Analysis of a risk prevention document using dependability techniques: a first step towards an effectiveness model

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Abstract. Major hazard prevention is a main challenge given that it's particularly based on information communicated to the public. In France, preventive information is notably provided by the way of local regulatory documents. Unfortunately, the law imposes only few specifications concerning their content therefore one can question the impact on the general population relative to the way the document is concretely realized. Ergo, the purpose of our work is to propose an analytical methodology to evaluate preventive risk communication document effectiveness. The methodology is based on dependability approaches and is applied in this paper to the DICRIM (In French "Document d'Information Communal sur les Risques Majeurs" that means in English "Municipal Information Document on Major Risks"). DICRIM is due and made by mayors and addressed to the public to provide information on major hazards affecting their municipalities. An analysis of law compliance of the document is carried out thanks to the identification of regulatory detection elements. The latter are applied to a database of 30 DICRIMs. This analysis leads to a discussion on points such as usefulness of the elements missing. External and Internal function analysis permits the identification of the form and content constraints and service and technical functions of the document and its components (here its sections). Their results are used to carry out a FMEA (Failure Modes and Effects Analysis) which allows to define the dysfunctions and to identify detection elements. The latter permits to evaluate the effectiveness of form and content of each components of the document. The outputs are validated by experts from the different fields investigated. Those results are obtained to build in future works a decision support model for the municipality (or specialized consulting firms) in charge of drawing up documents.

1 Introduction

Every year, major natural phenomena cause human and material disasters. Recently, in August 2016, an earthquake of magnitude 6.2 occurred in central Italy causing 250 deaths (CatNat, 2017). Two months before, in the same year, the River Seine in France rose to a height of 6.10 meters and overflowed, causing 4 deaths, 24 injuries and a great amount of material damage throughout the different departments it traverses (CatNat, 2016). Preventive policies have been implemented to manage the consequences of these disasters, such as the Hyogo or Sendai frameworks for action and disaster risk reduction (*UNISDR* 2015). Transmission of preventive information is equally important and has been the topic of current discussions highlighted by recent scientific researches (Newell and al. 2015) and international institutions as the United Nations (*UNISDR* 2015; United Nations 2006).

In France, numerous prevention systems and organizations exist to manage both natural and technological hazards. Risk prevention requires the involvement of many stakeholders ranging from public authorities, experts and infrastructure managers to individuals and communities. In France, the legislation that relates policies and prevention of natural hazards is imposed through different legislative texts. In 1987, the need for emergency management is addressed and the right of access to preventive public information is recognized. In 2004, the 1987 law was updated and modernized. Notably, changes insist on necessarily diffusing preventive information to the General Public (Observatoire Régional des Risques Majeurs en Provence-Alpes-Côte d'Azur 2017). An example is demonstrated in Figure 1 which shows the regulatory tools linked to urbanism and/or used for diffusing preventive information and its exchange between different stakeholders. For instance, in a town threaten by floods, Mayor must make a Flood Risk Prevention Plan (PPRI) that will be approved by Prefect. General Public will then give their opinion on this plan. Different forms of communication (public meetings, information kits, posters, etc.) are used not only to provide safety recommendations but also as means of increasing individual knowledge of risk.
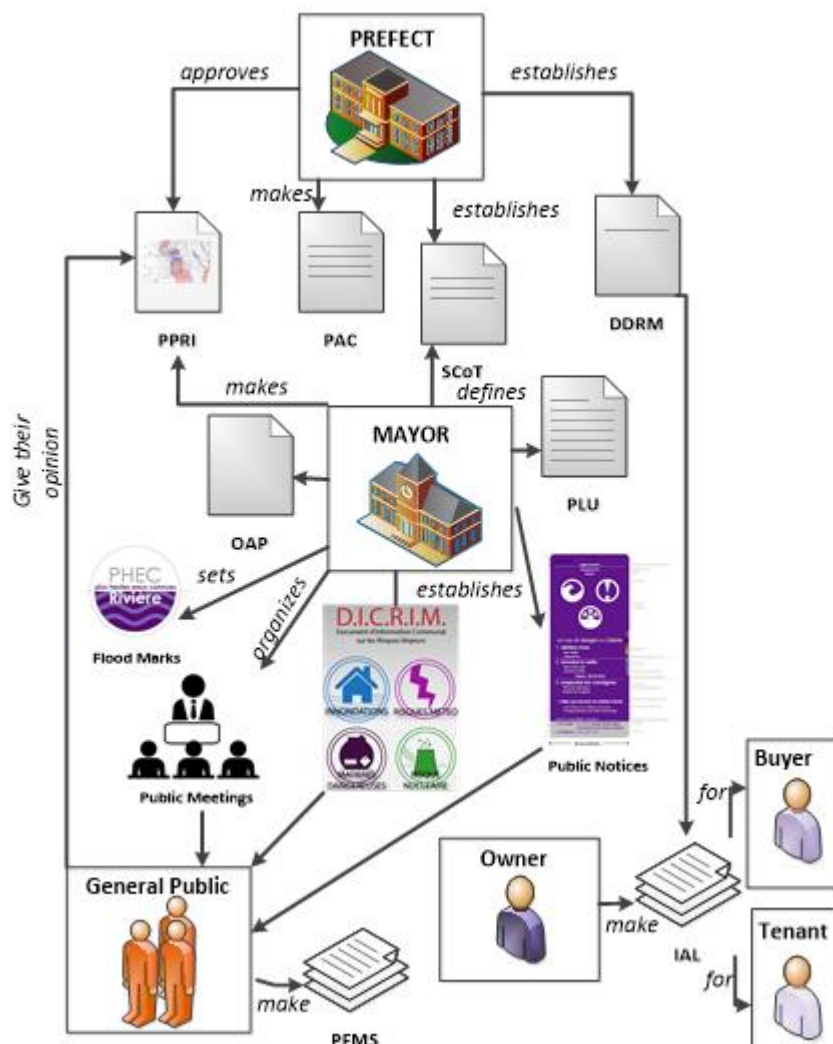
Figure 1[1]: French regulatory prevention information throughout the town: Territorial Coherence Schemes (SCoT); Knowledge over Existing Data (PAC); Flood Risk Prevention Plan (PPRI); Development and Planning Guidelines (OAP); Urban Local Plan (PLU); Departmental Document on Major Risks (DDRM); Municipal Information Document on Major Risks (DICRIM); Public notices; Purchaser Tenant Information (IAL); Familial Plan for Safety Layout (PFMS); Public meetings; Flood Marks

This is highly significant as human behaviour during major disasters is influenced by their own knowledge of risk (Enrico L. Quarantelli 2008).

Behaviours, however, are not necessarily the result of logical and rational reasoning. Attitudes of denial or risk underestimation, often found among inhabitants exposed to natural hazards, are commonly interpreted as an "addiction to risk", and sometimes judged as an incomprehensible unawareness in the face of a known and visible danger. This is the cognitive dissonance phenomenon described by (Festinger 1957). For example, a person living in an area that they know to be exposed to a natural hazard is clearly in cognitive dissonance (Schoeneich and Busset-Henchoz 1998). This makes it possible to better understand certain attitudes of

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[1] Prefect is a government representative of an area or department (France territorial division). It is thus responsible for public order, ensures the application of laws and regulations and verifies that the local authorities (Town Hall or EPCI which is a grouping of town halls) respect them as well.

scepticism, or even mistrust, towards technical or scientific studies and information. Indeed, to reduce the psychological discomfort caused by dissonance, individuals can act on their risk representations. Cognitive biases can then substitute knowledge of individual risk as an act of denial, which consists in trivialising the risk involved and is similar to a phenomenon of disbelief (Weiss, Colbeau-Justin, and Marchand 2006) or an illusion of control, which consists in believing that one has control or influence over external or random events (Langer 1975). (Kahneman and Tversky 1979) and then (Slovic, Fischhoff, and Lichtenstein 1982) argue that people form their judgments heuristically, based on their experience, habits, or cultural traditions that enable them to construct their cognitive risk representation. In fact, people fear that they will find themselves unsecured and that their certainties will be undermined by consulting information on the risks affecting their living environment.

Residents are also generally thought to have a lower human vulnerability than tourists, as risk awareness is often attributed to locally rooted populations (Hubert and De Vanssay 2005). However, in the sample of victims of floods in the Mediterranean between 1998 and 2011 studied by (Boissier 2013), only 30 out of 203 people were not residents. Even though several other factors may have to be considered, non-residents are less vulnerable because they are more prone to taking instructions, more respectful of evacuation orders and less inclined to take risks (going to school to pick up their children, saving personal belongings because less property needs to be saved, etc.) as pointed out by (Ruin 2007).

However, communication on risk can become a form of indirect experience of risk and thus a way of strengthening its acceptance and stimulating the involvement of exposed populations (Festinger 1957). If information is transmitted effectively people are more prompted to adopt pertinent behaviour during the event as they have better knowledge of the associated risks and the safety recommendations for better risk prevention (Siegrist and Cvetkovich 2000). Results from a research study showed that information seeking by citizens seems to coincide with the intention to take preventive actions (Kievik and Gutteling 2011). Providing regulatory information to citizens can also lead to further information seeking (Hagemeier-Klose and Wagner 2009). Consequently the public needs to be periodically informed about the hazards and the levels of risk they are exposed to and how their situation is changing (United Nations 2006). For (Paton, Smith, and Johnston 2000) a major challenge for risk communication is ensuring that the information provided is meaningful to recipients and motivates risk acceptance.

Although significant progress has been made (recent decrees, investment by towns, more resources, etc.), certain features regarding risk information remain disappointing such as the uneven implementation and lack of control over these resources (IRMa and al. 2015), different behavioral instructions from one document to another even in reference to the same phenomenon (MAAF 2013), incomplete information about the hazards to which the population is exposed to and so on. It is also very difficult to establish if preventive communication tools achieve their purpose in terms of being appropriated by the local population (AFCPN 2013). Do they empower citizens with respect to knowledge on the risks that concern them? (Cutter 1993; Lindell and Perry 2004). To give such answers it is important to analyse the effectiveness of such preventive communication tools. Effectiveness is the level of achievement of planned activities and achievement of expected results (Association Française de Normalisation 2005). It refers to the concepts of function and dysfunction. Are those preventive tools made to be

effective in terms of appropriation by the General Public? It is important to evaluate if those preventive communication tools reach their goal while conforming to the law.

For the purpose of rising to this challenge, this article has the objective of proposing an approach capable of analyzing preventive communication document, in terms of its effectiveness. The DICRIM is used as an application of the method proposed. The article is structured according to the following plan: it first examines selected methods for analyzing the effectiveness of communication tools; it then presents the methodology proposed after which the results of its application to the DICRIM are shown. A part of these results is applied to a DICRIM database. The article ends with the conclusion and perspectives.

2. State of the art

2.1 Effectiveness of risk prevention communication tools: case of the DICRIM

In this work, we focus on preventive risk communication in regulatory documents (informal communication by social networks and by word of mouth is not considered). In France, information and knowledge are communicated at a communal level using different means (cf. Figure 1). Mayor establishes DICRIM intended for the public and based on information contained in DDRM (Departmental Document on Major Risks) made by the Prefect. DDRM lists all essential information on major natural and technological risks at the level of their department. The municipalities required to produce a DICRIM are those in which there are Risk Prevention Plans and / or those designated by prefectural decree because of their exposure to a particular major risk.

Mayor must also inform population about major hazards at least every two years by the way of public meetings. In addition, the safety instructions contained in the DICRIM and those which may be laid down by the operators or owners of the premises and land referred to in Article R. 125-14 of the Environmental Code are made public by means of posters. These posters are made based on a model set by the State. The Mayor is also required to establish flood markers in the municipality and carry out an inventory. They correspond to historical or new exceptional floods. They make it possible to refine the expertise of historical floods, but also to bring to life the memory of flood risk. With regard to residents, there are two distinct preventive information obligations established by the Environmental Code for purchasers and tenants: (i) information on the natural hazards affecting the property and (ii) information on claims resulting from recognized natural disasters which affected all or part of the property concerned. This Information for Buyers and Tenants (IAL) concerns: all lessors or sellers and all types of real estate, regardless of the destination (seasonal rentals also) (MEDDE 2013). General Public is also encouraged to establish their PFMS (family safety plan). PFMS is a booklet with holes, given by the State, people should fill with information concerning them. For instance, the booklet helps them to check if they own all equipment needed in the event of a crisis.

We chose to focus on DICRIM because, in the French government's overall strategy for risk prevention, it is the main reference document in terms of informing the public about the natural and technological risks affecting the municipal territory. A brochure, film or advertisement may be just one part of a larger campaign to promote hazard readiness, and these items can and should be tested separately for efficacy and effectiveness prior to broad deployment (Sanquini, Thapaliya, and Wood 2016).

In general, inequality in terms of updating the specifications, transmitting the information and controlling the execution of preventive information tools is observed and this concerns also the DICRIM. For example, in PACA region, in December 2016 only half of communities concerned have realized their DICRIM (ORRM 2016). Furthermore, the French government gives indications only on the general content of the document without providing any standards notably regarding the design of the document. Works and writing guides have been proposed to develop DICRIMs (Clément and al. 2012; CEPRI 2013; IRMa 2014) but the justifications of these recommendations are not clearly and fully presented which leads to disparate documents in terms of content and form. The effectiveness of some DICRIM with the large number of pages with the citizens is also questionable, as is that of other DICRIMs containing a reduced number of pages, which can lead to oversimplification and significant loss of information. Finally, there is no link between quantity and compliance of DICRIM (Douvinet and al. 2013) ; having a DICRIM does not mean that municipalities provide good preventive information under the law (Rode 2012).

Effectiveness of some contents in DICRIM is also questionable. For instance, the law required that DICRIM own maps regarding each hazard threatening the given town. Those maps are used to show to the population the hazard level geographically distributed on the territory of the municipality. But those maps are often similar to those elaborated in PPR, which is mainly used by experts, and they are not thinking to communicate to the Great Public. Flood maps are frequently seen as an information tool rather than a communication tool (Meyer and al. 2012).That is why some maps are really difficult to understand by people which is regrettable because maps often firstly draws people attention before text. Some works proposes an evaluation of flood maps effectiveness notably based on interviews or eye-tracking and also give recommendations that should be used for hazard maps contained in DICRIM (Meyer and al. 2012; Fuchs and al. 2009).

These elements must be considered carefully because individual cognitive perception is reinforced or weakened by the form and contend of the provided informative document; document communication is intended to be helpful and to result in the expected impact (Terpstra, Lindell, and Gutteling 2009). Consequently, assessing the effectiveness (form and content) of such legislative texts and the information they contain is an indispensable challenge, especially since this issue has received very little attention and only a few works on it have been published to date (Gominet 2007; Kellens, Terpstra, and De Maeyer 2013).

2.2 Analysis of candidate methodologies

Evaluating effectiveness requires the development and improvement of tools and methods. Such methods currently exist in different fields of study: advertising, geography, engineering, etc. They apply to different systems and are generally divided into three categories, according to whether: (i) they involve formal population samples; (ii) they do not involve formal population samples but rely on population perception assessment; (iii) they are based on systemic, analytical methods that do not involve the population.

Regarding communication and marketing, advertising is one of the major tools used by companies to disseminate "persuasive" information on their markets, to inform, persuade and remind (McArthur and Griffin 1997). Methods have been developed to assess the effectiveness of advertising (pre- and post- advertising tests).

These different methodological approaches based on questionnaires are of great interest. Current studies performed to evaluate the effectiveness of preventive risk communication (including DICRIM) for the public are classically conducted using the same methodological tools: surveys (either pre- or post-diffusion of the document) by questionnaires. (Gominet 2010) and (Duaut and Luneau 2008), for example, obtained their results through prior surveys of mountain communities subject to natural hazards. In the same vein, the French Minister of Agriculture conducted a series of interviews with various stakeholders on subjects including risk, to measure the effectiveness of DICRIMs or to at least obtain their views on these documents (MAAF 2013). Moreover, communicating on risk can be considered as pertaining to "advertising" on how to protect oneself. As stated above, the challenge is to make the public aware of risk, get them to accept it and protect themselves by taking appropriate actions (Renn 2014). The risk communication documents must therefore have a persuasive effect on the population in the same way as advertising seeks to convince a consumer. If the questionnaires are well constructed and the results interpreted with rigor, these methods allow predicting the impact communication should have with regard to the pre-test and make it possible to modify the content prior to publication if necessary. In the post-test phase, they also allow obtaining feedback on communication, on what worked or not, and on any dysfunctions in order to consider possible corrections and a new communication campaign. However, these methods also have limitations. Indeed, they require building a representative sample of the population that may require a budget and human and material resources which can be substantial. Moreover, these methods are focused on opinions and do not take into account factors that omit individuals' feelings.

Some methods do not require the use of a representative sample of the population but need indirect intervention:
- advertising efficiency standards for establishing performance comparisons, without it being necessary to use population samples;
- "connected" methods to evaluate the effectiveness of advertising such as the association of flyers, web sites and / or mobile applications (QR code, website audience, image recognition, etc.). For instance, a flyer can be effective if it has a QR code. It is then possible to quantify the number of "flashes" generated by people with their smartphones to visit the associated websites. The higher the number of visits, the more effective the flyer is deemed to be.
- ROI detection elements (return on investment) (click rates, visits, cookies, etc.) related to digital advertising and tracking capabilities. They allow, for example, making post-tests a certain time after the broadcast of a message to identify individuals previously exposed to it.

Connected methods can be useful in that they will help to determine whether a risk communication document have aroused the interest of people by convincing them, for example, to go to the associated websites (using QR code) for additional information after reading of the document. These evaluation methods also appear relevant to our case study mainly because they do not require the intervention of inhabitants to assess effectiveness. However, there is an indirect need for some people to be involved by clicking or using QR code... If it can give an idea of the effectiveness about the retrieval of risk communication documents it does not provide information about the impact of its reading. Is the information really received? Although relevant regarding some aspects, these methods can be expensive.

Finally, the use of systemic, analytical methods based on structural, functional and dysfunctional analysis of the system under study seems relevant for the analysis. Their results could be used in the next works to build an evaluation model of effectiveness based on aggregated formalized indicators. Constructing an effective model will, of course, require involving the public but this won't be necessary when municipalities for instance arrive to use the model. In such a sense, it could be financial gain for them. Effectiveness is the level of achievement of planned activities and achievement of expected results (Association Française de Normalisation 2005). It refers to the concepts of function and dysfunction. Thus analytical methods, such as dependability analysis used in engineering, seem relevant. DICRIMs, and other risk communication documents, are subject to complex processes involving interdisciplinary concepts (information processing, cognition, communication, etc.). The lack of a formal, detailed framework (form and content), and lack of familiarity by the public make their effectiveness difficult to assess without a systemic and rational approach. Dependability methods allow the identification of risks and analysis of behaviour and failures. These methods are qualitative (Preliminary Analysis of Hazards, FMEA, Summarized Breakdowns Combinations Method) and quantitative (Fault Tree Method, Event Tree Method, etc.), based on the construction of state graphs (Space States Method, stochastic Petri nets), and on simulation (Monte-Carlo simulation). They were developed for complex industrial systems and applied in different domains (Peyras, Royet, and Boissier 2006; Zouakia, Bouami, and Tkiouat 1999; Bambara and al. 2015). These methods are interesting as they enable identifying the elements involved in the effectiveness of the system under study, determining the causes and effects of dysfunctions and listing detection elements able to pinpoint the occurrence of dysfunctions. Our work takes this direction and aims it at applying a function and dysfunction analysis method to a risk communication document. The problem to overcome is that the methods chosen must be adapted to our context, which is not one of engineering, but one of risk prevention. The first successful application of dependability methods in such a context was carried out in a field that interests us: the diagnosis of contingency plan failures (Girard and al. 2014; Piatyszek and Karagiannis 2012; Bambara and al. 2015). In other words, the systemic analysis of the risk communication documents such as DICRIM can provide the means of performing a qualitative analysis of effectiveness. Previous work evaluating the effectiveness of a DICRIM is based on ad hoc surveys carried out at the level of given municipalities or territories, on a given document. They also need significant human and material resources. This work differs from previous because it allows to obtain a generic approach based on systemic and analytical reasoning applicable to any risk communication document.

3. Methodology proposed to assess effectiveness of a risk preventive communication document

The development of our method of analysis leads to various types of indicators (compliance, form, content), the combination of which are used to assess the effectiveness of the document. This method is generic and applicable to different documents of prevention. Figure 2 shows the global approach of the methodology we propose. In this paper, results of steps shown in solid line boxes are presented. Steps of dotted line boxes are perspectives.
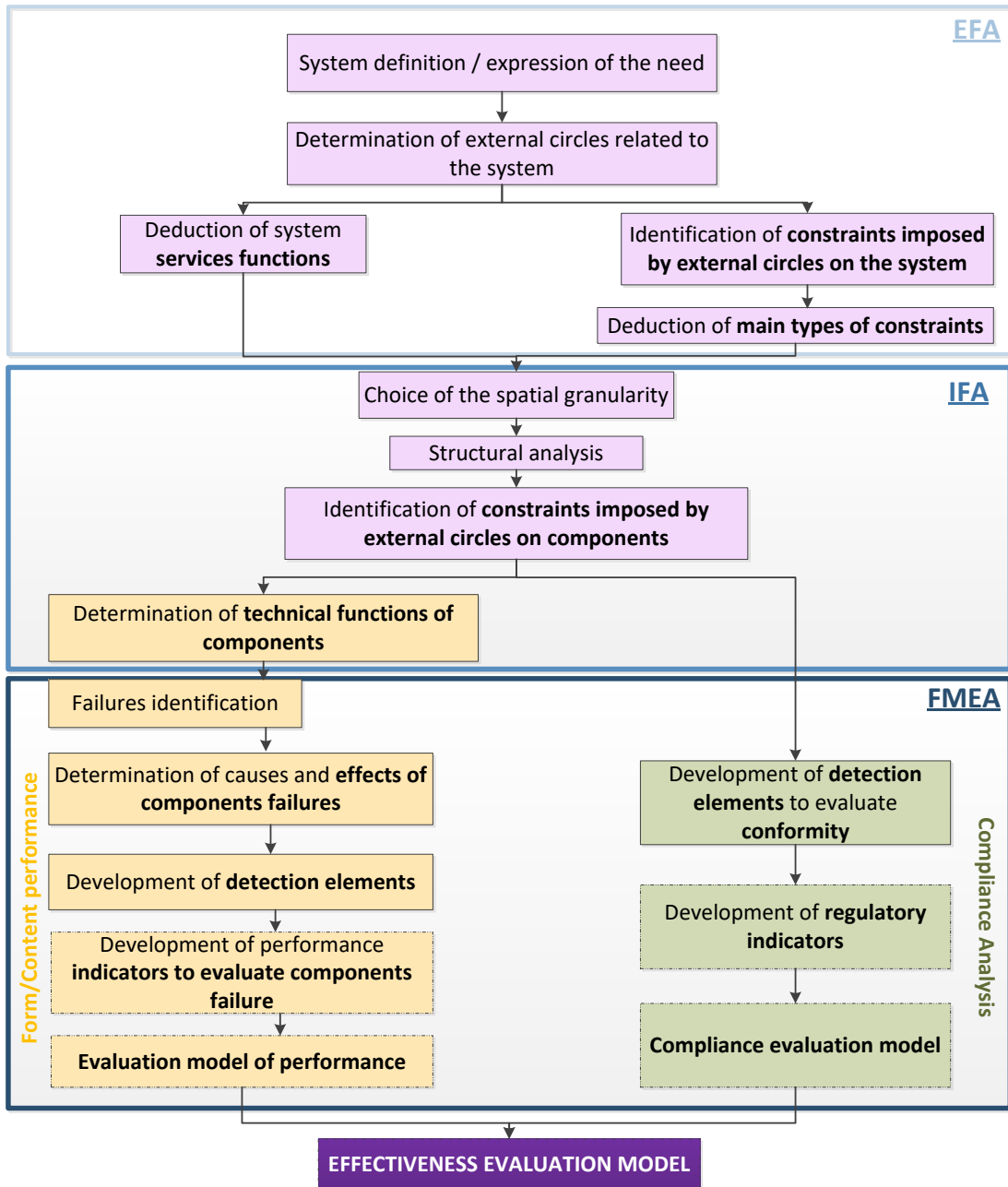
Figure 2 : Global methodology proposed and followed to build the effectiveness evaluation model: detailed steps leading to the detection elements. Dotted boxes show future works.

The method proposed considers functioning and dysfunctioning of the system, here preventive communication document.

It consists of a functional analysis that fully describes the functions and relationships in the system and the constraints it fulfills. A constraint is a "characteristic, effect or design provision that has been made mandatory or prohibited for any reason whatsoever. No other possibility is left" (AFNOR 2015).

Once the system is analysed, a change of the granularity of analysis is made to study the system components. A structural analysis allows determining those components. Three types of constraints are identified linked to those components. Regulatory constraints to evaluate conformity and form and content constraints to evaluate performance are identified.

An analysis of regulatory requirements is carried out. To analyse effectiveness of the preventive communication document, first we must analyse its compliance to the law. This conformity analysis is made by identifying detection elements and indicators in future works. A database of documents is made and used to apply those regulatory detection elements.

In parallel, functions of components are analysed. Functions are systematically characterized, classified and evaluated (AFNOR 2014). For the functional analysis we chose to use the APTE method that can be applied successfully to our case study as a quick test, as proposed in (Ghariani, Curt, and Tacnet 2014). It is one of the dependability methods used most and generally provides the basis for a subsequent Failure Mode Effects Analysis (FMEA) which is the next part of the approach. FMEA is an inductive method of analyzing potential failures in a system. It systematically considers each system component and its failure modes one after another. Failures are identified by non-compliance with constraints. Detection elements are also listed, allowing the identification of this non-compliance. The results of FMEA analyses are presented with a diagram in a bow tie form, specifically designed for the type of system studied. The detection elements were formulated by making use of the literature. For example, the field of advertising was investigated for the part concerning the information preventive document's form. FMEA results were validated by experts. When performing an FMEA in an industrial situation, specialists in different areas are classically involved in completing and validating the results obtained. Several domains are necessary to evaluate the effectiveness of preventive from risk and communication: that justifies the choice we made for experts in our work. Three experts were asked to carry out this task: two are experts who have performed research in technological or natural risk analysis for more than 15 years, while the third is a communication expert with 27 years of experience in the field.

Later, detection elements will be formalized as indicators. An indicator is information that helps a stakeholder, an individual or a community in general, to carry out the course of actions needed to achieve a goal or to evaluate a result (Bonnefous and Courtois 2001). It should be formalized in order to make its use repeatable and reproducible (Curt, Peyras, and Boissier 2010). Indicators will be aggregated with each other to form a model that will give an effectiveness score as output. Feedbacks will also be provided by the model to know which component must be improved and how. This evaluation effectiveness model will be a decision support model for the municipality (or specialized consulting firms) in charge of drawing up documents. This model would allow evaluating the effectiveness of existing preventive communication documents and identifying the corrective actions needed to improve their effectiveness.

The results shown below stem from the application of the method to the case of the DICRIM. As said before, Indicators and the construction of an effectiveness evaluation model represent our future work for which only some examples will be shown in this paper.

4 System functions: External functional analysis

The EFA consists of 3 main steps: system definition, expression of needs, and determination of relationships with external environments.

4.1 System definition and needs satsfied by the system: the DICRIM

First, it is necessary to define the system to be studied precisely. Limits are defined, which then lead to considering the interactions with external environments. The system therefore takes into account the document (DICRIM) with its content, form and accessibility as described by the relevant law.

The main headings and information to be included in the DICRIM are listed in the National Model for the application of the Environment Code (Articles L 125 - 2 and R 125 - 9 to R 125 - 27) issued by the MTES (French Ministry of Ecological Transition and Solidary)(MEDDE 2013). Our analysis will be based on it. It is a framework with general information that must be used both by mayor and prefect to create respectively DICRIM and DDRM. To do so they have to use this framework and to add specific information, for instance information regarding the municipal territory for mayor. The major risks that must be dealt with in the DICRIM (according to their occurrence in the given town) are listed in the National Model and are as follows: floods, earthquakes, ground movements, forest fires, avalanches, storms/cyclones, volcanic eruptions, dam failures, nuclear accidents, industrial accidents and mining risks. There is no legal obligation regarding the document's format. The DICRIM can be consulted by the public at the town hall as a paper document. In some towns it is also distributed directly in the mailboxes of inhabitant or posted on the municipal website in digitized form or more rarely, in interactive mode.

EFA is used for translating the need satisfied by the system. In general, the latter can be formalized by three questions applied here to the DICRIM: (1) To whom is the system dedicated? - Response: To the General Public; (2) On what does it act? - Response: On its knowledge and risk perception; (3) Why is this action necessary? (that is to say, for what purpose does the system exist?) - Response: To inform on hazards and on how to act when phenomena occur.

4.2 External circles

It is then necessary to determine the external circles that interact with the system. They are made up of human elements, natural elements or part of other systems which can act on the document or be subject to its actions. The inventory of these external circles (designer, director, regulations, residential accommodation, etc.) is established by examining the environment of the DICRIM. We also highlight interactions between these areas and the DICRIM. Figure 3 illustrates the design, construction and operation process (reading and use by the public). Interactions are materialized between the system and its environment using a functional block diagram, in which we distinguish the contact relationships (represented by straight segments) and flows (represented by arcs). Interactions between an external circle and DICRIM identify constraints to be considered. Flow relationships between 2 external circles identify the service functions performed by the system. The quality of the external circles and the analysis of interactions determine the completeness of the functions obtained.
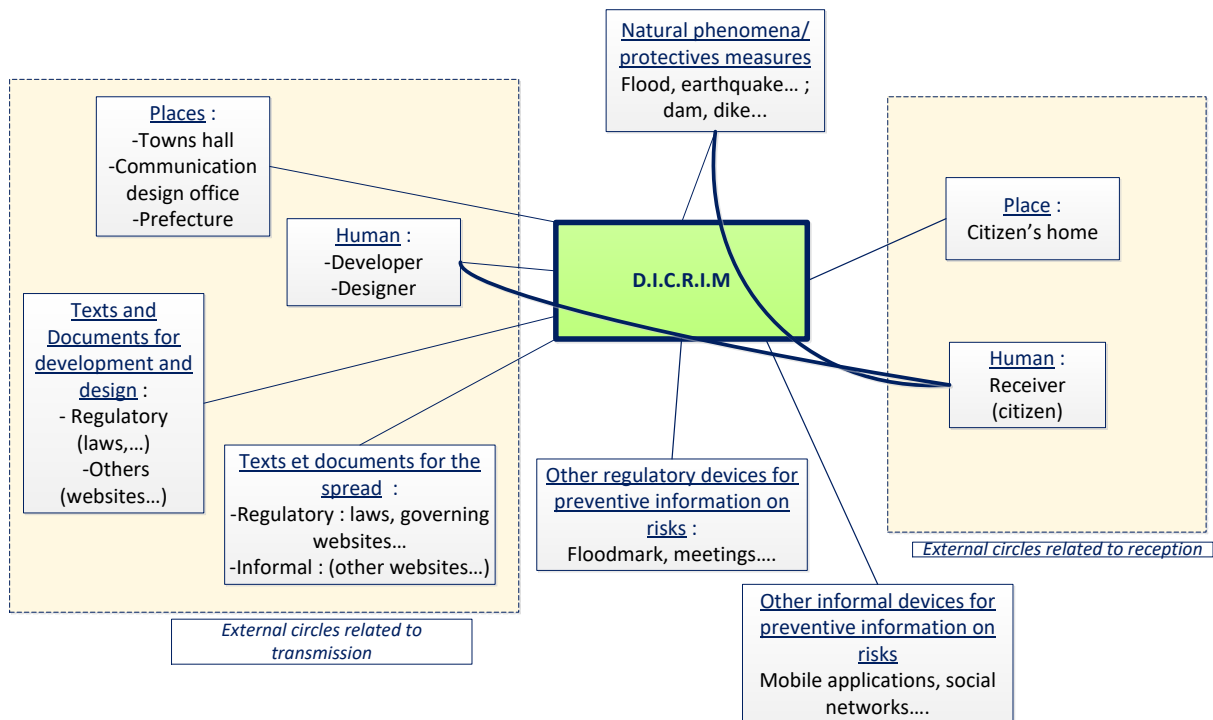
Figure 3 : Functional block diagram for DICRIM

4.3 Service function and constraints

Service functions reflect the objective of a system. They are determined through relations between two external environments. Figure 3 shows that the transmitter (developer and designer) is linked with the receiver through the document. This is the process involved in preventive information on hazards. With the DICRIM, the receiver, that is to say the public, is also related to major events when they happen. They must implement what they learn from the document in terms of behaviour. Two DICRIM Service functions are then deduced:

1) Service Function 1 (SF1): the DICRIM informs on maintaining and fueling risk culture (learning in the operational phase). We consider that risk culture is fueled by 4 main elements: risk awareness, knowledge, acceptance and memory (Johnson 1993; Terpstra 2011).

2) Service Function 2 (SF2): the DICRIM informs on acting appropriately when facing a major event (decision-making in the operational phase). An appropriate act is based on the way the event is detected and good practices (Bostrom and Löfstedt 2003).

These are functions fulfilled by the document to satisfy the constraints exerted on it by external circles. Constraints are obtained by examining the external circles in interaction with the document. They are listed in Table I (extract).

Types	External cycles	Constraints (DICRIM must…)
Places	Inhabitants home	-Have been received -Have been keep
	Town hall	-To be designed -To be available -To be diffused
	Communication design office	-To be developed
	Prefecture	-To be archived
Human	Designer	-To be correctly designed in order to respect Human/Designer; Human/Receptor; Natural phenomena/protectives measures; Texts and Documents for development and design constraints
	Developer	-To be correctly developed in order to be correctly designed in order to respect Human/Designer; Human/Receptor; Natural phenomena/protectives measures; Texts and Documents for development and design constraints
	Transmitter	-Widely spread -Respect « have been received » by Places/Inhabitant's home
	Receptor	-To be designed and developed to capture attention -To be designed and developed in order to persuade receptor to read the DICRIM -To be designed and developed in order to promote understanding and recording of information
Major phenomena/protectives measures	-Floods, earthquakes, … -Dams, dikes…	-Inform on major phenomena and on protection measures taken by town to overcome them.
Texts and Documents for development and design	Laws	-Respect laws
	Model	-Follow national model given by MTES
	Governmental Websites	-Respect safety instructions or recommendations they contain
	Departmental Document on Major Risks (DDRM)	-Synthetize and adapt information contained in the DDRM to the General Public
…	…	….

Table I : Extract of the table showing constraints features highlighted by the interactions between the DICRIM and external circles

As shown by Table I, constraints can be classified into 4 main groups: regulatory obligations ("compliance with laws", "in line with the national model given by MTES"…), content constraints ("inform on major phenomena…"), form constraints ("to be correctly designed"…), and information flow ("have been received", "have been kept"…). Three of these groups, regulatory/content/form, will be kept to analyse the constraints at the component level (compliance and internal functional analysis). At this scale, we will not consider the fourth group (information flow) because it does not concern the component level. It is taken into account at a higher level of granularity when the global system is considered.

5. Structural analysis of a DICRIM

Structural analysis aims at listing all the components of the system. The DICRIM components are identified in the national model issued by the MTES. There are at least 16 components (cf. Table 2). More components are possible because 6 among those 16 (Components n°5 to n°10) are applied for each hazard encountered in the town studied; the 10 elements out of 16 remaining do not depend on hazard. For instance, if two hazards threaten the town, there will be 22 components (10 + 2x6). That is why there can be as many as 76 (10 + 11x6) components in the DICRIM if a town faces all the hazards listed in the national model (11 hazards, consult § 3.1).

Municipalities are free to introduce non-legislated components; however, we do not consider this option at this stage of the analysis.

Following the requirements described in (31), the DICRIM is composed of: a word from the mayor, a DICRIM presentation, several information for each hazard affecting the town (risk presentation, prevention and protection actions, safety instructions, mapping), information about other preventive information devices (public notices, flood marks…), emergency phone numbers and equipments to always have at home to be ready. To facilitate our systemic analysis these requirements are viewed as components. The list of those components is as followed:

-Component 1: Cover page (Cp1)

-Component 2: Editorial with a word from the mayor (Cp2)

-Component 3: Summary (Cp3)

-Component 4: DICRIM presentation (Cp4)

- Component 5: Presentation of the risk in the town (Cp5)

- Component 6: Prevention actions at town level (Cp6)

- Component 7: Police and protection actions (Cp7)

- Component 8: General safety instructions (Cp8)

- Component 9: Specific safety instructions (Cp9)

- Component 10: Mapping 1/25.000th (Cp10)

- Component 11: Communal poster (Cp11)

- Component 12: Flood marks and highest known flood zone (Cp12)

- Component 13: Underground cavities and marl pits(Cp13)

- Component 14: Where to get more information (Cp14)

- Component 15: Emergency phone numbers (Cp15)

- Component 16: Equipment to always have at home to be ready (Cp16)

6. Compliance analysis and application to a DICRIM database

To analyse its effectiveness, first we must analyse the DICRIMs compliance to the law by identifying detection elements. This compliance analysis is based on the National Model. Indeed, it was mentioned earlier that government provides some general instructions regarding the content of DICRIM in the form of a national model. We can think that this model has been strongly discussed in order to make the DICRIM as effective as possible. The regulation detection elements we listed allow the evaluation of the presence or absence of the required content for each component. Components 5 to 10 associated with a given risk are characterized by 19

detection elements, i. e. 19 elements required by law. 10 risks being considered here, this gives a total of 190 elements. Component 4 (DICRIM presentation) is characterized by 6 detection elements. Component 13 specific to underground cavities and marl pits are broken down into 2 detection elements. The remaining components are not detailed in the national model, so it is only one detection element each and there are 7. Altogether, there are 205 detection elements to assess compliance with the law for a given DICRIM. Although this number is high, the production of such detection elements simplifies their appropriation if compared to the tack of localizing them in the National Model which is very long (360 pages) and where requirements about DICRIM are mixed with DDRM regulations and general information about major hazards. Moreover, as they are presence/absence detection elements, the assessment of the whole sets of symptoms can be quite rapid (~ 20 minutes per DICRIM). The completeness of the DICRIM can be verified thanks to them. In our future works, when they will be formalized as indicators and their number will be highly reduced, but they can already be used as they are.

To apply those regulatory detection elements, we built a database of 30 DICRIMs. Those DICRIMs were all produced by towns located in the Provence-Alpes-Côte-d'Azur region in France. The DICRIMs were retrieved from municipal websites. A variety of DICRIMs were collected, considering: the number and types of hazards affecting the town, the size of the town in terms of number of inhabitants or surface area, the environment of the town (mountain, sea, countryside) and criteria regarding the document itself were also considered. The DICRIM's were more or less long (from 5 to 56 pages – not linked with the number of risks identified). The average length was 20 pages. Their dates of creation also varied with some more being recent than others (from 2003 to 2015).

In this application, we wanted to analyse compliance with regulations for all the DICRIMs. We did not consider mining and volcanic risks because they did not threaten any of the 30 towns studied. That is why 199 detection elements were used during this analysis. Each DICRIM was carefully read and each detection element was filled with the number "1" if the element was present or a "0" if it was absent. The mention "nc" (not concerned) was noted if the hazard asked by certain detection elements was absent in the town studied. The results are presented in table form. An extract from this table is shown in Table II.

Results highlight that there is a big lack of elements in all the DICRIM reports. In fact, the existing elements seldom reach half of the total requirements per DICIRM. For instance, town 1 contains 58 of 128 required elements or town 5 only 40 of 125 required elements ergo in both cases their number is less than half of the elements needed. In conclusion, table IX shows that none of the DICRIMs exposed in the database fulfills the requirements of elements.

Elements relative to hazard safety instructions were those which were most present in the DICRIM database. This observation is interesting because safety instructions are major part of one of the two service functions of a DICRIM. The second most common element concerned "the presentation of the DICRIM's role", an important means of capturing readers' attention.

This analysis also showed that 19 elements required by the national model were not present in any DICRIM in the database, 22 are only present in one DICRIM each time and 18 in two DICRIM. These observations lead to questions regarding the relevance of these elements. In particular, one of them was nearly always missing: that of the role of insurance for each hazard. Some people may think they will be better compensated in case of

damages on their property than they will really be. It can unconsciously lead them to less prepare their own safety in prevention when a phenomenon is announced. "History of the risk concerned in the municipality by mentioning the most significant events" was also often absent, which was unfortunate in our own opinion. Mentioning significant events is an effective way of raising public awareness of hazards that threaten the town in which they live. It is also a way of preserving memory of the risk. In addition, the lack of a hazard map and a list of equipment necessary in the case of an event is regrettable. Indeed, to our mind they are also important elements for both service functions of the DICRIM.

While these observations show interesting results, we must nevertheless remain cautious about such conclusions with regard to the number of DICRIMs contained in the database. This number is sufficient to test the feasibility of the method, but it will be necessary in future work to increase this number for further results.

The analysis of the presence of elements allows evaluating to what extent the DICRIM does or does not comply with the regulations. However, this does not necessarily provide any conclusion on the effectiveness of these DICRIMs. The use of other non-regulatory, formal and substantive detection elements is necessary to achieve such a measure. Determination of formal and substantive detection elements needs to identify functions and dysfunctions of components contained in a DICRIM.

Detection elements/ Towns	Town 1	Town 2	Town 3	Town 4	Town 5	Town 6	Town 7	Town 8	Town 9	TOTAL (in the whole database – 30 DICRIM)
Presentation of the role of DICRIM	1	1	0	1	1	1	1	1	…	**27**
Major definitions of risk and terms characterizing them	0	0	1	1	1	1	1	0	…	**15**
Description of flooding event	1	1	1	1	1	1	1	1	…	**26**
Story of flood risk in the town by mentioning the most significant events	0	0	1	0	1	1	1	0	…	**12**
Explanations of the flood monitoring implemented	1	1	1	1	0	0	1	1	…	**21**
Description of existing population flood warning alerts	0	0	0	1	0	0	0	1	…	**19**
Symbolization of pictograms (floods)	1	1	1	1	1	1	1	1	…	**24**
Safety instructions relative to flooding and advocated in the national model and in the DDRM	1	1	1	1	1	1	1	1	…	**29**
…	…	…	…	…	…	…	…	…	…	**…**
Description of the phenomenon "transport of dangerous goods"	Nc	1	1	1	1	1	1	Nc	…	**25**

Story of transport of dangerous goods risk in the town by reference to the most significant events	Nc	0	1	0	0	1	0	Nc	…	**5**
…	…	…	…	…	…	…	…	…	…	**…**
Mention of contacts, phone numbers and website links.	1	1	1	1	0	1	1	1	…	**25**
Mention of each of the minimum items of equipment required: portable radio with extra batteries, flashlight, drinking water, food supply, containment equipment, first aid kit, personal papers, emergency medicine, blankets, extra clothing	0	0	0	0	0	0	1	0	…	**17**
TOTAL (/number of elements required)	**58 /128**	**40 /108**	**70 /143**	**82 /144**	**40 /145**	**42 /126**	**66 /106**	**46 /91**	…	

Table II: Application of regulatory detection elements in an DICRIM database (extract)

7. Components functions: Technical Functional Analysis

Technical Functional Analysis (TFA) is the part of functional analysis that helps to formalize and study the architecture of the product (structural analysis) and identify the technical functions of the components (AFNOR 2015).

7.1 Components / Service functions

Regulatory components identified during the structural analysis (cf. section 5.) are listed in Table III according to whether they concern the first service function of the system (the global DICRIM) or the second, identified in section 4.

Component	Service function 1 (SF1): *Informs to maintain and fuel risk culture.*	Service function 2 (SF2): *informs on acting appropriately when facing a major phenomenon*
Cover page (Cp1)	X	
Editorial with a word from the mayor (Cp2)	X	
Summary (Cp3)	X	
DICRIM presentation (Cp4)	X	
Presentation of the risk in the town (Cp5)	X	
Prevention actions at town level (Cp6)	X	X
Police and protection actions (Cp7)	X	X
General safety instructions (Cp8)		X
Specific safety instructions (Cp9)		X
Mapping 1/25.000th (Cp10)	X	
Communal poster (Cp11)		X
Flood marks and highest known flood zone (Cp12)	X	
Underground cavities and marl pits(Cp13)	X	
Where to get more information (Cp14)	X	
Emergency phone numbers (Cp15)		X
Equipment to always have at home to be ready (Cp16)		X

Table III: Components and links with service functions

Some components are specific to one or the other service function. For instance, components 1 to 5 are specific to SF1. On the contrary, components 15 and 16 are specific to SF2. Indeed, they correspond to emergency phone numbers and equipment, two elements used in case of an event to act appropriately. Some components also perform both service functions. This is the case, for instance, of "policy and protection actions" (Cp7) because they participate in fostering the acceptance of risk, which is one of the elements of risk culture characterizing SF1. Indeed, protection actions result in explanations of departmental rescue plans, for example, which make people realize that the risk must be taken seriously. CP7 also performs SF2 insofar as it also gives information

on the way the public will be alerted if an adverse event occurs. Alerting is one of the factors that characterize SF2. Finally, all the components are linked to at least one service function.

7.2 Service Functions / Technical Functions

Each component has one or more functions, so-called technical functions. They contribute to the service functions. Moreover, they must satisfy the constraints. The technical functions are now linked to the different components: a component fulfills one or more technical functions (Figure 4).
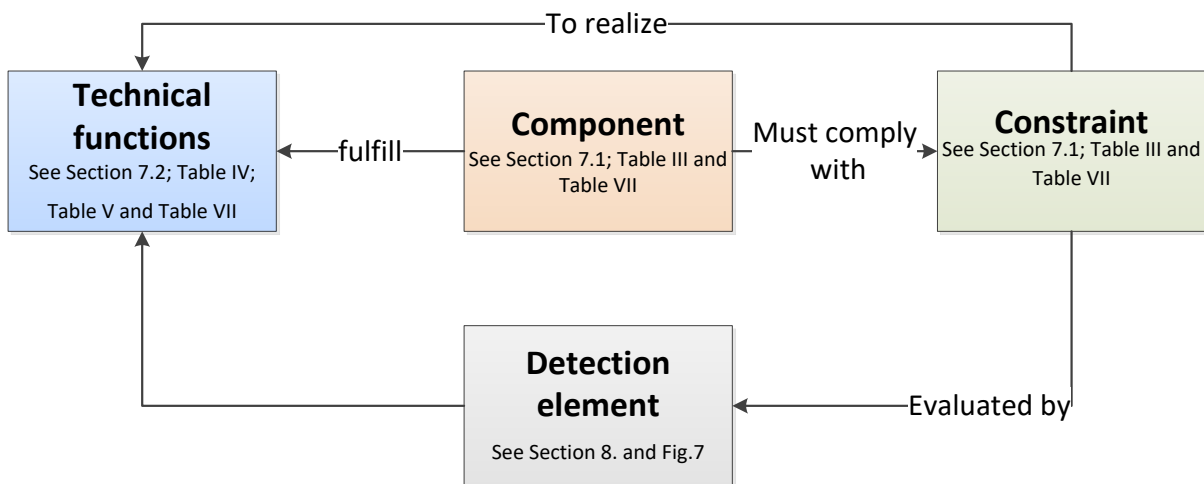
Figure 4 : Role of the entities of the method.

When establishing the two service functions of the DICRIM, some elements were identified as being linked to both of them. Here, these 6 identified elements are expressed in terms of 6 technical functions: 4 contribute to risk culture and 2 concern actions during an event. The technical functions of all the components are listed in Table IV according to whether they concern the first service function or the second.

Service Functions	Technical Functions
Informs to maintain and fuel risk culture	-Inform to raise awareness of risk (TF1) - -Inform to fuel knowledge on risk (TF2) -Inform to foster the acceptance of risk (TF3) -Inform to maintain risk memory (TF4)
Informs as to the appropriate action to be taken when facing a major phenomenon	-Inform on event detection (TF5) -Make known the appropriate reflexes to adopt if a phenomenon occurs (TF6)

Table IV: list of technical functions identified for both service functions of DICRIM

The identification of the technical functions is based on the following elements. The "culture of risk" is not to be seen as a more or less distributed capital but rather as a pragmatic relationship to the danger that is constructed and rebuilt perpetually, sometimes individually, sometimes collectively (CEPRI 2013). It begins by risk awareness. Knowing the flood does not imply feeling directly concerned by this risk. This awareness of risk has a subjective dimension, specific to each individual or group (leads to define TF1)(Defossez 2012). Conversely, the awareness of what constitutes risk to oneself or to a group cannot be effective without some knowledge of this risk. This knowledge, theoretical and practical and corresponding to TF2, is also built up over time, in particular by means of information received formally or informally, such as the reception of a DICRIM for example. Knowledge and awareness about risk need to be maintained in time, so that it can be forgotten. For a variety of reasons, the transmission of ancestral knowledge has gradually been extinguished. New populations from urban areas and tourists are often unaware of the risk their municipality is exposed to. Moreover, a phenomenon may possess a very long period of return, even leading the long-settled populations to the same place forgot the danger still present (CEPRI 2013). It leads to the TF4 characterizing memory of risk. To hope an appropriated behaviour, acceptance of risk is also crucial (TF3). Again, this process is strongly related to the nature of the risk communication that has been carried out, including the credibility of the source. When an individual feels vulnerable to risk, feeling that he or she is deprived and without means to cope with risk, he or she has more difficulty accepting the risk and tends to take refuge in the denial of that risk. Denial is part of a set of perception biases (overconfidence, anchoring effect…) which can occur in the face of risk, which runs counter to the ingredients described above and which build the culture of risk (awareness, knowledge, memory, acceptance) (Figure 5) (Mary and Wildavsky 1987).
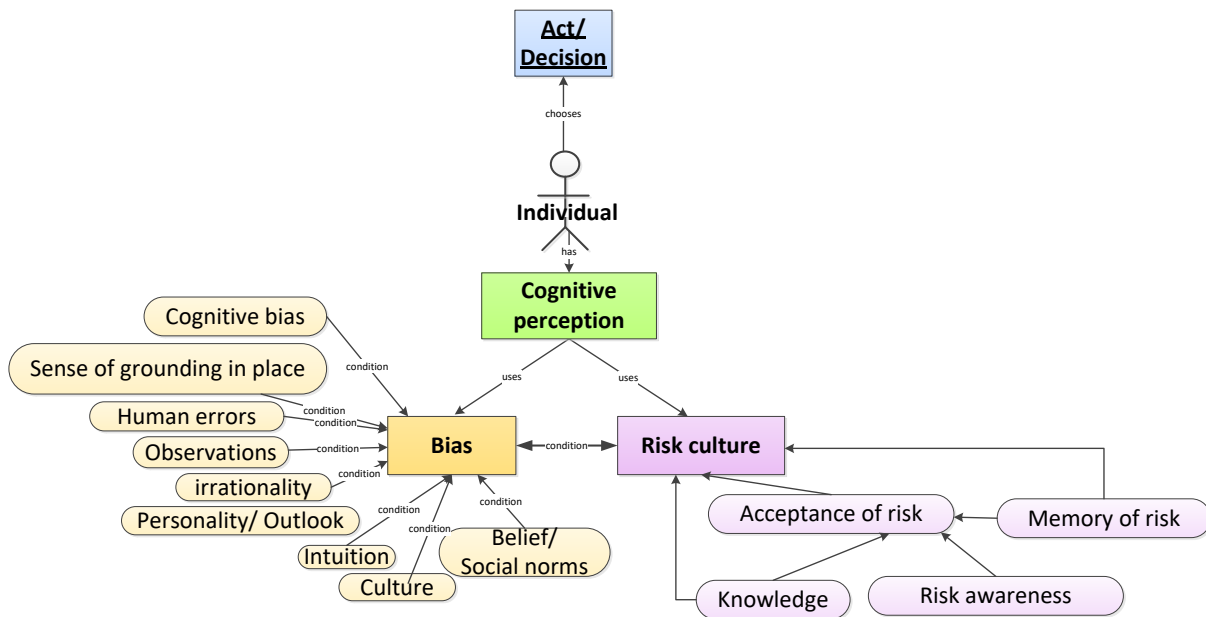
Figure 5 : Factors influencing a decision-making process related to the occurrence of a phenomenon

In many cases, cognitive bias takes precedence over the rationality of a decision (Slovic 1987). For example, over-confidence corresponds to an overestimation of his knowledge or an underestimation of his uncertainty (Kahneman and Tversky 1979). Most of the time subjects underestimate what they do not know. Preventive risk information systems such as the DICRIM therefore exist with a view to avoiding as much as possible a bias take precedence in decision-making context. The DICRIM would therefore contribute to the risk culture by deepening these major ingredients by using technical functions. The DICRIM also informs on acting appropriately when facing a major event. An appropriate act is based on the way the event is detected (leading to TF5) and good practices characterizing TF6 (Bostrom and Löfstedt 2003).

Table V represents the membership of each technical function identified for the 16 DICRIM components. We consider that components 5 to 10 generally concern each hazard. Generally, all the functions are covered by at least 5 components and all the components perform at least one function. TF1 is filled with ten components. This is the function performed by most of the components. Cp14 satisfies all the technical functions of both service functions. Components 8, 9, 15 and 16 perform only one function (TF6). The pairs of components 1/2, 3/4 and 12/13 fulfill the same functions. Cp5 performs all the technical functions linked to SF 1 and CP 11 the two technical functions of SF 2.

Component	TF1	TF2	TF3	TF4	TF5	TF6
Cover page (Cp1)	✓	✓				
Editorial with a word from the mayor (Cp2)	✓	✓				
Summary (Cp3)	✓	✓	✓			
DICRIM presentation (Cp4)	✓	✓	✓			
Presentation of the risk in the town (Cp5)	✓	✓	✓	✓		
Prevention actions at town level (Cp6)	✓	✓		✓	✓	
Police and protection actions (Cp7)		✓		✓	✓	
General safety instructions (Cp8)						✓
Specific safety instructions (Cp9)						✓
Mapping 1/25.000th (Cp10)	✓	✓	✓			
Communal poster (Cp11)					✓	
Flood marks and highest known flood zone (Cp12)	✓		✓			
Underground cavities and marl pits(Cp13)	✓		✓			
Where to get more information (Cp14)	✓	✓	✓	✓	✓	
Emergency phone numbers (Cp15)						✓
Equipment to always have at home to be ready (Cp16)						✓

Table V: membership of each technical function identified for the 16 components (TF1 : -Inform to raise awareness of risk ; TF2 : -Inform to fuel knowledge on risk ; TF3 : Inform to foster the acceptance of risk ; TF4 : Inform to maintain risk memory ; TF5 : Inform on event detection ; TF6 : -Make known the appropriate reflexes to adopt if a phenomenon occurs)

The redundancy in this table is obvious. However, hasty conclusions must not be drawn from these observations. For example, although two components fulfill a single function, this does not mean that one duplicates another. Depending on the context, fueling the same function by several components may be beneficial. For example, awareness may not be immediate and require the addition of more information. Conversely, too much knowledge can cause boredom for the reader who may lose interest in the topic or the whole component. A detailed analysis will be performed when identifying adjustments to the content of the regulatory document. This concerns works in progress, not presented here, that consists in interviewing the population about their perception of the DICRIM.

7.3 Constraints satisfied by the components

To fulfill its technical function, a component must conform to one or more constraints (cf. Figure 4). The respect for the constraints by components are evaluated by detection elements that will be showed later in the article. The first constraints are regulatory ones but during our analysis we found that these constraints were not sufficient when the aim is to evaluate the effectiveness of the DICRIM. Other constraints were identified in the EFA when listing the constraints exerted on the DICRIM by external circles. The same groups must be considered here regarding the scale of the components. They are content constraints and form constraints identified in the literature (communication, advertising, etc.). It was necessary to add form constraints because the national model does not include any specific instruction on this part whereas it plays a crucial role in the

effectiveness of a communication. It was also necessary to add content constraints because it remain essential details for effectiveness not covered by the regulatory requirements. Table VI shows an extract of constraints filled by each component relative to content characteristics. Table VI is composed of a total of 9 columns. Each component satisfies at least one constraint. The first three DICRIM components must persuade the reader to continue reading the DICRIM because they are usually the first items they see when they open the document. There are, however, no regulations on these three components. The designer is therefore free to develop the DICRIM. Each component must capture attention to be read.

The same type of table was produced for form constraints (6 columns).

Component\Content constraints	Persuade to read the DICRIM	Capture attention	Promote understanding and recording information to maintain and fuel risk culture	Promote understanding and recording information to act appropriately when facing a major phenomenon	...
Cover page (Cp1)	■	■	■		
Editorial with a word from the mayor (Cp2)	■	■	■		
Summary (Cp3)	■	■	■		
DICRIM presentation (Cp4)		■	■		
Presentation of the risk in the town (Cp5)		■	■		
Prevention actions at town level (Cp6)		■	■	■	
Police and protection actions (Cp7)		■	■	■	
General safety instructions (Cp8)		■		■	
Specific safety instructions (Cp9)		■		■	
Mapping 1/25.000th (Cp10)		■	■		
Communal poster (Cp11)		■		■	
Flood marks and highest known flood zone (Cp12)		■	■		
Underground cavities and marl pits(Cp13)		■	■		
Where to get more information (Cp14)		■	■	■	
Emergency phone numbers (Cp15)		■		■	
Equipment to always have at home to be ready (Cp16)		■		■	

Table VI: Content constraints satisfied by each component (extract)

7.4 Functional analysis table

For each component, the technical functions along with the service function they refer to and the constraints are then gathered in Functional Analysis Tables. Table VII presented below for the component "Editorial with a word from the mayor" is an example.

Component 2	Service function	Technical function	Constraints
Editorial with a word from the mayor	*Informs to maintain and nurture the culture of risk*	-Inform to raise awareness of risk -Inform to foster the acceptance of risk	Form: -To be designed and developed to capture attention -To be designed and developed in order to persuade the receptor to read the DICRIM
			Content: -To be designed and developed in order to persuade the receptor to read the DICRIM -To be designed and developed in order to reassure the reader -Introduce DICRIM function -Explain importance of risk management

Table VII : Functional analysis table for Component 2

8. Causes, effects and detection of components failures

The results produced by the functional analysis form the basis for performing an FMEA. The FMEA is carried out for each function performed by the components of the document. All the failure modes (that is to say functions not carried out) that can occur during the different life cycles of the document and their causes and effects are identified. It is essential to investigate the causes and effects of malfunctions carefully to detect them and then propose feedback to avoid them. Effects are not used in our work but they will be important results in the future steps of building the model of evaluation effectiveness. Furthermore, as we said before, a component must satisfy a constraint to perform a technical function. Non-compliance with the constraints is seen here as a cause of dysfunction (cf. Figure 4) and they are therefore essential to identify detection elements. Compliance with the constraints is evaluated by one or more "detection elements" (Figure 4).

The results of the FMEA are presented in a diagram with a bow tie form. Figure 6 presents an example for the Editorial component.
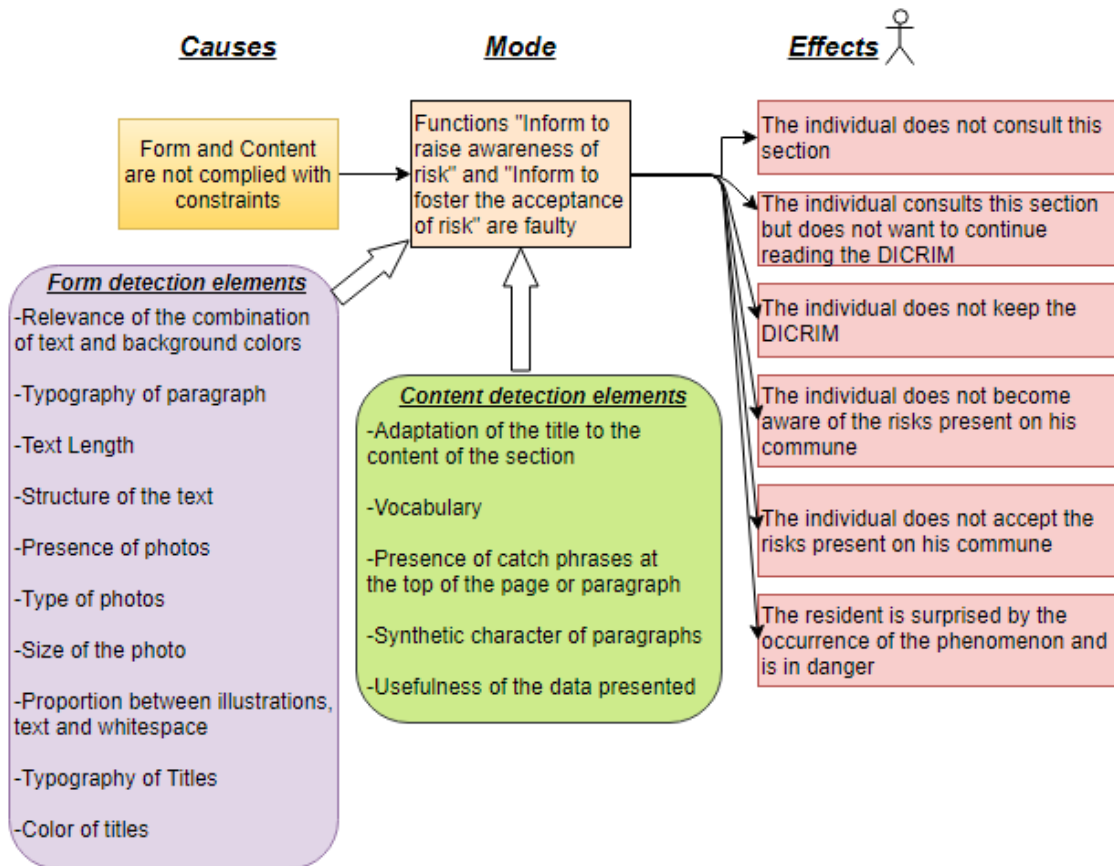
Figure 6: Diagram with a bow tie showing FMEA for Component 2

An editorial with a word from the mayor is defective when its functions "Inform to raise awareness of risk" and "inform to foster the acceptance of risk" are faulty. It occurs when form and content of the editorial are not complied with constraints. To detect those failures form detection elements and content detection elements are used such as evaluate the typography, the text length, the vocabulary... Those failures can have some negative effects. For instance, as the editorial is not effective, the reader does not consult this section, it may not want to continue to read the DICRIM or even not accept the risks present on its town.

To detect failures of components we identify: detection elements regarding form and content. The scales of indicators are based on literature and experts. These scales require the mobilization of different disciplines such as in semiotics with for example the improvement of colours (Chesneau 2006), or the study of the zones of interest of an image. (Judd, Durand, and Torralba 2012) study, for example, the ability of visual salience models to predict areas of interest in an image. (Fabrikant, Hespanha, and Hegarty 2010) study how visual salience and training to cartographic reading impact the effectiveness of a map. Using an experimental protocol studying eye movements, feeling and answering volunteers' questions on different types of maps, (Palka 2015), for example, showed that the most useful maps are characterized by a quantity of information contained in them. The location of the fixations has also allowed him to define which areas of the map attract the eye with their graphic or informational characteristics. This knowledge from different fields will in fact be exploited in more detail in our future work during the development of the indicators.

For form, 13 generic detection elements were identified. They are used for one or other of the 16 DICRIM components according to what they allow to detect. The same approach is followed for the 7 content detection elements identified. In future works, content and form detection elements will be formalized as indicators and presented in a grid form. An example of those indicators is shown in Table VIII. It allows evaluating the length of the component, here the "Editorial" component, regarding number of pages combined with the font size. This is one of the important features to take into account for evaluating its effectiveness.

Name	IC6 – Component length
Definition	The aim is to evaluate the length of the whole "Editorial" component
Scale and references	10: 1/8 or 1/4 page and the font is of standard size (usually 12) 6: 1/2 page and font size is standard 5: 1/8 or ¼ page and the font is greater than 14 3: the font is greater than 14 and the length is greater than 1/4 page 2:> 1/2 page or the font is less than 10
Place characteristic	At the beginning of the DICRIM - On the page where the editorial is located

Table VIII : Example of an indicator grid here related to the evaluation of the length of the editorial component

Then all those form and content indicators will be aggregated to form an effectiveness detection model. Several aggregation operators can be used such as weighted average or minimal… In Figure 7, an example of the effectiveness model is showed. It contains indicators with their hypothetical weights, used to demonstrate how a "bad" score becomes useful to detect where feedback must be applied to improve a given components' overall score.
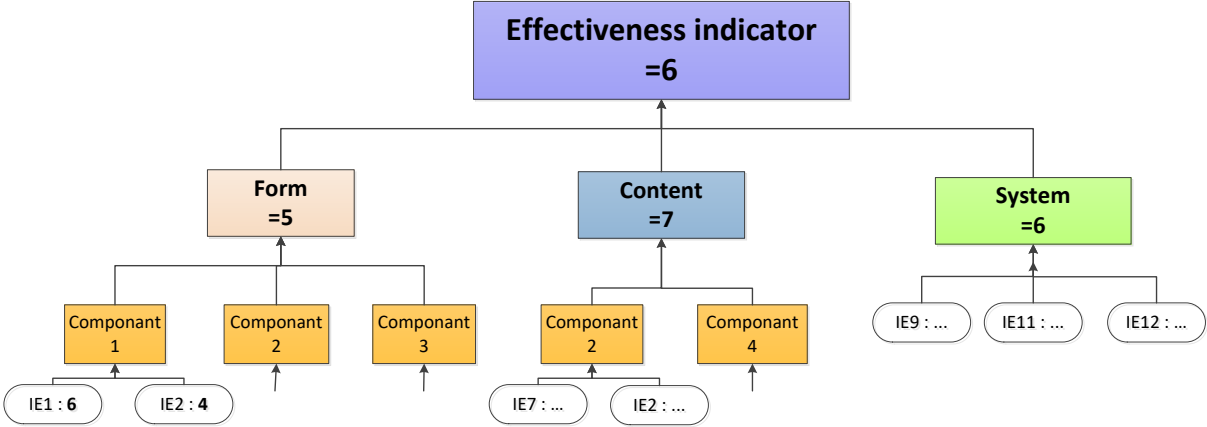
Figure 7 : Example of the functioning of the future model of effectiveness by indicators aggregation

9. Conclusion and Perspectives

Providing information and communication is essential for raising awareness of risks and disseminating knowledge on their nature and on how to act if a phenomenon occurs. That is why it is crucial to ensure that relevant information and communication is available to those who use them. It allows decisions to be taken without bias. However, few works currently propose to evaluate their effectiveness. Existing works often require a sample population or are expensive to perform. According to the means available, such studies are not always possible. Furthermore, these methods are specific to the sites where they must be applied and are not necessarily generic. In this study we proposed an analytical methodology that allows identifying preventive communication documents functions and dysfunctions. It lies at the interface between several existing approaches, from different fields (engineering, advertising, etc.). This method was applied to the DICRIM one of the main French document used to inform Great Public about risk at a communal level. Results included the identification of regulatory detection elements. These detection elements were then used to analyse existing documents and show their degree of conformity with the regulations. A challenge in the future will be to analyse whether component redundancy is strictly necessary (Table V). Indeed, we observed that some components fulfilled the same function, raising doubts as to their usefulness. Likewise, the application of the database showed that several elements demanded by the regulations were systematically missing from the DICRIMs studied. This also led to questioning the need for these elements to fulfill the objectives of the document.

The approach is generic and could be applied to other documents, notably for preventive risk management such as the family safety plan intended to help families. Families have to complete it themselves in order to prepare for the possible occurrence of an event. Our approach and its general procedure (EFA and FMEA), service functions, types of constraints, form constraints, and some of regulatory and content constraints may be applied to the case of family safety plans.

This study is the first step towards a decision support model for the municipality (or specialized consulting firms) in charge of drawing up documents. This model would allow evaluating the effectiveness of existing preventive communication documents and identifying the corrective actions needed to improve their effectiveness. In the next step (not presented here), the causes and effects identified with the FMEA method will be used to define models for the quantitative assessment of DICRIM efficiency. Detection elements will become indicators formalized and those will be used as input data in these models. This is an essential step towards the overall goal. Its results are crucial for ensuring the basis of models and for structuring them.

References

AFCPN. 2013. « Réflexion sur l'information préventive sur les risques naturels ».

AFNOR. 2014. « NF EN 1325 (2014-04-26) ».

———. 2015. « NF EN ISO 9000 (2015-10-15) ».

Association Française de Normalisation. 2005. « Lexique, définitions normalisées ». *NF EN ISO 9000*. afnor.fr.

Bambara, G., L. Peyras, H. Felix, et D. Serre. 2015. « Developing a functional model for cities impacted by a natural hazard: application to a city affected by flooding ». *Natural Hazards and Earth System Sciences*, nᵒ 15:603‑15.

BBCNews. 2016. « Paris floods: Seine level starts dropping after 30-year high », 4 juin 2016. www.bbc.com.

Boissier, L. 2013. « La mortalité liée aux crues torrentielles dans le Sud de la France: une approche de la vulnérabilité humaine face à l'inondation ». Montpellier: niversité Paul Valéry-Montpellier III.

Bostrom, A., et R.E. Löfstedt. 2003. « Communicating Risk:Wireless and Hardwired ». *Risk Analysis* 23 (2).

CEPRI. 2013. « Sensibiliser les populations exposées au risque d'inondation Comprendre les mécanismes du changement de la perception et du comportement Les collectivités en Europe pour la prévention du risque d'inondation ». Les guides du CEPRI.

Chesneau, E. 2006. « Modèle d'amélioration automatique des contrastes de couleur en cartographie - Application aux Cartes de risque ». Université de Marne-la-Vallée.

Clément, A., E. Chesneau, G. Celle, F. Giannoccaro, F. Fournel, et L. Paduano. 2012. « Elaboration d'un Document d'Information Communal sur les Risques Majeurs interactif : Guide de recommandations ». Les dossiers de l'Institut des Risques Majeurs.

Cutter, S. 1993. « Living with risk : the geography of technological hazards ». *Edward Arnold*, 214p.

Defossez, Stéphanie. 2012. « Réglementation vs conscience du risque dans le processus de gestion individuelle du risque inondation ». *Géocarrefour* 86 (3-4):281‑90.

Douvinet, Johny, Rémi Pallares, Cyrille Genre-Grandpierre, Mathilde Gralepois, Sylvain Rode, et Sylvie Servain-Courant. 2013. « L'information sur les risques majeurs à l'échelle communale : Occurrence et facteurs explicatifs du DICRIM, un outil préventif sous-utilisé ». *cybergeo*, nᵒ Espace, société, territoire.

Duaut, Mylène, et Aymeric Luneau. 2008. « Le risque et les AllevardinsSavoirs et représentations sur le milieu allevardin. » université Pierre Mendès France http://www.irmagrenoble.com/PDF/actualite/articles/rapport1_juin2008_annexes.pdf.

Enrico L. Quarantelli. 2008. « Conventional Beliefs and Counterintuitive Realities ». *Social Research: An International Quarterly of the Social Sciences* 75 (3):873‑904.

Fabrikant, S.I., S.R. Hespanha, et M. Hegarty. 2010. « Cognitively inspired and perceptually salient graphic displays for efficient spatial inference making ». In *Annals of the Association of American Geographers*, 1:13‑29.

Festinger, L. 1957. « A theory of cognitive dissonance ». *Stanford University Press*.

Fuchs, S., K. Spachinger, W. Dorner, J. Rochman, et K. Serrhini. 2009. « Evaluating cartographic design in flood risk mapping ». *Environmental Hazards* 8:52‑70.

Ghariani, Nabgha, Corinne Curt, et Jean-Marc Tacnet. 2014. « Analyse du fonctionnement et des dysfonctionnements des dispositifs de protection contre les crues torrentielles ». In . Aix-en-provence.

Gominet, Sébastien. 2007. « Les habitants de la commune de la Terrasse (Isère) connaissent-ils les risques auxquels ils sont exposés ? », mars. http://www.irma-grenoble.com/01actualite/01articles_afficher.php?id_actualite=172.

———. 2010. « Deux enquêtes auprès de la population de Pont-de-Claix pour estimer l'efficacité du DICRIM », novembre. http://www.irma-grenoble.com/01actualite/01articles_afficher.php?id_actualite=418.

Hagemeier-Klose, M., et K. Wagner. 2009. « Evaluation of flood hazard maps in print and web mapping services as information tools in flood risk communication ». *Natural Hazards and Earth System Sciences* 9:563‑74.

Hubert, G., et B. De Vanssay. 2005. « Le risque d'inondation et la cartographie réglementaire. Analyse de l'efficacité, des impacts et de l'appropriation locale de la politique de prévention ». Programme" Evaluation et Prise en compte des Risques naturels et technologiques. Ministère de l'Ecologie et du Développement Durable.

IRMa. 2014. « Information préventive des populations – Mémento du Maire et des élus locaux ». www.mementodumaire.net.

IRMa, PARN, Pacte, et Région Rhône-Alpes. 2015. « L'information préventive sur les risques naturels, au-delà du réglementaire, quelles approches alternatives en Rhône-Alpes ? » In .

Johnson, BB. 1993. « Advancing understanding of knowledge's role in lay risk perception ». *Health and Safety* 189.

Judd, T., F. Durand, et A. Torralba. 2012. « A benchmark of computational models of saliency to predict human fixations. » *MITLibrairies*.

Kahneman, D., et A. Tversky. 1979. « Prospect Theory: An Analysis of Decision under Risk ». *Econometrica* 47 n°2:263‑92.

Kellens, W., T. Terpstra, et P De Maeyer. 2013. « Perception and Communication of Flood Risks: A Systematic Review of Empirical Research ». *Risk Analysis* 33 (1). https://doi.org/10.1111/j.1539-6924.2012.01844.x.

Kievik, Milou, et Jan M. Gutteling. 2011. « Yes, we can: motivate Dutch citizens to engage in self-protective behavior with regard to flood risks ». *Natural Hazards*.

Langer, E.J. 1975. « The illusion of control ». *Journal of personality and social psychology* 2 (32):311.

Lindell, M.K., et R.W. Perry. 2004. « Communicating Environmental Risk in Multiethnic Communities ». *Thousand Oaks CA: Sage*.

MAAF, MEDDE. 2013. « Évaluation des dispositions visant à l'information préventive des citoyens vis-à-vis des risques naturels auxquels ils peuvent être exposés ». n°008684-01.

Mary, D., et A. Wildavsky. 1987. « Risk and culture. An essay on the selection of technological and environmental dangers ». *Revue française de sociologie* 28 n°1:178‑81.

McArthur, DN., et T. Griffin. 1997. « A marketing management view of integrated marketing communications ». *Journal of Advertising Research* 37 (5):19‑26.

MEDDE. 2013. « DDRM/DICRM - Maquette nationale pour l'application du code de l'environnement - articles L125-2 et R125-5 à R125-27 ».

Meyer, V., C. Kuhlicke, J. Luther, S. Fuchs, S. Priest, W. Dorner, K. Serrhini, et al. 2012. « Recommendations for the user-specific enhancement of flood maps ». *Natural Hazards and Earth System Sciences* 12:1701‑16.

Newell, Ben R., Tim Rakow, Eldad Yechiam, et Michael Sambur. 2015. « Rare disaster information can increase risk-taking ». *Macmillan Publishers Limited*, Natural Climate Change, .

Observatoire Régionale des Risques Majeurs en Provence-Alpes-Côte d'Azur. 2017. « Les principales lois en matière de gestion des risques naturels ».

Palka, G. 2015. « Amélioration de la cartographie du risque d'inondation par l'intégration des besoins et préférences des destinataires ». Tours: Université François-Rabelais.

Paton, D., L. Smith, et D.M. Johnston. 2000. « Volcanic HAzards: Risk Perception and Preparedness ». *New Zealand Journal of Psychology* 29 (2):86‑91.

Peyras, L., P. Royet, et D. Boissier. 2006. « Dam ageing diagnosis and risk analysis: Development of methods to support expert judgment ». *Canadian Geotechnical Journal 43* 2 (43):169‑86.

Renn, Ortwin. 2014. « Four questions for risk communication: a response to Roger Kasperson ». *Journal of Risk Research*. https://doi.org/10.1080/13669877.2014.940601.

Rode, Sylvain. 2012. « Le chêne ou le roseau : quelles stratégies de gestion du risque d'inondation en France ?Oak or reed: how to manage flood risk in France? » https://cybergeo.revues.org/25299.

Ruin, I. 2007. « Conduite à contre-courant. Les pratiques de mobilité dans le Gard: facteur de vulnérabilité aux crues rapides ». Grenoble: Université Joseph-Fourier-.

Sanquini, Anne M., Sundar Thapaliya, et Michele M. Wood. 2016. « A survey instrument to isolate effectiveness of a novel risk communication intervention ». *Natural Hazards* 82:59‑72.

Schoeneich, P., et M.C. Busset-Henchoz. 1998. « La dissonance cognitive: facteur explicatif de l'accoutumance au risque ». *Revue de géographie alpine* 2 (86):53‑62.

Siegrist, M., et G. Cvetkovich. 2000. « Perception of hazards : the role of social trust and knowledge ». *Risk Analysis* 20 (5):713‑19.

Slovic, P. 1987. « Perception of risk ». *Science* 236:280‑85.

Slovic, P., B. Fischhoff, et S. Lichtenstein. 1982. « Why Study Risk Perception? » *Risk Analysis* 2 (2):83‑93.

Terpstra, T. 2011. « Emotions, Trust, and Perceived Risk: Affective and Cognitive Routes to Flood Preparedness Behavior ». *Risk Analysis* 31 (10):1658‑75.

Terpstra, T., MK. Lindell, et JM. Gutteling. 2009. « Does communicating (Flood) risk affect (Flood) risk perceptions? Results of a Quasi-Experimental study ». *Risk Analysis* 29 (8):1141‑55.

UNISDR. 2015. « Sendai Framework for Disaster Risk Reduction », 2015. https://www.unisdr.org/we/coordinate/sendai-framework.

United Nations. 2006. « Global Survey of Early Warning Systems - An assessment of capacities, gaps and opportunities towards building a comprehensive global early warning system for all natural hazards ».

Weiss, K., L. Colbeau-Justin, et D Marchand. 2006. « Entre connaissance, mémoire et oublis : représentations de l'environnement et réactions face à une catastrophe naturelle ». *Psychologie sociale de l'environnement.*, 145‑56.

Zouakia, R., D. Bouami, et M. Tkiouat. 1999. « Industrial systems maintenance modelling using Petri nets ». *Reliability Engineering & System Safety*, Elsevier, 65 (2):119‑24.