i.e. with many edges, that correspond to flood risk management solutions ('alerte' with 51 connections, 'prise de conscience' with 25 connections, or 'état de catastrophe naturelle' with 29 connections) and organisations (e.g. 'SNCF' with 46 connections or 'Louvre' with 52 connections) or public figures (e.g. 'Manuel Valls' with 33 connections or 'François Hollande' with 26 connections). Graph navigation is also helpful to examine which topics and actors are associated together (e.g. 'Métropole du Grand Paris' and 'désimpérméabilisation' co-occur), and which organisations and public figures assemble in clusters of stakeholders (for instance 'Ségolène Royal', 'Ministère de l'Environnement', 'Bruno Janet'–Head of modelling centre at Vigicrues–and 'IRSTEA'). By zooming out to visualise the entire Graph (Fig. 6.2), it is possible to identify six main subsets that correspond to six clusters of debate topics and actors. Each cluster is assumed to be associated with a macro-theme, i.e. an expression that sums up to which resilience management area the key terms, included in the same cluster, refer to. The colour of the cluster is automatically defined by Gargantext algorithm, while we chose the name of each macro-theme:

1. The green macro-theme *Monitoring system* that brings together topics such as 'sensors', 'data', 'modelling', 'observation', 'estimates', 'possible underestimations', as well as actors that include national authorities (the French Ministry of the Environment, the Minister of the Environment, Vigicrues) and researchers (IRSTEA, Vazken Andreassian).

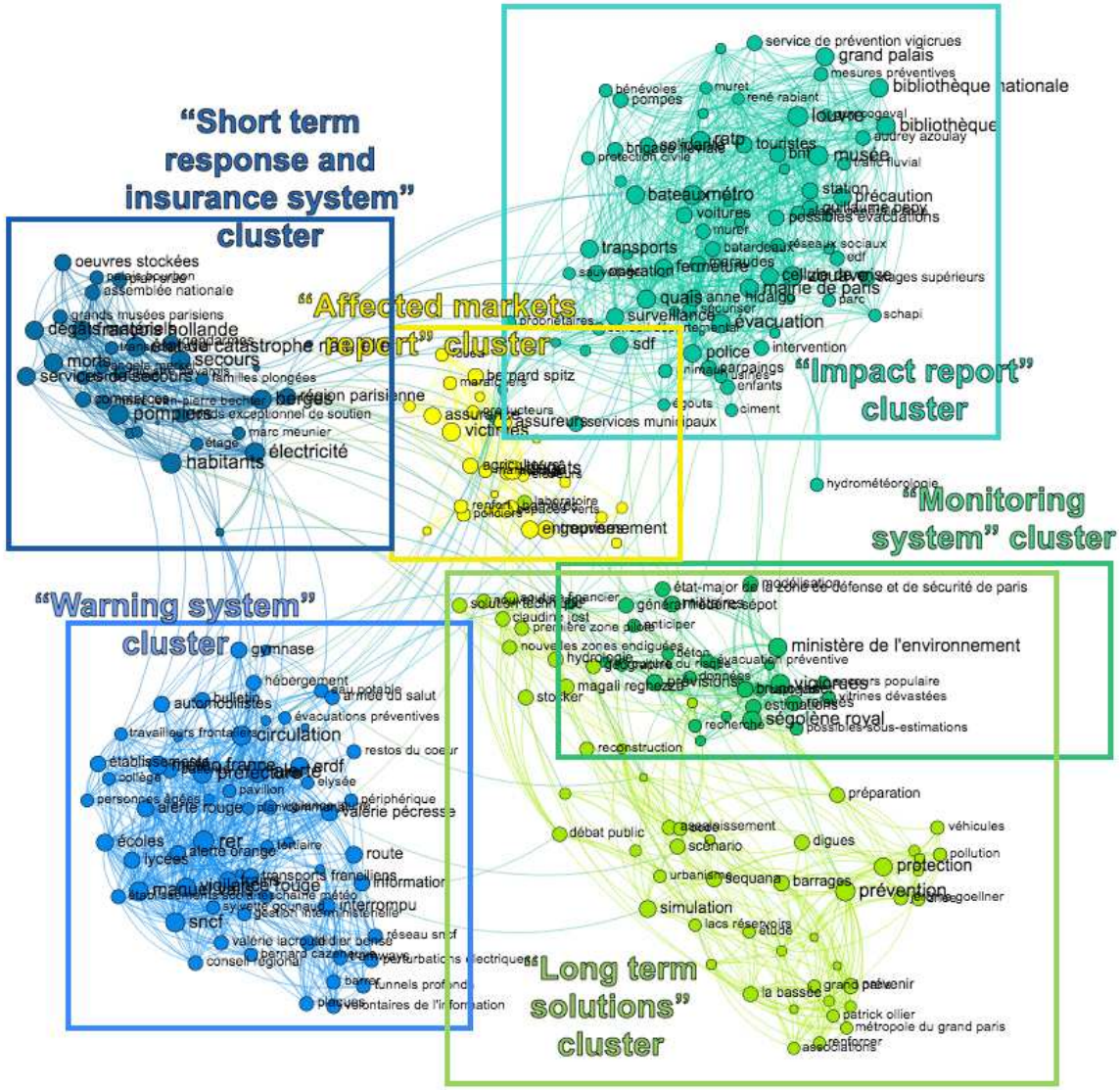


FIGURE 6.2. Graph representation of the press articles on the 2016 Seine River flood: co-occurrence graph computed on the basis of the measure of conditional proximity between the terms listed in Suppl.2 (Vicari, 2019) and extracted from the corpus of press articles.

2. The light-blue macro-theme *Warning system* that covers key terms such as 'red vigilance', 'warning', 'information', 'municipal plan', 'shelter', 'traffic' and actors, including government representatives (the French Minister of the Interior, the Prime Minister), a law enforcement institution (Préfecture), a transport company (SNCF), the national meteorological service (Météo France), an electric utility company (ERDF), vulnerable population (elderly people).

3. The turquoise macro-theme *Impact report* that gathers topics such as 'rescue', 'closure' or 'evacuation' of the 'museum', 'station', 'hospitals', 'transports", 'boats', 'cars', 'electric network', 'zouave' and actors such as local authorities (the Mayor of Paris, Departmental Council), cultural institutions ('Louvre', 'Grand Palais", National French Library), rescue services ('police', 'volunteers', 'civil protection", 'René Rabiant'), affected population ('tourists', 'tenants').

4. The dark-blue macro-theme *Short term response and insurance system* that brings together 'state of natural emergency', 'fire brigade', 'rescue services', 'stored art works', 'François Hollande", 'the National Assembly', 'inhabitants'.

5. The yellow macro-theme *Affected markets report* with topics like 'damages', 'repair', 'farms', 'agricultural holdings', 'companies', 'market gardening', 'insurance', 'diagnosis' and actors that include the victims ('farmers', 'producers', 'victims', 'ship owners'), organisations representing them ('farmers' union') and insurers ('Bernard Spitz');

6. The light-green macro-theme *Long term solutions* includes topics like 'awareness raising', 'prevention', 'soil sealing reduction', 'La Bassée pilot project', 'memory', 'preparation', 'first pilot area', 'new structure', 'public debate', 'retention basin', 'reinforce', 'simulation'; and actors such as local authorities ('Regional Department of Environment and Energy', 'Métropole du Grand Paris', 'associations', 'public territorial agencies', the mayors of Saint-Maur-des-Fossés and Rueil-Malmaison, the Hydrology Director at the Public Agency of the Seine Grands Lacs Basin).

6.3.4 Quantitative analysis of the nodes and the edges

Further information on the graph can be obtained through a quantitative analysis: the values corresponding to the node degrees and to the edge weights can be easily extracted through Gephi (an open source graph visualisation software, gephi.com). As it is shown in Fig. 6.3, the nodes with the highest degree (>30) concern warning and emergency

management, especially management of public infrastructure, indeed they are located in the two biggest clusters (the light-blue cluster and the turquoise cluster). For instance, the node with the highest degree is 'RER' (the Paris region commuter rail service) with 55 connections. Concerning the actors, law enforcement and rescue services are among the nodes with the highest degree. These values are necessary but not sufficient for a accurate analysis of the role played by these actors and topics in the debate. For instance, two nodes with the same degree can have a different impact if one is connected only locally (in the same cluster) and the other one is connected globally. Nevertheless, we can suppose that the press focused on the immediate flood impacts, affecting a relevant portion of the population in their daily life. A detailed analysis of other measures that characterise graphs, such as the centrality measure, would be necessary to confirm this hypothesis.

In Fig. 6.4 the most probable co-occurrences (i.e. the highest edge weights) are identified with the label of the corresponding couple of nodes. The figure highlights which terms tend to be paired: terms that concern the same risk management field (e.g. rescue services); terms that concern the same area of affected activities (agriculture or transports); terms that concern infrastructure located in the same flood-prone area; two terms that refer to an action and the object to which this action is directed (e.g. 'clubs' and 'closing') or a subject and an action performed by it (e.g. 'trains' and 'normally circulating').

6.4 Press coverage of the Côte d'Azur flood in 2015

286 articles were extracted through Europresse. We used the following criteria in the selection: French press articles from 15/09/2015 to 15/02/2015, with a title including the terms 'crue' or 'inond*' and a reference to at least one of the locations affected by the flood[3].

[3]The titles of the articles selected for the second case study have a title referring to at least one of the following locations: The titles of the articles selected for the second case study have a title referring to at least one of the following locations: 'Alpes-Maritimes' or 'Cannes' or 'Antibes' or 'Vallauris' or 'Biot' or 'Mandelieu-la-Napoule' or 'Bouches-du-Rhône' or 'Var' or 'Vaucluse' or 'Drôme' or 'Siagne' or 'Brague' or 'Fréjus' or 'Reyran' or 'Vallauris-Golfe-Juan' or 'Cagnes-sur-Mer' or 'Le Cannet Mougins' or 'Nice' or 'Roquefort-les-Pins' or 'La Roquette-sur- Siagne' or 'Théoule-sur-Mer' or 'Valbonne' or 'Villeneuve-Loubet' or 'Les Arcs' or 'Brignoles' or 'Cabasse' or 'Callas' or 'Camps-la-Source' or 'Flassans-sur-Issole' or 'Côte d'Azur' or 'sud-est' or 'Flayosc' or 'Forcalqueiret' or 'Fréjus' or 'Méounes-lès-Montrieux' or 'La Motte' or 'Néoules' or 'Puget-sur-Argens' or 'La Roquebrussanne' or 'Saint-Antonin-du-Var' or 'Saint-Raphaël' or 'Le Thoronet' or 'Trans-en-Provence'.

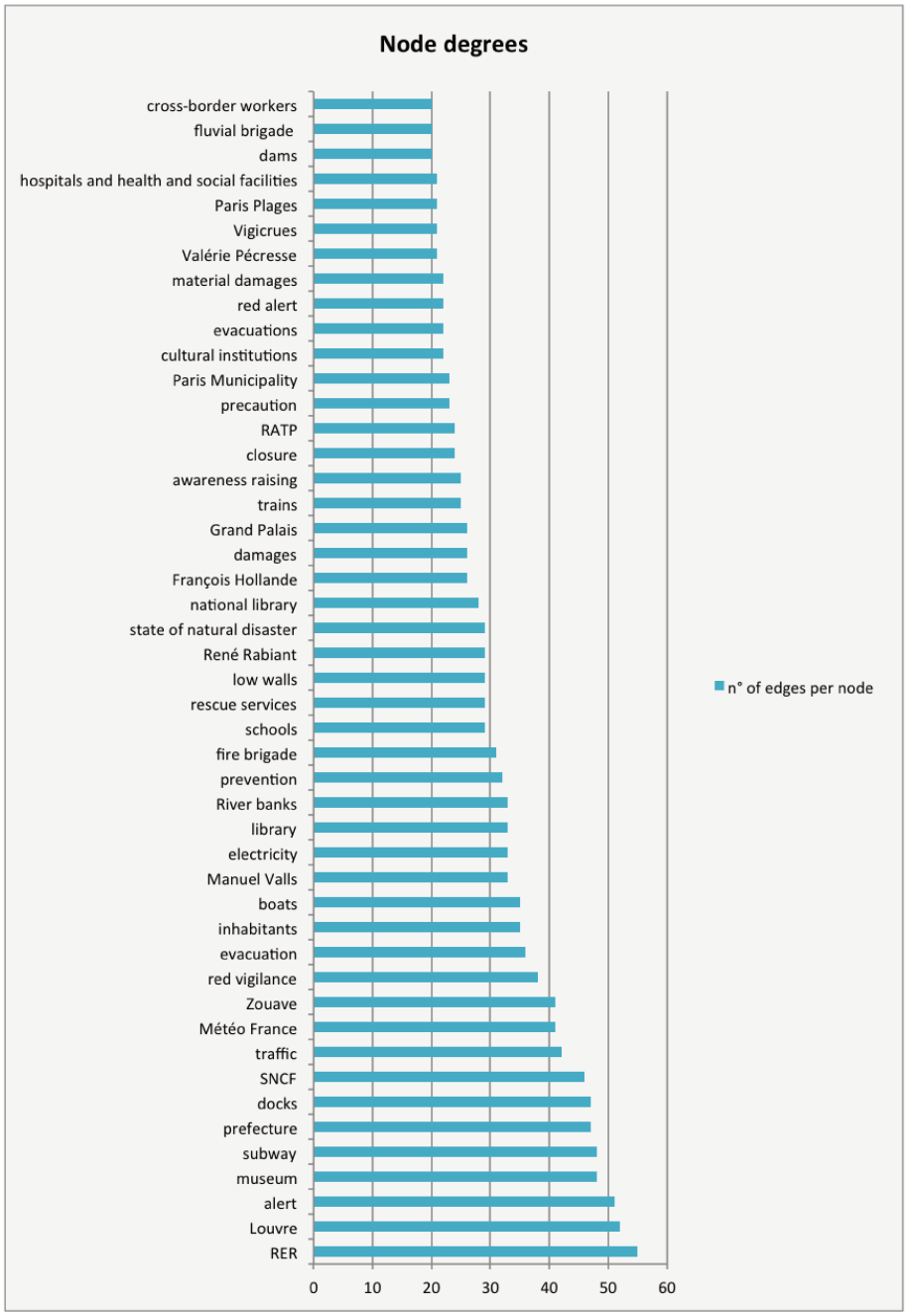


FIGURE 6.3. The key terms corresponding to the nodes of the graph with the highest degree. The graph representation is based on a corpus of press articles on the 2016 Seine River flood: it was computed on the basis of the measure of conditional proximity between the terms listed in Suppl.2 (Vicari, 2019) and extracted from the corpus of press articles on the 2016 Seine River flood.

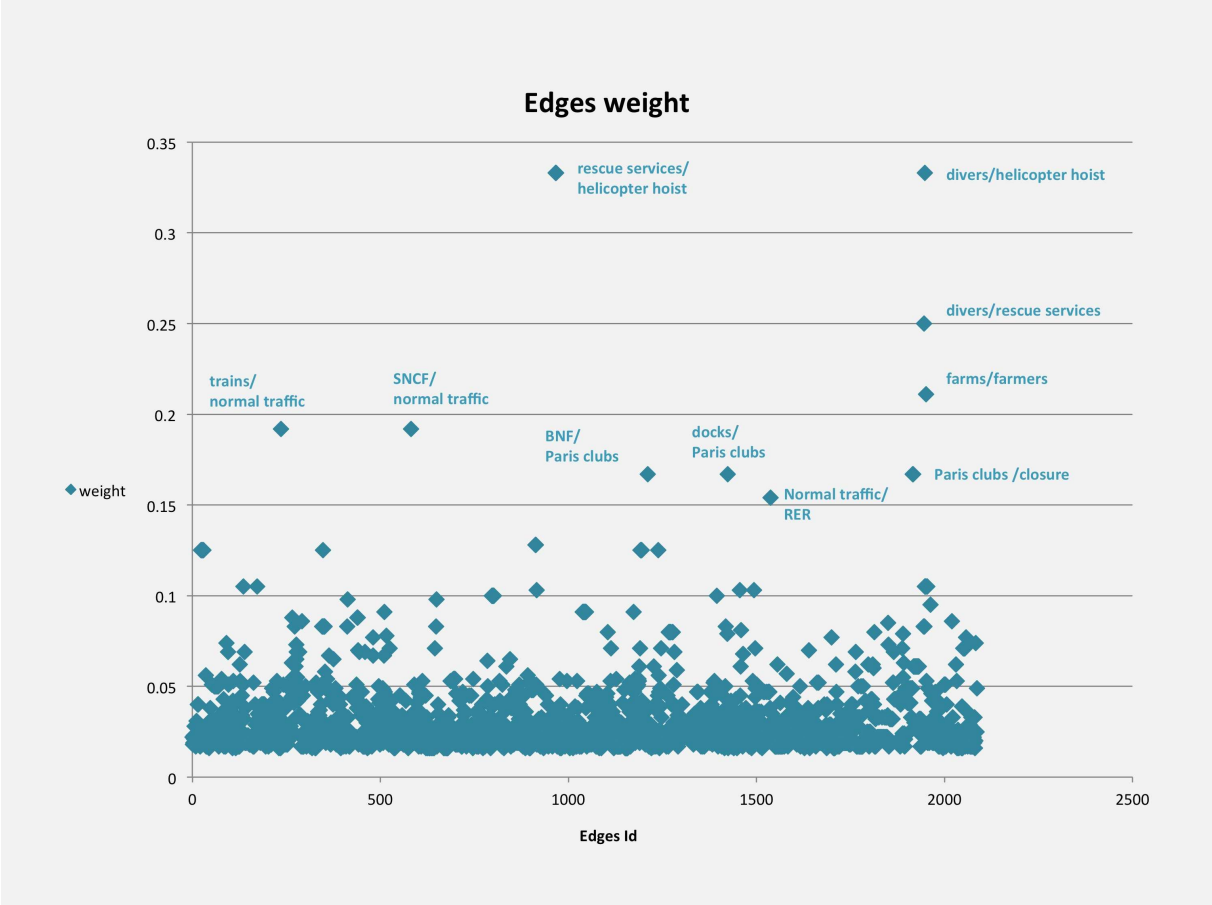


FIGURE 6.4. The most probable pairs of key terms corresponding to the edges with the highest weight in the graph. The graph is based on a corpus of press articles on the 2016 Seine River flood and on key terms listed in Suppl.2 (Vicari, 2019).

6.4.1 Aggregated analysis

Since the total amount of articles for this case study is smaller, the peak of published terms per day (see Fig. 6.1d) is obviously reduced (108 articles on the 4th of October, corresponding to 14772 terms). As shown in Fig. 6.1d, after the maximum peak (on the 4th of October), the number of terms per day decreases less progressively than in the Paris case studies (Fig.6.1a, 6.1b). This characteristic of the curve can be explained by the limited media visibility of the region, another reason might be a different evolution of the river flow (a very slow decrease of water levels in the case of the Seine River). A peculiarity in Fig. 6.1d is that there are two small peaks on the 12th of October (with the news of two rescued persons and two victims) and then on the 28th of October (with the

news of the mayor of Cannes calling for help to the movie celebrities).

In order to assess the visibility that was given to the debate on flood risk management solutions, the term list (formerly created) was used to identify a subset in the second corpus (Fig. 6.1d). As in the previous experiment, terms with less than five occurrences were excluded. The portion of terms referring to flood risk management solutions varies from 0% to 9%, which is close to the percentages of the first case study.

6.4.2 Graph representation and visual observation

In a second stage, the key term list was enriched with terms corresponding to public figures and organisations, affected infrastructure and properties. After merging synonyms, declensions of terms and equivalent forms, the list of key terms was used to generate a co-occurrence graph, based on conditional proximity between terms, (Fig. 6.5) with 104 nodes and 676 edges. Because of the smaller key terms occurrence, the graph includes a reduced number of nodes and edges. However, it is still possible to identify four macro-themes:

- A turquoise subset of terms referring to the macro-theme *Emergency management*.
- A green subset of terms related to the macro-theme *Monitoring system and prevention*.
- A light-blue subset of terms related to the macro-theme *Reconstruction*;
- A violet subset of terms related the macro-theme *Impact record*.

Except for the macro-theme 'Impact record', the other themes are not equivalent to those identified in the first graph. This is indicative of a certain variability between different cases of flooding, in terms of the resilience levers that get the press attention.

6.4.3 Quantitative analysis of the nodes and the edges

The nodes with the highest degree (Fig. 6.6) correspond to the terms 'deaths', 'missing' and 'victims' and to the following actors: the government (including the Prime Minister and the French president), the inhabitants, the rescue services (the volunteers, the police, the fire brigade), Cannes mayor, celebrities and insurers. We can suppose that the high number of victims led the media attention to the affected populations and to those actors

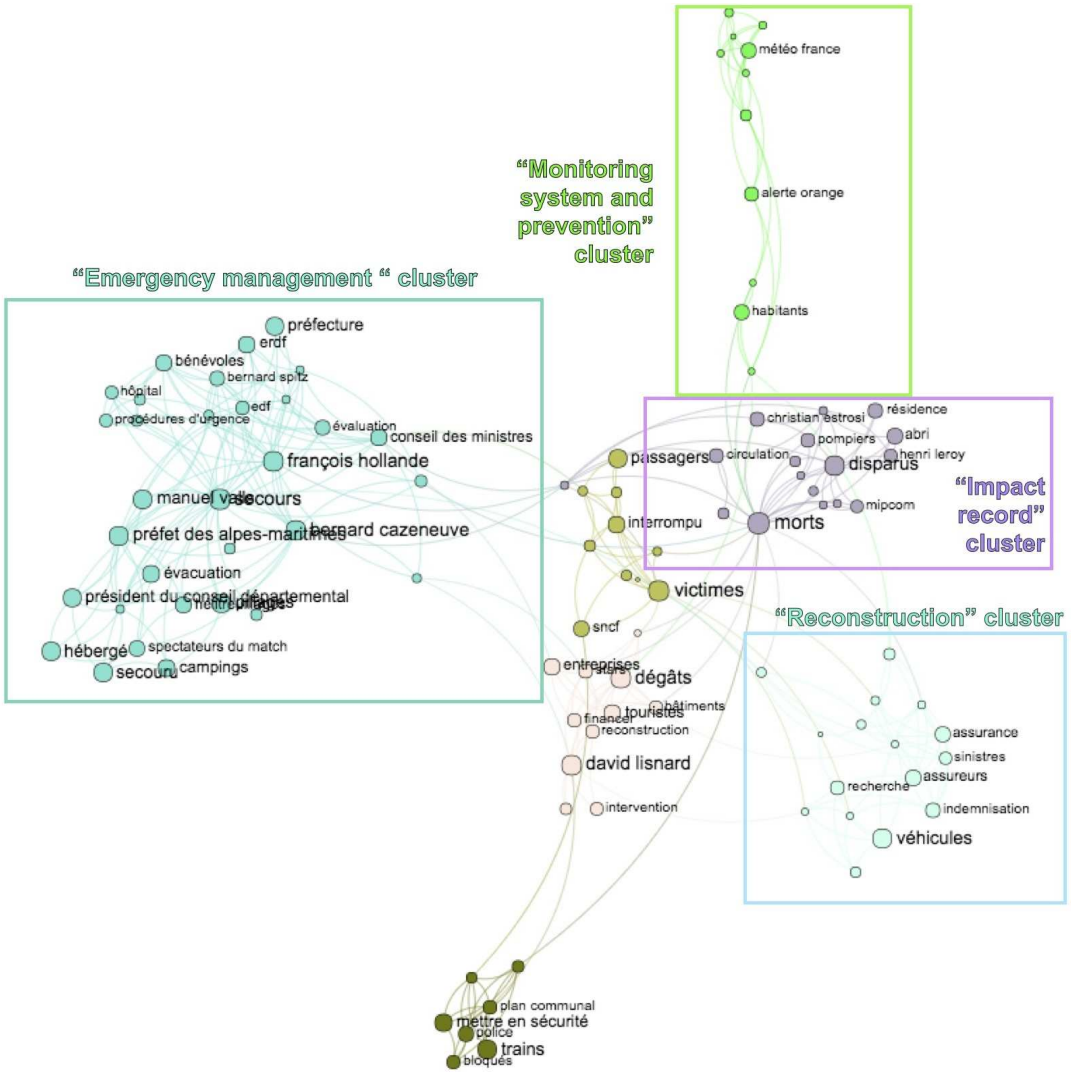


FIGURE 6.5. Graph representation of the press articles on the 2015 flood in Côte d'Azur: co-occurrence graph computed on the basis of the measure of conditional proximity between the terms listed in Suppl.6 (Vicari, 2019) and extracted from the corpus of press articles.

who were involved in rescue and compensation payment. National institutions were involved in allowing the necessary procedures to attract funding for the reconstruction; furthermore, government representatives spoke to the press in commemoration of the victims. The Mayor of Cannes, David Lisnard, was also in the media spotlight, when he asked to the film stars to financially support his city.

The values corresponding to the edges weight (Fig. 6.7) show that the most probable co-occurrences have some similarities with the trends described in the previous case study: some couple of terms concern the same area of flood resilience management (such as forecasts, impact report, awareness raising and prevention or compensations for the victims); other couples of terms can be identified as actions and related objects (e.g. an event cancellation). Two actors that are frequently coupled are CNRS and Météo France: indeed both organisations are mentioned as partners of HyMeX (a project on understanding, quantifying and modelling the hydrological cycle in the Mediterranean). Furthermore, experts from these two organisations received considerable media attention in relation to debate on the flood causes (climate evolution and urbanisation) and on how flood resilience can be enhanced through more accurate forecasts. Other researchers from IRSTEA and University of Avignon were questioned by the press about the importance of awareness raising (‘sensibilisation’).

6.5 Twitter coverage of the Seine River flood in 2016

6.5.1 Extraction of the dataset

The corpus of tweets covering the Seine River flood of June 2016 was extracted through ‘Twitter Advanced Search’ (twitter.com/search- advanced). The selection criteria were a time span (from 28/05/2016 to 2/7/2016) and relevant hashtags (‘#crue’ or ‘#crueparis’ and ‘#crueseine’ or ‘#inondation’ or ‘#inondations’ or ‘#pluies’ or ‘#Seine’). As it is suggested by Bruns and Liang (2012), if only hashtagged tweets are captured it is possible to focus on those tweets where key terms related to a flood are marked as important information. Geo-location wasn’t used as a criterion because the sample of tweets would had been very small: few users provide such detail with their tweet (Bruns et Liang, 2012). The corpus was then refined by deleting duplicates. In order to facilitate a comparison with the previous corpora, the tweets that mentioned locations outside the Paris region were deleted as well. As a result, the final corpus included 7984 tweets.

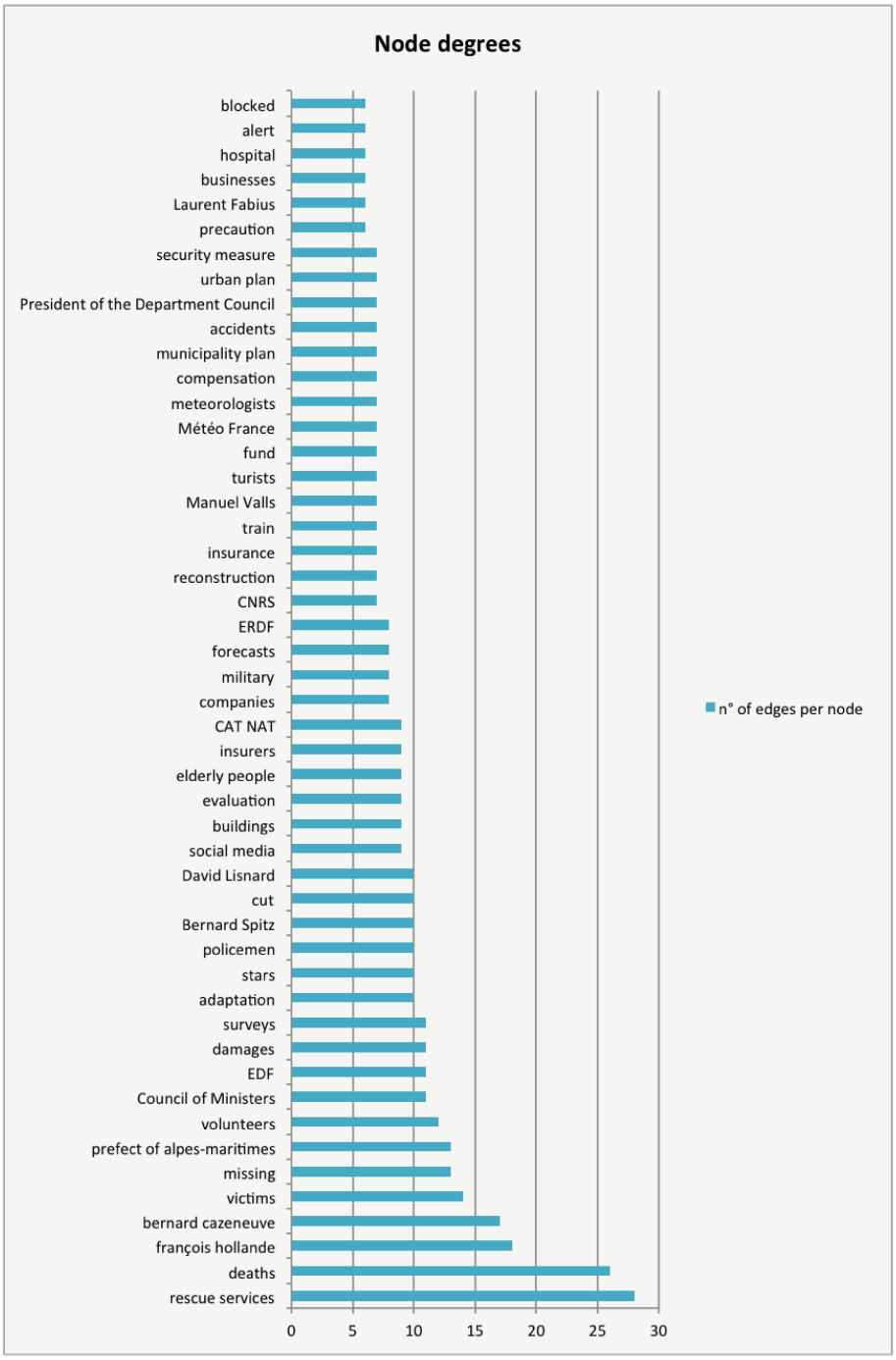


FIGURE 6.6. The key terms corresponding to the nodes with the highest degrees in the graph. The graph representation is based on a corpus of press articles on the 2015 Côte d'Azur flood: it was computed on the basis of the measure of conditional proximity between the terms listed in Suppl.6 (Vicari, 2019) and extracted from the corpus of press articles.

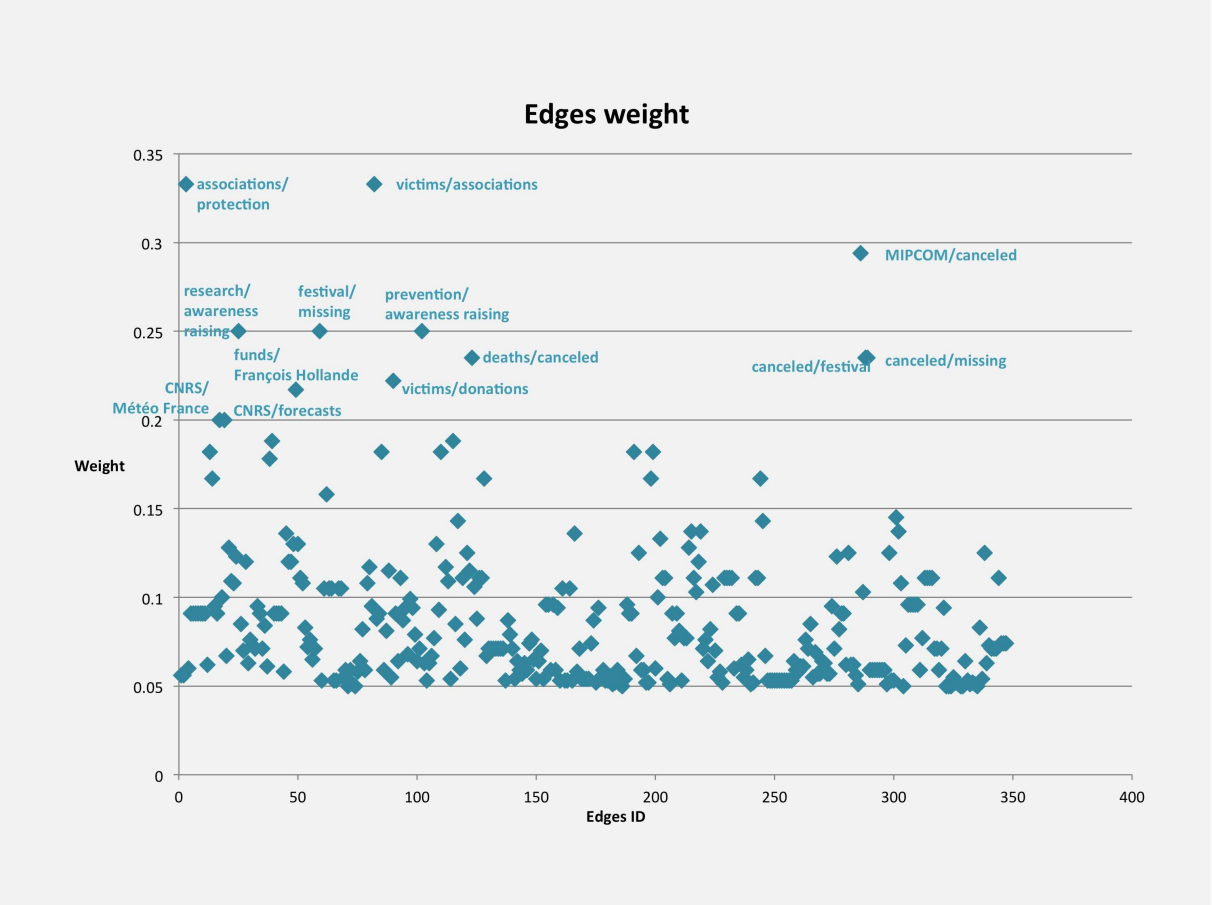


FIGURE 6.7. The most probable co-occurrences corresponding to the edges with the highest weight in the graph. The graph is based on a corpus of press articles on the 2015 Côte d'Azur flood and on key terms listed in Suppl.6 (Vicari, 2019).

As in the previous case studies, an aggregated analysis of the sample of tweets was carried out with Gargantext: Figure 6.1c highlights that a term peak occurred on the 3rd of June 2016 when the Seine River discharge was highest. Like in the case of the press coverage of the Seine River flood, a correlation exists between the social representation of a meteorological event and its physical environmental impact. However it should be noticed that the maximum peak is not significant as in the histograms based on the press corpora.

6.5.2 Aggregated analysis

A list of terms related to flood risk management solutions enabled us to observe that a minority of terms referred to these solutions. The list (first row in Table 6.2) was established on the basis of the previous term list and relevant new terms that are specific to Twitter jargon and also include English terms. The dark-blue columns in Fig. 6.1c represent the portion of terms referring to flood risk management solutions that varies between 0% and 3.5% of the total number of terms published per day. The occurrence of key terms was so limited that it was not possible to represent a significant graph, even after extracting terms referring to stakeholders and affected infrastructure. Indeed, the majority of tweets included in the corpus only describe the flood event and its impact. This is due to the limited numbers of characters that are allowed for each tweet (up to 140 in 2016) and that make the information essential, unless the tweet includes a link to an external webpage (the contents of which can't be automatically analysed through Gargantext). Twitter indeed is conducive to a fragmented communication.

Even if the thematic patterns of tweets cannot be represented through a graph, we can push forward an aggregated analysis. We can identify thematic groups of key terms (Table 6.2) and their frequency as it was done by Vieweg et al. (2010). As shown in Fig. 6.8, a major portion of key terms (3143 occurrences) consists in purely factual information, with references to the time and location of the flood event. According to this result, Twitter might be primarily used as a means to disseminate warnings. The category 'flood risk management solutions' (1420 occurrences) includes a relevant portion of key terms, as well as the 'stakeholders' category (1060 occurrences). However, they are less frequent than terms describing the weather event (1506 occurrences) and its impact (1644 occurrences). On the contrary, the debate on the causes (72 occurrences) and risks (320 occurrences) is of little account.

6.5.3 Users' profile and behaviour

Besides this thematic analysis, the same sample of tweets can be used to investigate the behaviour of its users, their profiles and their interactions. This is the specific added value of social media data. We followed an approach which draws on the maps presented in the Climaps platform[4]. We identified the most active, liked and retweeted users in

[4]'Reading the state of climate change from digital media' (climaps.eu, last access: 05/07/2018): http://disq.us/t/1gj2hci

Table 6.3: Five thematic groups of key terms based on the tweets on the 2016 Seine River flood. The key terms were extracted from the tweet corpus.

THEMATIC GROUP	KEY TERMS EXTRACTED FROM THE CORPUS OF TWEETS
FLOOD RISK MANAGEMENT SOLUTIONS	agents, opération, mobilisés, exercices, nous intervenons, urgent, une aide, soutien, barrage, catastrophenaturelle, cellules de crise, assurances, vigilances, vigilance orange, vigicrue, alert, aides, vigilance rouge, pompiers, vigilance jaune, fonds, police, prévention, sécurité, alerte rouge, secours, surveillance, appel aux dons, évacuation, sont mobilisées, alerte orange, vigilance orange, plouf, urgent, simulation, nous intervenons, catnat, précaution, bénévoles, sauvetage, mobilisation, GEMAPI, réparations, bétons, pcsorsay, catastrophesnaturelles, reconnaissance, travaux, mission, watergate, culture, aloa
MEDIA CONTENT/ SOURCE	photos, périscope, info, photography, images, direct sur, vidéos, photographe, pic, view, news, artwork, streetphotography, cartes, journal, pictures, photooftheday, nofilter, picoftheday, faitsdivers, longexposure @ paris, photography HTTPS, latergram, une image, infographie, actu, communiqué, msgu, vidéo, blog, dessin, qag, rediff, hashtag, www.youtube.com/watch, sky, Flickr, afp, nouvellerepublique, BFMTV, FRANCE2, septahuit, facebook
TIME/ LOCATION	matin, cet après-midi, week, hier soir, lundi, yesterday, tomorrow, Sunday, spring, départements, Nemours, communes, Essonne, city, Alma, Juvisy, Yvelines, IDF, Bercy, Europe, Montargis, Marne, Melun, ville, Poissy, régions, Chatou, Austerlitz, Puteaux, Val-de-Marne, Pontneuf, Boulogne-Billancourt, Seine-et-Marne, Longjumeau, Hauts-de-Seine, pont Mirabeau, Bièvre, Courbevoie, pont Alexandre iii, Issy, cité, Jatte, Neuilly, Eiffel, Bastille, îles, Concorde, village, Palais de Justice, sites, Paname, quai de Seine, Yerres, Bougival, Île Saint-Louis, Île de la Cité, grigny, campagne, Louvre, pont de l'Alma, suresnes, Georges Pompidou, Reuil, pont Mirabeau, Alfortville, Asnières, Notre-Dame, cathédral, Notre-Dame, Notre Dame, paris plage, Orsay, tunnel, château, park, Lyon, statueofliberty, sur berges, arts
RISK	risque, zone inondable, crue centennale, danger, crue historique, crise est hautement probable, menace, threat, soyez prudent, soyez vigilant
IMPACT	touché, catastrophe, cause, boue, stations, millions d'euros, milliards d'euros, inondée, charges, crise, streets, ports, patrimoine, cars, bateaux, sculptures, difficulté, navigation, débordé, débordements, bilan, sécher, rouvertes, impacts, laseinedeborde, major flood, coupé, bloqué, bridge, sinistrées, circulation, museum, banks, dégâts, tourisme, boats, cultures, victims, rerc, fermées, pollutions, œuvre, trains, maison, mort, agriculture, rue, archives, voitures, stations, transports, collection, bouchons, expo, facture, cars, metro, sinistres, gare, vache, inondés, PIB, concert, assainissement, batobus, immobilier, moustique, restaurant
CAUSES	climatechange, climate, chgt climatique, sous-estimée, sous-estimé, développement urbain
WEATHER EVENTS	décrue, highest level, météo, rain, meteo, record, mesure, hauteurs, unfetter, water levels, level, monte, seine baisse, mètres, décrue, feet, seine level, weather, stabilisation, landmarks, comparaison, meters, ça monte, grêle, averses, déluge, normal levels, niveau, précipitations, zouave, nasa, évolution, cumul
OTHER NEWS	loitravail, grève, grevessncf, nonddl, grèves, attentats, Brexit, manif, migrants, CGT, nuitdebout
EMOTIONAL CONTENT/ HUMOUR	parisjetaime, thankful,love, courage, impressionnant, fluctuatnecmergitur, hope, pariswelovеyou, parismaville, merci à, une pensée, bottes, humour, swim, uber, insolite, pigeon, venise,lol
STAKEHOLDERS	hidalgo, particuliers, habitants, conseil, masson delmotte, personnes, mairie, maires, populations, people, particuliers, collectivités, communes concernées, maire, vlacroute, slefoll, Grand-Paris, seveso, conseil des ministres, comité de bassin, SNCF, Parisiens, hollande, Valls, enfants, RATP, entreprises, fraeco, ccr, courtier, clients, tourist, experts, tpe, AFA, IPRG, PME, agriculteurs, Ségolène

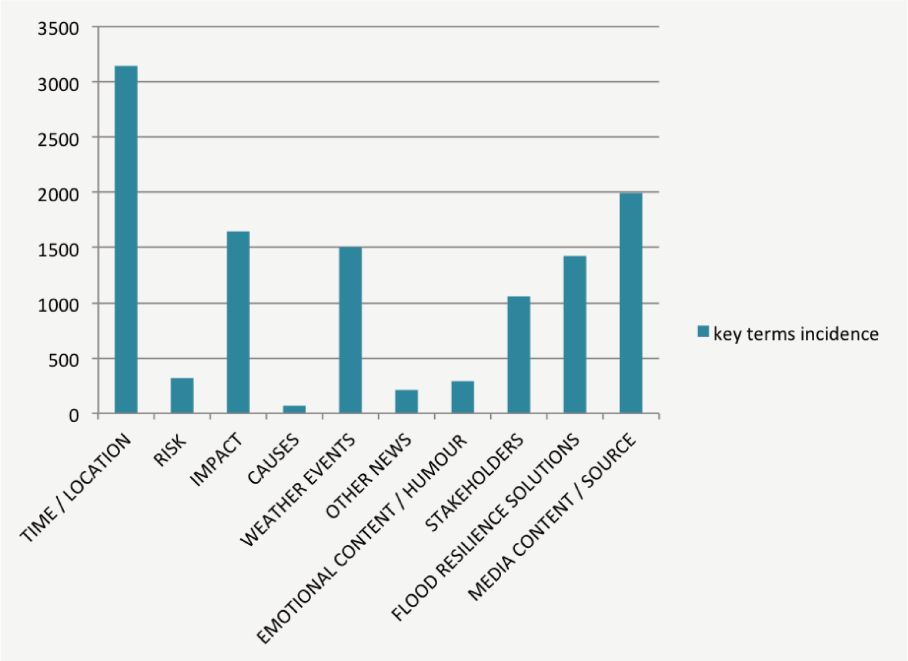


FIGURE 6.8. Twitter coverage of the 2016 Seine River flood: key terms incidence aggregated in ten thematic categories. The key terms were extracted from the tweets corpus.

the sample. We consider as the 'most active users' those accounts that published more than 10 tweets in one month: we counted 59 users with this characteristic. The 'most liked users' are those accounts that received more than 50 likes per tweet in one month: 43 users have this characteristic. We name those accounts that received more than 50 retweets per tweet in one month as the 'most retweeted users': we counted 58 users with this characteristic.

Figure 6.9a highlights that individual Twitter accounts (i.e. accounts that aren't owned by an organisation but by a person) represent a relevant portion of the most active users as well as of the most popular users. Among the most active users, 37% own an individual account. The most liked users are characterised by a majority of individual accounts (65%). The percentage is reduced in the case of the most retweeted users: only 46% of them own an individual account. Hence, with a percentage difference of 19%, tweets from individuals generated less retweets than likes. Twitter followers seem to prefer supporting individual accounts by liking their tweets, while they tend to retweet less frequently–probably only when the tweet content is valuable and worth being relayed.

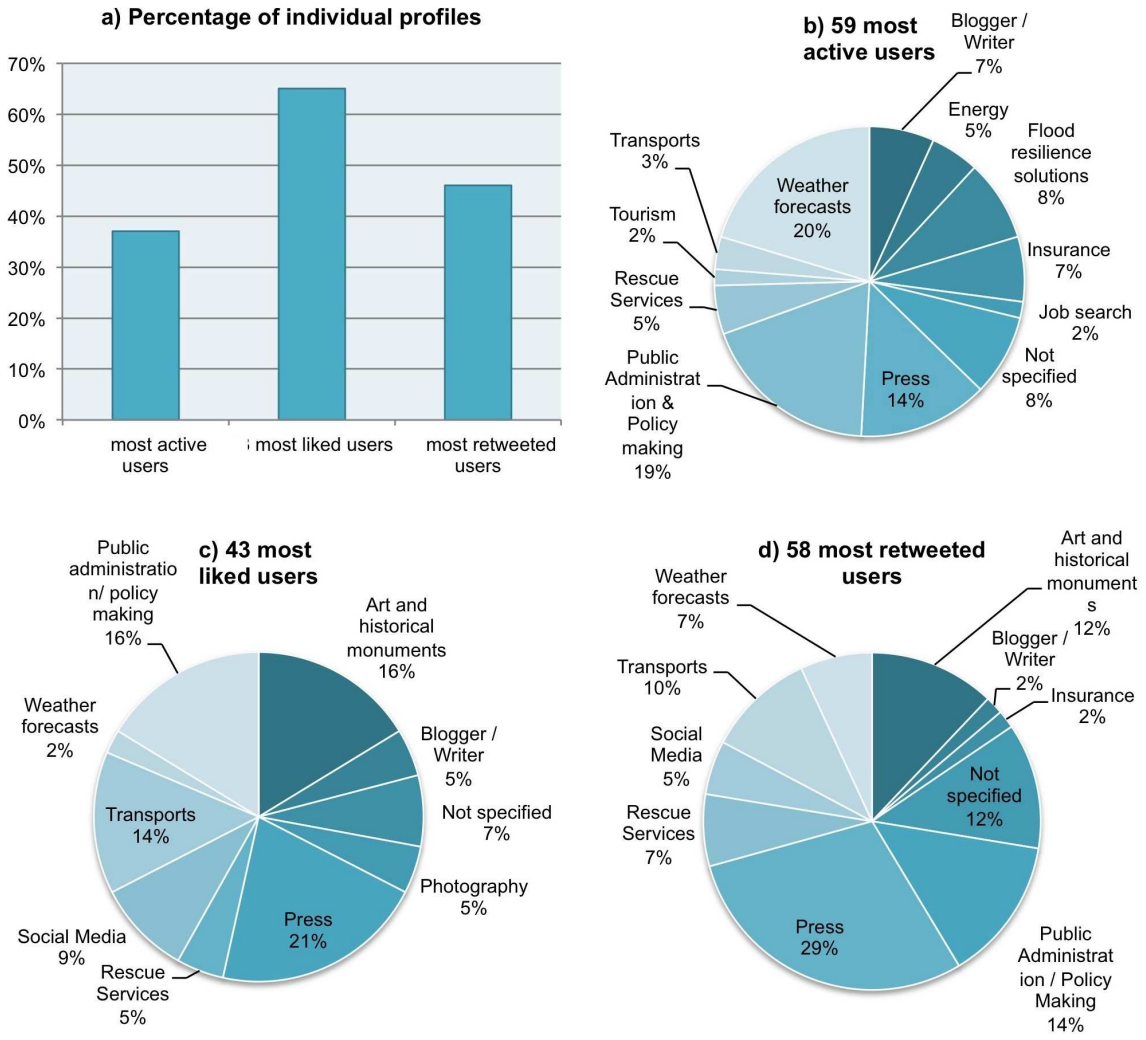


FIGURE 6.9. The users' behaviour (Twitter coverage of the 2016 Seine River flood): (a) percentage of individual profiles; (b) area of activity of the most active users (59 users who published more than 10 tweets in one month); (c) area of activity of the most liked users (43 users who received more than 50 likes per tweet in one month); (d) area of activity of the most retweeted users (58 users who received more than 50 retweets per tweet in one month). These data were extracted from the tweet corpus and completed with information available on Twitter users' profile pages.

Figure 6.9b presents the area of activity of the 59 Twitter users who published at least ten tweets in June 2016 on the topic of the Seine River flood. The activity area of these Twitter users was established on the basis of the description included in their account. The majority of users deal with weather forecasts (20%) or public administration/policy-making (19%), the next biggest area of activity gathers those users who are active in the field of journalism (14%). A first inference can be made on the basis of these percentages: information tweeted by public authorities and policy-makers seems more frequent than information tweeted by rescue services (5%). This marked difference could be explained by the fact that rescue services usually centralise information management.

Figure 6.10 zooms into the first five most active users. It is possible to observe the impact that frequently tweeting has in terms of popularity, i.e. in terms of likes and retweets. By highlighting the mean values and the upper bound[5] values, it is possible to see that retweets and likes follow similar patterns. If the number of likes is high, the number of retweets will probably be high as well.

As shown in Fig. 6.9c the most liked users are journalists (21%), followed by users who operate in the field of public administration/policy-making (16%), art/historical monuments (16%) and transports (14%). The press seems to raise broad interest: in the changing landscape of digital media, the press continues to be considered as a source of reliable information. Public authorities and policy makers are frequently in the social media spotlight, as their views can have direct consequences for the society. The popularity of the accounts related to art/historical monuments and transports is likely due to the fact that Paris region inhabitants, as well as tourists and people travelling across the region, felt strongly affected by the flood impacts on museums and transport infrastructure.

By looking at the areas of activity of the most retweeted accounts in Fig. 6.9d, we can notice similar trends to those presented in Fig. 6.9c: the most relevant segment is the press (29%), followed by public authorities/policy making (14%) and art/historical monuments (12%). The portion of tweets published by users who deal with transports is smaller (10%) than in Fig. 6.9c with a percentage difference of 4%. A small difference that could be explained by the fact that these tweets describe how transport workers

[5]After finding the interquartile range (IQR) and the upper quartile (Q3), the upper bound is calculated with the following formula : Upper bound = Q3+1.5*IQR.

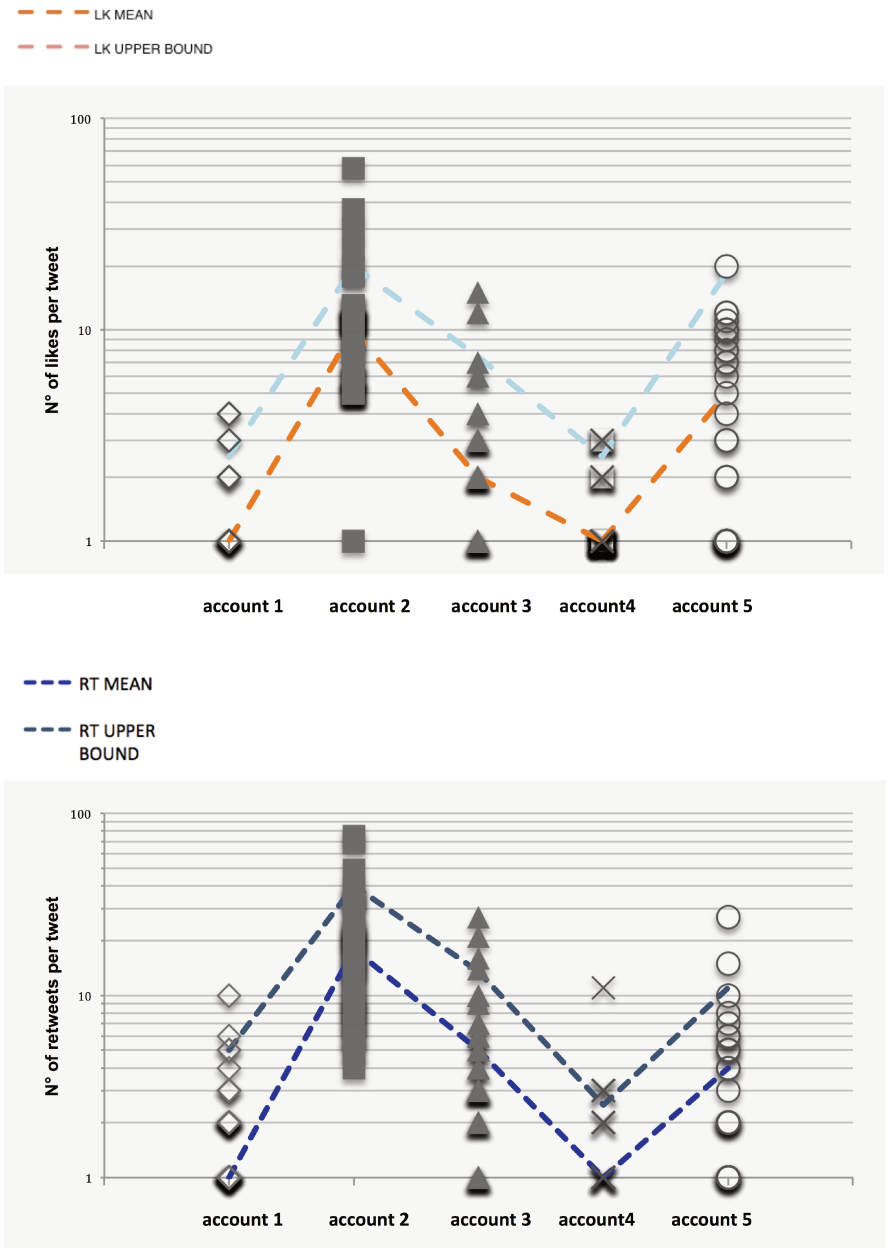


FIGURE 6.10. The users' behaviour: number of likes and number of retweets received by the five most active users for each of their tweets. These data were extracted from the tweet corpus.

cope with the flood, but they don't convey helpful information for the passengers.

6.6 Results and discussion

6.6.1 Comparison of the four histograms

The case studies discussed in this chapter aim at illustrating how big data exploration techniques can be used to investigate the digital media debate on urban resilience to extreme weather. The first step of the analysis consisted in observing the media coverage distribution over one month. The four histograms presented in Fig. 6.1 are based on four different datasets: press articles on the 2016 Seine River flood; press articles on the 2018 Seine River flood; press articles on the 2015 flood in the Côte d'Azur Department; tweets on the 2016 Seine River flood. A comparison of the four histograms highlights that, in the press as well as in social media, the peak of publications per day is determined by the date of the highest river discharge. This clearly proves a correlation between a meteorological event and its social representation. A possible explanation could be that the press tends to rather focus on the immediate consequences of natural disasters (Houston et al., 2012). Twitter seems to follow the same trend as the press. Figure 6.1 also shows a noteworthy difference between the Côte d'Azur flood and the two Seine River floods. The 2015 and 2018 Seine River floods are marked by a slower decrease of press coverage, after the maximum coverage peak is reached. This kind of evolution is probably due to the high media visibility of Paris, and it could had been reinforced by the very slow decrease of water levels of the Seine River.

A list of terms related to flood risk management solutions was defined through iteration between manual analysis of the datasets and automated text mining. An aggregated analysis of these key terms resulted in the identification of thematic subsets in each dataset and observing the distribution of the number of published key terms per day (Fig. 6.1). The limited portion of terms referring to flood risk management solutions let us suppose that the media tend to rather focus on the immediate consequences of natural disasters (Houston et al., 2012), but this hypothesis should be validated by exploring what are the other categories of terms. The comparison between the four datasets calls attention to the minor discussion on flood risk management solutions on Twitter if we compare it to the debate in the press. Indeed Twitter is a social media that is typically used as an early warning system: to disseminate factual information on the

time and location of a flood.

6.6.2 Comparison of the graph representations

The next stage of the analysis involved graph representation applied to the 2016 Seine River flood case study and to the 2015 Côte d'Azur case study. Thanks to an observation of the thematic clusters it was possible to gain a qualitative insight on how the debate on flood resilience is structured. The macro-theme 'impact record' appears in both graphs and it is probably a recurring topic in the press coverage of natural disasters. Identifying the nodes with high degrees and of the most probable links in the graph enabled us to outline a hypothesis on possible leading topics and actors and to highlight which terms tend to be coupled together. A comparison between the first case study and the second one reveals some interesting differences between the two. In the first corpus of articles, the debate on various levers for flood risk management is well developed and detailed. Furthermore, specific stakeholders can be associated with specific risk management levers. As regards the second corpus, we suppose that the important number of victims drew the media attention to the tragic impact of the flood event and to emergency management. Hence, we assume that the key stakeholders were the victims and those organisations that were involved in rescue activities and economic compensation. A study of the other measures that characterise graphs could validate these assumptions.

We should finally mention some unexpected results. The terms "pompiers" and "secours" co-occur in the first graph representation, but not in the second one. Furthermore, in the first graph some stakeholders, that have a key role in flood risk management in Paris (e.g. waste water managers), are absent. There is also no reference to the debate on resilience solutions as an alternative to defence solutions. An hypothesis is that these stakeholders and topics had a very limited visibility in the 2016 media debate on Paris flood risk management.

6.6.3 Tweet analysis

Graph representation supported by Gargantext isn't suitable for a corpus of tweets. However, an aggregated analysis of Twitter terms thematic categories is more appropriate for the purpose of this research. Moreover, Twitter data are valuable since they contain information on the profile of its users, as well as metrics that describe how the users interact. Indeed, it is possible to identify the most active users and the users who publish

the most popular tweets. By focusing on the tweets that obtained more than fifty likes or more than fifty retweets, it is possible to observe that the most popular tweets are published by the press and public authorities, i.e. those actors that are also visible in the press. Percentages presented in Fig. 6.9c and Fig. 6.9d suggest that the leading opinion makers in the debate on Paris flood risk are Twitter users who operate in the media sector and in the public administration/policy-making sector. Twitter is a media open to any contributor, however it seems that in this specific case study the most popular users are those actors that are also visible in the press. Even though, in the age of digital media and public relations, the sources and mediators of information have proliferated (Bucchi, 2013), we can suppose that, in case of disaster or emergency, the press and public institutions are preferred as reliable sources of information. Fig. 6.9c and 6.9d also call attention to a widespread interest among Twitter users in the flood impact on transports and cultural heritage. This is probably specific to a population that lives or travels in a metropolis with a dense transport network and a very high concentration of historical monuments and museums.

6.7 Conclusions

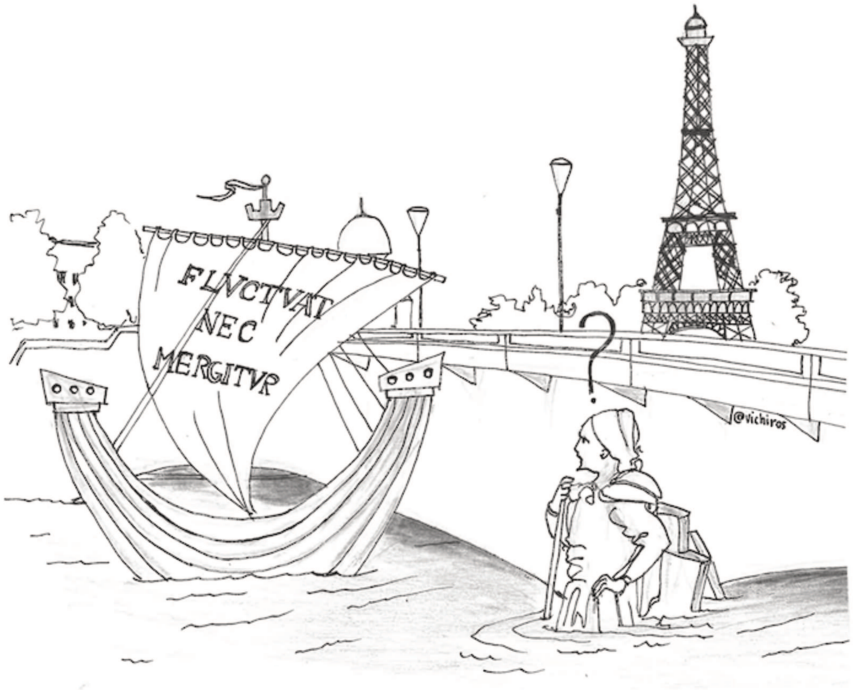
In this chapter we employed big data exploration techniques to appraise how urban resilience to extreme weather is perceived in the digital media debate. Through this study, we firstly intended to test communication metrics that can be integrated into a wider assessment of urban resilience to weather extremes. Secondly, we aimed at gaining an insight of the social perception of flood resilience in two French urban areas. More specifically, through the experiments presented in this chapter we obtained quantitative data on:

- The correlation existing between the intensity of the digital media debate (a social factor) and the level of the river discharge (an environmental factor);
- The evolution of the intensity of the debate over time, in two different locations and in two different media contexts (French press and Twitter);
- The topics and actors mentioned by the press that correspond to high degree nodes, and how these patterns change in two different urban areas;
- The differences that exist in terms of quality of the contents (i.e. reference to flood risk management solutions) between the press coverage of a flood event and the

Twitter coverage of the same event;

- The most frequent connections that exist among these topics and actors, and how these socio-semantic patterns change in two different urban areas;
- The most prominent topics in the Twitter debate;
- The profile of the most active and the most popular Twitter users.

These initial results are promising: they led to a complex understanding of the social construction of reality through the digital media debate. However, we must recall that these experiments focus on the media debate and exploit Web data that are produced during and immediately after a climate risk. In the next chapter we complement this study, by considering a longer time scale and the slow evolution of socio-semantic patterns in the political sphere.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CHAPTER 7

A GRAPH REPRESENTATION OF ONLINE STRATEGIC DOCUMENTS RELEASED BY PUBLIC AUTHORITIES

This chapter aims at exploring how policy and decision makers perceive climate risks management issues and express it through the Web. Indeed, since the early 2000s, the French national and local authorities made increasing efforts to facilitate public access to administrative documents through digitalisation and online publication (European Commission, 2017). The recent "Digital Republic" bill (www.republique-numerique.fr) – that since 2016 requires central and local governments to automatically publish online a wide range of administrative documents and data – illustrates how paramount the Internet has become in the relation between the public bodies and the citizens.

We propose to exploit recent advances in big data exploration techniques, applied to online texts, to examine the strategies implemented by public authorities in Paris. In particular, we try to answer the following questions: how do public authorities' perceptions evolve in the long term? Indeed, these are key actors who can strongly influence urban resilience, or more specifically the outcomes of a resilience project, through policy-making and decision-making.

Chapter 4 includes a qualitative analysis comparing twelve documents on the topic of flood resilience in Paris region that were published online by international, national,

and local authorities from 2003 to 2017. In this chapter, the same documents will be analysed through semantic network representation. A comparison will be made between the documents published in 2008–2010 and in 2015–2017 in order to highlight the rise and fall of some terms over five years and to see if advanced text mining brought new insights that were not revealed through the qualitative analysis.

7.1 Method and data

The experiment consisted of the following steps. Each of the twelve documents was divided into smaller meaning units, since Gargantext can analyse documents with the maximum length of a press article or a scientific abstract. Key terms were extracted through automatic selection (based on Gargantext algorithms). The term list was then refined through manual selection in order to keep only those terms referring to risk management solutions, stakeholders, infrastructure at risk. Synonyms, declensions of terms and equivalent forms were merged. As a result, the term list includes 269 key terms.

Two subsets of documents were selected for graph representation, in order to observe the rise and fall of some key terms over time. The first subset includes 'DDRM of Paris' [1] (Préfecture de Police, 2009), 'DICR of Paris' (Mairie de Paris, 2009), 'PFMS' (Oumraou et al., 2010); the second subset comprises 'SLGRI of the Paris region' (DRIEE and SGZD de Paris, 2016), 'PCS of Paris' (Mairie de Paris and Préfecture de Police, 2015), 'Climate and Energy Plan' (Mairie de Paris, Direction des Espaces Verts et de l'Environnement, Agence d'Écologie Urbaine, 2015), 'PGRI' (DRIEE, 2015), 'CPIER Seine River Plan' (DRIEE/DBSN, 2015), 'Paris Resilience Strategy' (Mairie de Paris and 100 Resilient Cities, 2017). These subsets were selected on the basis of the following principles: they include complete documents; the time interval between the last document of the first subset and the first document of the second subset is long enough (five years) to observe a pattern evolution; each subset covers a period of two years. Since a limited number

[1]The following abbreviations will be employed to refer to some of the strategic documents released by the public authorities:, 'DICR' stands for 'Document d'Information Communal sur les Risques' ('Municipality Risk Information Document'), 'DDRM of Paris' stands for 'Dossier Départemental des Risques Majeurs de Paris' ('Department File on Major Risks'), 'PFMS' stands for 'Plan Familial de mise en Sûreté' ('Security Family Plan'), 'PGRI' stands for 'Plan de Gestion du Risque d'Inondation' (Flood risk management plan), 'PCS stands for Plan Communal de Sauvegarde (Safeguard Municipality Plan), 'CPIER' stands for 'Contrat de Plan Interrégional entre l'État et les Régions' (Interregional Plan Contract between the State and the Regions).

of old strategies are available on the Web, the graph computed on the basis of the first subset has a smaller number of nodes and edges.

The two co-occurrence graphs were computed on the basis of the measure of semantic proximity between key terms that is called distributional distance [2]: this approach is more appropriate for a corpus composed of meaning units that didn't pre-exist but were created for the analysis with Gargantext. Once the two graphs were computed, it was possible to identify clusters of nodes, the nodes with the highest degrees, and observe the evolution of these patterns over five years.

7.2 Results

7.2.1 Documents released between 2008 and 2010

Figure 7.1 presents a graph representation of 104 nodes and 1521 edges based on the documents released between 2008 and 2010. We can identify two meaningful clusters that can be associated with two thematic categories [3]:

1. *Early warning and rescue* includes nodes associated with terms such as 'fire brigade', 'the national radio broadcaster', 'sirens', 'alert', 'rescue services', 'emergency accommodation', 'provisions', 'victims';

2. *Risk description and protection* with nodes such as 'classified infrastructure', 'pollutants', 'technological risks', 'deaths', 'health', 'diseases', 'natural risks', 'safeguard', 'protection', 'police', 'préfecture'.

Figure 7.2 presents the nodes with the highest degrees, i.e. the graph nodes with the largest number of edges. These nodes correspond to terms related to emergency management. Indeed, some of these terms refer to *emergency management solutions* such as 'the national radio broadcaster' (25 edges), 'communication' (23 c.), 'cleaning' (19 c.), 'food provision' (16 c.), 'sirens' (16 c.). Other terms refer to *stakeholders involved in crisis management such* as 'the fire brigade' (22 c.), 'préfecture' (21 c.), 'rescue services' (21 c.), 'police' (19 c.), 'population' (21 c.), 'victims' (18 c.), 'elderly people' (16 c.), 'RATP' (18 c.). The chart includes terms referring to different types of risks: 'technological risks'

[2]The distributional proximity measures if two key terms have a similar co-occurrences profile with all the terms of the maps: for example two synonyms will probably be connected (iscpif.fr/gargantext/your-first-map/).

[3]We defined each category name.

(23 edges), 'heat' (25 c.), 'natural hazards' (15 c.). Except for 'Plan Familial de Mise en Sûreté' that is a national strategy, the other documents are dedicated to Paris inner city area as a context. Nevertheless, there are multiple references to both the 'Seine' River (15 c.) and the 'Marne' River (19 c.).

7.2.2 Documents released between 2015 and 2017

The second graph representation (Fig. 7.3) has a reduced number of nodes (251) and edges (6153). This is due to the fact that there are more and longer texts dated between 2015 and 2017. Thanks to this richer structure it is easier to identify relevant clusters and associate each of them with a thematic category:

1. *Integrated risk management, subsidiarity and nature-based solutions* includes key terms like 'resilient', 'climate evolution', 'climate change', 'heat wave plan', 'droughts', 'urban cold', 'ice', 'adaptation', 'adaptation strategy', 'cooperation', 'social action', 'associations', 'neighbours', 'parents', 'experimentation', 'innovation', 'parks', 'to cool', 'fresh', 'vegetated', 'green areas';

2. The *Defence systems, prevention and multi-scale governance* cluster with terms such as 'dams', 'low walls', 'embankments', 'regulation', 'prevention', 'classified installations'; organisations and locations such as the 'Regional Environment and Energy Direction', 'Seine–Saint-Denis', 'Val-de-Marne', 'Great Paris Metropolis', 'Department Direction of Territories', 'Île-de-France', 'Haute-Marne', 'Saint-Maur', 'Yonne';

3. The *Information and protection* cluster with 'vulnerable', 'vulnerability, "awareness raising", "risk culture", "risk knowledge", "forecasts", "monitoring", "knowledge", communication', 'protection', 'security', 'safeguard', 'storage', 'retention sites', 'flood-prone areas', 'urban planning and water management master plan', 'flood risk management plan'.

Figure 7.4 highlights that new key terms correspond to high degree nodes in the second graph. References are made to common causes ('extreme climate conditions' with 60 edges, 'climate change' with 61 c., 'climate evolution' with 69 c.) or joint solutions ('multiple benefits' with 52 c., 'adaptation strategy' with 54 c., 'urban resilience' with 59 c., 'risk culture' 53 c.) for different kinds of issues such as 'high temperature' 67 c., 'biodiversity' 64 c., 'storms' 59 c., 'diseases' 57 c. We can also observe that some terms

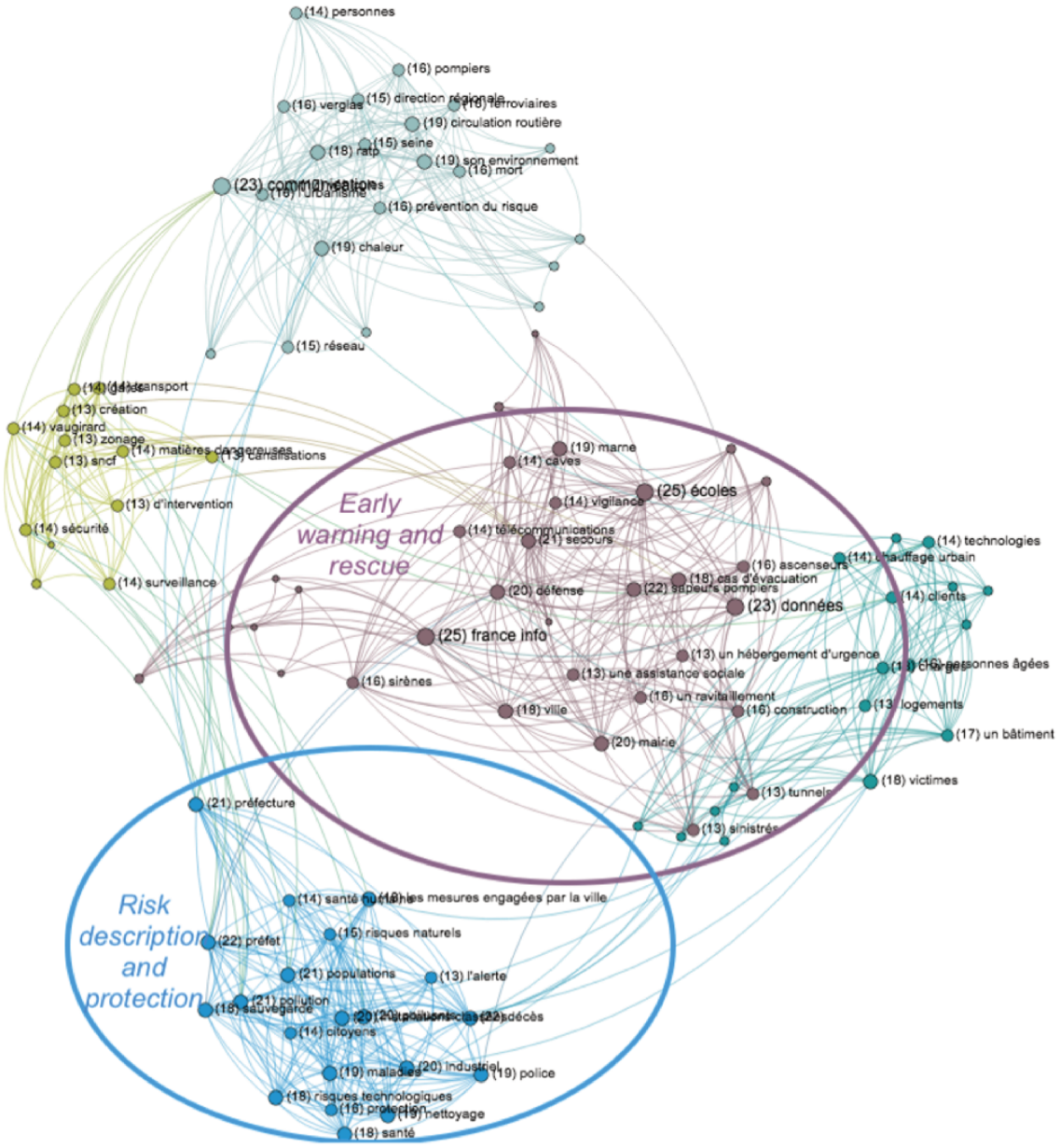

FIGURE 7.1. graph representation based on 2008–2010 strategies: the graph representation was computed on the basis of the measure of distributional proximity between the terms listed in Suppl.8 (Vicari, 2019) and extracted from the documents released from 2008 to 2010, included in the corpus Suppl.7 (Vicari, 2019).

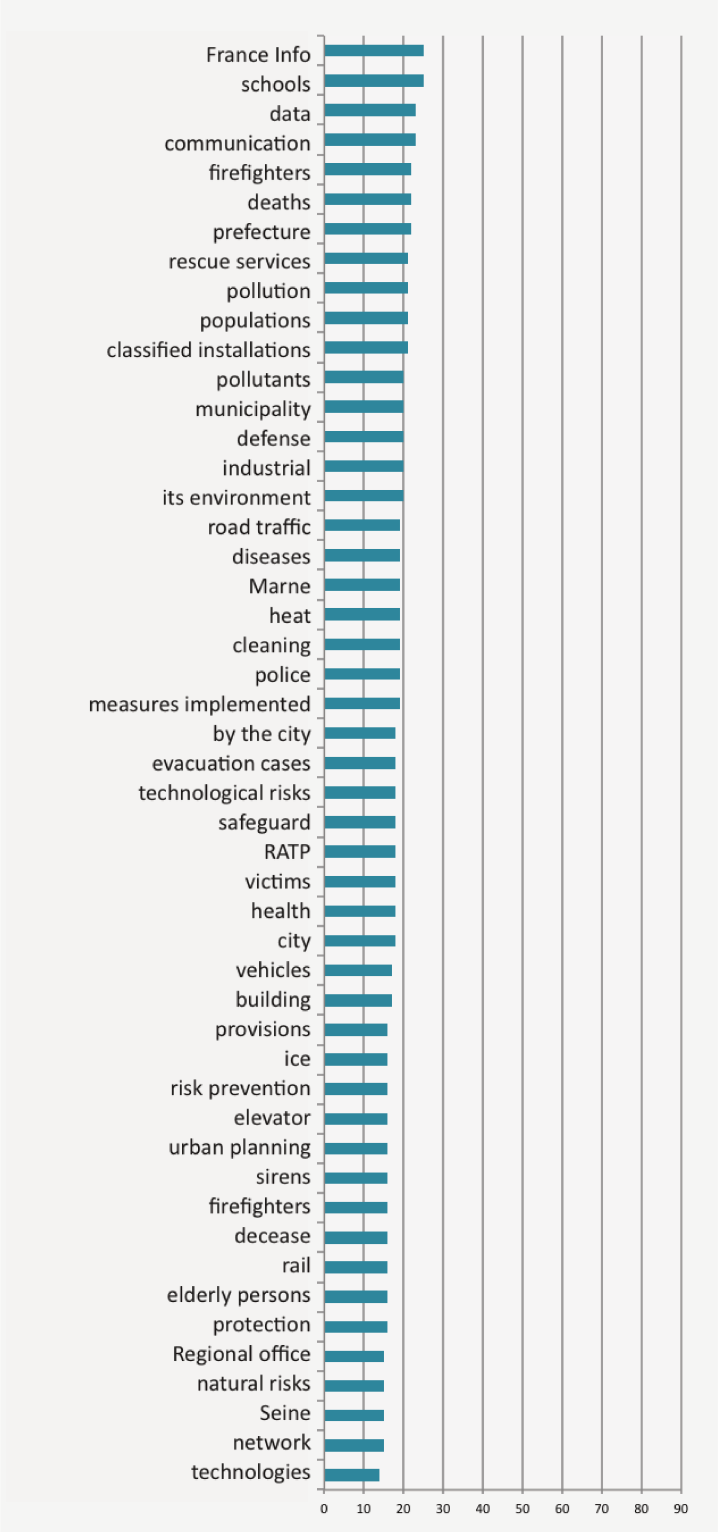

FIGURE 7.2. Terms corresponding to high degree nodes in the graph representation based on strategies released by the public authorities in 2008-2010. The graph was computed on the basis of the measure of distributional proximity between the terms listed in Suppl.8 (Vicari, 2019) and extracted from the 2008-2010 documents, included in the corpus Suppl.7 (Vicari, 2019).

refer to nature-based solutions ('green areas' 62 c., 'vegetate' 61 c., 'garden' 57 c., 'trees' 57 c.) and long-term strategies ('integration' 65 c., 'risk culture' 53 c., 'knowledge' 58 c., 'experimentation' 66 c.) as well as to more traditional solutions ('prevention' 73 c., 'forecasts' 61 c.).

'Seine Normandie Basin' is a node with a very high degree (80 edges). Other high degree nodes corresponding to stakeholders are 'inhabitants' (56 c.), 'vulnerable people' (63 c.) and 'local authorities' (61 c.). We can finally notice that the node degrees have a higher variability than in the previous graph: this is due to the fact that the number of nodes and edges is bigger in the second graph.

7.3 Discussion

As discussed in Chap. 4, 'Integrated risk management' and 'Outreach efforts and stakeholders' involvement' are two priorities that, according to the qualitative review, characterise recent strategies to cope with flood risk in Paris. These two trends were confirmed by the analysis based on graph representation. In comparing the two graphs, we can make a first observation on the role of the population in flood risk management. The graph representations, as well as the qualitative review, highlight that since 2015 the citizens seem to have a more active role, while in 2008–2010 they were simply expected to stay informed and follow the emergency advice.

We can also notice that in the second graph representation (Fig. 7.3) the main novelty is the cluster corresponding to the thematic category 'Integrated approach to risk management, subsidiarity and nature-based solutions'[4]. These aspects were also brought out in the qualitative review, except for the topic 'nature-based solutions' which is seems to be a key lever of the strategies depicted in Fig. 7.3. Nevertheless, traditional solutions are still maintained, as highlighted by the cluster 'Defence systems, prevention and multi-scale governance' in Fig. 7.3. The same cluster calls attention to a multi-scale approach to governance and risk management that appeared since 2015. According to the recent documents, especially in the case of flood risk, new resilience strategies should consider the whole Seine River Basin that includes the locations and local authorities

[4]'Nature-based solutions are defined as actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.' (Cohen-Shacham et al., 2016).

FIGURE 7.3. Graph representation of 2015–2017 documents: graph representation of the strategies developed by the public authorities to cope with the Seine River flood and released from 2015 to 2017. Graph representation based on 2015–2017 strategies: the graph was computed on the basis of the measure of distributional proximity between the terms listed in Suppl.8 (Vicari, 2019) and extracted from the documents released from 2015 to 2017, included in the corpus Suppl.7 (Vicari, 2019).

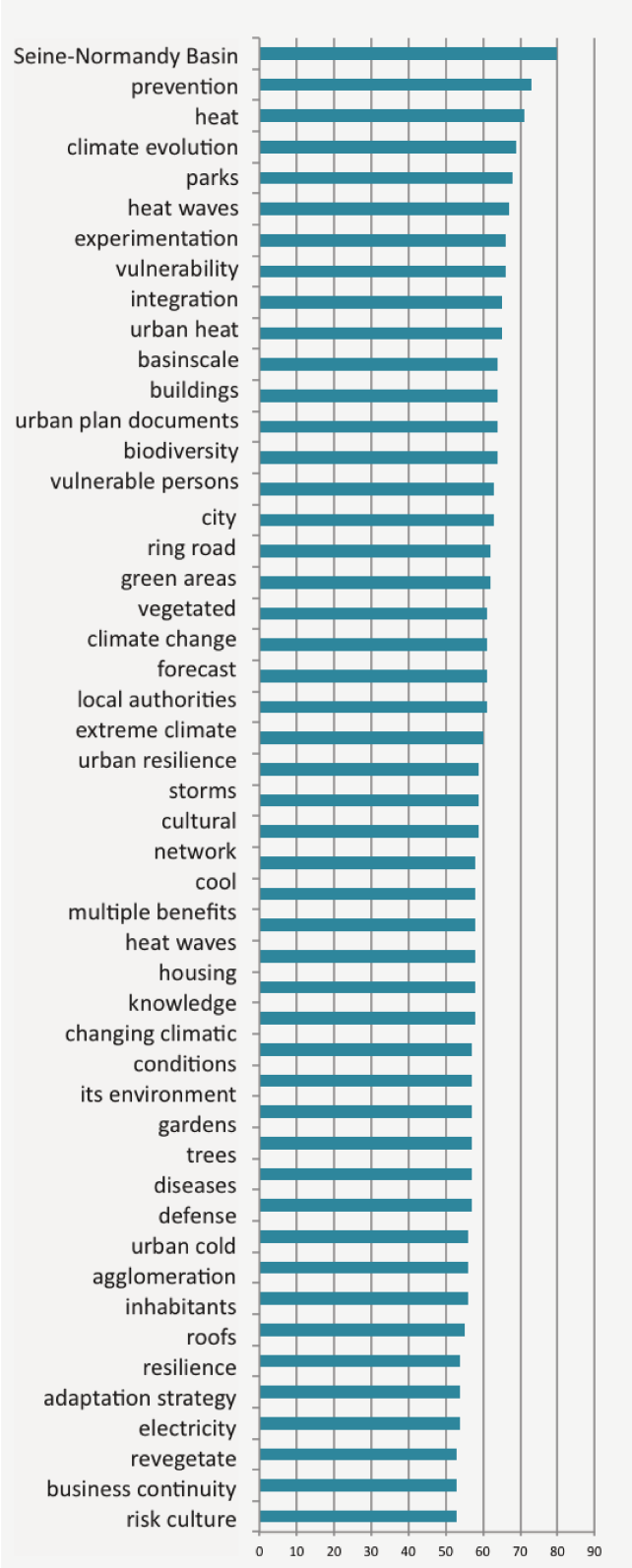

FIGURE 7.4. Terms corresponding to high degree nodes in the 2015-2017 graph (based on distributional proximity between the terms listed in Suppl.8 and extracted from the 2015-2017 documents included in Suppl.7 in Vicari, 2019).

mentioned in the cluster.

The quantitative analysis of node degrees in the 2008-2010 graph highlights terms related to emergency management, an important theme according to the observation of the 2008-2010 graph clusters. The documents consider a wide range of risks, but there is no reference to interactions among different risks, such as correlated causes and impacts or integrated solutions. An interesting aspect–that did not emerged in the qualitative review–is that two high degree nodes extracted from the 2008–2010 documents correspond to the 'Seine' River as well as to the 'Marne' River. The Marne River is a Seine River tributary: hence, there is interdependency between the water discharge of the two rivers. Even though the older documents don't include explicit references to a multi-scale approach, they seem to consider the causes and the origins of flood risks at a larger space scale than only the inner-city area of Paris.

As for the analysis of the high degree nodes in the second graph, it called attention to the fact that, since 2015, the public authorities adopted an integrated and long-term approach to understand and face climate-related risks in the Paris region. This assumption is in line with the observations of the 2015-2017 graph clusters. Terms referring to nature-based solutions appear among the high degree nodes, even though traditional solutions are still considered: this is also consistent with the results based on the observation of the 2015-2017 graph clusters.

7.4 Conclusions

The study presented in this paper compares a qualitative review with an analysis supported by big data exploration techniques. Most of the conclusions of the review are confirmed through the second stage of the study. Furthermore, the graph representations brought new results that were not revealed through the review.

Representation and observation of co-occurrence graphs (based on measures of distributional proximity between terms) coupled with quantitative analysis of their nodes led to the detection of a variety of issues addressed in the strategic documents, as well as the clusters of topics that are recognisable as thematic categories. Furthermore, the comparison between the two subsets of documents, released in different time periods,

made possible to examine the slow evolution of public authorities' visions of risks and solutions over five years. The analysis of the graphs could be completed with a detailed study of all the graph measures (e.g. centrality measure).

The analysis also calls attention to the stakeholders involved in these strategies, however these results are limited. Indeed, these documents are not meant to depict a variety of opinions–like in the case of the press articles and tweets analysed by the authors in a previous study. Each discussed strategy represents the unique point of view of the organisation that released the text.

Nevertheless, it was possible to confirm and detail the recent trends of the strategies implemented by the public authorities in the Paris region: an integrated and multi-scale approach to urban risks, increasing efforts to develop subsidiarity and nature-based solutions. These results provide interesting insights into the representation (through the Internet) of policy and decision-making processes that tackle the challenges posed by flood risk in Paris.

CHAPTER 8

CONCLUSIONS

The Resilience Strategy addresses the challenges associated with the Seine River in a cross-cutting and comprehensive way: it proposes to raise citizen awareness of flood risks, to rally them through the community solidarity networks, especially if a flood occurs; to predict the impacts of shocks and stresses, related to the river, on the infrastructures and adapt them; to enable the city administration to better take into account these risks; to guide partners involved in the watershed climate adaptation, to renew and strengthen cooperation with municipalities and farmers located upstream, etc. (Mairie de Paris and The Rockefeller Foundation, 2017)

The resilience strategy of Paris Municipality addresses urban risks across different dimensions of an urban system. For instance, the actions aimed to support the Seine River management include actions such as predicting the impacts of weather extremes, adapting urban infrastructures, reinforcing the risk culture among the population as well as in the public administration, enhancing citizens' active involvement through a solidarity network, reinforcing partnerships with those stakeholders involved in climate adaptation of the river basin. Furthermore multiple time and space scales are considered: e.g. short term and long term goals were defined and some actions concern peri-urban and rural areas of the Seine River Basin, while others focus on specific neighbourhoods

in Paris 'intra-muros'.

The *Paris Resilience Strategy* (Marie de Paris and 100RC, 2017) and other earlier strategies (OECD, 2014; MEDDE, 2014; DRIEE, 2015; DRIEE and SGZD de Paris, 2016) call attention to the need to monitor the progress that is made through resilience metrics. This thesis contributes to the development of current resilience assessments and investigates the interactions between the socio-economic and physical environmental dimensions of a city exposed to extreme weather. In particular, this research analyses the role of communication in urban resilience and defines related indicators that benefit from the recent advances in big data exploration techniques. This outcome resulted from the following steps:

- An analysis of the literature on social-ecological resilience and recent assessment methods to identify concepts and practices that are adequate to evaluate urban resilience to climate risks.
- A review of the theoretical and empirical tools adopted by SIA (Social Impact Assessment) experts to apprehend how the social sphere affects territorial development projects.
- A study of the available and recurrent communication variables in the context of Paris resilience strategies that resulted into a definition of six categories of relevant RCIs (Resilience Communication Indicators).
- Implementation of these RCIs through experiments based on SIA research techniques (questionnaire, interviews, media monitoring), and computer aided exploration of unstructured big data (advanced text mining and graph representation).

8.1 Guidances to assess urban resilience to extreme weather

Chapter 2 introduces the concept of social-ecological resilience as the theoretical frame of this research. This approach makes possible a comprehension of the interplay between socio-economic sub-systems and physical environmental sub-systems. Different resilience assessment methodologies proposed by academics and practitioners are then compared in term of definitions of resilience, space and time scales, explored shocks and

stresses, quantitative and qualitative metrics, degree of implementation, communication indicators. This review led to the following principles to design resilience indicators for urban areas coping with climate pressures. Such indicators should:

- Refer to the "social-ecological" definition of resilience;
- Define a general composite index of resilience and sub-indexes that measure specified and general resilience, the properties associated to resilience, different interacting components of an urban system, as well as its multiple scales;
- Include indicators to monitor the communication processes and their interactions with other resilience drivers;
- Identify for each indicator a quantitative variable, a resilience threshold, the consequences of threshold trespassing and interactions with other thresholds;
- Normalise different value ranges in a unique scale;
- Use a digital support for automated assessment of resilience;
- Involve stakeholders in the assessment process.

The review also highlighted that resilience assessment methods include some indicators addressing communication processes, especially in the domains of governance and public engagement. The focus of these indicators is usually on the presence or absence of communication efforts, their frequency and resonance, their effectiveness, their impacts in terms of knowledge, preparedness, awareness. A reflection on the quality of communication contents, the socio-semantic networks and interplay with other resilience drivers seem to be currently missing. Furthermore, these indicators focus on a description of the general state of communication processes and infrastructure in an urban area and and are not related to the effects of specific communication activities. Concerning the research methods that are used to monitor communication processes, these are quite similar to the techniques adopted by SIA experts to investigate the social construction of reality.

8.2 SIA concepts and methods to relate social impact to territorial development

The third chapter of the thesis explores how SIA experts investigate the interactions between the social dimension and the other dimensions of a territory. Assessment of social impacts has become a key aspect for researchers and decision makers involved in territorial development, including risk management projects in flood-prone urban areas. Indeed, adverse or favourable social impacts can affect the outcomes of a project, its feasibility and durability.

Social impacts also include the so-called *social construction of reality*. Especially in case of controversy, the point of view of stakeholders and their attitude towards an issue must be taken into account. The success of a project or action strongly relies on converging points of view. With due consideration for stakeholders' opinions, it is possible to develop a favourable context for a project implementation. Hence, SIA also involves an evaluation of the social construction of reality and the communication processes that influence it.

Relevant social variables, including communication variables, are identified during the "scoping phase" of the SIA process. Scoping is necessary to point at the key issues of the study and at the variables that can provide an insight on the focus of the assessment. Different research methods can be used to monitor these variables. Ideally, combining different methods is recommended since it ensures comprehensive and reliable observations, predictions and related proposals for action.

It should be finally noted that SIA techniques involve a range of biases that can distort the results of a study: spatial and seasonal bias (data are limited to accessible areas or periods when field research is feasible), personal and professional bias (e.g. distortions due the cultural background of an interview respondent). Nevertheless, SIA provides helpful insights to monitor social processes, and in particular in relation to the social construction of reality concept, the scoping phase, the integration of different research techniques and the SIA bias. These insights were used in the fourth chapter to define indicators of the role of communication in Paris climate resilience.

8.3 Resilience Communication Indicators for the Paris region and its climate challenges

Chapter 4 explores what are relevant communication variables that are available in the context of urban resilience strategies addressing flood risks. In the last five years in the Paris region, public authorities showed increasing efforts to facilitate access to information on climate risk management, encourage citizen participation and share responsibilities with them. Unlike the strategies released by public authorities before 2014, recent strategic documents define in a detailed manner the communication objectives, the profile of the target audiences and propose innovative outreach and public engagement activities. Furthermore, they refer to risk culture development as a priority: instead of focusing on emergency warning, as in the past, recent documents treat of outreach and public engagement as opportunities to raise awareness and educate urban communities with long term effects.

This trend results from a political will to apply the principle of subsidiarity and decentralise risk management (Tanguy, 2015) that led public authorities to pay attention to the citizens' perceptions. The communication between public authorities and citizens, especially a two–way dialogue, is becoming a keystone of resilience strategies since it facilitates mutual understanding, identification of shared goals and cooperation.

A hypothesis of relevant communication variables can be outlined on the basis of the communication objectives, target audiences and communication activities of twelve flood resilience strategies, implemented in Paris from 2003 to 2017. These variables are conceived as activity-driven tools that can be adopted by the decision makers to evaluate if the communication goals were achieved. Hence, these indicators are tailored to each resilience strategy and context specificity and rely on the available communication data that can be collected for evaluation. Nevertheless, these variables can be grouped into six recurring categories: 1) communication intensity, 2) content quality, 3) participatory communication, 4) comparison between different time periods, locations and target audiences, 5) interplay with other resilience drivers, 6) socio-semantic networks.

These categories can serve as guiding criteria to include relevant Resilience Communication Indicators in a wider urban resilience assessment. *Relevant* refers, here, to consistency with the principles listed in Chap. 2 so that RCIs can be integrated in a wider

resilience assessment, as sub-indexes of a composite indicator. Furthermore, we propose a dynamic perspective with RCIs that can be employed to detect resilience changes and the causes related to a past or ongoing communication activity. Relevant communication indicators should also consider the SIA concepts and techniques discussed in Chap. 3: they should provide insights on the social construction of reality, should be defined during the scoping phase, possibly combine different research methods and consider related biases. These RCIs were tested through experiments that are presented in Chap. 5 to 7.

8.4 Implementation of RCIs through experiments based on SIA techniques

Chapter 5 presents different kinds of experiments that were carried out during the Interreg IVB NWE RainGain project. These experiments were undertaken to evaluate communication activities addressed to non–specialist audiences and were tailored for this flood resilience project and the Paris region. Each experiment takes into account some of the six guiding criteria for RCIs, listed in Chap. 4. Moreover, the experiments are based on different quantitative and qualitative research techniques, usually adopted by SIA experts (and presented in Chap. 3).

Firstly, these experiments led to an analysis the role of press relations and of the exhibition in the attainment of the project goals, i.e. urban flood resilience. The media monitoring highlighted that awareness was raised, among the media and their audience, on urban flood issues and on emerging scientific and technological solutions. The questionnaire showed that the impact of the exhibition and the brochure was positive but modest in terms of information dissemination. However, they were effective tools to reassure the respondents on security issues and encourage them to support the implementation of the flood resilience project.

Secondly, these experiments provide relevant insights on the following methodological aspects.

The first experiment consisted in monitoring the media coverage of the RainGain project. We analysed the intensity of communication (criterion 1), compared different time periods (criterion 4), and identified the correlations between communication and another resilience driver (a meteorological event) (criterion 5). The results highlight that press coverage frequency and audience size are two RCIs that can be used to estimate

the size and profile of the reached population. The experiment also demonstrates that the interplay between the environmental dimension (weather hazards) and the social dimension (a communication process) can be quantified.

The second experiment is a questionnaire administered to the visitors of an exhibition: we examined the quality of communication (criterion 2) and compared different sub–groups of audiences (criterion 4). The results of the questionnaire experiment can't be generalised to a larger population, since the sample size isn't statistically significant. Nevertheless, this experiment illustrates how an exhibition evaluation can be carried out during the implementation of a communication strategy. We succeeded in designing an experiment aimed at assessing the perception and interpretation of a message by the receiver. Furthermore, it was possible to compare the results of the experimental group with the results of the control group, and to convert different answer rates to a unique scale of 1 to 100 per cent.

The third experiment is based on interviews and is aimed at providing data for preliminary research and support monitoring of RCIs. Open-ended questions were helpful to zoom into the individual reasoning of the respondents. In the context of a wider resilience assessment, based on quantitative metrics, interviews could be adopted for preliminary studies. For instance, this qualitative research method could be a support to define adequate questionnaire questions. Interviews would also be helpful during a stage of result validation.

Through these three experiments we tested some of the RCIs with the support of SIA techniques. Media monitoring, questionnaires and interviews are widely used techniques, but the RCIs are a novel concept and have characteristics that are different from usual resilience indicators related to communication processes. We are prudent in generalising the validity of our conclusions that are based on a limited number of small-scale experiments. However, the outcomes of this experimentation pave the way to other developments.

The methods tested through these three assessments complement each other. This confirms the need to use different techniques to comprehend the role of communication in urban resilience. Furthermore, the results endorse the conclusion that quantitative met-

rics are necessary to include communication indicators in resilience assessments. Indeed, numerical data facilitate the study of interactions between communication phenomena and other urban dimensions and functions that impact on resilience. Furthermore, these are useful to apprehend the evolution of impacts over time.

The RCIs can be tested against larger samples thanks to computer-aided exploration of big data. In particular, advanced text mining coupled to graph representation of Web communication contents can be used to investigate two other categories of communication variables: participatory communication (criterion 3) and socio-semantic networks (criterion 6). With these techniques it is possible to easily move from the observation of the global trends of a population to the exploration of individual patterns. Furthermore, in the context of a wider resilience assessment, digital communication datasets are valuable since these enable quantitative analysis of social relations. Chapter 6 presents experiments that exploit these techniques to appraise the quantity and quality of digital media contents (including interactive media), their space-time variability and their socio-semantic patterns.

8.5 Implementation of RCIs through experiments based on unstructured big data exploration techniques

The experiments described in Chapter 6 show how digital research enables the analysis of the issues that are addressed in the digital media debate. Moreover, this method provides insights on the stakeholders that can potentially influence the debate and, therefore, the community attitudes towards an issue. As discussed in Chap. 3, these attitudes constitute the so-called social construction of reality that can affect a territorial development project, such as a resilience project, and can therefore influence urban resilience. Three corpora of Web communications were examined: press articles covering the June 2016 Seine River flood; press articles covering the October 2015 Côte d'Azur flood; tweets on the 2016 Seine River flood. The analysis of these datasets involved an iteration between manual and automated extraction of hundreds of key terms, co-occurrence graph representations based on the measures of conditional proximity between key terms, automated cluster visualisation (computed by Louvain algorithm), and profiling of social media users.

A first aggregated analysis was applied to the three corpora and it highlighted how press coverage and the content quality evolve over time, in different locations, in different media context (press vs social media). This confirms that, as stated in Chap. 5, correlations between a communication variable, such as the intensity of the digital media debate, and an environmental variable, e.g. the level of the river discharge, can be observed and quantified.

Two graphs were computed on the basis of the two press corpora. Visual observation of graphs associated with quantitative analysis of the nodes and edges enabled us to identify communities of key topics and actors. It was also possible to identify the frequent links and clusters that these topics and actors tend to form in the journalistic sphere. The comparison of the two graphs was essential to observe how these patterns change in two different urban areas.

Graph representation, computed with Gargantext, isn't adequate for tweet corpora. Indeed, the meaning units (i.e. tweets) are too short to obtain a meaningful graph representation based on key terms co-occurrence. Nevertheless, the experiment showed that computer aided text mining can be used to identify recurrent thematic categories of key terms. This dataset also proved to be a valuable source of information on the profile and the interactions of the Twitter users. In fact, the last part of the analysis provided interesting insights on the profile of the users that are the most active and of those that publish the most popular tweets.

This kind of experiment can be pushed forward. The analysis of the short-term perceptions, which are expressed through the press and the social media during the flood or immediately after it, can be enriched with a study on the slow and long-term evolution of the public authorities' perceptions. Moreover, SIA methods can be adopted to verify the results obtained through automated exploration of big data. With this intention, we designed the experiment presented in Chap. 7.

In Chap. 7, big data exploration techniques are exploited to examine the strategies implemented by public authorities over 15 years in Paris and released on the Web. These documents were previously reviewed in Chap. 4 where it is discussed that subsidiarity and an integrated approach to climate risk management emerged in recent years. On the

basis of this review, we selected key terms concerning flood risk management. We then used this list to compute a co-occurrence graph and to identify clusters of terms that are often correlated. The node degrees were then measured to detect the high degree nodes. The experiment was repeated with two sample subsets corresponding to two different time periods (2008–2010 and 2015–2017): this was necessary to observe the evolution of these patterns over time.

The results obtained from this last experiment confirm the observations thoroughly discussed in Chap. 4. Furthermore, new outcomes emerge that were not obtained through the qualitative review. The following clusters of topics reveal other interesting trends in recent public authority strategies: a multi-scale approach to risks and an increasing effort to develop nature-based solutions. However, this experiment has its limits. Even though the names of few stakeholders are detected as high degree nodes, these results can't be considered as meaningful. The main reason is that the examined documents depict a unique point of view, i.e. the view of the institution that designed the strategy, and not a variety of opinions and perspectives as the press articles and tweets examined in Chap. 6.

8.6 Perspectives

The research results presented in this thesis are promising. The experiments led to a complex understanding of the intensity and quality of communications. These also enabled us to appraise the underlying socio-semantic networks and the interplay between communication processes and environmental phenomena. Furthermore, it was possible to observe the evolution of these variables in different locations and over time.

Nevertheless, we encountered the following experimental constraints:

- The press monitoring, carried out during the RainGain project, didn't provide insights on the quality of the contents, but only on the amount of media coverage;
- The questionnaire on the RainGain exhibition was administered to a limited sample of volunteer respondents;
- Advanced text mining and graph representation of press articles is an analysis of texts that are produced through the specific process and in the specific context of the journalistic sphere;

- Analysis of tweets provides insights on the opinion of Twitter users who have specific socio-demographic characteristics. We were able to analyse only the profile of the most popular users and the behaviour of the most active users. We didn't examine the images included in the tweets.
- In the case of the press articles analysis, as well as in the tweet analysis, we examined only documents that were published shortly after the flood (from on month to six months).
- Advanced text mining and graph representation of public authorities' strategies was based on a corpus of heterogeneous texts that describe the point of view of the institutions that released the documents.
- Node degrees and edge weights are two graph measures that are necessary but not sufficient for a quantitative analysis of the role played by social actors and topics in a debate;
- Thanks to these experiments we were able to detect specific communication trends and we made hypothesis on how these trends could affect urban resilience (see Fig. 8.1). These hypothesis should be validated with a general urban resilience assessment.

These limitations can be addressed with further research.

Big data exploration techniques can be used for communication assessment in the framework of future urban resilience projects in order to overcome the methodological constraints that we encountered during the RainGain project.

At the same time, the analysis based on advanced text mining and graph representation can lead to even more accurate results in the future.

The quantitative analysis of graph representations can be pushed forward by examining in detail all the graph measures (e.g. centrality measure).

Tweets analysis can be more fruitful if supported with automated exploration of Twitter accounts and graph representation of likes and retweets. It would be then possible to analyse larger samples of user data, and easily move from an aggregated level to a detailed level of analysis.

As it concerns the corpus of public authority documents, from a methodological point of view, it would be ideal to have a sample of documents with a uniform format, released

on a regular basis, by the same institution and in similar production conditions. This is the case of the session proceedings of the French National Assembly or the proceedings of Paris Municipal Council meetings. Other examples, from abroad, are the United States Congressional Hearings or the State of the European Union.

All the results of the experiments exploiting digital text datasets, and presented in Chap. 6 to 7, could be verified with interviews. Indeed, such SIA methods can be used to detect possible biases induced by the Web and the text production context and process. Interviews could be also helpful to examine how Twitter images are perceived, Interviews could be also helpful to examine how images are perceived, as proposed by Bucchi and Saracino (2016) in their study on visual science literacy. This emphasises again the advantage of using complementary techniques to analyse the role of communication in urban resilience.

Moreover, the proposed research focuses on flood risk in the Paris region, but it could be applied to a different location or it could be extended to other climate-related risks, as well as to a wider range of urban shocks and stresses. In the case of graph representations of the media debate (Chap. 6), we could consider a longer time scale, for instance by comparing the Seine River flood of 2016 with the one that occurred in 2018.

In the future, we also envisage pushing forward our research by studying the correlations that might exist between digital communication trends and other resilience variables, such as: the number of citizens affected by extreme weather, the surface of regreened areas, the amount of insurance compensation for natural disasters, etc. In this manner, we aim to further develop a comprehensive approach to integrate communication indicators in a general resilience assessment.

To conclude, we believe that we met our main aim of contributing to the development of research on resilience and communication in cities coping with climate risks. We also consider that these results will be beneficial to support urban resilience projects by reinforcing their connection with the local population, as well as their policy making and decision-making contexts. As highlighted in the Paris Resilience Strategy, these are essential premises to optimise the impact of resilience strategies on urban communities and ecosystems.

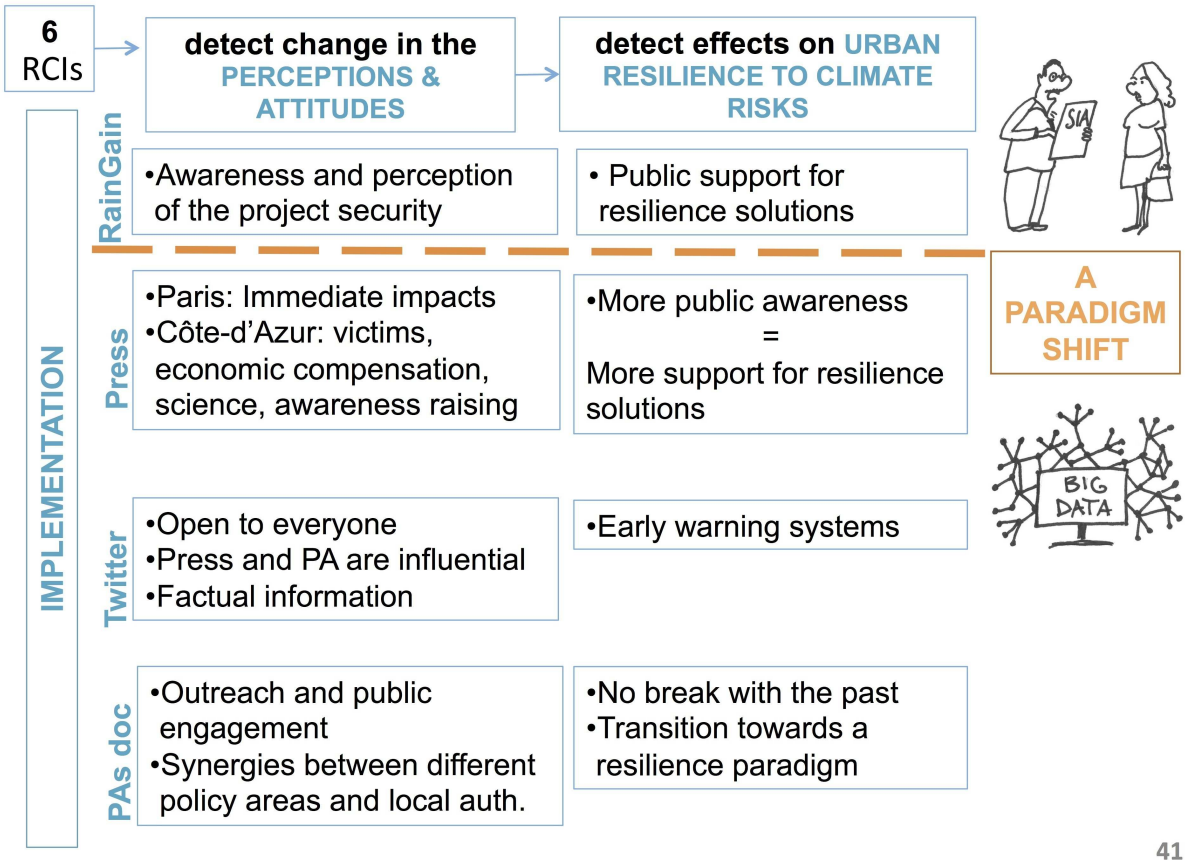

FIGURE 8.1. Diagram of the empirical part of the thesis and the research perspectives.

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APPENDIX A

COMPARISON MATRIX OF RESILIENCE ASSESSMENT METHODS.

APPENDIX A: Comparison matrix of resilience assessment methods.

	Definition of resilience	**Resilience of what**	**Resilience to what**	**General index**	**Sub-indexes**	**qualitative/ quantitative variables**	**State of Implementation**	**Communication indicators**
			URBAN RESILIENCE INDICATORS					
i. SRSC (UN/ISDR, 2009, 2015, 2017)	The ability of a system, community or society exposed to hazards to **resist, absorb, accommodate to and recover** from the effects of a hazard in a **timely** and **efficient** manner, including through the **preservation and restoration** of its essential basic **structures and functions.**	Cities	Shocks (natural and manmade) such as floods, earthquakes, hurricanes, wildfires, chemical spills, power outages, as well as chronic stresses occurring over longer time scales, such as groundwater depletion or deforestation, or socio-economic issues such as homelessness and unemployment.	**Reduction of:** 1. Mortality 2. Affected people 3. Economic losses, 4. Damages to infrastructure and service disruption **Increase of:** 1. N° of countries with a disaster reduction strategy 2. International cooperation to developing	**Ten essentials:** 1. Organise for disaster resilience. 2. Identify, understand and use current and future risk scenarios. 3. Strengthen financial capability for resilience. 4. Pursue resilient urban development and design. 5. Safeguard natural buffers to enhance the protective functions offered by natural capital. 6. Strengthen institutional capacity for resilience.	Quantitative and qualitative (0–5scale)	4300 cities	Yes

APPENDIX A: Comparison matrix of resilience assessment methods.

				countries 3. Early warning systems and disaster risk information assessments and people access to it.	7. Understand and strengthen societal capacity for resilience. 8. Increase infrastructure resilience. 9. Ensure effective disaster response. 10. Expedite recovery and build back better.			
ii. MAES (Maes et al., 2016; 2018)	The capacity of a social-ecological system to **absorb or withstand perturbations** and other stressors such that the system **remains within the same regime**, essentially **maintaining its structure and functions.**	Europe, member states, regions, metropolis, urban areas.	Environmental pressures	*Currently unavailable*	- **Pressure indicators** - **Ecosystem conditions indicators:** environmental quality; ecosystem attributes (functional attributes; structural attributes).	Quantitative	10 cities in Portugal (Cascais, Oeiras, Lisbon), Italy (Padua, Trento, Rome), the Netherlands (Utrecht), Poland (Poznań), Spain (Barcelona) and Norway (Oslo).	No

APPENDIX A: Comparison matrix of resilience assessment methods.

iii. AIRT (Tanguy, 2015; http://wikhydro.developpement-durable.gouv.fr)	The capacity of a system (or a territory) **to reach a new equilibrium** after a strong perturbation. The new equilibrium can be different from the state of the system before the perturbation. Indeed resilience also relies on the **ability to innovate, to reorganise, and to adapt** to new potential system states.	Territories	Natural and technological disasters	*Currently unavailable*	*Currently unavailable*	Qualitative	AIRT was implemented in: - 4 sites affected by disasters - 3 sites where a security intervention was performed - 3 sites where a confirmed risk is being monitored - 1 site where a river flood could occur - 1 site affected by an intense storm The results are available online.	Yes

APPENDIX A: Comparison matrix of resilience assessment methods.

vi. 100RC (100resilientcities.org; da Silva and Morera, 2014; Rockefeller Foundation and Arup, 2015; 2017)	The capacity of individuals, communities, institutions, businesses, and systems within a city to **survive, adapt, and grow** no matter what kind of chronic stresses and acute shocks they experience.	Cities	- **Chronic stresses**: high unemployment, inefficient public transports, food and water shortages, endemic violence… - **Acute shocks**: earthquakes, floods, disease outbreaks, terrorist attacks…	**7 key qualities**: reflective, resourceful, inclusive, integrated, robust, redundant, flexible **4 urban dimensions**: health & well-being, economy & society, infrastructure & environment, leadership & strategy	12 goals related to the 4 urban dimensions 52 resilience indicators	Qualitative and quantitative	The 100RC network members implement the CRF assessment as an early stage of the 'road to resilience' process.	Yes

APPENDIX A: Comparison matrix of resilience assessment methods.

vii. RA (Resilience Alliance, 2010)	The capacity of a system to **absorb disturbances** and **reorganise while undergoing change** so as to **retain** essentially the same **function, structure, identity and feedback**.	Social-ecological systems	Any disturbance that causes a disruption to a system such as drought, flood, fire, disease, or hurricanes, as well as recessions, innovations, technological change, and revolutions. 'Pulse' disturbance occurs as a relatively discrete in time ; 'press' disturbance is a more gradual or cumulative pressure on a system.	-	**- Specific resilience:** 1. Slow changing variables with critical threshold in the **socioeconomic system** at the focal scale, at smaller scale and at larger scale 2. Slow changing variables with critical threshold in the **biophysical system** at the focal scale, at smaller scale and at larger scale **- General resilience:** diversity, openness, reserves, tightness of feedback, modularity. **- Governance system:** 1. Adaptive governance and institutions 2. Social networks	Quantitative and qualitative	The assessment framework has been implemented in 13 locations all over the world. The details on each location background needs, on the project objectives and outcomes are available on resalliance.org.	Yes

APPENDIX A: Comparison matrix of resilience assessment methods.

viii. BRIC-DROP (Cutter et al., 2008, 2010, 2014)	The ability of a social system to **respond and recover from disasters** and includes those inherent conditions that enable the system to **absorb impacts and cope with an event**, as well as **post-event**, adaptive processes that facilitate the ability of the **social system** to **reorganise, change, and learn** in response to a threat.	Community	Natural hazards	Composite disaster resilience indicator	6 resilience dimensions: 1. Environmental resilience. 2. Social resilience. 3. Economic resilience. 4. Institutional resilience. 5. Infrastructure/housing resilience. 6. Resilience due to community capital.	Quantitative (normalised to 0–6 score)	3108 counties in the United States	Yes

APPENDIX A: Comparison matrix of resilience assessment methods.

INDICATORS TO ASSESS URBAN RESILIENCE TO WEATHER EXTREMES								
ix. UNR (Lhomme et al., 2010; 2013a; 2013b)	The ability of a city to **absorb disturbance and recover its functions** after a disturbance.	Cities	Floods	Resilience indicator	3 indicators for: - Network absorption capacity - Network recovery capacity - Network resistance capacity	Quantitative	Automated assessment by a Web-GIS prototype was tested in two pilot sites: - In Orléans (France) with a focus on the road network redundancy; - In Dublin (Ireland) with a focus on the sewage system recovery capacity. Results are available in two academic papers by Lhomme et al. (2013, 2015).	No

APPENDIX A: Comparison matrix of resilience assessment methods.

iv. SMARTeST (SMARTeST project, 2011; Tourbier, 2012; 2013)	The ability of a system/community/society/defence to **react to and recover** from the damaging effect of realised hazards.	Urban areas	Floods	-	4 Resilience levels: 1. Spatial-ecological flood resilience; 2. Structural flood resilience; 3. Social flood resilience; 4. Flood risk resilience. The weight of each level can vary.	Qualitative	*Currently unknown*	Yes
v. 4Rs-5Cs (Keating et al., 2014; 2017)	The ability of a system, community or society to **pursue its social, ecological and economic development and growth** objectives, while **managing its disaster risk** over time in a mutually reinforcing way.	Community	Floods	- **4 Resilience properties:** Robustness, Redundancy, Resourcefulness, Rapidity - **5 Capitals:** Physical, Financial, Human, Social, Natural	- 88 sources of resilience measured with an A-D score. - 29 outcome measures when a flood occurs.	Qualitative	75 communities in eight different countries	Yes

APPENDIX B

COMMUNICATION INDICATORS IN THE LITERATURE ON RESILIENCE ASSESSMENT.

APPENDIX B: Communication indicators in the literature on resilience assessment.

	i. DRSC (UN/ISDR, 2017)	**iii. AIRT** (wikhydro.developpement-durable.gouv.fr, 2014)	**iv. SMARTeST** (Tourbier, 2013)	**v. 4Rs-5Cs** (Keating et al. 2017)	**vi. 100RC** (Rockefeller Foundation and ARUP, 2017)	**vii. RA** (Resilience Alliance, 2010)	**viii. DROP-BRIC** (Cutter et al., 2014)
EARLY WARNING SYSTEMS	- Use of mobile and e-mail 'systems of engagement' to enable citizens to receive and give updates before and after a disaster -Existence and effectiveness of early warning systems -Reach of warning		- Flood warning location specific	- Early warning systems (EWS)			
INSTITUTIONAL RELATIONS AND TRANSPARENCY	- Extent to which data on the city's resilience position is shared with other organisations involved with the city's resilience - Extent to which data on the city's resilience position is shared with the community organisations and public - Effort taken to learn		- Public availability of information on flood resilience measures and flood proof	-Coordination mechanism across communities - Culture for community information sharing - Strategies for the delivery of actionable information for flood management - Early-warning	- Effective coordination with other government bodies	- Analysis of the governance system based on social network mapping	- Performance regimes-state capital - Performance regimes-nearest metro area

APPENDIX B: Communication indicators in the literature on resilience assessment.

	from what other cities, states and countries (and companies) do to increase resilience - Interoperability with neighbouring cities/states and other levels of government of critical systems and procedures			system function			
PUBLIC OUTREACH	- Exposure of public to education and awareness materials/ messaging				-Widespread community awareness and preparedness		
PUBLIC ENGAGEMENT	- Consultation in Plan Making - Coverage of community or 'grass roots' organisation(s) throughout the city - Effectiveness of community network - Social connectedness and neighbourhood cohesion - Engagement of vulnerable groups of the population	Questions discussed in the Working Group 'The citizen at the heart of resilience': - What to expect from the citizens? - How to improve public information and education with the aim of encouraging active and engaged citizens?	- Stakeholder participation	- Community representative bodies/structures for flood management coordination - Social participation in flood management-related activities	- Proactive multi-stakeholder collaboration - Effective mechanisms for communities to engage with government - Consultative planning process - Actively engaged		-Population stability -Place attachment-not recent immigrants - Place attachment native-born residents Political engagement - Social capital-religious organisations

APPENDIX B: Communication indicators in the literature on resilience assessment.

	- Extent to which employers act as a channel with employees - Frequency of engagement - Existence of emergency response plans that integrate professional responders and community organisations - Extent to which there has been stakeholder consultation around the 'event recovery and reboot' plans	- What is the means of action that citizens have? - What is the citizen sphere of action? - What are the benefits and costs for the society?			citizens		- Social capital-civic organisations - Social capital-disaster volunteerism
EDUCATION	- Accessibility of education and training to all linguistic groups in the city - Validation of effectiveness of education			- Educational attainment - Functioning and equitable education system -Education provision	-Adequate education for all		- Educational attainment equality - English language competency
TRAINING	- Availability, take-up of training focussed on Risk and Resilience (Professional Training) - System / process for			- First aid knowledge - Formal community emergency services			- Citizen disaster preparedness and response skills - Local disaster training

APPENDIX B: Communication indicators in the literature on resilience assessment.

	updating relevant training - Accessibility of education and training to all linguistic groups in the city - Practices and rehearsals – involving both the public and professionals - Effectiveness of drills and training			integrate flood advice and management			
COMMUNICATION INFRASTRUCTURE	- Communication service days at risk of loss - Designated critical asset service days at risk of loss from communication failure - Cost of communication restoration			-Communication infrastructure	- Reliable communications technology		- Communication capacity (% Households with telephone service available)

APPENDIX C

PRINCIPLES OF SIA GOOD PRACTICES.

APPENDIX C: Principles of SIA good practices.

PRINCIPLE	DESCRIPTION
1. Involve the diverse public	Identify and involve all potentially affected groups and individuals. Public involvement should be an active and interactive process, in which members of the public are full participants in the SIA enterprise.
2. Analyse impact equity	Identify who will win and who will lose, and emphasise vulnerability of under-represented groups. Identification of all groups that are likely to be affected by an action is central to the concept of impact equity. Impact equity must be considered in close and sympathetic consultation with affected communities. Analysis should begin during scoping to ensure that important issues are not left out.
3. Focus the assessment	Deal with the issues and public concerns that really count not those that are just 'easy to count'. Most often, time and resource constraints affect the scope of the assessment and the extent to which it can be done within the time available.
4. Identify methods and assumptions and define significance	Describe how the SIA is conducted, what assumptions are used and how significance is determined. A social impacts assessment needs to focus on impacts found to be significant in terms of context and intensity considerations. Context includes such considerations as: whole society, affected regions, affected interests and localities.
5. Provide feedback on social impacts to project planners	Identify problems that could be solved with changes to the proposed action or alternatives. Findings from the SIA should feed back into project design to mitigate adverse impacts and enhance positive ones. The impact assessment, therefore, should be designed as a dynamic process involving cycles of project design, assessment, redesign, and reassessment. Public comments on the draft assessment contribute importantly to this process of feedback and modification.

APPENDIX C: Principles of SIA good practices.

6. Use SIA practitioners	Trained social scientists employing social science methods will provide the best results. An experienced SIA practitioner will know the data, and be familiar and conversant with existing social science evidence pertaining to impacts that have occurred elsewhere, which may be relevant to the impact area in question. This breadth of knowledge and experience can prove invaluable in identifying important impacts that may not surface as public concerns. A social scientist will be able to identify the full range of important impacts and then will be able to select the appropriate measurement procedures. Having a social scientist as part of the interdisciplinary team will also reduce the probability that an important social impact could go unrecognised.
7. Establish monitoring and mitigation programmes	Managing uncertainty by monitoring and mitigating adverse impacts. Monitoring significant social impact variables and any programmes that have been put into place to mitigate them is crucial to the SIA process. Identifying a monitoring infrastructure is a key element of the local planning process. Monitoring and mitigation should be a joint programme managers' and community responsibility and both activities should occur on an iterative basis throughout the project life cycle.
8. Identify data sources	Using published social scientific literature, secondary data and primary data from the affected area. Published scientific literature includes journal articles, books, and reports available from similar projects. Secondary data sources are the census, vital statistics, geographical data, relevant programme agency publications, and routine data collected by state and federal agencies. Primary data from the affected area includes surveys, oral histories and informant interviews.
9. Plan for gaps in data	SIA practitioners often have to produce an assessment in the absence of all the relevant or even the necessary data. Evaluation of the missing information and developing a strategy for proceeding becomes important even if the information is approximate. However, they have to make clear any incomplete or unavailable information and the reasons why this could not be obtained.

(Source: Inter-organisational Committee on Guidelines and Principles for Social Impact Assessment, 1994)

APPENDIX A

APPENDIX D

FLOOD RESILIENCE STRATEGIES IMPLEMENTED IN PARIS FROM 2003 TO 2017: COMPARISON OF THE COMMUNICATION CONTEXT, OBJECTIVES, TARGET AUDIENCES, COMMUNICATION ACTIVITIES AND COMMUNICATION VARIABLES.

APPENDIX D: Comparison of flood resilience strategies implemented in Paris from 2003 to 2017 (communication context, objectives, target audiences, communication activities and communication variables).

	a) Communication context	**b) Communication objectives**	**c) Target audiences**	**d) Communication activities**	**e) Observations on potential communication variables**
1) PPRI OF PARIS (DRULE IDF, 2003)		Behave in a responsible manner	1) Inhabitants 2) Workers 3) Hospitalised people 4) Owners of dangerous products	Maps	1) Maps easily accessible, nr of consultations, interpreted as expected, expected action
2) PARIS DDRM (Préfecture de Police, 2009)	1) Time of reaction & information dissemination are important 2) Attraction/spread of the consequences of an extreme event 3) Increase of phone calls	1) Involve the citizens 2) Unite Paris with the first ring of departments	Paris population	1) DICRIM 2) Early warning system 3) National and local radio 4) DDRM: how to behave 5) Plan Seine 6) PPRI: urban planning 7) PPRI: metro & RER protection 8) ORSEC: organise rescue/relief efforts 9) Shedding system 10) Weather warning map	1) Are documents & maps are easily accessible, interpreted as expected, nr of consultations, expected action 2) News item frequency, the audience, interpretation, expected action 3) Number of victims, damages
3) DICR (Mairie de Paris, 2009)		Develop a culture of civil security	Paris population	1) PCS: indications for public servants 2) Early warning systems: sirens, speakers, LED panels, phone calls, radio, TV, Internet 3) National warning system 4) DIREN, Météo France flood warning maps 5) PPRI: maps of flood-prone area, rules & actions 6) Citizens are recommended**:** - Prepare a PFS	1) Are maps accessible, nr of consultations, interpreted as expected, expected action 2) Time of message transfer, audience size and response, expected action 3) Nr of readerships, how many readers memorised, expected action

APPENDIX D: Comparison of flood resilience strategies implemented in Paris from 2003 to 2017 (communication context, objectives, target audiences, communication activities and communication variables).

				- Gather information on warning levels, weather forecasts, recommendations - Follow recommendations - Keep updated (radio), follow security recommendations - Inform public authorities of dangers	
4) ORSEC - PFMS (Oumraou, 2010)		1) Inform families 2) Enhance individual responsibility, autonomy 3) Guide families	Families in France	1) Local sources of information: e.g. risques.gouv.fr, DDRM, PCS 2) A CD with indications on recommended behaviour 3) Early warning systems: National Sirens Network, phone calls, SMS, loudspeakers, church bells, visits	1) Nr of readers, nr of plans produced, capacity of preparation and response, request for assistance 2) Increase of the website visitors' number, who consulted risk reports
5) SNGRI (MEDDE, 2014)	1) Inequalities in the manner in which people face risk. 2) Widespread vision of the society as technologically advanced and a weak risk perception.	1) Developing a risk culture & informing with the following goals: - Preventive information - Ensuring early warning - Training 2) Operational information and crisis simulation 3) Improving public awareness raising	1) Public authorities 2) Businesses 3) Inhabitants 4) Public institutions in flood-prone areas	1) Consultation with the public & stakeholders 2) Concrete accessible actions are needed 3) Getting prepared to crisis: - PCS - Cartography of potential flood prone areas - Business continuity plans - Family safety plans - Safety and promotion of cultural heritage 4) Tools for preventive information: - Department report on major risks; - Municipality information document - Information for property purchasers and tenants 5) Developing new flood information	1) A long-term evaluation is planned: - 100% of PCS should be produced by 2018 - long term evaluation with quantitative assessment 2) A communication assessment should: - Are plans, maps, documents accessible, nr of consultations, interpreted as expected, expected action - Are new communication tools developed

APPENDIX D: Comparison of flood resilience strategies implemented in Paris from 2003 to 2017 (communication context, objectives, target audiences, communication activities and communication variables).

				tools 6) PAPI & PSR: over 60 flood resilience projects promoting risk knowledge and culture	
6) PAPI SEINE & MARNE RIVERS (EPTB SGL, 2014)	1) Greater Paris inhabitants underestimate flood risk 2) Emergency managers have an outstanding knowledge of flood impact data	Develop flood risk knowledge and culture, preparedness to emergency management	1) Inhabitants 2) Educational community 3) Property managers 4) Industries 5) Local public services 6) Local authorities 7) Especially the population of flood-prone areas 8) But also the rest of the population	39 awareness raising actions are planned tailored to the local needs: 1) Resource centre 2) 3 smartphone applications 3) Visualise through 3D technology flood prone areas in order to: 4) Information on social networks 5) Documents and workshops to support training 6) Other actions for different target audiences, with different tools	1) Nr and profile of visitors, how is the information interpreted and used, improvement in risk culture and emergency response 2) Mobile app: data on user profile, location, behaviour; flood risk perception, emergency response 3) Perceptions & skills implementation capacity after the workshops 4) Audience size, profile, perceptions, behaviour
7) OECD REVIEW OF THE SEINE RIVER BASIN (OECD, 2014)	1) Citizens' and decision makers' risk perception is very limited; French risk regulation don't define quantified objectives for risk awareness 2) Awareness has increased in large companies	Reinforcing the 'risk culture': 1) Developing risk knowledge 2) Enhancing river culture 3) Enhancing public engagement	1) Citizens 2) SMEs 3) Decision-makers	1) Consultation of citizens 2) Innovative communication approaches	1) According to the document: lack of quantified objectives for risk culture *2)* What could be improved: - Risk culture, river culture, stakeholder accountability before and after a communication action - Nr and profile of participants to consultations, interactions, collective meaning construction, behaviour

APPENDIX D: Comparison of flood resilience strategies implemented in Paris from 2003 to 2017 (communication context, objectives, target audiences, communication activities and communication variables).

8) PGRI (Mairie de Paris, DEVE, AEU, 2015) / SLGRI – TRI (DRIEE, SGZDS de Paris, 2016)	1) Maintaining and developing risk culture 2) Flood risk information	1) Preventive Information, communication, risk culture 2) Memory on flood risk 3) Integrate risk culture 4) Engaging all stakeholders 5) New information means 6) Inform on the impact of human activity 7) Raise mayors' awareness, facilitate mayors' communication 8) Inform, involve industries 9) Sharing knowledge 10) Raising mayors' awareness	1) Citizens 2) Industry, agriculture sectors 3) Urban planners 4) School pupils 5) Policy makers, decision makers, project developers 7) Public authorities 8) Social and economic actors	1) PPR 2) Training & communication tools on vulnerability reduction 3) Municipalities undertake the following activities: - Signage of past flood river levels; - DICRIM, PCS - Inventory of existing PCS, DICRIM available online - Update the population though public meetings - Website and leaflets - Communication plans describing flood risk, impacts, risk management measures, individual measures 4) Information on climate change impacts 5) Information and training on the advantages of wetland & floodplain 6) Information through the consular chambers. 7) Tailored training 8) Public institutions collaborating to educational programmes 9) Information on flood risks in pedagogical programmes and cultural events on water environment 10) These recommendations translate into local actions tailored to the needs of 15 TRI 11) Île-de-France local strategy	1) According to the document: - Evaluation of the plan in 2021 with evaluation questions, indicators - Evaluation question 'Does the plan facilitate risk culture development?'; implementation rates of PCS and DICRIM + other quantitative indicators or qualitative analysis could be developed during the plan implementation - In IDF: assessment of risk culture and widespread communication assessment 2) What could be improved: - Accessible plans, nr of consultations, interpreted as expected, expected action - Signage: audience size, profile, perceptions, behaviour - Training: perceptions and skills - Public meetings: participants' nr and profile, interaction, collective meaning construction, behaviour change - Web pages and leaflets: nr and profile of visitors, perceptions, used information - Resource Centre: number and profile of visitors, perceptions, used information

APPENDIX D: Comparison of flood resilience strategies implemented in Paris from 2003 to 2017 (communication context, objectives, target audiences, communication activities and communication variables).

				proposes the following communication activities: - Resource Centre with technical information - Strategic communication plan tailored to local culture - Awareness raising, training for school pupils - Information for local authorities through resource centre, DDRM - Training on hazard data - Flood river level signage - Awareness raising, training for different decision makers 12) Maps	

APPENDIX D: Comparison of flood resilience strategies implemented in Paris from 2003 to 2017 (communication context, objectives, target audiences, communication activities and communication variables).

9) PLAN CLIMAT ÉNERGIE (Mairie de Paris, DEVE, AEU)		Protect the population, raise awareness, stakeholders' engagement: 1) Improving the information system & safety instructions 2) Maintaining access to communication networks 3) Better taking into account stakeholders behaviours, expectations 4) Raising awareness and enhancing active involvement 5) Encouraging solidarity	1) Paris inhabitants, 2) Workers in Paris 3) Paris visitors 4) Local economic actors 5) Civil society 6) Vulnerable citizens	1) Information and warning system 2) Awareness raising events 3) Dissemination through the media 4) Multilingual instructions 5) Dissemination public transports, social media, SMS 6) Paris map 7) Communication systems focused on guaranteeing people and activities safety 8) 'Participatory budget', 'Greening licence', 'Paris Climate Action Chart' 9) Traditional and new communication means 10) Activities addressed to the youth 11) Solidarity systems (e.g. Chalex file)	1) Rate of attendance, Nr of press articles, readerships, audience, perceptions, response, behaviour, attitudes, risk culture 2) Rate of assistance requests 3) Public engagement activities: participants' nr and profile, interaction, collective meaning construction, implementation
10) PCS OF PARIS (Marie de Paris and Préfecture de Paris, 2015)	1) A flood in the city of Paris could cause considerable damages 2) 850 000 people could suffer of flood consequences 3) The social diversity, frequent demonstrations & strikes	Raise awareness, develop risk culture, security instructions: 1) Any citizen should keep himself informed before and during a flood 2) Public information will improve the municipality capacity of response to risks	1) Inhabitants 2) Tourists 3) Institutions 4) Industries, businesses 5) Property managers 6) Boat owners 7) Vulnerable people 8) Paris suburbs	*During normal situations:* 1) Families should prepare a PFMS, follow the guide 2) Maps 3) Campaigns on extreme weather 4) Support to vulnerable population: e.g. Chalex file, 'Commerçants Solidaires' 5) DICRIM 6) City of Paris magazines 7) City of Paris websites 8) Electronic Information Displays 9) A mobile app 10) Social networks 11) Public meetings	1) Alarm frequency, spatial range, false alarms, rates of attendance, population reached by the civilian protection, nr of press articles, media audience, nr of website visitors, visit duration, nr of e-mails, posts/ comments, nr of application users, profile of visitors/users/followers, nr of phone calls... 2) Interpretation, behaviour, attitudes, risk culture

APPENDIX D: Comparison of flood resilience strategies implemented in Paris from 2003 to 2017 (communication context, objectives, target audiences, communication activities and communication variables).

				12) Civilian Security 13) Operational Monitoring Centre & Information and Communication Direction monitor the media *During crisis:* 1) Monitoring Centre manages any warning 2) Visual or sound signals with different warning means: - Sirens - Electronic displays, Internet - Civilian Protection	
11) CPIER PLAN SEINE (DRIEE/DBSN 2015)	Follows the PLAN for 2007-2013, is based on State-Region contracts	1) Raise awareness, promote implemented activities 2) Develop a risk culture	Stakeholders of the Seine River Basin	Create a shared information site	who and how many are the stakeholders, quality of shared information, who and how they are benefiting from this information.

APPENDIX D: Comparison of flood resilience strategies implemented in Paris from 2003 to 2017 (communication context, objectives, target audiences, communication activities and communication variables).

12) PARIS RESILIENCE STRATEGY (Mairie de Paris, 100RC, 2017)	1) The terrorist attacks have shown that inhabitants can have a key role in facing emergency 2) Exploiting the opportunities offered by the new technologies, guaranteeing citizens' interests and conservation of resources	1) Create a culture of action and solidarity; 2) Facilitate citizens' initiatives for their active involvement; 3) Inform and train the population to cope with risk 4) Involve the population in urban innovation 5) Encourage the citizens, local organisations to implement resilient solutions 6) Prepare everyone to stresses and shocks 7) Exploit new technologies for communication 8) Enhance solidarity 9) Connect citizens who want to help vulnerable people 10) Reinforce networking and cooperation at different space scales 11) Reinforce networking with other cities 12) Paris as a leader city	1) The inhabitants of the Île-de-France region and Seine River Basin (beyond inner Paris), 2) Vulnerable individuals 3) Neighbourhood networks 4) Local authorities 5) Businesses, companies 6) Farmers 7) Associations 8) Research institutions 9) Land planners 10) Developers 11) Network operators 12) Dealers, logisticians 13) Landlords 14) Restaurant managers 15) Cultural actors 16) The civilian security 17) The fire brigade	1) Regular consultations of partners, citizens, economic actors 2) Support citizens in designing and implementing resilience solutions 3) Exchanges at international level 4) Workshops for citizens 5) A solidarity network 6) A centre dedicated to resilience 7) An interactive map on urban resilience challenges 8) Pedagogical tools and videos, on terrorism 9) Communication campaign to promote psychological support 10) Interactive platform on social practices and association activities 11) FMGP	1) Perception of risk, security, existing solutions 2) Nr of citizens involved 3) Responsible behaviour and solidarity actions 4) Requests for assistance, rescue seeker profiles 5) Nr of participants at consultations, Web platform visitors, active users, Network members 6) Nr of international meetings, attendance, developed and implemented solutions with partners, citizens 7) Integrate communication assessment in a wider resilience assessment

APPENDIX E

COMPLEMENTARY DATA ON THE "QUESTIONNAIRE ADMINISTERED TO THE VISITORS OF AN EXHIBITION".

APPENDIX E: Complementary data on the "Questionnaire administered to the visitors of an exhibition"

Demographic characteristics of the 31 respondents*			
SEX		**EDUCATION**	
Unknown	2 respond. (6 %)	Unknown	1 r. (3 %)
Women	13 r. (42 %)	High-school diploma / Professional diploma of higher education	17 r. (55 %)
Men	16 r. (52 %)	Bachelor/ Master / PhD degree	13 r. (42 %)
AGE		**OCCUPATION**	
Unknown	7 r. (22.5 %)	Unknown	1 r. (3 %)
20-29 years	11 r. (35 %)	Worker	21 r. (68 %)
30-39 years	7 r. (22.5 %)	Student	9 r. (29 %)
40-49 years	6 r. (19 %)		

*** Six experts (who answered "Yes" to the question "Do you have any background knowledge in this scientific field that is due to your professional experience?") were excluded from the initial sample of 37 respondents.**

Questions	Answers	N° of respondents who ticked each option*
Did you visit the exhibition in the hall of the school presenting the RainGain project and the weather radar that will be installed on the roof of the Bienvenüe building?	Yes	13
	No.	18
Did you read the brochure distributed during the exhibition?	Yes	5
	No	8
What does the radar look like?	A green screen with luminous points corresponding to hydrometeors.	6
	A tower of eight metres.	4
	A rectangular box located along the side of the highway.	4
	A rotating parabola.	17
What is the spatial scale of the weather data provided by the radar?	France scale.	4
	Paris region scale.	7
	From department scale to street scale.	20
What are the advantages of X band weather radars compared to C band and S band radars? (more than one option might be correct)	A higher spatial resolution.	13
	The revisit time of the radar is reduced.	6
	The diameter of the dish is reduced to 1.80 m.	8
	The radar range is greater.	15
	Investment costs are reduced.	10
	The pollution of land echoes (that affects meteorological echoes and is produced by the radar antenna) is reduced.	9
What kind of radiation is ionising, i.e. is able to transfer enough energy to the matter it crosses to	A portion of the ultraviolet rays.	14
	The X-rays.	15
	Infrared rays.	4
	C-band and S-band waves.	4

APPENDIX E: Complementary data on the "Questionnaire administered to the visitors of an exhibition"

modify the atoms and molecules ? (more than one option might be correct)	X-band waves.	9
The weather radar of the school will make possible (more than one option might be correct):	Improve fine-scale observation of rainfall	23
	10 minutes rainfall now casts.	17
	One day weather forecast.	7
	Detect when drivers violate speed limits.	0
	Detect intruders entering the building at night.	0
Why is it important to measure precipitations at small scale? (more than one option might be correct)	To improve management of waste water systems.	20
	To reduce risks of floods and pollution.	19
	To obtain reliable long-term forecasts (up to one month in advance).	8
If I work on the campus, exposure to the radar frequencies is:	Intense	3
	Moderate	7
	Very moderate	13
	Non-existent	8
RainGain is a project that concerns the following urban agglomerations:	Paris region, Berlin, Greater London, Recife, Singapore	8
	Paris region, Greater London, Rotterdam, Leuven	15
	Paris region, Lyon, Marseilles, Nantes, Nice	8
Do you think that the information on the RainGain project:	Should be improved.	9
	Should be intensified.	6
	It is necessary.	14
	It is superfluous.	2
Other comments and observations on the project?		Nobody answered this unique open-ended question.

APPENDIX F

DESIGN OF THE INTERVIEW QUESTIONS AND COMPLEMENTARY DATA.

APPENDIX F: Design of the interview questions and complementary data

Both interview sessions were designed through a participatory process involving the international project team (the communication officer, the scientists and the practitioners), and external staff (from the European Commission Interreg Programme, École des Ponts and Terre et Avenir association) who provided a third party advise.

DESIGN OF THE QUESTIONS ON THE PROMOTIONAL VIDEO (Table 1)

These interview questions were designed with the following purposes: assessing the clarity of the video and the intepretation of the respondent (Qa); assessing the information gaps and the interests of the respondent (Qb); obtaining a more general opinion on the video and gathering data on relevant aspects that the examiners might not anticipate (Qc); improving the design of questions in future evaluations (Qa – Qc). The evaluator started each interview by asking the respondent to present himself and has administered the questions in a colloquial manner.

DESIGN OF THE QUESTIONS TO THE SNAPSHOT INTERVIEWS ON THE WORKSHOP (Table 2)

The interviewer started each session by asking the respondent to present himself and has administered the questions in a colloquial manner. The three questions in the table designed with the following purposes: assessing the attractiveness of the workshop activities and the involvement of the participants (Qa); assessing the interpretation and the interests of the respondents (Qb); obtaining a more general opinion and gathering data on relevant aspects that the examiners might not anticipate (Qc); improving the design of questions in future evaluations (Qa – Qc).

ANSWERS TO THE SNAPSHOT INTERVIEWS

Questions	Answers
a. What did you like in this workshop?	1. The experiment with the flour.
	2. The animation showing how rainfall is produced.
	3. The experiment with flour and rain drops.
	4. The animation showing that rainfall comes from the clouds.
	5. The weather radar.
	6. The explanations about the weather radar and how rainfall drops are measured.
	7. Everything.
	8. (Silence).
	9. The flour experiment.
	10. The flour experiment and how rainfall drops behave.
	11. When the scientists Auguste introduced himself.
	12. The experiment with water and flour.
	13. The flour experiment with the pipettes that replaced real rainfall.
	14. The wire experiment.
	15. The water and flour experiment and how the (workshop) space is decorated.
	16. Everything.
	17. The disdromenters animation.
	18. The water and flour experiment.
b. What did you learn that you didn't know before?	1. I didn't know that we can measure rainfall drops in this way.
	2. Rainfall water originally comes from the sea. Too much rainfall in the sewer system can cause floods.
	3. How rainfall is produced.
	4. (Silence).
	5. Now I'm more interested in the topic.

	6. I didn't know how rainfall can be measured.
	7. What weather radars are meant for.
	8. More explanations about the radar.
	9. How rainfall is formed from vapour that comes from the sea.
	10. What has been said about rainfall drops and weather forecasts.
	11. What is the profession of meteorology meant to.
	12. We can do measurements with simple tools.
	13. We can do these experiments at home; when the water evaporates, it is stocked (in the clouds) and it then produces rainfall.
	14. I learnt about radars.
	15. There are different ways to measure water.
	16. Many things, for instance that rainfall drops are very small.
	17. How we measure rainfall.
	18. We can measure rainfall with simple tools.
c. Is there anything you didn't understand or you would like to learn more about?	1. No.
	2. Who made these discoveries about rainfall.
	3. No.
	4. How the water cycle was discovered and who made the discovery.
	5. No.
	6. No.
	7. No, I asked questions when needed.
	8. No.
	9. The existing solutions to reduce flood risk.
	10. How floods occur.
	11. What x-band waves are meant to.
	12. What a radar is meant to and how it works.
	13. No.
	14. What are radars used for? What are the photos of sewer systems about?
	15. What is the photo exhibition about?
	16. No.
	17. How we have to position the flour in the dish.
	18. The part (of the workshop) on radars.