# Assessing the impact of outreach strategies in cities coping with climate risks

Rosa Vicari[1], Ioulia Tchiguirinskaia[1], Daniel Schertzer[1]

[1]Laboratory HM&Co, U. Paris Est / École des Ponts ParisTech, Champs−sur−Marne, 77455, France

*Correspondence to*: Rosa Vicari (rosa.vicari@enpc.fr)

**Abstract.** The resilience of our cities to weather extremes relies both on physical environmental factors and on socio−economic factors. The latters include communication processes among the members of an urban community. This paper presents a study that aims at appraising how public outreach campaigns influence urban resilience. According to this research, seizing the added value of science outreach efforts calls for an assessment method that takes into consideration the interactions between communication processes and other urban resilience drivers. The paper begins by presenting examples of methods to assess urban resilience to weather extremes. We show that communication impact is not accurately taken into account through these methods, despite nowadays science outreach and public engagement are gaining importance in urban resilience projects. We use five guiding criteria to define 'Resilience Communication Indicators' and present three communication assessment experiments based on these criteria. These experiments have been undertaken to assess communication activities addressed to non−specialist audiences and tailored for a flood resilience project in the Paris region. Different quantitative and qualitative research methods have been tested through these experiments, with the goal of apprehending their strengths and weaknesses in the framework of urban resilience strategies.

## 1 Introduction

Cities are complex systems, with multiple functions and interacting components, where climate pressures contribute to their complexity (Ruth and Coelho, 2007). In this paper, we refer to the social−ecological resilience as a theoretical frame, since it allows apprehending the complex interactions among social, economic, physical and environmental components of urban systems. The early engineering interpretation of resilience was concerned about the capacity of a stable system to absorb a stress and to continue to maintain its function. The 'social−ecological resilience' approach outlined by Holling (1973) departed from the mainstream interpretation of resilience by pointing at renewal, re−organisation, innovation, development and adaptation as important capacities of a resilient system (Gunderson and Holling, 2002; Berkes et al., 2003; Adger, 2006, Folke et al., 2010). This approach presupposes the use of resilience indicators as an empirical basis to translate the concept of social−ecological resilience into practice. Once different urban components and functions are identified as 'resilience drivers', specific variables are chosen to measure the impact of each of them on urban resilience.

In this study, we propose to explore how urban resilience assessments can better take into account the interactions between science outreach and other resilience drivers. With this general scope, we examine:

(i) the variables that are available in the context of a flood resilience project (RainGain) and that can be adopted as 'RCI' (Resilience Communication Indicators');

(ii) the strengths and weaknesses of different methods that can be employed to monitor these indicators.

After outlining the concept of social−ecological resilience and discussing the worth of resilience metrics in Sect. 2, we give an overview of different assessment frameworks that consider communication impact in Sect. 3. We consider that this impact is not sufficiently explored in the literature on urban resilience indicators, despite the growing importance of science outreach in urban resilience projects and strategies. Some examples of flood resilience strategies implemented in the Paris region are recalled in Sect. 4 and used as a basis to outline guiding criteria for selection of RCI. These indicators are based on quantitative variables since numerical data allow exploring the correlations between communication and other resilience drivers. In Sect. 5 we present three experiments undertaken in the framework of the European project Interreg NWE IVB RainGain to test different assessment methods: media monitoring, a questionnaire, and interviews.

## 2 Social−ecological resilience, from theory to implementation

According to the social−ecological resilience perspective, ‘resilience’ can be defined as the "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Walker et al., 2004). ‘Transformability’ and ‘adaptability’ (Folke et al., 2010) are considered as essential characteristics of a resilient system. This approach puts the accent on uncertainty, non−linear dynamics, interplay between gradual change and rapid change (Walker and Meyers, 2004). The trajectory followed by a system after a perturbation can’t be described as reaching ‘stable states’ or ‘equilibriums’, but rather with the concepts of ‘regimes’ or ‘attractors’ (Carpenter, 2003).

These dynamics involve interactions across different time and space scales (Schertzer and Lovejoy, 2004; Tchiguirinskaia et al., 2014), as well as throughout different socio−economic and physical environmental dimensions of a system (Kirch, 2005; Millennium Ecosystem Assessment (MA), 2005). This multi−dimensional perspective is particularly suited to studying the complexity of urban systems and the influence of communication processes on resilience. Cities have multiple components and functions, including the communication factors that can be defined as part of the social dimension and that obviously have interdependencies with the economic, physical and environmental dimensions.

By the 2000s, increasing attention among academics, as well as practitioners, has been devoted to the implementation of resilience. Putting the concept of social−ecological resilience into practice involves relevant changes in policy and decision−making. Indeed, the social−ecological resilience approach emphasizes the need to apply the principle of subsidiarity, i.e. to decentralise risk management, to encourage citizen participation and share responsibilities with them (Tanguy, 2015). In Sect. 4, we discuss some cases of recent resilience strategies implemented in the Paris region that entail

engagement activities. These examples illustrate how public outreach and citizens' perceptions are gaining importance, as a consequence of the implementation of the subsidiarity principle.

Going beyond theory and implementing resilience requires resilience metrics: relevant indexes allow 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 stakeholders' involvement during and after a project. According to Carpenter et al. (2001), resilience metrics allow testing hypotheses on the dynamics of systems and enable cross-system comparisons.

A first necessary step to design resilience metrics is to identify the disturbance and the system we are interested in. Even though the interplay with other scales and other shocks or stresses shouldn't be ignored, answering the question "resilience of what, to what?" (Carpenter et al., 2001) is an essential basis to establish resilience indicators. The same relevant variables can be then compared in different systems (e.g. different cities) or in the same system at different moments. In this paper, the focus is on cities facing climate risks: in the next sections we present examples of resilience assessment frameworks that are adequate to urban areas coping with extreme weather (Sect. 3); we then discuss the role of communication in flood resilience strategies implemented in the Paris region and we outline guidelines to define RCI for cities facing climate risks (Sect. 4); we finally compare different communication assessment techniques that have been tested in the framework of RainGain, a European research project on urban flood resilience (Sect. 5).

The resilience assessment approaches presented in the next section are quite 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 on-site implementation. However, none of these approaches sufficiently investigates the impact of communication processes and, more specifically, of science outreach.

## 3 Communication indicators in the literature on resilience assessment techniques

According to Charrière et al. (2017), impact assessment of risk communication campaigns isn't a widespread practice yet. This trend can be also observed in the literature on resilience indicators. This section presents three resilience assessment frameworks that consider the impact of communication processes, a feature that is not so common among the available indicators for cities coping with weather extremes (for a review, see Vicari et al., 2015).

### 3.1 Resilience Alliance

'Resilience Alliance' (RA) (Resilience Alliance, 2010) is an international, multidisciplinary research organisation that develops guidelines to assess resilience of social–ecological systems and to implement sustainable development strategies. RA outlines an assessment framework that is consistent with the social–ecological approach. According to this method, multiple spatial and temporal interacting scales most be considered. Furthermore, for each variable, a threshold

should be defined. If the threshold is crossed, the effects on other social and ecological variables most be identified. Communication is evaluated in terms of 'information sharing', a factor that characterises social relations among stakeholders. According to the RA method, communication needs to be monitored since it affects the dynamics of systems. Social relations and information flows are analysed by comparing different social network structures: e.g. a highly centralised network or a network composed of two isolated subgroups. The RA approach doesn't offer any tool to investigate the intensity or quality of information exchange.

### 3.2 The Disaster Resilience Of Place model and the Baseline Indicators for Communities

The 'DROP' (Disaster Resilience Of Place) model and the related 'BRIC' (Baseline Resilience Indicators for Communities) (Cutter et al. 2008; 2010) 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 at different spatial scales. It outlines a composite resilience index, with sub-indexes corresponding to different dimensions of the urban system. These indexes are exclusively quantitative variables that are converted into a normalised scale. Communication impact is taken into account, though in a rather limited manner: the percentage of population with a telephone is used as an indicator of communication capacity. Hence, other important communication infrastructures – such as mobile phones, Internet, TV and radio – as well as the communication processes are not considered.

### 3.3 The Hyogo Framework for Action

The 'Hyogo Framework for Action' (HFA) is an assessment approach developed by the United Nations secretariat of the International Strategy for Disaster Reduction. It is widespread worldwide, with about 270 municipalities that have implemented it (www.preventionweb.net). "Indicators of Progress: Guidance on Measuring the Reduction of Disaster Risks and the Implementation of the Hyogo Framework for Action" was published in 2008 (UN/ISDR, 2008), following the request of national governments for a tool to assess their progress toward the goals of the "Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters" (UN/ISDR, 2007). Even though qualitative assessment is widely used, quantitative variables are also considered. However, it should be noted that there are discrepancies between the HFA approach and the social-ecological resilience perspective. The HFA points at disaster reduction in the context of sustainable development, rather than at resilience as an overall objective. Furthermore, policy making factors prevail on other resilience drivers.

Among the selected assessment frameworks, the HFA is the method that puts most emphasis on the importance of education and dissemination in risk management. One of the five priorities for action is to "use knowledge, innovation and education to build a culture of safety and resilience at all levels". Examples of indicators associated with this priority are: "development of community based training", "presence or extent of applicable education material". Another HFA priority, that is related to communication, is to "Identify, assess and monitor disaster risks and enhance warning", with indicators such as "Coverage by type and objective of media markets with programming disaster management awareness" and "Early

warning information and alerts reaching populations at risk". None of these indicators examine the quality of communication.

Among the nine assessment frameworks reviewed by Vicari et al. (2015), only the three methods presented in this section refer to communication effects. Furthermore, the RA, DROP−BRIC and HFA methods offer a range of communication indicators that aren't enough sophisticated to evaluate science outreach activities, especially in terms of quality. However, these three assessment frameworks call attention to the importance of communication in resilience strategies and open the path to further research on RCI. As it is discussed in the next section, communication has a key role in the recent Paris flood resilience strategies. These practices are a helpful basis to identify relevant communication variables and outline guidelines for RCI.

We should finally note that the RA approach employs quantitative variables to study the correlations between social factors and ecological factors. Moreover, the DROP−BRIC method shows that quantitative indicators facilitate the comparison of different spatial scales. These observations are in line with the conclusions of the review by Vicari et al. (2015) that have led us to focus on quantitative communication variables, as those presented in the next section.

## 4 Assessing the impact of communication on urban resilience to extreme weather

In the last five years in the Paris region, public authorities have shown increasing efforts to facilitate access to information on climate risk management, encourage citizens' participation and share responsibilities with them. Unlike the strategies released by public authorities before 2014, recent strategic documents (EPBT SGL, 2014; MEDDE, 2014; OECD, 2014; DRIEE, 2015; DRIEE/DBSN, 2015; Mairie de Paris and Prefecture de Police, 2015; Mairie de Paris, Direction des Espaces Verts et de l'Environnement, Agence d'Écologie Urbaine, 2015; Mairie de Paris and 100 Resilient Cities, 2017) 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 have 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.

Even though recent resilience strategies frequently entail a communication strategy, French public strategies on flood resilience barely refer to communication impact assessment. The French "National Strategy for Flood Risk Management" (MEDDE, 2014) and the "Flood Risk Management Plan 2016−2021: Seine−Normandy Basin" (DRIEE, 2015) identify quite rudimentary communication metrics. A hypothesis of relevant communication variables has been outlined by Vicari et al. (2016). In this former study, quantitative variables are selected on the basis of the communication objectives, target audiences and communication actions of 13 flood resilience strategies, implemented in Paris from 2003 to 2017. These

variables are conceived as tools that can be adopted by the decision makers to evaluate if the communication goals have been achieved. Hence, these indicators are tailored to each resilience strategy and context specificity and they rely on the available communication data that can be collected for evaluation. Nevertheless, these variables can be grouped into five recurring categories that are listed below. The following categories can serve as guiding criteria to include relevant RCI in a wider urban resilience assessment (such as those presented in Sect. 3):

i. ***Intensity:*** number of tweets, retweets, followers, comments, attendees, website unique visitors, visit duration, number of press news, readerships, etc. Each rate can be broken down by different sub−groups of audience.

ii. ***Quality*** (Did it reach the adequate target audience? Was the message correctly received? Does the response match with what was expected?): number of distributed messages that are consistent with the campaign key messages, percentage of target audience that had a good understanding of the messages, percentage of audience who gained knowledge through the campaign, percentage of target audience that took action to contribute to the campaign goal achievement. Each rate can be broken down by different sub−groups of audience.

iii. ***Participatory communication:*** percentage of target audience who contributed to disseminate information, percentage of citizen information that contributed to change 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).

iv. ***Comparison***: between different time periods, locations and target audiences.

v. ***Interplay with other resilience drivers:*** examples of correlations between communication and other urban system components are a) policy makers that have been influenced by the media coverage of a flood (e.g. a debate on insurance issues or alarm dysfunction); b) an information campaign that has contributed to decrease damages and injuries; c) a new transport connection that has increased the attendance rate and variety of participants to a conference. This criterion allows to establish the connection between RCI and other resilience indicators and to integrate communication assessment in a wider resilience assessment framework.

The next section presents three different kinds of experiments that have been carried out in the framework of the RainGain project. Each experiment takes into account some of the five guiding criteria listed above. More specifically, the first experiment "Media coverage monitoring" explores the intensity of communication (criterion i), it compares different time periods (criterion iv) and highlights the correlations between communication and another resilience driver, i.e. a meteorological event (criterion v). The second experiment "Survey administered to the visitors of an exhibition" explores the quality of communication (criterion ii) and compares different sub−groups of audiences (criterion iv). The third experiment "Interviews" concerns the quality of communication (criterion ii).

## 5 The RainGain project: experiences in communication assessment for a urban resilience project

The HM&Co (Hydrology Meteorology and Complexity) laboratory of École des Ponts ParisTech has coordinated several research projects aimed at enhancing urban resilience to extreme weather. HM&Co research projects also involve developing

and strengthening a network of stakeholders through dissemination and public engagement activities. HM&Co has striven in this direction by first being involved in the participatory workshops addressed to the stakeholders of the ERANET Crue SUCAs and FP7 SMARTeST projects. After these first experiences, HM&Co has coordinated a four−year long communication strategy in the framework of the 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 mobilized so that vulnerability to urban pluvial flooding is reduced and resilience is enhanced" (Interreg NWE IVB RainGain, 2011).

The frequency of communication activities and their impact, in terms of audience size, have been monitored since the beginning of the communication plan. This has enabled HM&Co to adjust the communication activities during the project implementation when problems were revealed. Indeed, precise target values have been established in the communication strategy. During the execution of the plan, the target values have been periodically compared with the attained values in order to appraise if sufficient efforts and resources were devoted to specific activities (Fig. 1).

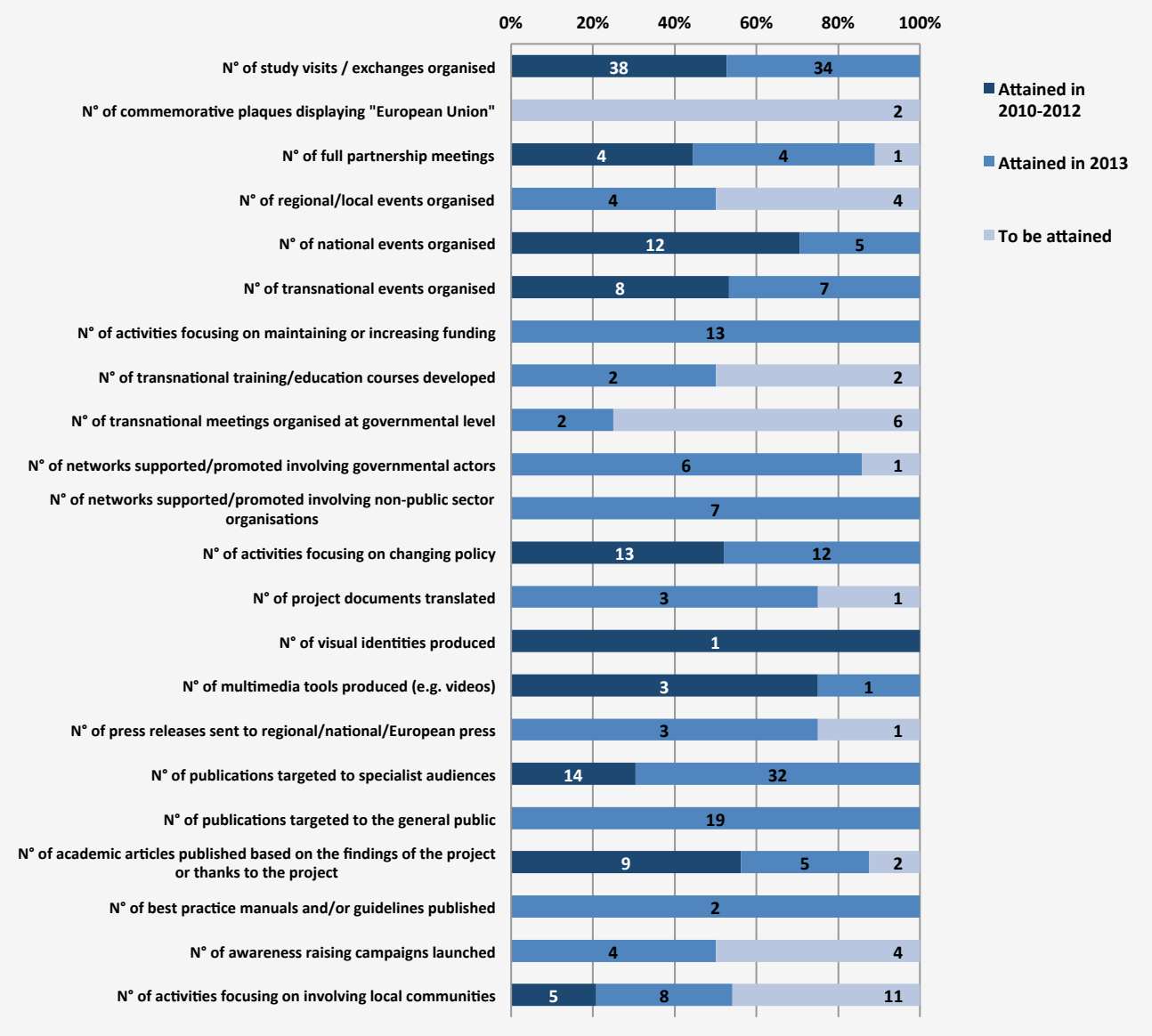



**Figure 1: Monitoring of the frequency of the RainGain communication activities in 2013. During the execution of the RainGain communication plan, the target values (to be attained by the end of the project) were periodically compared with the attained values.**

## 5.1 Media coverage monitoring

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

- Feedbacks from the Communication Department of École des Ponts that constantly monitors, through Europresse (europresse.com), if the media mention "École des Ponts".
- Search on Google News of press news that include the key−word "RainGain".
- Feedbacks from the researchers that were interviewed by the press on the RainGain project.
- Data on the audience size of printed press have been collected on each newspaper website.

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

Figure 2 shows that during specific months the number of news has rapidly increased. Two kinds of events have 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 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.

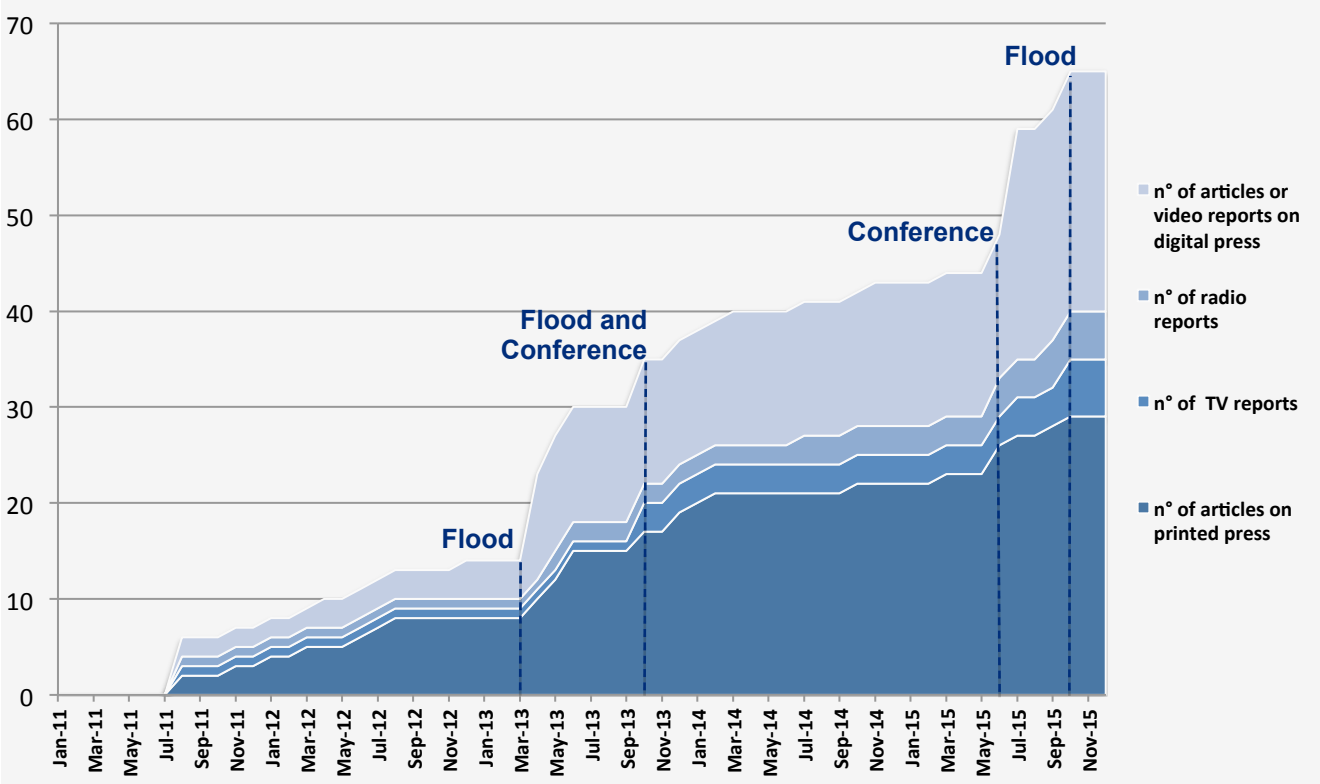


**Figure 2: Number of news (printed press, digital press, TV and radio) concerning the RainGain project and published from July 2011 to November 2015. The number of news has rapidly raised during specific events: 1) dissemination of a press release on the project (March 2013); 2) a flood event in The 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).**

Data on the number of printed press news have been compared to the data on the newspaper audience size. As Figure 3 shows, the ratio between the number of articles and the audience size is variable. Indeed, different newspapers have different impacts in terms of audience size, hence the impact of a news 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.

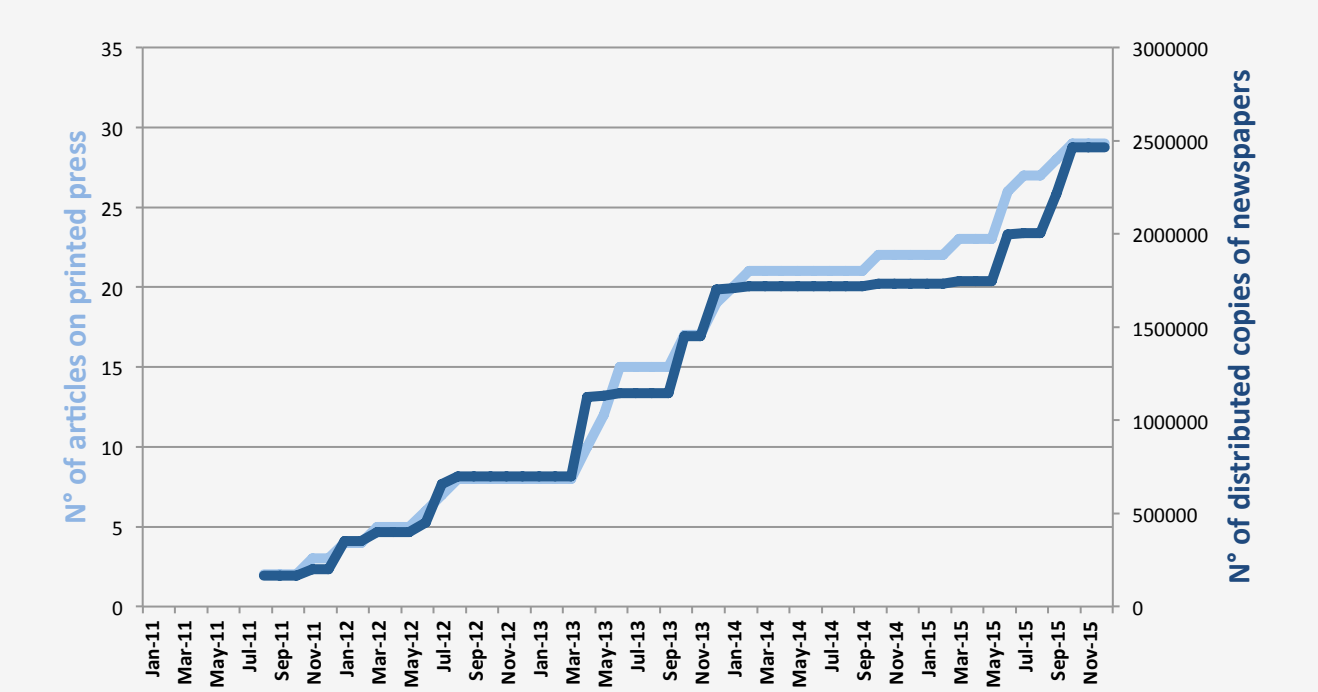



**Figure 3: The ratio between the number of articles and the audience size of printed press. The differences between the two curves are due to the fact that different newspapers have different impacts in term of audience size, hence the impact of a news is variable according to the newspaper that publishes it.**

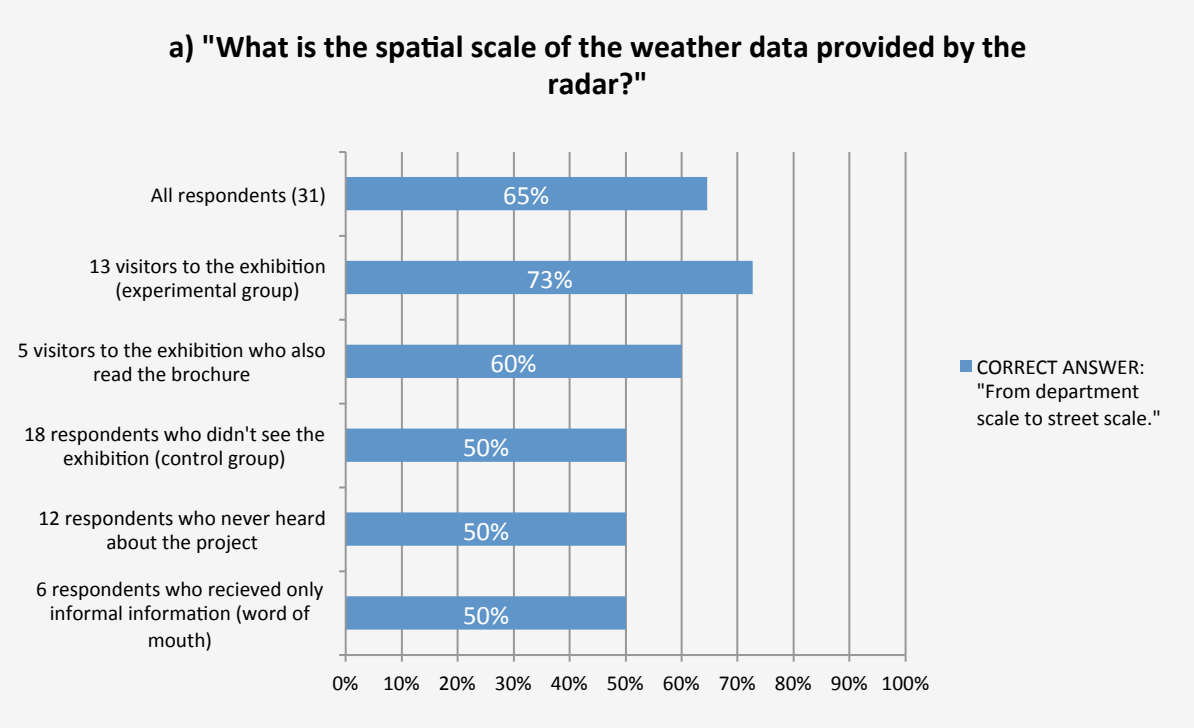
The frequency of press news and the audience size are two RCI that allows identifying the population that has received a specific message. This is a necessary step to evaluate the communication effects on citizens' perceptions and urban community resilience. The RCI employed in this experiment also allow to observe how the resonance of a message evolves over time (Fig. 2 and 3) and to identify possible correlations with other resilience drivers (e.g. a meteorological event, as it shown in Fig. 1). Nevertheless, an aggregated analysis of press news doesn't give any insight on the quality of the communication contents.

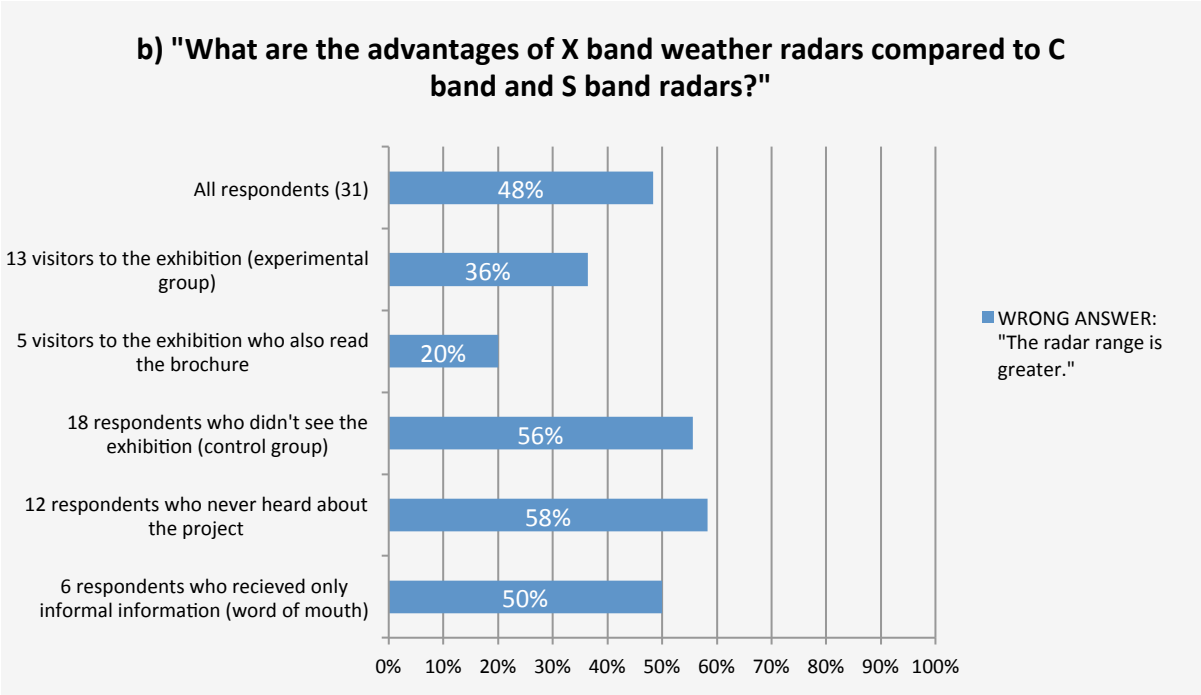
### 5.2 Survey administered to the visitors of an exhibition

The experiment presented in this section illustrates how RCI based on a survey can capture the quality of communication and if the audience has understood and accepted a message. Indeed, even if a communication activity reaches a wide public, the communication impact on urban resilience will vary according to the way the message is perceived. Survey questions, such as those presented in this experiment, provide variables (e.g. frequency of correct questions, frequency of high risk perception) that can be used as RCI to assess the respondent comprehension and perception.

Following an exhibition dedicated to the RainGain project (April 2014), a survey has been distributed to the visitors. The questionnaire aimed at exploring if the exhibition was understood and if it changed the visitors' perception of RainGain (Persoz, 2014). 37 respondents have been recruited on a voluntary basis among the 513 workers and 827 students of École des Ponts. They have been invited through internal mailing to complete an online survey form. The sample has been expected to be small, since no monetary incentive was provided for survey participation and there was no examiner who could individually reach each potential respondent to solicit his answers. We were also aware that surveys give limited insights on the cognitive processes that shape individual and social perceptions. However, rather than to obtaining results that can be generalised to a wider population, our main objective was to test if quantitative research can be employed to evaluate the quality of communication. 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 survey included questions on the professional background of the respondents. These questions allowed to exclude six experts 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. 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 has been 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 received only informal information (from word of mouth); 4) 12 participants who never heard about the project. In order to perform a comparative experiment, the first subset has been considered as the experimental group with 13 respondents, while the third and fourth subsets have been considered as the control group with 18 respondents. We have used the Fisher's Exact test to compare the answers of the experimental group with those of the control group.


a) "What is the spatial scale of the weather data provided by the radar?"
All respondents (31)
65%
13 visitors to the exhibition (experimental group)
73%
5 visitors to the exhibition who also read the brochure
60%
18 respondents who didn't see the exhibition (control group)
50%
12 respondents who never heard about the project
50%
6 respondents who recieved only informal information (word of mouth)
50%
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
CORRECT ANSWER: "From department scale to street scale."


b) "What are the advantages of X band weather radars compared to C band and S band radars?"
All respondents (31)
48%
13 visitors to the exhibition (experimental group)
36%
5 visitors to the exhibition who also read the brochure
20%
18 respondents who didn't see the exhibition (control group)
56%
12 respondents who never heard about the project
58%
6 respondents who recieved only informal information (word of mouth)
50%
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
WRONG ANSWER: "The radar range is greater."

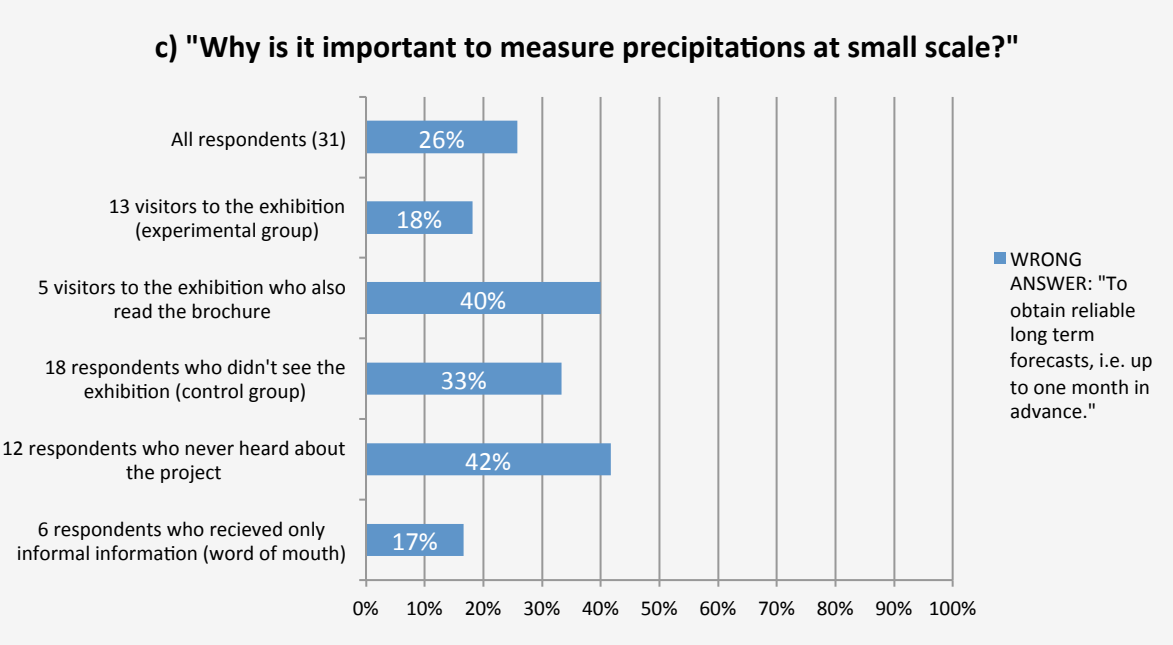



**Figure 4: The answers to three of the survey questions on the RainGain exhibition held in April 2014.**

Figure 4(a) shows that the number of exhibition visitors who have 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. 4(b), 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. 4(c), the number of visitors who have provided a wrong response to the question "Why is it important 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 knowledge dissemination.

An unexpected result concerns the responses of the exhibition visitors who read the brochure in Fig. 4(a) and 4(c). In Fig. 4(a) the rate of correct responses of the visitors who read the brochure is lower (60 %) than in the experimental group (73%). Figure 4(c) shows that the rate of wrong answers among the visitors who read the brochures is surprisingly high (40%): it is close to the rate of wrong answers of the respondents who never heard about the project (42 %). A plausible explanation is that the visitors who picked the brochure have spent little time to read the exhibition panels and that part of the brochure information was not enough didactic and suitable for the general public.

Figure 4(c) 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. According to this figure, face−to−face communication can strongly reinforce transmission of highly technical information.

Figure 5 presents the answers to a survey question aimed at evaluating the visitors' risk perception after the exhibition and if this event reinforced the project acceptance. The results show that the exhibition and the brochure, i.e. formal and official information, helped to reassure the visitors on security issues. Word of mouth communication didn't have such a positive effect as formal information, but neither did it compromise the achievement of the project goals.

The Fisher Exact test[1] has been 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 of the experimental group and of the control group aren't statistically significant.

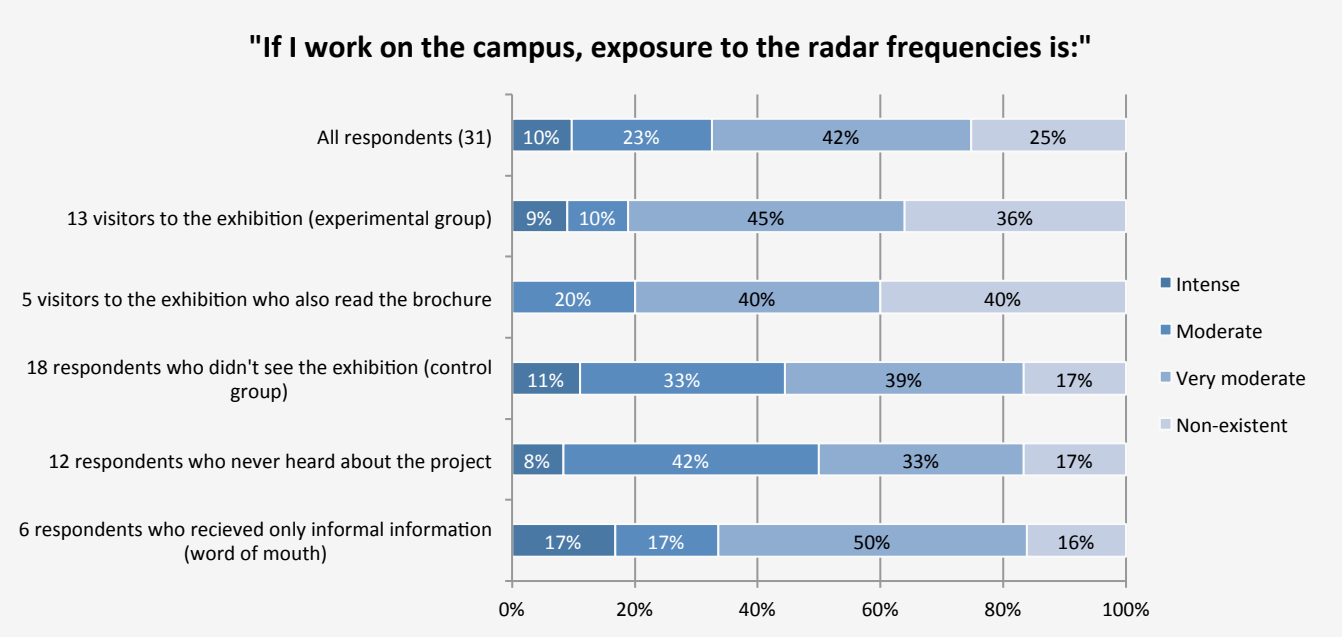



**Figure 5: Answers to a survey question evaluating the risk perception of the visitors after the RainGain exhibition.**

### 5.3 Interviews

While surveys with close−ended questions allow quantifying 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 RCI. Nevertheless, this is a helpful evaluation method to be adopted for exploratory studies or to validate the results of a survey.

[1] We have computed a 2x2 contingency table, for each survey question, with the frequencies of: a) the correct answers of the experimental group; b) the correct answers of the control group; c) the wrong answers of the experimental group; d) the wrong answers of the control group. We have 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:

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

Two assessments based on open–ended questions have been conducted during the RainGain project to evaluate the impact of outreach activities.

One of the achievements of RainGain has been 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 has involved a wide range of outreach activities and means. One of the promotional contents, that have been 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, the manager of the school café and a charismatic and well–known figure on the campus, has been involved as the speaker of the video. While the video has been broadcast on Youtube and on the school screens, four interviews have been held. The questions aimed to appraise what kind of information the audience expected and how they interpreted the video contents. The respondents have been selected from the list of students invited to the conference and they have answered to the examiner on a voluntary basis.

| |
|---|
| **What was unclear in the video and why?** |
| **Which aspects of the project would you like to learn more about?** |
| **What are the strengths and weaknesses of this video?** |

**Table 2: Questions to the audience of the video "Jeanine presents the radar" (Mulard, 2015).**

The video has been appreciated by the respondents who found it "catchy" thanks to its dynamic pacing and the charisma of the speaker. They have 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 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 ("Does the radar allow predicting 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 surveys addressed to students from an engineering school. For instance, 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 3), has been undertaken in November 2015 to evaluate the impact of a workshop on RainGain (held during the Provin Climate Forum). The respondents were all the participants of the workshop: 20 pupils, aged eight years, 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 has highlighted that the audience enjoyed and memorized very well a manual activity on rainfall observation where they were active participants. It also revealed that the third question was misunderstood. Its purpose was to assess the clarity and exhaustiveness of the communication contents, but the respondents have 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.

| |
|---|
| **What did you like in this workshop?** |
| **What did you learn that you didn't know before?** |
| **Is there anything you didn't understand or you would like to learn more about?** |

**Table 3: Questions to the participants of the RainGain workshop, held by Auguste Gires in the framework of the Provin Forum (November 2015).**

## 6 Conclusions and perspectives

The increasing awareness of the role that citizens can play as active actors of urban resilience make essential the development of relevant communication indicators. This study highlights that quantitative metrics are a promising tool for communication assessment in the framework of resilience strategies.

The experiments carried out during the RainGain project have brought out valuable RCI. A preliminary study of Paris flood resilience strategies and the related communication plans has allowed us to identify five recurring categories of communication variables. Each category constitutes a helpful guidance to define RCI. At this stage of the research, we are cautious in generalising the validity of the RCI guiding criteria because they refer to the resilience communication strategies adopted in a unique region to cope with a specific climate risk. Nevertheless, this work paves the way to future developments. The same applies to the following conclusions that are the result of a limited number of small-scale experiments.

The media monitoring experiment highlights that news frequency and audience size are two RCI that allow identifying the population that has been 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 investigate the quality of the contents that have spread through press news: for instance, if the representation of scientific innovation by

the press is positive or negative and what are the correlations with the concept of resilient cities. Computer–assisted text mining tools are a possible methodological path to be followed.

Such big data exploration techniques would also allow overcoming time and cost constraints that have been encountered with the survey experiment, the results of which should be validated with a larger sample. However, thanks to this experiment it has been possible to: 1) design RCI aimed at evaluating to what extent a message has been understood and accepted 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 normalize the response ratings to different questions.

Qualitative assessment methods, such as interviews, allow 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 methods tested through these three experiments appear to be complementary and endorse the following conclusions: assessment aimed to investigate the impact of communication on resilience cannot rely on a unique technique and quantitative analysis is paramount in this context. Indeed, data in numerical form facilitate the study of interactions 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 this study, we envisage to compare the present results with those obtained by investigating the quality of digital media contents and the cognitive dynamics that occur through the Web. In a resilience assessment perspective, the advantage of digital communication datasets is that they allow extracting numerical data on social relations. Moreover, thanks to computer aided exploration techniques it is possible to both consider the global trend and the individual behaviour. The RCI employed in the media monitoring and survey experiments could be tested on larger scales thanks to big data exploration techniques. At the same time, the methods discussed in this paper can be used to detect possible biases induced by the Web. This emphasises again the need to use complimentary techniques to assess communication impact on urban resilience.

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