Sorting the good from the bad smartphone applications to alert residents facing disasters – Experiments in France

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ABSTRACT

The number of smartphone applications to alert and inform the population in a risk situation in France is too large and these solutions are still unknow by the population. This study proposes an evaluation protocol based on various indicators, which take into account the capacity of the applications to send a targeted alert, their attractiveness, the ability of individuals to emit information and number of hazards considered. The results obtained on 50 applications deployed in France show that very few of them meet the objectives of the alert, in the sense defined by civil security, because of a single-risk approach, a unique sense of communication, and the low acceptance of these solutions by citizens.

Keywords

Alert, smartphone application, major risks.

INTRODUCTION

The combination of unpredictable hazards with climate change and increased exposure of populations makes territory more and more vulnerable (Kelman, 2011; Vinet *et al.*, 2017). The physical extent of the disaster makes it very hard for residents or affected human to react in timely fashion. Significant research and development efforts are required to create or improve systems to predict natural disasters, and to efficiently alert humans at the earliest possible time through different communication channels (Carley *et al.*, 2015; Choy *et al.*, 2016; Lindsay, 2011; Matveeva, 2006). The purpose of the alert is to warn citizens against a threat, a danger (Linardi, 2016) so that citizens can make decision and take action for safety (Daupras *et al.*, 2015; Sorensen, 2000). Due to its shorter temporality, the term "alert" differs from the term "warning" which takes into account forecasting and hazard monitoring. Thus, the alerting tools goals are: 1) spreading alert messages to citizens to inform them on the nature of the danger and its intensity; 2) advise citizens about actions to undertake.

In this paper, we focus on a specific alerting tool, smartphones applications, in order to measure the potential effectiveness of these solutions to play a role during alerts. Such solutions represent considerable scientific interest in the way this tool impacts our environment (Barr *et al.*, 2015; Brownlee and Liang, 2011), our economy (Poushter, 2016) and our displacements (Adoue, 2015): in 2015, 3.7 billion people have a smartphone in the world. During a crisis, smartphone apps change the way in which people interact (Goodchild, 2007 ; Laurila, 2013 ; Slingsby *et al*., 2013), especially during alerts (Chatzimilioudis *et al.*, 2011 ; De Longeville *et al*., 2010 ; Douvinet *et al.*, 2017 et 2018 ; Fajardo et Oppus, 2009 ; Kouadio, 2016). Mostly, smartphone applications have the potential to improve the accuracy and timeliness of information over events in progress, to improve planning and alerts and communications between institutions and humans (Slingsby *et al.*, 2013): 1) they can locate citizens in real-time and communicate with them; 2) they can generate a "two-ways" interaction between users and decision centers, in an ascending logic (Goodchild, 2007); 3) smartphones messages and signals are moreover more understandable than sound signals (alarms) or shorter signs.

The development of smartphone applications to alert in the case of disasters has greatly increased since the years 2010 (namely after the seismic damage that has occurred in Haïti or after floods in Brisbane, Australia). In France, these tools are gradually being used since 2014 (Kouadio, 2016; Douvinet *et al.*, 2017). French government has launched its own app dedicated to alerts at the national level in June 2016, especially due to the increasing risk of terrorism since 2015. SAIP® app (*Alert and Information System for the Population*) has nonetheless been abandoned in May 2018, due to several missed and false alerts. In parallel, specific alert applications have been displayed since 2015 at the local level (in several municipalities like Nîmes, Nice, Hyères, Athis-Mons, etc.). In addition, private companies have massively engaged in the development of these solutions on an international scale (operating in the world, like ELERT®, Qwidam®, Signalert®, WeatherAlert®, etc.) in order to cover all hazards and probable related dangers. In many cases, applications results from public-private partnerships and need significant human and economic resources, and a major political decision to develop them.

In France, the massive creation of smartphone applications cause a high competitive logic between stakeholders involved, and a strong confusion for citizens who struggle to find their way in the face of the diversity of solutions. All available solutions present variable criteria and characteristics, especially in terms of the communication mode, the price, the spatial coverture, etc. Thus, it remains difficult for citizens, stakeholders or scientists, to know the best solutions. This has the consequence of increasing the gap between citizens who want efficient and operational emergency applications, and institutions that are reluctant to invest digital tools (Vogel, 2017).

In the scientific literature, most of the studies are focused on the technical capabilities of applications (Fragkiadakis *et al*., 2011; Chatzimilioudis *et al.*, 2011) rather than how the content is perceived by the public (Lindsay, 2011). Furthermore, the social appropriation of smartphone applications is still poorly and insufficiently documented (Bopp *et al.*, 2019; Douvinet, 2018). Thus, comparing several smartphone applications available in France since few years, this article supplies two contributions. First, we experienced a retrieval method to classify and hierarchize the "good from the bad smartphone applications" proposing to alert users to natural risks. A "good application" simultaneously corresponds to the need to attract attention and deliver an instructional message (DGSCGC, 2013). The method has been designed to "put oneself in the shoes of a future user", to go beyond standard indicators that are limited to measures the internal efficiency of applications and are insufficient to explore how humans play a major role during crises. Second, we wish to select the applications with the high scores and discuss the opportunity to develop them in France. Such a choice might impulse major political changes, as sirens remain the priority for the French government in charge of alerting the population facing disasters since the end of the 2nd World War (Vogel, 2017; Douvinet, 2018).

The paper is organized as follows. Section 2 presents the data collection and the main elements used to implement the evaluation. Section 3 presents the obtained results through the evaluation of 50 applications displayed in

France. In section 4 and 5, the benefits and limits of the evaluation tools as well as the results are discussed, and conclusions are drawn in Section 6.

METHODS AND DATA COLLECTION

The basic elements needed for the evaluation are explained here and a functional description of each indicator is introduced. Applications have been uploaded in March 2018 *via* specialized search engines (Google Play®, Play Store®) using keywords: alert, risk, SOS, warning, disasters, hazards, etc. Every application has been rigorously tested and only applications allowing the sending of an alert to a risk have been retained.

Our evaluation method is first based on four major indicators identified using the scientific literature and experiences feedback. A "good" smartphone application for the alert must be regarded according to (1) its potential to alert and inform the user in case of disasters (with the postulate that such information is relevant); (2) its potential to allow interactivity between users and the decision center; (3) its potential to take into account all the existing hazards on the France territory (to permit adaptation to various situations); (4) its potential to be attractive to prevent users from deleting them.

The potential of alerting and informing users

French authorities define the alert as a signal intended to warn citizens of a danger, imminent or in the process of producing its effects, which may affect their physical integrity and requires the adoption of a reflexive backup behavior (DGSCGC, 2013). Then, the alert process is expected to: 1) be intrusive, with a clear and short message that breaks with usual information; 2) be targeted, by defining an alert zone; 3) trigger an immediate response to exposed populations (Douvinet, 2018). In this sense, a good application needs to support people in the affected area to take the correct actions (Kouadio, 2016). First, applications can send a push notification, an interruptive message that appears on the screens even if the application is closed, that corresponds to the interruptive character and intrusive expected alerts (Tang *et al*., 2013). Secondly, applications allow geolocation of users. Precious during crisis management, the "location-based mobile telephony services" (Aloudat *et al*., 2014) allows the sending of a targeted alert to citizens located in the potential area of the hazard, provided that they agree to communicate their position. Smartphone applications have other capabilities in improving the dissemination of alert messages and their understanding thanks to hazards visualization in real time on map interfaces or the possibility to relay alerts through Social Medias.

The potential of interactivity

Humans have a better perception of risks when they have been integrated in the design and preventive phase (Gaillard *et al.,* 2010; Garcia, 2012). Citizens are empowered to observe and transmit data through the Internet, connected objects or crowdmapping (Becker and Bendett, 2015; Riccardi, 2016; Ziemke, 2012). In addition, decision centers need to quickly acquire accurate information in times of crisis (Villela *et al*., 2018). A good smartphone application may allow citizens to interact with warning systems (Budhatoki *et al.*, 2010; Horita *et al*., 2013; Okolloh, 2009). Interactive applications allow users to detect all "weak signals" revealing disasters in progress (Kouadio, 2016). In this sense, a single "top-down" broadcast communication mode, coming from the decision center to users, is less relevant than a "bottom-up" mode of dissemination from the user to the decision center, or than a "peer-to-peer" mode enabled by a mesh network deployment.

The multi-hazard dimension

The multi-hazard concept refers to the fact that different hazards may threaten the same element and that one event may trigger others (Liu *et al.,* 2017, Nadim and Liu, 2013). Consequently, a smartphone application developed to alert people facing to a single hazard is limited. In France, 12 major risks are identified and defined by the authorities as "the threat to human people and his direct environment (…) whose gravity is such that society is absolutely overwhelmed by the immensity of disaster" (DGSCGC, 2013). Eight natural risks exist (flood, earthquake, volcanic eruption, movement of land, avalanche, forest fires, cyclone and storm) and the other four are anthropogenic risks (nuclear risk, industrial risk, transport of hazardous materials, dam failure). Although the distribution of hazards is very heterogeneous in France, an application developed throughout France must take into account these 12 major risks. Thus, the app will be adapted to various situations that users can face. We don't take into account here cascading effects between hazards considering that humans need to be alerted whatever the spatial distribution of hazards.

The potential of attractiveness

The attractiveness of an application is a key parameter to its general use. The user is able to determine (during its first use) if one application is useful or not for him (Adoue, 2015). If two applications present similar functionality, the quantity and quality of information provided and its ergonomic aspect are determinant in the user choice (Adoue, 2015). The color choice is particularly decisive in the user's appreciation of the app (Weinclich, 2014). Some researchers then aim to ensure compatibility between the characteristics of users, the technical products, and the systems in order to facilitate their use (Barcenilla and Bastien, 2009). Attractiveness is a fuzzy parameter involving user experiences on the product. Poorly studied in the scientific field, the user experience requires evaluating both pragmatic qualities (usefulness, usability) and hedonic qualities (stimulation, identification perceived by users on the product (Hassenzahl, 2004; Väätäjä *et al.*, 2009). In our research, without being able to assess such user qualities, it is only possible to look at the pragmatic qualities of applications. The usefulness of apps can be assessed through various offered functionalities: interactive cartography and usefulness of information (such as real-time traffic or weather, presence of information and instructions on risk, etc). The usability can also be checked with the presence or absence of advertising and detected bugs. Price of apps is also a parameter of this indicator.

How to convert qualitative criteria into quantified indexes?

Figure 1 details the methodology used to evaluate applications. The four indicators are defined by a certain number of settings ranging from 0 to 1 and weighted according to their importance.

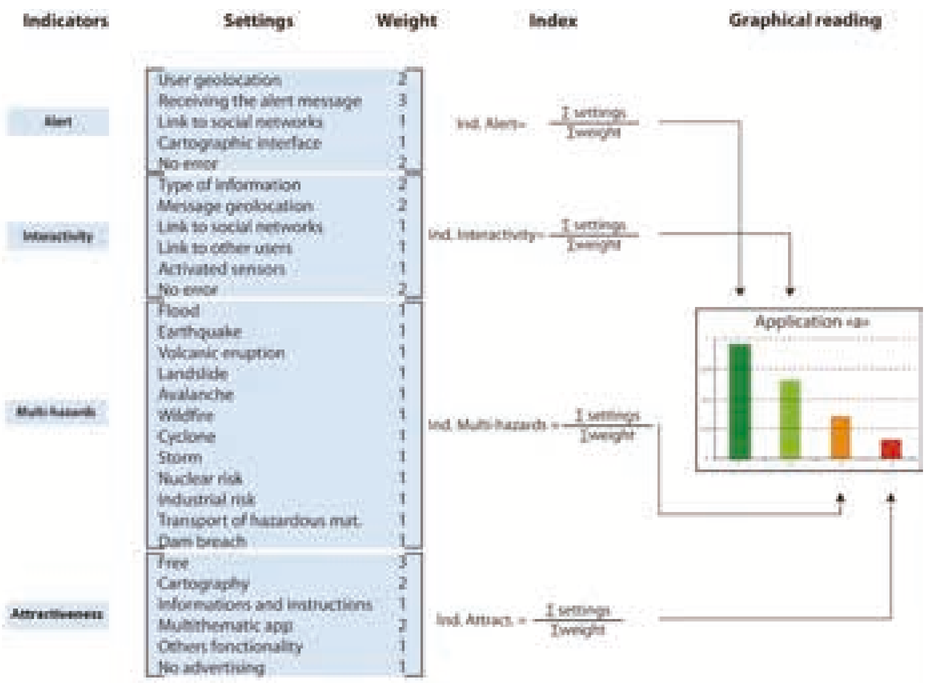

Figure 1. Indicators and selected settings to define them.

With this methodology, each criterion can be measured in the same units, and differences in values on different criteria are comparable and can be offset (Serre, 2005). Settings were weighted with a simplified point rating system (1, 2 or 3), according to the literature review. Therefore, such a method emphasizes the importance of application functionality in the field of alerts (Shan and Lai, 2015, Shih *et al*., 2013), including the issuance of information by users (Chatzimilioudis *et al*., 2012) and the attractiveness of applications (Weinlich *et al*., 2014). Finally, the sum of the settings was aggregated and ranged from 0 to 1 to propose an index per indicator. The four indexes obtained make the classification easier between applications. One graph finally presents the results obtained for all indicators, to avoid an excessive loss of information with initial setting an increasing color refers to the obtained values. This method fits directly into the main principles of the *Multi-criteria Hierarchization Methods* (MHM), invented by Saaty (1984) and which can now be distinguished according to the objectives and points of view (Maystre *et al*., 1994).

RESULTS

This method was first tested on four applications and experimented on fifty applications dedicated to alerting humans in case of disasters. The selected sample renders the compilation of a wide variety of functional applications available in France possible.

Detailed results for each indicator

Surprisingly, the attractiveness globally performing well for all applications, whereas the alert, multi-hazards dimension or interactivity indicators are heterogeneous (Table 1 and Figure 2). The high average (0.64) and the minimal variation for attractiveness (0.45) are explained by the fact that 35 applications are free, 34 allow the visualization of a disaster on maps and 23 complete alert messages with behavior guidelines and information. Only 11 free applications contain advertising and some apps have features to directly contact relief or reassure loved ones. The calculated average for the alert indicator (0.58) and dispersion of values are explained by the fact that geolocation and reception of the message have been weighted: 36 applications allow the geolocation of users, including 32 automatically, and 25 use the push notification. 22 applications allow interactions with other social media and 36 are related to a mapping of a disaster in real time. 36 do not present any error or malfunctions during the test phase, whereas the quality of reception disturbs the performance of others (14). The calculated average for interactivity (0.29) is weakest, and highest standard variations are explained by the fact that only 20 applications allow current relations between users and decision centers. Some of them (17) activate at least one predefined sensor (digital camera or voice recorder), but only 7 allow comments within social media and only 11 allow users to exchange information with other users. But 18 applications present malfunctions in the information sending test phase, including 13 applications where these malfunctions have a strong impact on the quality of information sending. The multi-hazard is also discussed: 23 applications are multi-hazard but only 11 take into account all the hazards related to a major disaster in France. 14 tested applications focus on a single hazard (mainly in the case of earthquakes or floods). 7 applications do not take into account any of the 12 hazards selected in this study. Most solutions (Table 2) consider natural disasters (79.4%) and rather than anthropogenic disasters (20.6%).

Table 1. Detailed results for each indicator.

	Alert	**Interactivity**	**Multi-hazard**	**Attractiveness**
Average	0.58	0.29	0.64	0.64
Mode	0.56	0.00	0.08	0.60
Decile 1	0.00	0.00	0.00	0.45
Decile 9	0.89	0.78	1.00	0.90

Table 2. Hazard taken into account by the applications.

Type of disasters	Number of app	Type of disaster	Number of apps
Flood	30	Snow avalanche	19
Cyclone	25	Volcanic eruption	18
Storm	24	Landslide	16
Earthquake	24	Industrial risk	12
Wildfire	21	Dam break	11

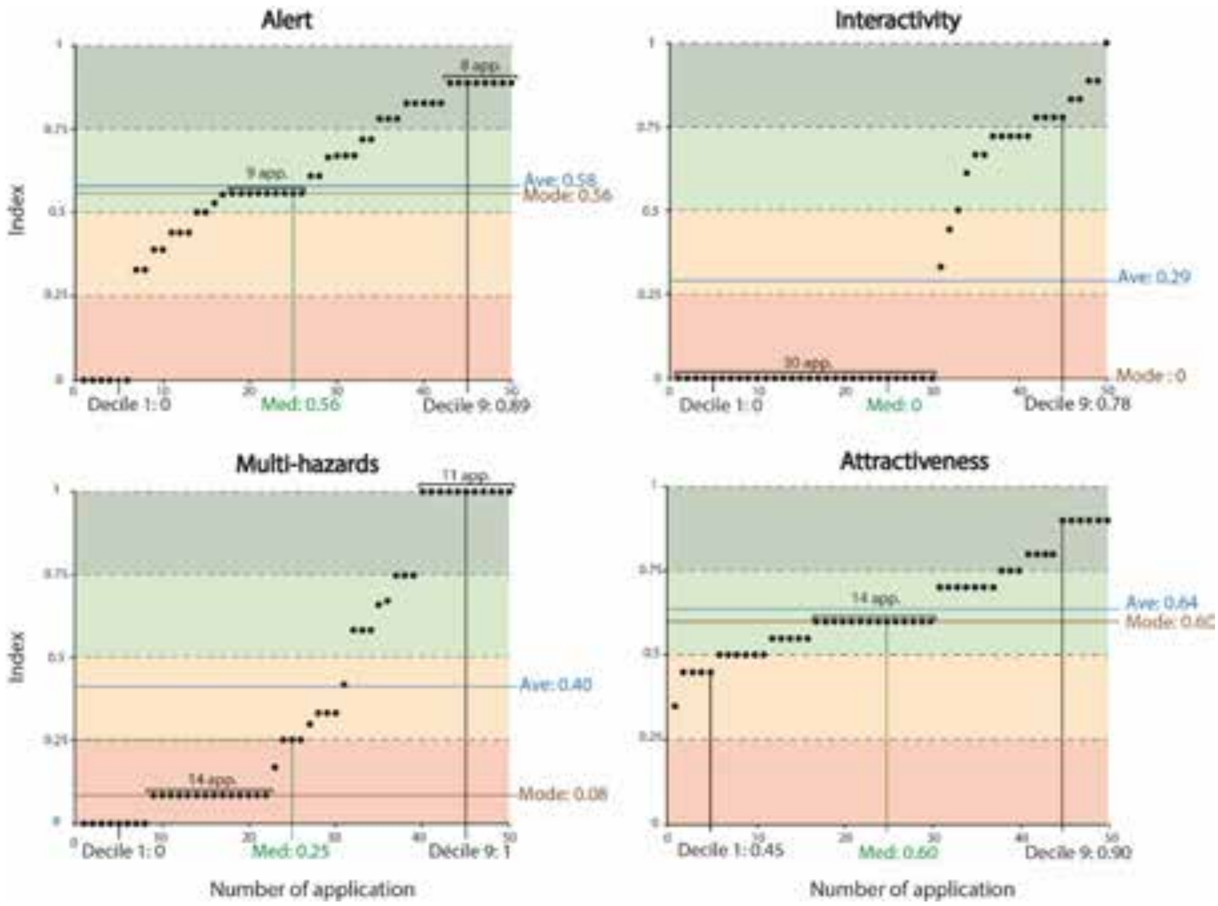

Figure 2. Ranking of results for the four indicators.

Global overview

The overall evaluation (Figure 3) provides additional lessons. Only 4 applications have their 4 indexes greater than 0.50 whereas 34 apps have at least one zero index. 3 applications present a global index greater than 3.00, while 28 applications have a global index of less than 2.00. Consequently, a few applications are really considered effective at alerting humans, but their number appears limited. By classifying these 50 applications, we obtained a curve with regular ascendancy. The standard deviation equals 0.35 and deciles 1 and 9 are not in extreme values (respectively 1.14 and 2.69). Applications are mostly private (34 applications) and companies aim at democratizing their own products as widely as possible (Douvinet *et al.*, 2017). Hence a high prevalence of applications that can be used on a global or continental scale: over the 25 displayed at global or continental levels, 21 are managed by private entities (Tables 3 and 4).

Table 3. Nature of hosting structures for applications.

Managing structures	Number of app	Global index
Institutional apps	16	2.01
Governement	*4*	*2.26*
Local	*5*	*1.91*
Non-governemental organisations	*7*	*1.86*
Private companies	34	1.87

Table 4. Type of spatial deployment for the 50 studied applications.

Spatial coverture	Number of app	Global index
Local level	5	2.09
National level	20	1.72
Continental level	9	2.05
In the world	16	1.70

The 5 applications obtaining the best results are shown in Table 5. These applications are multi-hazard, participative, and so present a good potential to be an effective alert tool for humans in the case of a disaster. Some others have a good evaluation for only one indicator, but insufficiently take into account the complexity of the alert process and its interactivity. The interactions between all stakeholders is therefore crucial as it currently leads to a certain reverse hierarchy of information: the latter, until this point confined in top-down stream (only going from the authorities towards the population) must now take into account bottom up and horizontal streams, ranging from the users to the authorities or between users (Coyle *et al.,* 2009; Douvinet, 2018).

Table 5. Values obtained for the five best applications.

Tested applications	Alert index	Interactivity index	Multi-hazard index	Attractiveness index	Global index
Elert®	0.89	1.00	1	0,6	3,49
Vialert®	0.67	0,72	1	0,7	3,09
Signalert Pro ®	0.89	0,89	0,75	0,5	3,03
Qwidam ®	0.61	0,70	1	0,55	2,88
HelpMe ®	0.44	0,89	1	0,5	2,83


Alerte inondation
Alerta Huracan
Asteroid Alert
Athis -Mons
FloodWatch
Quake Alert
Flood Near Me NWS
Emergency Services: Europe
Alerte orage Meteoplaza
Alerte pluie UE
Alerte pluie Meteoplaza
My Earthquake Alert
La croix rouge
AlertsPro
Earthquake Alert
Natural Disaster Monitor
Riskalertes
CodeRED
Aviva risque météo
Météo-Languedoc
eQuake
Tornado - American Red Cross
Hazard Alert
Wildfire Alert
White-risk
SAIP
Inondation et catastrophe
Flood Alert live England Wales
Huricane - American Red Cross
Spotlight
Signalert
Alerte citoyen
Waze
Disaster Ready
Séisme+
Disaster Alert
Katwarn
Hyeres Risque
IGAD-ASIGN
MyPredict
Lastquake
Risque Nice
Semarang Disaster Alert
FEMA
My Public Alert & Notico
HelpMe
Qwidam
Signalert Pro
Vialert
ELERT
Legend
1 : Alert ; 2 : Interactivity ; 3 : multi-hazards; 4 : attractivity
Score < 0.25
Score de 0.26 à 0.50
Score de 0.51 à 0.75
Score > 0.76
Score = 1
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Figure 3. Classification comparing the 50 applications according to all calculated indicators.

LIMITATIONS

In this paper, we evaluated the effectiveness of smartphone applications in case of disasters. As research on this matter is still at an early stage, more studies need to be done to develop the calculation of weighted settings and to quantify the performance of people in using such solutions.

Several limits could be stated in our study. The choice of the weighting coefficients has a significant influence on the results. Thus, if we remove the weighting of settings, giving each one an equivalent weight, we obtain a variation of values ranging from -1.09 to 0.97 (figure 4), which is high for global indices between 0 and 4. However, the weighting is based precisely on results from the scientific literature, and not giving weight to certain criteria would therefore make no sense.

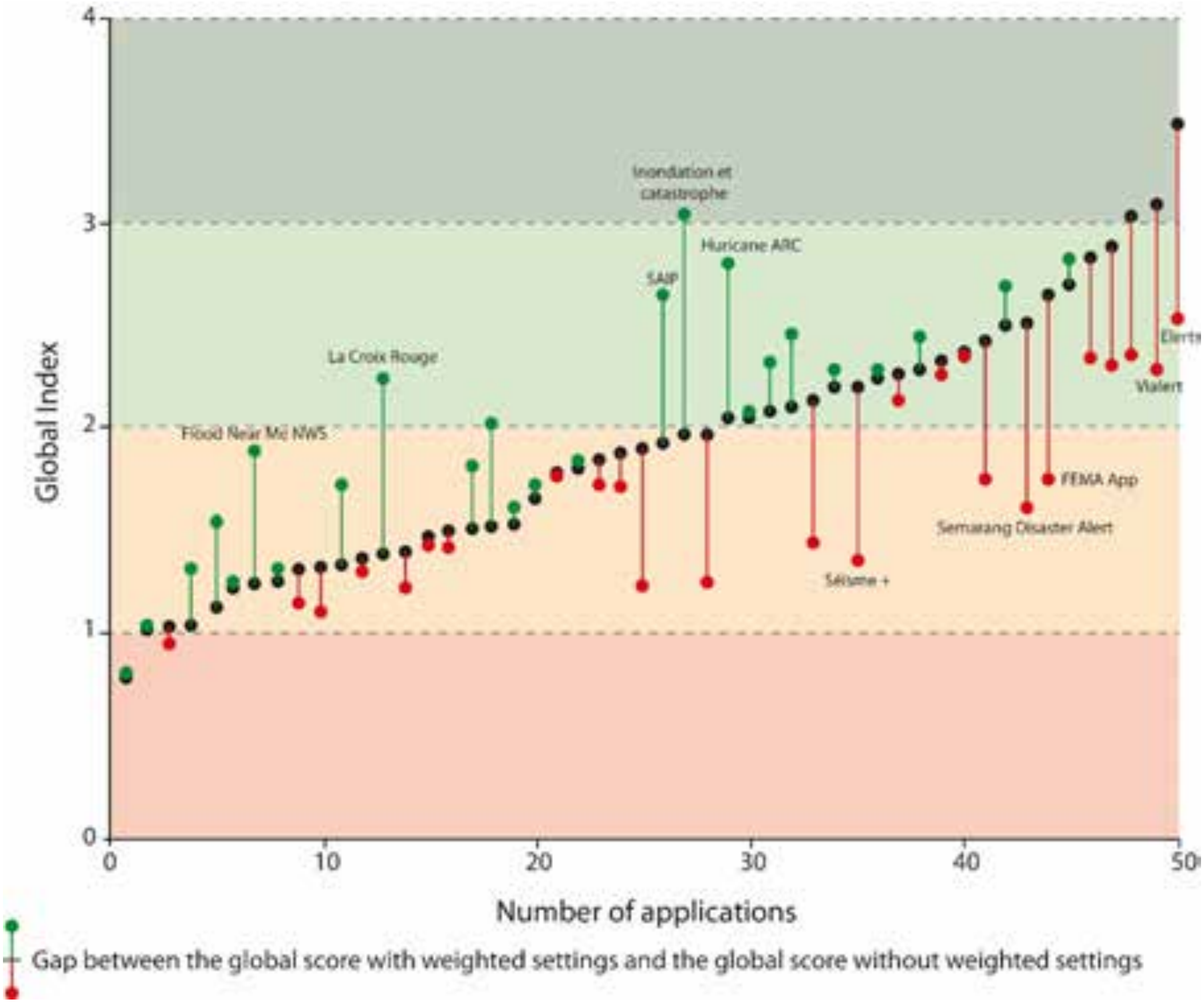

Figure 4. Gap of results between weighted and unweighted settings

Many applications do not obtain good indicators, regardless of the calculation method. This work suggests that many of them do not really answer to the main objectives retained for alerting humans in case of disasters.

Another limit is the quantification of the response phase behavior of people (Lindsay, 2011). It seems to be not useful to create a ready-for-use smartphone application without ensuring training and support. Downstream information has already shown its inefficiency, both in the fields of prevention and alert in France (Vinet, 2010). As such, we must avoid keeping the same thinking scheme. Moreover, without real appropriation of these new means by the citizens, applications could disappear as fast as they emerged (Douvinet, 2018).

Due to a lack of data, this work did not assess how application managers proceed to send an alert or process information from users. Some managers make the choice to automatically switch information from official organizations in the forecast of hazards (Météo-France, Vigicrues, BRRM, etc.). Other managers set up an on-call duty team to process all the information in real time. But this information is not available for all evaluated applications. The download number was also not taken into account because of confusing data: download ranges on Google Play® are too wide and there is no information on removing applications by users.

DISCUSSIONS

Clearly, this work has well shown that the studied solutions do not reach their objectives and it undoubtedly adds further misunderstanding for citizens. This is paradoxical because, the pervasive aspect of smartphone makes it possible to hold cross-cutting discussions between various stakeholders (citizens, institutions and associations) and facilitates quicker information. The faster signals may be detected (for example, pictures showing damages), the faster managers may be able to trigger emergency response actions and the sooner they may be able to support citizens and provide relief to victims. But a problem remains to be solved: citizens can spread false or wrong information through applications and the Internet. False information are spread "significantly farther, faster, deeper, and more broadly than the truth in all categories of information" through Social Medias (Vosoughi *et al*., 2018). However, mass participation in crowdsourcing tends to rectify the place of false information in Social Medias (Alexander, 2014). Several groups are attempting to increase the veracity and the accuracy of crowdsourced data (like "Hacker Against Natural Disaster") and "the cost of responding to a false alarm is far less than not responding" (Riccardi, 2016).

In France, authorities are unable to use this technology because of institutional regulatory protocols that are not designed to manage such fast-paced timescales (Vogel, 2017). The establishment of "community managers" by the crisis center is a first step but remains insufficient. This issue must be solved to dramatically improve warning systems. In the field of smartphone applications, the collaborative aspect could be improved in three stages: 1) before a disaster occurs, awareness campaigns, collection of data, and training for citizens-sensors should be carried out, which could lead to selection or specialization of "citizen monitors" (a specific role entrusted to each users according to their abilities) ; 2) during the crisis, collecting information in real-time would be greatly facilitated by upstream training, aiming to only pass reliable information on. Therefore, monitors could also turn into "stakeholder", able to move by following guidelines taught in the upstream phase and to act within the area where the crisis is occurring. Guidance provided by a rescue center in real-time is also a possibility; 3) downstream of the crisis, there is a need of taking into account the evolution of the crisis, witnessing and enabling institutional aid to improve training, intervention and crisis management processes. These steps aimed at strengthening the prevention of human and material damages during current or exceptional disasters. This method requires much more support than mere data collection applications such as crowdsourcing or crisis-mapping (Douvinet *et al*., 2017). It is crucial to recommend the use of real-time operational systems, awareness and training measures.

Otherwise, to enhance applications uses, there is an urgent need to sensitize the citizens to commit the "internet of things" and organize training exercises (Gisclard, 2017). In that respect, smartphone applications boost discussions around resilience, which defends the idea that a population must be autonomous (it may be isolated in times of danger), united and involved before being able of using the existing tools. However, in places where the perception of risk is low, the Cell Broadcast might be more appropriate than an application to alert citizens. Cell Broadcast is a message sent to cell phones in a predefined area and does not require the download of an application (which requires a minimum of risk culture). This means does not allow interactivity between users and crisis managers but it allows to alert effectively and quickly a large number of citizens. Smartphones are also expensive objects, less used by old and less graduated people and dependent on the Internet network. Thus, these tools increase territorial and social disparities and their use must be done in addition to other means of alert.

CONCLUSIONS

This study evaluated a method to classify and compare different smartphone applications dedicated to alert in France. The application evaluation was focused on four points: 1) their ability to alert users; 2) their ability to be interactive; 3) their ability to take into account the 12 majors risks identified in France; 4) their attractiveness.

Surprisingly, few of them really reached the original objectives, while many claimed to be as such. Many applications have limited potential because it doesn't take into account the possibility of interactivity enabled by smartphones. We must give citizens the ability to interact with alerting means. This criterion is a prerequisite for the implementation and appropriation of smartphone applications by citizens (Coleman *et al.*, 2009; Gisclard, 2017). Moreover, many studied solutions have a vision of the hazards which is limited to the scale of their territory. These results reflect two restrictive choices made my managers. Firstly, they not consider citizens as an actor able to observe and communicate during crises. Secondly, they forget the fact that a territory is often subject to various risks, and that more complex or unpredictable phenomena (cascading effects, simultaneous risks) can occur there.

Our results need larger-scale debate. It raises this specific question: it is necessary to multiply the solutions at local scales, for increasing the understanding of dangers by residents, or does the French government have urgently to display a new national smartphone application, even after the issues observed in the use of SAIP® during two years? Our results in this work highlight large-scale solutions because local solutions present more problems in their software and functionality, and induce inequalities between territories and humans. Whatever the discussions arise from the type of indicators, the nature of retrieval method or the weighted coefficients allocated to several parameters, this work argues that the high number of applications strongly induces confusion and concurrence between stakeholders implicated in the alert process. In the same time, the emergence of numerous smartphone applications reveals a lack in the actual political choice carried out by the institutions. Finally, the institution must take into consideration connected objects to develop systems different from the sirens which remain the main tool used in France.

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