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Testing the effectiveness of visual risk communication in reality. A research approach that is beneficial for both scientists and communities at risk

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Extended Abstract

INTRODUCTION

One of the key actions for disaster risk reduction is raising awareness (UNISDR, 2004). When funding is lacking such non-structural mitigation measures are particularly important to engage as they often cost less than structural mitigation measures (Phillips et al., 2011). On way to increase risk awareness is through risk communication, including visual risk communication. Trumbo (1999) defines visual communication as "*a process of sending and receiving messages using visual images and representation to structure the message*". Visual communication can be realized through a wide range of tools: pictures, movies, charts, graphics, maps and objects. The benefits of using visuals in risk communication are to help understand and think, to remember content, to make the information more realistic, to clarify abstract concepts, and to put facts into context (Schwarzenegger & Renteria, 2006).

Risk communication efforts should be effective, especially if these are the main mitigation measure in place. Therefore, they must be evaluated to ensure their effectiveness. Evaluation of risk communication's effectiveness allows improving future programs, choosing between alternative efforts and justifying them (Rohrmann 1992, 1998). The need for evaluating risk communication efforts is stressed by several authors (Penning-Rowsell & Handmer 1990, Covello et al. 1991, McCallum 1995, Lipkus & Hollands 1999, Lundgren & McMakin 2004). In this study, we are interested in outcome evaluation (Rohrmann, 1992).

Previous research (Charrière et al. 2012) showed that visual risk communication linked to natural hazards is mostly evaluated in terms of user's requirements, ability to understand the content, or satisfaction with the diverse components of the tool(s) and that its impact on risk awareness is not researched. Most of the risk communication evaluations are performed in a lab-type environments (eg. Spachinger et al. 2008).

Our approach differs in the sense that we decided to test a real communication effort. However, we did not use an existing one but designed our own. This process was conducted according to collaborative research principles, meaning that we created it in collaboration with the local stakeholders. Moreover, our research activity should be beneficial and significant for the community in which we work as well as for science. This contribution will

present the process that allowed us to design an exhibition in the Ubaye Valley (France) and the methodology that was developed to measure changes in risk awareness.

DESIGNING THE 'ALERTE' EXHIBITION

Using an exhibition as an experimental setting to test the effectiveness of visuals for raising awareness is not an idea that came from us: it resulted from a long consultation process with stakeholders from Barcelonnette (Southern French Alps), our case study. Three visits were needed to develop this idea (consultation phase). Two additional visits to the case study were required to put it into practice (collaboration phase).

Consultation and collaboration with local stakeholders

In short, the principal stakeholders in France related to risk management are the major and his/her deputies. who are responsible of the security on the municipality's territory, the *Préfet,* who takes over when the event concerns more than one municipality and the local technicians from the local branch of the national organization *Restauration des Terrains en Montagnes* (RTM), whose main roles are linked to hazard mapping and structural mitigation measures. We collaborated mostly with the latter as well as with the employees of the Municipal Library.

The contact with RTM technicians was made at the very beginning of the consultation phase through the help of senior scientists. It appeared almost instantly that they were very inclined to collaborate and this was shown true throughout the development of the communication effort: they assisted in many ways in the whole process, as it will be explained further on.

Introduction and access to other stakeholders developed according to the snowball approach: a first stakeholder facilitated the access to other ones, and so on. The employees of the Municipal Library were met after being introduced by the two deputies of Barcelonnette (Education and Culture). Another example is the contacts made via the RTM technicians to inhabitants that were videotaped for the exhibition (testimonies). This approach proved very successful in our work in the small community (7500 inhabitants in 2006) of the Ubaye valley.

Target the audience of the project

Although the population was a priori set to be the audience that would be targeted, the stakeholders' consultation allowed to refine that group to more precise sub-groups. Elderly inhabitants living in the valley for a long time, children and tourists were proposed by the stakeholders to be the sub-groups of the population on which the research activity should focus.

Elderly people and children can be more vulnerable to natural disasters than other age groups (Cutter et al. 2003) and it is thus interesting to concentrate the research on them. But the focus on those two sub-groups of the population is also due to several other reasons.

Elderly inhabitants that lived in the Ubaye valley are believed to be an interesting group to test the impact of a communication effort. It is assumed that this sub-group of the population has more experience with natural hazards occurring in the case study than other sub-group of the population (younger adults, children) as they have lived there for a longer time. In consequence, it can be assumed that communicating about natural hazards with them might have a lower impact on their awareness than with other sub-group of the population. Therefore, including the elderly people in the research design can help to test this assumption.

Children are a very important group to include in such research. It is commonly accepted that they are a good group to target in order to spread out information to other groups of the population (Finnis et al. 2004) and thus to improve the awareness of the whole population. From a scientific point of view, this sub-group is very interesting because few studies about risk awareness and preparedness include children in their sample. From a practical point of view, the great interest of the educational stakeholders to the project identified during the first phase of the consultation, as well as the fact that the children are gathered in one structure (the school) that is easy to approach, make them an ideal target group for a communication effort and the associated research activity.

The potential to include tourists in the research activity was highlighted during a discussion with the *Sous-Préfète*[1] of Barcelonnette. She referred to tourists as a priority group to inform about natural hazards as their knowledge of the area, the phenomena that can take place and the action to take might be partial or inexistent. Therefore, two tourism information centres, two hotels, two campings and two providers of outdoors activities were visited. Generally, it appeared from these informal discussions that these stakeholders were not particularly willing to collaborate with us. Therefore, the focus on tourists was not pursued.

Eventually, all the three sub-groups (elderly, children and tourists) as well as teenagers and, to a limited extent, younger adults participated in the research activity due to the help of one of the main collaborating stakeholders, the employees of the Municipal Library where the exhibition took place. Thanks to their personal network in the valley and their high motivation to assist the research, they were able to promote the research activity and convince three groups of elderly people, one group of tourists, one group of employees of the National Park, 3 group of teenagers and 7 classes of children to participate in the full research activity. In addition, several younger adults and tourists that visited the exhibition in an independent way agreed to fill in a satisfaction survey.

Determine a specific testing activity

The first meeting with the employees of the Municipal Library was a brief encounter at the opening of an exhibition in the premises of the multimedia library. It is not known if this fact had any influence, but a few days after, during the first formal meeting, the Head of the Library came up with the idea of holding an exhibition on natural hazards. The only condition was that, to fit to the policies of the venue, the exhibition should address two different types of audience: adults and children. The reasons for which we pursued this idea were multiple. First the employees of the Municipal Library understood the need to design the exhibition in a way that can be used for research purposes as well. Secondly, they promised support in many aspects (funding, organization, access to participants). Very importantly, an exhibition is the perfect research setting to use a lot of different visuals and thus test their effectiveness. Finally, an exhibition is a real communication practice targeting the population and allowing to embrace the topic of natural hazards and associated risks from all the possible perspectives (natural phenomena and mitigation measures).

Determine the content of the exhibition

After the idea to create an exhibition was brought to us and we decided to pursue it, the time came to decide what will be displayed. Here again, the stakeholders' consultation and collaboration had an influence, as much as the literature review and the research questions.

From the stakeholders' consultation and collaboration, we derived that the exhibition should focus not only on the natural hazards on which the project CHANGES is centered, i.e.

[1] The *Sous-Préfets* and *Sous-Préfètes* are the assistants of the *Préfet/Préfèt* who is representing the French National State in the Regions or Departments.

landslides, debris flows and floods, but also on earthquakes and snow avalanches as they occur frequently in the Ubaye valley. Moreover, scientists familiar with the case study and most importantly local RTM technicians provided the large majority of information and data that was presented. Inhabitants also contributed by providing pictures and more significantly by agreeing to be interviewed on their personal experiences of natural hazards. These inhabitants were identified and selected based on the information provided by the RTM technicians. Finally, the reading level of the exhibition was chosen to accommodate the condition given by the multimedia library: the exhibition should target all age groups. Therefore, a reading level suitable for 10-15 years children was adopted, assuming that younger children would not have too much interest in the textual parts of the exhibition.

From our preliminary literature review and the research questions, the following points had to be taken into account. The exhibition should englobe as much as possible the topic of natural hazard and associated risks. Thus it was developed around two general aspects of the risk issue: the physical phenomena and the mitigation measures. Moreover, following the idea that the message of risk communication should be tailored to the situation (Höppner et al. 2010), the topics and sub-topics of the exhibition should be illustrated by local examples (except for one picture of avalanche from Norway and videos of earthquake from Japan). Visual tools (pictures, drawings, graphs, videos, objects) were prioritized, and text was only used as support. More complex information was nevertheless included (using supporting information boards) to address more comprehensively the topics and to satisfy more expert people.

The 'Alerte' exhibition

As the result of this stakeholders' consultation process, the exhibition "Alerte – 'ALEas Risques et proTEction' : Connaître les risques en montagne, c'est y être mieux préparé »[2] was held at the public multimedia library of Barcelonnette, the largest town of the Ubaye valley, between the 4th of December 2013 and the 19th of February 2014. Access to the exhibition, free of charge, was possible during the opening hours of the venue (18 hours a week). The exhibition was displayed in a space of 80m^2 consisting of 2 different rooms. The following exhibits were on display: 1 A0 poster on the risk concept; 8 A0 posters on hazards (floods, landslides, earthquakes and avalanches) and their local occurrence; 6 A0 posters on mitigation measures,;12 supportive information boards (30x30cm); a realistic flood scale model, based on the DEM of Barcelonnette; a seismograph; one set of videos of local events (except for earthquakes for which no local images exists and were replaced by Japanese examples); one poster with a timeline of all reported events from the 19th century onward and important regulation changes, highlights the major events; the same timeline in a numerical format; an emergency kit; a google earth map, presenting major events; and a set of 15 videos of local inhabitants technicians and scientists' testimonies.

Approximately 500 persons visited the exhibition. Half (n=253) were "independent visitors", i.e. people that came without being specifically invited. The age classes, determined by direct observation are the following: children and teenagers (31%), adults <50 years old (20%), adults over 50 years old (38%) and adults for which the age could not be estimated accurately enough (11%). The other half (n=241) were persons that were specially asked to come and participate in the research activities. This half is mainly composed of children from 7 to 11 years old (63%) and teenagers from the 9th to the 11th grades (15%). The rest were adults (22%), mainly over 50 years old.

[2] Literal English translation : « Alert – 'Hazards, risks and protection ' : Knowing the risks in mountains means being better prepared »

TESTING THE EXHIBITION

The evaluation of the exhibition was conducted using two instruments. First, a pretest-posttest research design was used to assess the impact of the visit on invited participants' risk awareness as well as their satisfaction. The pretest took place right before the visit while the posttest occurred just after it. The children participated in a second posttest 3 months after. Secondly, (2) radio-frequency Identification (RFID) technology was used to evaluate the attractiveness of the exhibits. "Independent" visitors were invited to fill in a satisfaction survey which is a combination of items of the pre- and post- tests. 50 of them agreed to complete the survey.

Pretest-posttest research design

The pretest and the posttest were designed according to the framework proposed by Enders (2001). This framework is based, among others, on the risk communication model of Rohrmann (1998), which stipulates that the outputs of the communication is influenced as much by the concrete communication as by the economic, societal and individual factors. Enders proposed 6 factors (and corresponding questions) that should be taken into account when investigating emergency awareness and preparedness: *hard knowledge*, *attitudes to risk*, *previous experiences of emergencies*, *exposure to awareness raising*, *ability to mitigate/ prepare/ respond* and *demographic characteristics*. The items of the questionnaires linked to those factors were inspired by the list proposed by Enders (2001) and adapted to our specific case study. We added the *worry level* and the *level of awareness* that the participants reported. Moreover, we decided to interrogate them on their satisfaction with the exhibition as well as the reasons why they came visit it.

The analysis of change, i.e. impacts of the exhibition, is conducted on the factors *attitudes to risk*, *exposure to awareness raising*, *ability to mitigate/prepare/respond*, *worry level* and *self-reported awareness* by repeating the questions asked in pretest in the posttest (Figure 1). The questions related to the remaining factors are asked either in the pretest or in the posttest. Questions are either 5-points Likert scale or close-ended types.

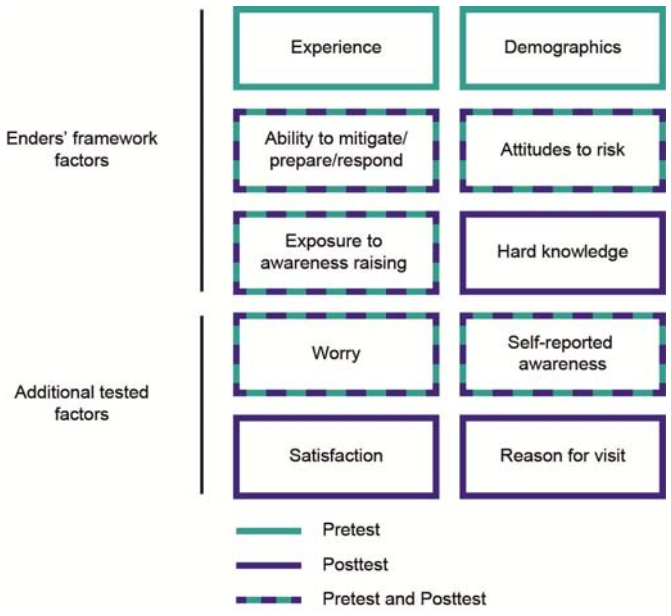

Figure 1; Framework to research change in risk awareness.

Due to the ordinal character of the 5-point Likert scale questions, a usual statistical analysis using parametric tests is not suitable as their assumption of normal distribution is not respected (Chao et al. 2010). Therefore, the change analysis is conducted using the non-parametric Wilcoxon signed-rank test. The explanation of the observed changes will be performed using an ordinal regression procedure (PLUM in SPSS), using the factors that were measured in the pretest or in the posttests as explaining variables of the factors for which changes are estimated between the pre- and posttests.

Radio-frequency identification (RFID)

Radio Frequency Identification (RFID) is a wireless technology that exploits radio waves to collect data from an identification chip and is used in many applications, for example, logistic (i.e. tracking of goods), tickets, toll systems and healthcare (Wu et al. 2009). In simple terms, RFID can measure when and how long a given tag is in front of a reader. Literature search shows that in exhibition and museums contexts, RFID is mostly used to improve or intensify the visit (e.g. Bannon et al., 2005; Hsi and Fait, 2005). However, there are very few studies or examples (e.g. Kanda et al, 2007) of the use of RFID to track visitors' in such environments, as we did in this study.

We favored RFID to track the visitors in the exhibition as other tracking methods are practically difficult to implement in the context of our study. Direct observation would have been ineffective as there was only one observer, which would only have been able to track one visitor at a time. Filming the visitors was not an option due to the very restrictive French laws on privacy. Finally, GPS methods are not yet able to measure precise movements in a small indoor space. RFID allowed us to simultaneously track as many visitors as we wanted while overcoming legal and practical issues.

The RFID appliances that we used for this research are eight antennas (Times-7 A6031 slimline) linked to a reader (Motorola XR480) and passive tags embedded in stickers that were placed in badges given to the visitors. The antennas were located at points of interest throughout the exhibition. These were chosen for the following reasons: (1) to encompass as much exhibition space as possible, (2) to measure time spent in front of exhibits as much diverse as possible, and (3) to comply with technical issues, i.e. reach of the antennas depending on the central reader position and presence of interfering material such as metal.

EXAMPLES OF RESULTS

This study allows to analyse the impact of the exhibition on risk awareness factors and the attractiveness of the visuals. As a glimpse of the complete analysis, we present an overview of the results.

Changes in awareness

The statistical analysis (Wilcoxon signed-rank test) of the factor *Attitude to risk*, question *How serious would the consequences be of an event occurring in the Ubaye valley?* (asked for avalanches, floods, landslides, debris flows and earthquakes separately, using 5-points Likert scale ranging from 1 = not at all and 5= a lot) resulted in several statistically significant results. For all the age groups considered (adults, teenagers and children) the visit of the exhibition induced an increase (i.e. analysis based on negative ranks) in the perceived seriousness of consequences of a flood event. The scores were significantly higher for the posttest than for the pretest (respectively $z = -2.828$, $p < .05$; $z = -3.672$, $p < .00$ and $z = -3.216$, $p < .01$). For the teenagers, the scores for avalanches and debris flows were also significantly higher for the posttest than for the pretest (respectively, $z = -2.878$, $p < .04$ and $z = -2.307$, $p < .021$).

Satisfaction

The answers to the questions *Do you agree with the following? : I liked the exhibition* and *The presentation of the exhibition is appropriate*; 1=not at all, 5 = a lot) show the exhibition was well-received (Figure 2A). Around 78% of the adults and teenagers that participated in the pretest-posttest research design and of the participants of the satisfaction survey gave a score of 4 or 5 to the statement *I liked the* exhibition. Approximately the same percentage of participants (74%) gave a score of 4 or 5 to the statement *The presentation of the exhibition is suitable*.

Attractiveness

The measurement of the relative time spent by the children that took part in the pretest-posttest research design in front of each exhibit equipped with a RFID antenna shows, not surprisingly, that the most attractive exhibits for the children are the interactive ones (the seismograph and the flood scale model) and the videos of events displayed on the TV (Figure 2B). Note that direct observation highlighted the fact that children spent a lot of time in front of the Ipads displaying the witnesses' interviews. This was not measured by the RFID system as the setting of the Ipads involved metal, which prevented the RFID system to work.

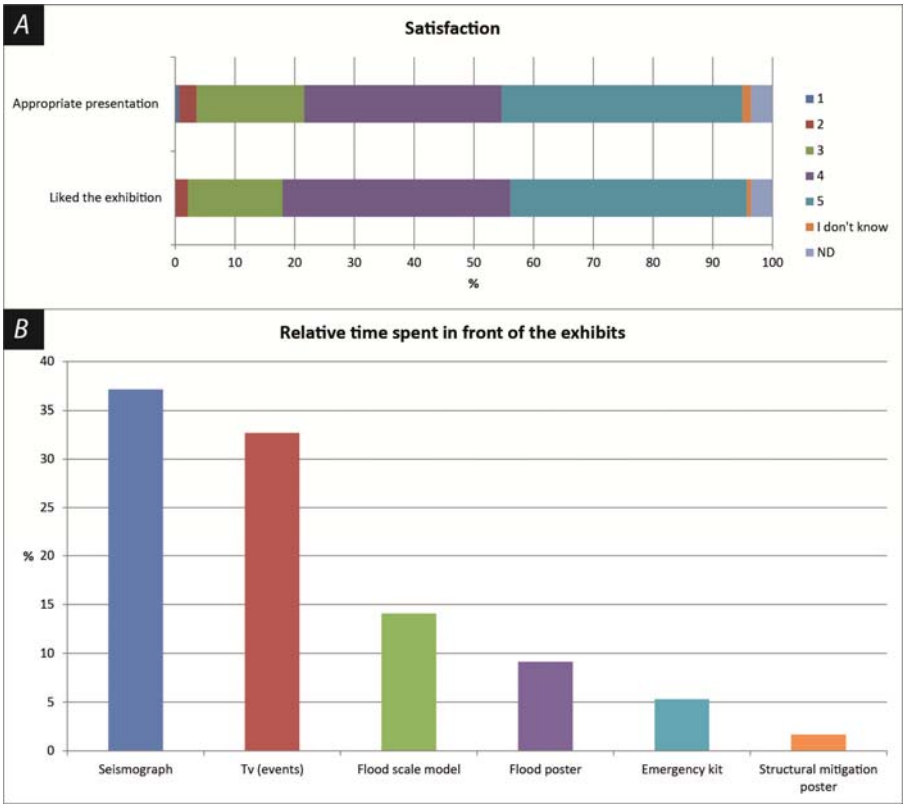

Figure 2: A) Results from two questions of the satisfaction factor. This graph combines results for the adults and teenagers that participated to the pretest-posttest research design and for the participants of the satisfaction survey. B) Relative time spent in front of each visitors by the children that participated to the pretest/posttest research design.

CONCLUDING REMARKS

This research was conducted according to collaborative research principles and has proven successful in this sense. Not only did we create a real communication effort in strong

collaboration with the local stakeholders but they also participated in the research by contributing to the data gathering. It allowed producing scientific results that increase the understanding of the effectiveness of risk communication. In addition, we observed that our activity triggered interactions between stakeholders that are not directly useful for the research but are certainly important for the community.

The scientific value of this work lies first in the method to measure risk awareness as such, as well as its variation due to the given treatment, i.e. the visit to an exhibition presenting all aspects of natural hazards. As we show with the example presented in this paper, the exhibition had an impact on the attitude to risk. Further analysis of the complete dataset are expected to give insight in which factors of awareness are affected as well and on the explanation of the observed changes. Therefore, this study will improve the understanding of risk awareness and the factors that need to be taken into account to measure it. A second innovative aspect consists in the merging of scientific research and real communication efforts. Although the effectiveness of visuals for risk communication has already been researched in a laboratory-type settings and several exhibitions on natural hazards have been created, the combination of the two is a first. The main foreseen outputs of the research are methodological as well as practical, i.e. guidelines for measuring risk awareness and implementing visual risk communication.

In addition to these scientific results which are by themselves relevant for society, our research activity was beneficial for the community in other way as well. The social relevance of the “Alerte” exhibition lies in the following observations. It first allowed the reinforcement of the relationships between stakeholders as they met and engage in a dialogue in the context of the design and creation of the exhibition. Moreover, it triggered memories of past events, especially for the older generations. In addition, it encouraged the exchange between generations at the exhibition as well as during peripheral activities that resulted from this research (e.g. meeting between the school children and one of the witnesses whose interview was presented in the exhibition). Finally, it promoted further communication efforts: during the exhibition, two conferences related to avalanche risks were proposed to the population; and informal discussions with stakeholders showed that they realized the importance of non-structural mitigation measures such as risk communication efforts.

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REFERENCES

Bannon, L, Benford, S, Bowers, J, & Heath C 2005, ‘Hybrid design creates innovative museum experiences’, *Communications of the ACM*, vol. 48, no. 3, pp. 62-65.

Chao, LW, Gow, J, Akintola, O, & PAULY MV 2010, ‘A comparative evaluation of two interventions for educator training in HIV/AIDS in South Africa’, *International journal of education and development using information and communication technology*, vol. 6, no. 1, pp. 1-14.

Charrière, MKM, Junier, SJ, Mostert, E & Bogaard TA 2012, ‘Flood risk communication - Visualization tools and evaluations of effectiveness’, *Comprehensive Flood Risk Management: Research for Policy and Practice*.

Covello, V, Fisher, A & Bratic Arkin E 1991, 'Evaluation and effective risk communication: Introduction', *Evaluation and Effective Risk Communications Workshop Proceedings*, pp. xi-xvii.

Cutter, SL, Boruff, BJ, & Shirley WL 2003, 'Social vulnerability to environmental hazards', *Social science quarterly*, vol. 84, no. 2, pp. 242-261.

Enders, J 2001, 'Measuring community awareness and preparedness for emergencies', *Australian Journal of Emergency Management,* vol. 16, no. 3), pp. 52-58.

Finnis, K, Standring, S, Johnston, D & Ronan K 2004, 'Children's understanding of natural hazards in Christchurch, New Zealand', *Australian Journal of Emergency Management,* vol. 19, no. 2, pp. 11-20.

Höppner ,C, Buchecker, M & Bründl M 2010, 'Risk communication and Natural Hazards', *CapHaz-Net - Social Capacity Building for Natural Hazards - Toward More Resilient Societies*, vol CapHaz-Net WP5 report, Birmensdorf, Switzerland.

Hsi, S, & Fait, H 2005, 'RFID enhances visitors' museum experience at the Exploratorium', *Communications of the ACM*, vol. 48, no.9, pp. 60-65

Kanda, T, Shiomi, M, Perrin, L, Nomura, T, Ishiguro, H, & Hagita N 2007, 'Analysis of people trajectories with ubiquitous sensors in a science museum', *Robotics and Automation*, pp. 4846-4853.

Lipkus, IM & Hollands JG 1999, The visual Communication of Risk, *Journal of the National Cancer Institute Monographs*, vol. 25, pp. 149-136.

Lundgren, R & McMakin A 2004, 'Risk communication - A Handbook for communicating environmental, safety and health risks', Battelle Press, Colombus, USA.

McCallum DB 1995, 'Risk Communication: a tool for behaviour change', *Reviewing the behavioural science knowledge base on technology transfer*, NIDA Research Monograph 155.

Penning-Rowsell, E, & Handmer J 1990, 'The changing context of risk communication', *Hazards and the communication of risk*, Handmer, J, & Penning-Rowsell E (eds.), Gower Technical.

Phillips, BD, Neal, DM, & Webb G 2011, *Introduction to emergency management*, CRC Press.

Rohrmann B 1992, 'The evaluation of risk communication effectiveness', *Acta Psychologica,* vol. 81, pp. 169-192.

Rohrmann B 1998, 'Assessing hazard information/communication programs', *Australian Psychologist*, vol. 33, no. 2, pp. 105-112.

Schwarzenegger, A, & Renteria HR 2006, 'Risk communication guide for state and local agencies', California Governor's Office of Emergency Services, 87p.

Spachinger, K, Dorner, W, Metzka, R, Serrhini, K & Fuchs S 2008, 'Flood risk and flood hazard maps – Visualization of hydrological risks', *XXIVth Conference of the Danubian Countries*, IOP Publishing.

Trumbo J 1999, 'Visual literacy and science communication', *Science Communication*, vol. 20, pp. 409-425.

UNISDR 2004, 'Living with risk: A global review of disaster reduction initiatives'.

Wu, DL, Ng, WW, Yeung, DS, & Ding HL 2009, 'A brief survey on current RFID applications', *Machine Learning and Cybernetics, v*ol. 4, pp. 2330-2335.