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New ICT architecture design for Lombardy region alerting system: The EXPO case study

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ABSTRACT/ASTRATTO

The continuous and rapid development and improvements in communication technologies had shown a noticeable reflection on the improvements in terms of effectiveness and reliability to translate hazard detecting data into useful information and decision making processes established between different communication lines inside the components and subsystems within hazard and risk warning systems. This thesis focuses on applying the new ICT concepts and architecture for developing new techniques for integrating multiple warning message dissemination tools for multi-hazard natural events. The state-of-art of an alerting system includes a number of components and processes which form different warning subsystems which, by means of communication lines, are integrated to shape the final framework for a complete alerting system. A new system, process based model had been proposed to elaborate a general framework of an integrated warning system. Moreover, a brief presentation and comparison had been conducted between the traditional and social media based alert message disseminating tools within the different alerting system lines of communication based on the main aspects to be considered when broadcasting a warning message, which had lead to the finding that there is no single communication tool can obtain gain satisfactory achievements for all of these aspects. Finally, a case study of the EXPO mega event in Milan, Lombardy region, Italy had been selected as a case for applying the latest telecommunication tools developments and applying ICT concepts and architecture in terms of developing a logic for new app applicable for smart phones and tablets, aimed for improving the communication effectiveness between the emergency management authorities and to provide a space for integrating different alert communication tools for public and EXPO attendees regarding natural hazards subjected by the region.

Il continuo e rapido sviluppo e miglioramento nel campo delle tecnologie di comunicazione ha mostrato una grande attenzione sullo studio dei possibili miglioramenti nella traduzione dei dati di rilevamento pericolo in informazioni utili, e nei processi decisionali stabiliti tra le diverse linee di comunicazione all'interno dei sitemi e dei loro sottoinsiemi di pericolo, in termini di efficacia e di affidabilità. Oggetto di questa tesi è il come applicare i nuovi concetti ICT per lo sviluppo di nuove tecnologie per l'integrazione di più strumenti di avviso pericolo, in caso di eventi naturali multi-rischio. Lo "stato-di-arte" di un sistema di allarme comprende un numero di componenti e processi che formano diversi sottosistemi premonitori che, per mezzo di linee di comunicazione, vengono integrati allo scopo di modellare il quadro finale per un sistema di allarme completo. Viene dunque proposto un nuovo sistema per poter proporre ed elaborare un quadro generale di un sistema di allarme integrato. Successivamente è stata condotta una breve presentazione, basata soprattutto sul confronto, tra i diversi avvisi di diffusione del pericolo (tradizionali e non - social media), all'interno delle differenti linee del sistema di comunicazione di avviso. Tale sistema è strutturato sui principali aspetti da considerare quando si trasmette un messaggio di avvertimento e ha portato alla constatazione finale, secondo la quale non esiste uno strumento di comunicazione unico in grado di raggiungere risultati soddisfacenti per quanto concerne tutti questi aspetti. Infine, si è trattato dell'evento di grande proporzioni dell'EXPO di Milano, e si è scelta l'Italia come paese in cui applicare gli ultimi sviluppi degli strumenti di telecomunicazione e l'applicazione dei concetti ICT. Si tratta di nuove applicazioni per smartphone e tablets volti a migliorare l'efficacia delle comunicazioni tra le autorità di gestione delle emergenze e a fornire uno spazio nuovo e differente per l'integrazione dei diversi strumenti di comunicazione di allarme. Tutto ciò è rivolto in primo luogo ai partecipanti pubblici dell'EXPO per quanto riguarda la grande problematica di pericolo e rischi naturali presenti nella regione.

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CHAPTER 1
Introduction

The evolution of the Alerting systems related to the hazardous events reveal of clear example of the different processes of data usage, which starts by obtaining rough data from detection directions to subsequent processes of understanding these data and translate them to useful information that help in corrective reactions and decision making using analysis and wisdom. Through decades of researches to agree on unified frameworks for an alerting system, the most effective one had been described into an integrated one, which is consisting of three main subsystems.

The first subsystem considered in an integrated alerting system is the detection subsystem, containing set of components and processes that are responsible for transforming the hazardous data collected from monitoring and detection organizations, into a set of useful and understandable pieces of information that can help the next subsystem for performing their variety of responses and processes in an accurate way. The second subsystem is denoted by the management subsystem, which includes the organizations which are responsible to collect and interoperate the data received by the detection subsystem. By the support of these data, associated with wisdom that is sourced from the past hazardous experiences and specialized knowledge to come out with corrective decisions that will help the public members within the territories to prevent any adverse consequences due to impending hazard related risks. As for the last subsystem, it is denoted by Response subsystem, which is bound by the response of public towards the alert notifications sent by the emergency one, where their processes start from interpreting these information and transform them into self guidelines to assure safety for the self and properties at the time of the hazardous risk occurrence.

Between these subsystems, there are two main lines of communications present. The first one is bound in the communication between the detection and management subsystems, while the second is considered in the communication between the management subsystem and response subsystem represented in the public members, communicating the messages within addressable and mass alert message dissemination methods respectively. For each of the both methods, there are variety of communication tools, each one is assessed by its message content, advantages and disadvantages in terms of fulfilling the main aspects to be considered when disseminating the warning message among the two main communication lines.

By the development of the web 2.0 technology, there had been lately a large variety of social media services, which allows their users to communicate with others in an interactive way. Where each user is offered to publish, comment, and share enteries related to any desired field, with the assurance of having these viewed by any registered user within that service. This on return can add great advantages when being used in hazard warnings in terms of fulfilling the main aspects to be considered in a warning message to and within the public members. The increasing popularity of these services motivated many governmental and non-governmental organizations for assessing their own pages within the social media networks to be able to publish their continuous updates related to any impending emergencies.

By applying the integrating subsystem to the case study of the main policies at Lombardy Region, Italy, it had been observed that risk alerting system within the region regarding the first main communication system is assessed by some limitations in the means of alert message context and tools of message dissemination; the regional authority is using a synchronous method for reporting the adverse weather conditions that are received from the main regional weather monitoring and forecasting center “ARPA” to the regional provinces emergency management represented in their Mayors according to the province’s normative,

where they send a daily weather criticality report including information about the hazards typology and impending locations, in addition to general meteo-forecasting information and brief guidelines, the matter that result a lack in providing continuous and up to date information sources to the mayors in the case of emergency occurrence, especially the multi-hazard related ones. Moreover, the used message dissemination tools and associated communication path provide a poor atmosphere for combining the advantages of each of the used tool. Regarding the communication between the emergency management and the public, there had been found two sets of challenges; the first set is regarding disseminating the warning messages for local public with fulfilling the main aspects to consider for the public warning message, the second set of challenges are present due to the presence of the EXPO event in Milan, which will be hosted by mid of 2015 for 6 months, with the expected number of 20 million visitors including 30% of foreigner comers. This by turn will need special consideration by Regione Lombardia due to the less knowledge about the Region's directions and emergency response protocols than the local ones.

So in this thesis, a brief study about the different processes and components of the different subsystems that define the framework of a complete integrated warning system, with specifiying the two main communication line within these systems and the main aspects to be considered will be presented. In addition, the different methods of warning message disseminations with the associated common used communication tools will be briefly explained including their main advantages and drawbacks. Morever, a brief description about the risk management policies within the Regione Lombardia organization and the EXPO event will be reveiled. Finally, the main limitations and challenges that are present within the main commuinication lines in Regione Lombardia alerting system will be mentioned, followed by the introduction to the LED app, which is considered as a proposed solution to overcome these limitations and challenges.

CHAPTER 2

Evolution of the structure of warning system and the main means of communication

2.1 From data to decision making

For the whole world that requires hundreds or thousands of decision makings from simple issues like going from home or no to decisions that can have their effect for international scale. As the severity and complexity of decisions tend to increase, it must be based on real assessments for the project maker/makers to guarantee more accuracy and reality of the decision. These assessments can be found of the data assessed about the incident that needs the human decisions. However, it is not enough, and even meaningless to have an enormous amount of data as long as they have not been provided in a form that can be understandable and usable for the user to use them for further processes that leads at the end for the decision making [1] The way to provide an understandable way for the assessed data is called information. It can be defined as the data that has been given a meaning by way of relational connection [1]. The meaning can be useful for the specific reason and way of using data or no.

In fact, to reach the points between obtaining the given data till processing decision would have some intermediate steps to be mentioned. Russel Ackoff [2] provides categories of the content of human mind which can be a good definition to be translated to understanding of the topic. These categories could be:

1. **Data:** raw material that can be found. It can be in any form like symbols or random numbers. Data are characterized of being raw; it is just existing without a defined reason or significance. It doesn’t give a self meaning

2. **Information:** as defined before, information is the term that adds the meaning to the assessed data. In the language of computers, the relational database produces information from its stored data.
3. **Knowledge:** It is a process that can be considered as deterministic. It is the phase of collecting the provided information for only examining and memorizing them. It can help to have a more awareness of the meaning of the information. Moreover, the more knowledge, the more ability of analysis of the provided information. However, Just knowledge cannot result a further knowledge. A simple example is that in the elementary schools, all students can memorize times table to a small limit of digits, but they cannot be able to calculate huge multiplications. For the computer side, most of the modeling and simulation applications do some processes of stored knowledge usage and exercising. In order to be able to get knowledge from insisting ones, a different category of mind set should be achieved which is "understanding".
4. **Understanding:** It can be considered as deterministic and interpolative. Both analysis and cognition are performed at this process. As described above, understanding if the thought of finding and producing a new knowledge using the given knowledge, based on old ones. This process highlights the difference between memorizing information and learning them, which respectively produce the difference between knowledge and understanding. It can be built upon information, knowledge, or even understanding itself. An example can be at the computer parlance in AI systems, where these systems are used to synthesize new knowledge from information and knowledge which had been stored at the database before.
5. **Wisdom:** This process can be considered the one which decision making had been conducted. This process is to derive new understandings and predictions of future ones which go behind the limits of even understandings

based on the current understanding. Wisdom is characterized as not deterministic, non probabilistic and an extrapolative process. This process includes the highest part of human consciousness as it contains the path from all the previous four categories to Wisdom one which includes asking questions with answers which might now be found in an easy way, and even without human answers periods at some cases. More simply, it can allow to give the possibility of decisions making in qualitative (something right or wrong, good or bad, etc..) and quantitative means (Numbers, values ,etc.) means.

From the above definitions for Ackoff categorization, it can be observed that the first four phases are considered past phases. Where obtaining Understanding, knowing information about data are performed as a total analysis and learning of previously known records, there is no contribution from them to determining future decisions and predictions. This is not the case of 5th category which is Wisdom. This process includes the interference with the uniquely human state and abilities not possessed by machines in order to translate all the previous 4 processes using human wisdom to derive new results and decisions. [1]. The transition of data at the different mentioned processes categories can be summarized in the following diagram:

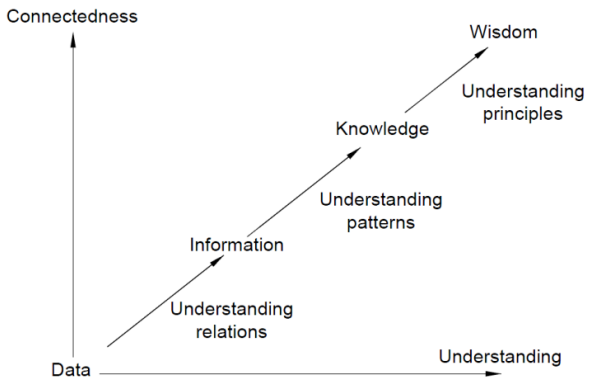

Figure 2.1 Flow of processes for data usage [1]

The diagram shows clearly the idea expressed before. That as the usage of data passes through the different mind processes, the more usefulness and better usage of raw data we have would be achieved (in the graph, in terms of understanding and connectedness).

An easy example can elaborate more the idea of the flow and transitions from data to wisdom and decision makings. Where the data phase can be described as stating that at the recent time it is raining, which is a fact stated without being connected to any aspects of any sorts. So by going further, the data can have information which embodies the understanding of the relationship of the raining phenomena to some related aspects which can be possibly causes and effects of raining, which can be that due to the temperature change lower than 15 degrees, it had started raining afterwards.

Still this level of information cannot give a reasonable predictability since it is not obligatory that raining can phenomena can start each time the temperature faces a drop. For this reason, the need for knowledge phase could be needed, where this phase represents the sequence of pre events that can describes what can happen afterwards. The knowledge phase can describe the phenomena as that due to the existence of high humidity and drop in temperature so the atmosphere will not be able to hold the moisture of air particles and it will start raining. Finally, Wisdom embodies more of an understanding of fundamental principles embodied within the knowledge that are essentially the basis for the knowledge being what it is. Wisdom is essentially systemic. This fact can be reflected by our example as that the reason of raining encompasses the understanding of the relation between the impacts that cause raining as evaporation, air current, temperature changes. [3]

2.2 Evolution of warning system

Warning systems reflect a perfect example of the flow of usage of data as mentioned before. In the simplest ways, The process of obtaining information about the expected emergency and communicating these information in an adequate way to those who need and can use it, then translating it into making clear decisions and adequate response in means of feasibility and time effectiveness can generally describe the definition of warning system. However, the complexity of any warning system is bounded the organizational structure and the work process, where they tie a huge quantity of specialists and different organizations working together in a suitable communication system [4]. For each of them, they should deliver their information in an understandable language for the receiving person or organization. For example, the information rate of precipitation measured by a regional monitoring center will not aware the public of a possible flood if they have just got the information in terms of numbers of gauge readings. For this purpose, a known structure and tools for delivering the information between different emergency stakeholders are the most important two aspects for a good warning system.

By years and decades of improvements and standardization of rules, warning systems had been reached to almost uniform structure and tools of communication either between different emergencies responsible organizations or to public. So in this chapter, a brief description of evolution of the structure of the warning system, and different communication tools between the different parties are going to be presented.

2.3 structure of warning system

As mentioned before, decades had been consumed in researches and discussions in order to find out the best structure of an effective warning system. The results of all of these researches had an outcome of a final agreement of the main framework of a

warning system and to which extent the diversity of the structure can affect its effectiveness. The most structure that had shown a reliability and effectiveness in application is the integrated one [4]. The integrated system has got two aspects which make it a peerless one. The first aspect is, that to ensure the preparedness of subjected events, the system is divided into a number of subsystems, The second aspect concern about the need to develop an adequate relationship between these subsystems and in its development at maintenance. There are main three subsystems in integrated systems which are detection subsystem, management subsystem and response subsystem as shown in figure 2.1

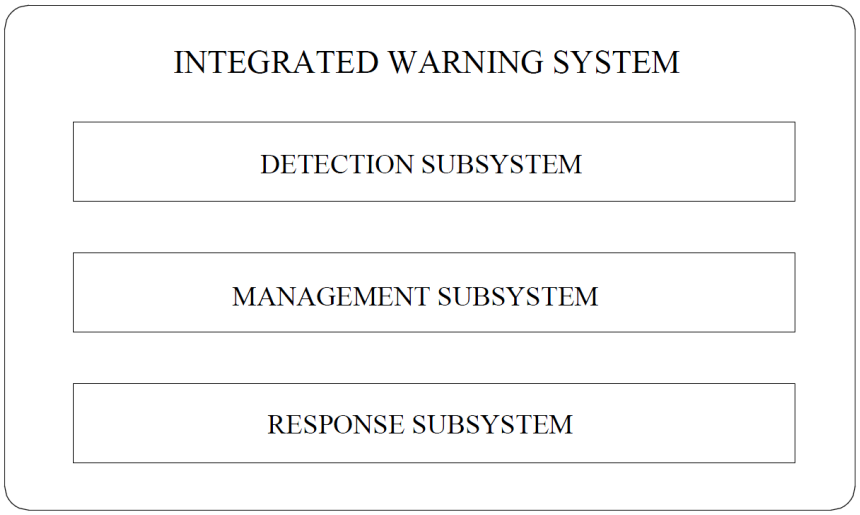

Figure 2.2 Main subsystems of an integrated warning system

So the following will be a brief explanation about each of these subsystems.

2.3.1 Detection subsystem

The detection subsystem basically consists of the processes of monitoring environmental or civil circumstances which can cause an expected emergency [4]. [5]. This system is mainly operated by scientists who use the increasingly improving science and technology for providing sophisticated tools for hazards

detection. However, still the public sector can play a role in monitoring an in means of observational detections that can be reported to other sectors. This subsystem is responsible for collecting data derived from the different monitoring tools and transferring them to assessed information which can help in statistical or technology based predications of expected hazardous events if this information had shown an increase over the pre-defined thresholds.

The detection subsystem functions are independent from hazard type, where their main functions are always being in direct communication with the management subsystem, which is in short responsible of transferring the information concerning the upcoming emergency to the civilian departments to make adequate responses. In any integrated warning system, this subsystem has two main characteristics. The first one is that clearance and routine of the phenomena to be detected should be assured. As for the second, there should be a clear and understandable means of communication between it and the management subsystem [4].

In a more complex definition, detection subsystems themselves include different components and processes, which define the main rule of them alternatively with time lapse [6]. Those components are shown in Fig 2.2

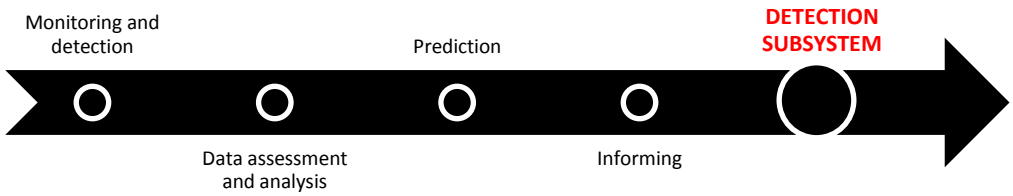

Figure 2.3 Components of detection subsystem

So in the following lines, the different components of detection subsystems will be briefly explained.

2.3.1.1 Monitoring and detection

This represents the initial process of a detection subsystem. In monitoring process, all the data obtained from the monitoring techniques regarding the probability of hazard occurrence will be collected for further analysis (described in the next process). There are two possibilities to perform a monitoring and detection process. The first one is to do it systematically, which means concerning about collecting the data token from regular observation and different measurement tools, and transforming them into information about the impending emergency. The second possibility, Is to make it serendipitously, public and members of monitoring organizations can have the role in providing information from the observation of factors that can happen by a coincidence but for purposes that don't have be related to a hazard. The last approach is less dependent on using of science and technology and more based on improvisation skills.

The most important issue that is assessed by the monitoritng and detection is the needed amount of information that can build enough knowledge about the possibility for an impending hazardous event. This issue can depend on many factors [7][8]. Those most main factors are:

1. The complexity of the hazard system to be monitored. For example, it is much more easy to predict chances for a flood more than an earthquake, since the first there are many foretelling factors that can be easily measured and give clear and confidential signs of a flood, as for the latter, it required loads of complex technological instruments and an enormous historical data about past earthquake hazards, and still the resulted information can provide

data about the expected earthquakes in an average probability of occurrence of 0.5-5% [9].

2. The adequacy of scientific history to predict an emergency, where obviously the extent of evolution and improvements of the science and technology which involves the measurement of an event type will by turn reflects the level of reliability of the information provided by these tools to give accurate and confidential predictions to the upcoming event.
3. The assessed resources for helping in detecting and warning, where the assets owned by an organization for monitoring and detecting issues will outcome more accurate and trustful results by the availability of more improved and up to date resources and staff who can use and deal with the available level of science and technology.
4. Other factors as type of required data assessment and needed level of confidence of the analysis of obtained data.

2.3.1.2 Data assessment and analysis

This is the second stage of a warning detection subsystem. The main process in this stage is to use the gathered information from the monitoring and detection process to have a general understanding of the whole studied monitoring system. This can be done by either applying the theories of the system (equations, curves, numbers, etc.) or by a direct observation and screening any abnormalities (measurement or indicators that shows an exceedance of defined thresholds) which can cause an impending hazard. [4].

Data assessments techniques are having a range from simple computations to making up complex model, and it can be obtained as indications from single variable, (like a flood from rate of precipitation or occurrence of a tsunami from an earthquake magnitude), or a set of variables and complex merging of these variables

(like accidents of nuclear power plants which can come from a complex system of possible computer or system failures).

As for the monitoring and detection process, data assessment and analysis are depending on factors which control the level of achievement of the main purposes of this process. These factors are:

1. The sufficiency of data to be assessed; as the data collected are more relevant to the type of studied hazard and the focused area, the more is the sufficiency of the data. For example, the presence of the wind indicators and local radar center at the coast of the state of new Jersey in USA helped in an accurate and early prediction of the hurricane Sandy at 2012 [10]. On the contrast, the absence of local weather information had helped in the increase of complexity of the situation of the analysis of hurricanes at Hawaii region in USA.
2. The rate of development of the theory relevant to the hazard measurement. For example, there is no unified universal theory of the strain release in a prediction of an earthquake [4].
3. The history and past experience of the expected hazard, where as mentioned before, facing a relevant to the region can help in better data assessment and analysis for two reasons. First, the presence of historical data about a hazard will increase the ability to observe an earlier and more accurate prediction of the hazard existence. For example, the historical data of floods in the Italian province Sondrio due to the exceeded discharge of Mallero river along the last century had helped in well defining accurate Thresholds in means of river upstream discharge, which can assure a more accurate data analysis of future measurements, as well as easier and faster detection of abnormalities that can cause floods and flash floods [11]. Second, the past experience will reflect the extent of reliability of the existing system of monitoring and data

analysis, which in turn, will assure the level of trust on the data assessed, or, at least, will give an idea about the possible system improvements to achieve a higher level of confidence assessed and analyzed data.

4. The resources available: as in the monitoring and detection process, the assessed data is limited by the resources available for producing the set of data and measurements. For example, the availability of a local weather center at a province will give much better results than the existence of regional one.

2.3.1.3 Prediction

The process of performing a forecast about the behavior of the hazard system to provide a useful way to estimate an accurate warning about an expected event is an ideal definition of Prediction process [4].

A good prediction process should ensure giving information about the hazards in some main aspects; First, it should give a brief information about the expected time of the impact of this hazard. Second, it should provide information about the location and covered area by this hazard. Moreover, the hazardous event severity, where obviously, it varies according to the type of hazard itself. For example, the expected severity of a flood can be expressed in terms of calculated river flow or the height difference between the head water level and the banks, while it will be the magnitude in Richter scale or other common scales in case of an earthquake. In addition, the prediction process should outcome the probability of the occurrence of the hazardous event. This type of information shows a criticality in to what extent it should be accurate. For example, even if the data analysis had exerted a result of the probability of an earthquake at a region of 1%, then it shouldn't be decided that this region will not face possible earthquakes. A relevant case is what happened in L'Aquilla city in Italy, where scientific and technological detection systems, when the analysis had been performed, that there is a tiny chance

of an occurrence of an earthquake that can happen the city which had been assumed to be neglected by the local authorities. However, an earthquake with a magnitude of 6.3 had take place few days after the official announcement of region's safety which resulted a huge number of loss in lives and property [12]. At last, the prediction process should also outcome the possible concequences of the hazard and of there are possible post-hazards (An example, a tsunami after an earthquake) that can take place.

As the data assessment and analysis detection subsystem component, the prediction stage is based on the data, theory, experience and history and available resources which are the factors the plays the role of achievement of the process purposes. However, this process assesses a main additional factor, which is the level of confidence of the results obtained. Where there is an existence of set of uncertainties that play roles in predictions and possible event scenarios in probabilistic means, so as the uncertainty is decided to have a smaller effect on the main event, the more accurate is the prediction [4].

2.3.1.4 Informing

Informing is considered as the final process of detection subsystem. Moreover, it acts like a transitional stage between detection and management subsystem. The informing process main purpose is to pass the information gathered by the members scientists and technologists to the members of the emergency management organizations to be able to take appropriate decisions of warning the public later on. The transfer of information is usually followed by agreed guidelines conducted by the system of the organization. These guidelines can include for example the lead times and the directions for which the data assessed and analyzed should be headed to, and the forms of transmission of these data. [4]. This requires a complete confidence of the detection departments to assure the need of sending warnings and alerts to the management organizations to prevent the occurrence of

fake alarms which can results lack of trust between the two subsystems and also between the public and the whole emergency and warning systems, the matter that can increase the social vulnerability in the future.

In an integrated warning system, there are an enormous number of members and organizations, each has roles of performing their tasks and the ability to receive and send data and information in all means. While all of the members and organizations are worked under one main challenge which is hazard tracking and mitigating the possible impacts, each organization is assigned to independent tasks according to its profession and purpose of establishment. This puts a difficult challenging in how these organizations can have a communication system that can provide a common language which results a full understanding of the data and information sent and received by each them. [13].

From the facts above, the main critical aspect in this process is to provide a mean of communication, as well an information context, which can be well understood by the management organizations. For example, members of emergency management organizations cannot understand a set of readings from a rain gauge instrument performed at a river monitoring center. Instead, simple information about the consequences of high precipitation rate in terms of river flow which will pass the thresholds can lead to a possible flood or flash flood.

2.3.2 Management subsystem

The second subsystem of an integrated warning system is the management subsystem. This subsystem has the purpose of receiving the information exerted from the data assessed and analyzed from the monitoring and detection organizations about the expected hazards and warn the public when the occurrence of the emergency had been guaranteed [4].

Before the decision of warning the public about the impending emergency, the management subsystem should be first capable to transform the assessed hazard information in terms of expected damages in all fields (for example loss of lives, damage of properties, etc.) and also in zoning their territories and assign different emergency characteristics in each zone. An example is what happened in city of Sondrio, where the readings of the flow of Mallero river had been transformed information locating area covered by a possible flash flood, and by means of damage curves and set of formulations, a complete damage assessment had been performed, the things that helped later on to construct a system of warning with priorities to the most zones under risk [11]

Like the detection subsystem, the management one itself is composed into several components and processes. See figure 2.4

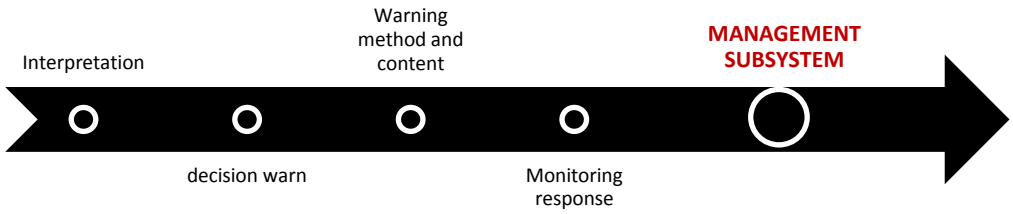

Figure 2.4 Components of Management subsystem

2.3.2.1 Interpretation

As explained at section 2.3.1.4, there is a need for a unique way of communication between the different the contributing organizations in the integrated warning systems. Interpretation process gives a good example of this issue. At this process, the management officials are responsible of transforming the given information from hazard detectors into a version that can be suitable for application in civil warning.

While members of detection subsystem should initially conduct and send hazard data that can be understood by the management subsystem as far as possible, still there is no guarantee that the latter ones will gain a complete understanding to the whole data. A first step in the interpretation process is to sort the received data as understood data and used, understood data but would not be used, and data that cannot be understood. For the latter one, a two way communication between the detection and management subsystem should be established for negotiation and inquiries. Of course, the more communication system is faster and more direct, the faster decisions can take place and will be more reliable ones [14]. An example to illustrate more, detection subsystem in a nuclear power plant can send information to the management one about a set of computer readings that can lead to a giant explosion. However, members of management subsystem cannot use these set of data to define the extent of the emergency and the context that can be included when warning the public; they will have a more need about the characteristics of the emergency itself like its timing, area that will be subjected to the explosion, consequences, etc. For these reasons, a direct contact will be there between both subsystems to gain a more clear background of the impending nuclear explosion.

2.3.2.2 Decision to warn

After the process of interpretation, now it should be that the management subsystem had gained a full understanding about the information regarding the expected hazard. The next main challenge that will be faced is whether the obtained data reveals the vitality to transform the warning into the public level or not. The main aspect that adds complexity to this process is the decision about who will activate the warning for public. The “who” can fall on one or more individuals or even a set of integrated organizations. Moreover, specifying the responsible for warning can be casual without previous notes about whom to chose or it can be highly formalized in other cases. While the past experiences may show different

ways used to identify the responsible people to take the warning to the next level, but still it is hard to decide which way best can fit the current case, so it can be simply said that this process is mainly based on wisdom. “Surprisingly, the decision to warn the public is one of the least understood aspects of warning systems” [4].

Other main challenge that is found in this process is to decide the adequate way for informing that can satisfy many concerns and consequences of this way later on. Some examples of these concerns can be about the criteria that should be used. An example can be like either to inform public about the expected percentage that heavy rain can take place or to just to give categorical warning that it will rain, the thing that will influence the degree of preparedness of people respectively. Other concern can be the impact of the warning way decision for the political point of view, examples can be in cases in civil hazards like terrorism or demonstrations.

It can be clearly concluded that the criticality of public warning process can bound in the fear that attacks the responsible parties due to the doubts about the consequences of the decision done; If the decision of not warning the public or underestimating the level of it had been chosen then the hazardous event take place, unwanted losses of lives and property will for sure take place, plus a situation of losing the trust between the public and authorities will be created. On the other hand, if the decision to warn or overestimating the limit of it had been chosen and there had not been an impact of a hazard, this can cause a case of embarrassment and unnecessary losses in social and economical means will take place. So as a result, this process plays a critical step that can indicate the success or failure of the whole warning system, where it shows the final result of all the use of science, technology, and management used to deliver a useful material for public that can save their lives and assets.

2.3.2.3 Methods and content of warning

After the determination of the ways that will be used in alerting public, the next stage is to determine message content, sources, means of communication and frequency concerning the warning which will be sent to the them. By years and decades of continuous improvements of technology, there had been evolution of different tools and means of communication, each of them includes its own characteristics and associated content of message [13]. For example, signs can include a short exact message but without any details or descriptions, while media can include more accurate and credible descriptions but it requires specific tools for sending and receiving messages.

When deciding the appropriate content of message, and respectively, the means of communication will be used. There are some main factors to take into considerations to be able to reach ideal decisions, these factors can be:

1. Accuracy of the message, where to be able to assure the adequate preparedness of public towards an expected emergency and avoiding social confusion, content of the alert should provide accurate information about the facts of it like timing, intensity, guidelines for protection or evacuation, etc.
2. The message should be reachable: This is one of the most important aspects, since it is worthless to conduct a perfect warning content, but sending it through communication lines which cannot be passed into people. For example, if some reports about a flood expected at a municipality which shows some significant scientific facts about its detection and providing perfect guidelines for perfection will be useless if the content of these reports are not going to be understood by normal people without any knowledge about this hazard. Also, publishing these

reports without any announcement for public to assess and have a look at them is also useless.

3. The trust behind these messages, this aspect is variable, where different people own different points of views about the information credibility. For example, some people will not be sure about the danger of the upcoming hazard except if the alerting had been come out from formal governmental communication tools like official regional TV channels, official websites, where phone calls or pamphlets can be enough to aware other sectors of public.

From the factors mentioned above, it is clear that depending on one mean of communication had never been enough to assure that all, or at least the majority, of public had been warned and gained enough awareness of an emergency. For that reason, it is obligatory for management subsystem to provide different tools to deliver the warning messages to public that can assure that all the public categories can receive the message and gain enough credibility about it.

2.3.2.4 Monitoring response

Last component of message subsystem is to assure that the success of message delivery and interpretations by public. This component seems important. However, it is really hard to implement, since the limitations of time and the Preoccupation of the organizations in further planning procedures towards the emergency ban them to obtain a specific system to track the response of public towards the given alerts. In fact, the best guarantee about the success of message delivery and understanding can be achieved by the previous stage which is choosing a variety of tools of communication that can reach all the public categories after a neat study of all available resources and communication technologies, and also by reviewing the past experiences.

2.3.3 Response subsystem

Since this subsystem doesn't have a strong relation to the core of the study area included in this thesis, only a short idea about it is going to be explained.

The last subsystem of an integrated warning system is mainly based on the public response to the warning messages sent by the management subsystem (section 2.3.2.4). Moreover, there is an additional warning component in this subsystem which is the role of unofficial warnings that can be transferred between individual members in management organization (like police, firemen, volunteers, etc.) and the public, or directly between people using their own understanding the response to the given warning [14]. The basic components of the response subsystem of an integrated warning system are shown in figure 2.5:

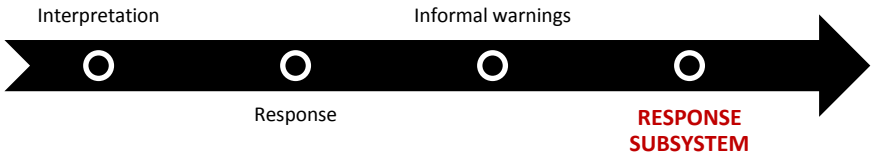

Figure 2.5 Components of Response subsystem

Where

1. Interpretation: This process is exactly defined as in the management subsystem, where it explains the people's transformation of given information from emergency management agency's in the means of steps and guidelines for self to assure their preparedness and safety during the emergency
2. Response: Defines the actual response steps people start to do after receiving and interpretation of the warning messages.

3. Informal warnings: As stated before, this stage defines the means of informal warnings between management organizations and public, and also between the public individuals.

2.3.4 The integrated warning system

The combinations of all the mentioned components and subsystems with adequate relationships and means of communication finally form an integrated warning system, fig 2.6 summarizing all of these components and subsystems, while their relationships and communication are going to be explained in later parts in this chapter

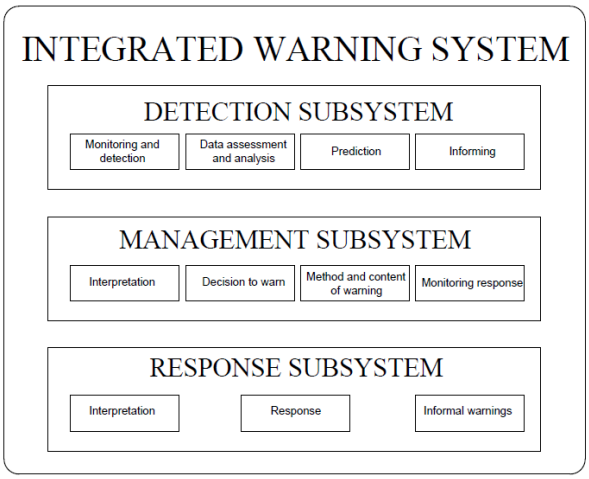

Figure 2.6 Overall subsystems of integrated warning system and their components

2.4 Evolution of message dissemination in warning systems

As stated in the previous section, an integrated warning system combines different subsystems, components and processes. The more development and improvements along these subsystems, and overcoming the limitations of the different components and processes, a more effective warning system will exist.

2.4.1 Integrated warning system model

From the whole mentioned processes and components of subsystems of a warning system, and also taking into account the proposed model by Mielti [4]. (which had been decided to conduct an modified model over it due to that It is only system based), a general model for a multi-hazard processes and system based warning system is proposed at fig 2.7. Note that the parts indicated in red represent the areas of interest at this thesis.

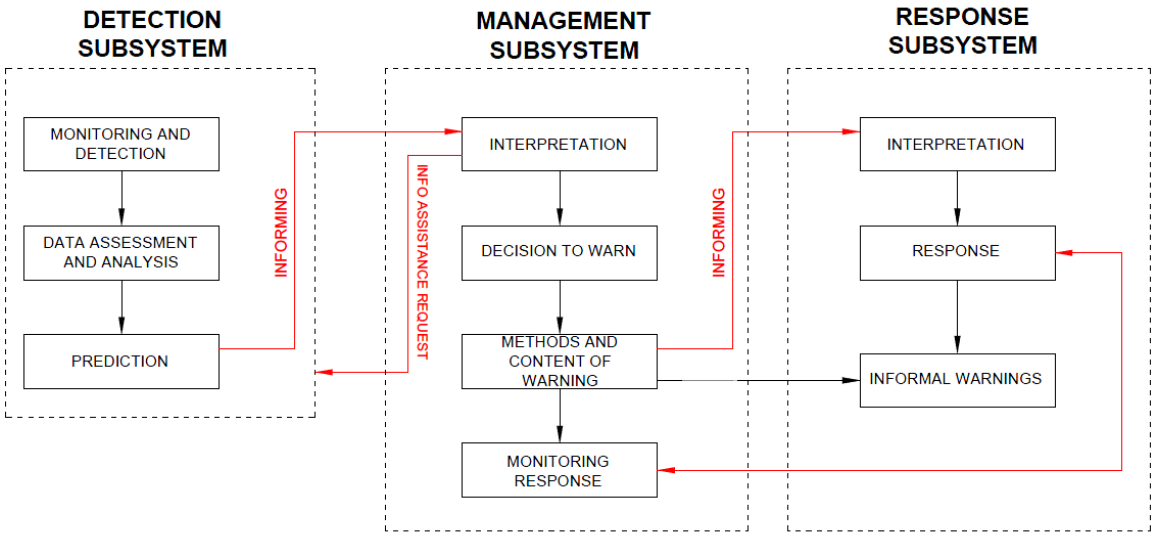

Figure 2.7 Proposed model of an integrated warning system

Once a whole framework of a warning system had been established, there is a need to establish links of communications between the different subsystems. This is the most important aspect that should be present in an alerting section, since it is totally meaningless to implement and develop any of those subsystems even with the most recent science, technologies and high qualified staff without being to transfer information in an adequate and understandable way for others. For that

reason, the following chapter sections will briefly focus on the general links of communications between the different subsystems of an integrated warning system with a deeper focus on the evolutions of the ways and tools that are being used for message dissemination for both informing process in a detection subsystem (section 2.3.1.4), and content of message in a management subsystem (section 2.3.2.3).

2.4.2 Message dissemination

The dissemination of warning messages is always a challenge for emergency management organizations for the presence of many factors that can influence the effectiveness of means of message dissemination to be chosen stated at section 2.3.2.3. Fortunately there are multiple ways of how to deliver a message. However, there is no universal recipe. Dissemination technologies and methods have to be adapted to the local situation, requirements and capacities to be effective. There is no single best method of warning dissemination that fits all [15]. In this section, a brief explanation of the main characteristics should be present in a warning message and their categories, as well as a set of available tools of message dissemination surveyed from different possible hazards.

2.4.2.1 Methods of messaging warnings

As stated in figure 2.8, there are more than a link of communication between the different warning subsystems, the main two links are the detection to management subsystem, which can be more defined as the path of information between a municipal or regional hazard monitoring and detection center to the single or multiple organizations which handle the management of the impending emergency. As for the second link, it is placed between the detection and response subsystem, which is associated with the transformation of the information received to the emergency managers to the whole public.

Obviously, the content and the detailing of the message at the two links will not be the same. For example, the management subsystem organizations will need detailed information about the area covered by a hazard of a flash flood and its intensity. This will not be the case for public, since the main information that they will need is short and brief information about the hazard with more care about the guidelines for protecting themselves and their properties. As a result, methods of making a warning message will have a variety of types with 3 main factors, which are to whom the message is going to be disseminated and what information is needed in its content. There are two main possible methodologies for a warning message which are **addressable** (Specific) and **mass** (general) disseminations [15].

2.4.2.1.1 Mass dissemination method

In a mass dissemination method, the message is to be distributed in a large scale with some general hazard data; it is characterized to be semi targeted, which means that the message is not sent to a particular person or organization. The main aim of this method is to assure the distribution of the message in the most rapid way for the recipients within a larger distribution scale. In the other hand, the particularity and specificity of the message will be less.

Public warning is perfectly describing the method of mass dissemination. When there is a need to alert public about an impending emergency, the main aspect that proves the efficiency of the alerting message is to assure its delivery for the whole public with their categories varieties and with a content that doesn't need a hazard specialist to understand it. For example, when there is need for a warning message sent to public about the an expected emergency of a nuclear power plant explosion, people will not have any benefit to know the scientific theories behind this emergency or the technological detecting machinery reading results. However they need other general flood warning content like the expected time of occurrence, the possible subsequences, the guidelines for evacuation if needed, etc.

In mass dissemination messages, it is almost to be impossible that all, or even most of the public will receive the warning for floods if a message had not been sent in a frequent bases and also if they are not having the capabilities or tools to receive the warning messages (for example, radio messages cannot be received by people who are not owning a radio transmitting devices or they had been not switched on). For that reason, mass dissemination messages should be always broadcasted in different means of communication and in repetitive bases. Mostly, the mass broadcasting means of communication, mainly media, are commonly used in this method.

2.4.2.1.2 Addressable dissemination method

With the only similarity between the two methods in the limitation of the time frame, in the contrary of mass dissemination, the addressable message main aspect is to include specific and detailed information in its content with a small scale of distribution. In fact, it is characterized by being fully targeted, which means that the messages are aimed to be sent to specific recipients; they can be particular organizations, member or group of members.

In a warning system, the communication between detection and management subsystems can provide an exact example of Addressable message dissemination. As mentioned in earlier parts of this chapter, emergency managers at warning management subsystems are responsible for interpretation of the data informed by the detection and monitoring agencies to use them in decision making and performing further actions towards a hazardous event. For that reason, the emergency management members are expecting well specified and detailed data about the expected hazard like its magnitude, origin location, and area covered by the threat and so on. This requires special set of communication means (reports, meetings, etc.) that can help in a full understanding of all the hazard characteristics

and its consequences, this makes the main aim of a warning message to be sent is to have a detailed content sent exclusively to the targeted organizations.

The frequency of message dissemination is not a critical issue in Addressable method, since it is easy to control and check its delivery to the targeted recipients due to their limited numbers. However, it is recommended that there should be a space for a double way communication between both subsystems to provide the ability of discussion and assistance for any unclear information in an adequate time period.

2.4.2.2 Warning message dissemination technologies

By the technological revolution along years and decades, there had been numerous amounts of tools of warning dissemination to choose from, each one of them has its own capabilities to send warning in its own way and each provides options that cannot be found in other tools and options that it cannot provide, though. This makes the difficulty of emergency management officials in taking the decisions for which tools should be used and which tools that should not. Moreover, they should be able to address their usage of the chosen tools in order to gain the most advantages that they can provide.

Some aspects should be taken into consideration when deciding to choose the tools for warning message dissemination. Clearly, the first main aspect bounds in checking the availability of tools assessed by the organization. This issue is so concerned especially at warning systems in a local scale, where usually the available levels of technologies of warning message dissemination will not be as present as in regional or cross regional warning systems. The second aspect to concern is the feasibility of the chosen tools, and whether they will fit into their required targets or not. For example, choosing sirens will not be an ideal solution in a developed area of the city with tall buildings or sky scrapers. Another important

aspect is to assure its ability to be reached to the targeted population, the fact that, as mentioned in previous parts in this chapter, will take the officials to the decision of choosing multi tools for message dissemination. A final possible aspect to be considered is to identify the possible message content that can be installed to the chosen notification tool, and whether it is going to vouch the full understanding of the Consignees or not. [15][4].

The message dissemination tools can be divided into three main categories as in fig 2.8. For each category, There is a set of warning messaging tools related to them.

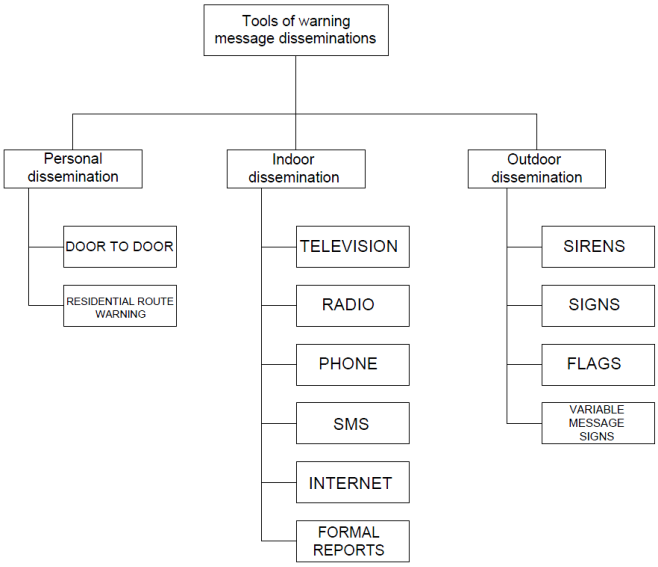

Figure 2.8 Tools of warning message dissemination [4][15]

By recalling the characteristics of the messages in Addressable and Mass dissemination methods, which belong respectively to the communication link between monitoring and management agencies, and between the management agencies to public, it can be concluded that not all of the message dissemination tools mentioned at fig 2.9 can be meaningful to be used in the both methods. For example, Notifications carried with TV tool will contain general hazard information

and safety guidelines which are meaningless to emergency managers for taking appropriate decisions. On the other hand, formal reports can be useful for management organizations since it can include some scientific data about the hazard with specific conclusions to take the adequate responses, but it will be needless for the public since that the data will not be understandable by a normal receiver and also these data will not outcome any useful information about the public adequate response.

After studying examples of warning systems in Shanghai , Indonesia. Also, with respect to the expected message content in the two message dissemination methods, the following tables include the usage of the two communication links for the set of tools of message dissemination. [15][16].

Table 2. 1 The usage of the different message dissemination tools among different communication links

Means of message dissemination	*Possible users*	
	Monitoring to management	*Management to public*
Door to door	X	X
Residential route warning		X
Television		X
Radio		X
Phone	X	X
SMS	X	X
Internet	X	X
Formal reports	X	
Sirens		X
Signs		X
Flags		X
Variable message signs		X

By the fact that the above tools of communications should be applied with some different ways within Mass and Addressable messaging, the next parts will briefly

explain the description of each of these tools, and how are they used for the two ways of warning communication.

2.4.2.2.1 Personal dissemination tools

These set of tools are considered the most classical ones for distributing a warning message for an impending hazard. Although they are remotely dependent on technology, their existence and effectiveness relies mainly on the management system; an adequate planning for the distribution and the communication between the management members who will go and perform this type of warning is strictly required to conduct an efficient warning messaging, fulfilling its targeted aim and in the least possible time. [15]

There are two tools that can be available at this approach, which are:

1. **Door to door communication:**

In this way of communication, a group of well trained people who are in deep awareness of the hazard and its leading emergency will be tasked to conduct direct personal warning message to other people or groups of people. This can usually be done by volunteers in case of warning to public or by organizations representatives in case of warning to emergency management organizations. This way of communication should have ready plans about how long it takes to assemble, equip and brief your personnel and how long door-knockers can remain in the area before they endanger their own safety.

In the case of warning the emergency managers by the monitoring and detection agencies, this type of communication can show efficiency; it will assure the specificity of the needed information about the incident from the monitoring and detecting agency. The content of the warning message will consist of an unlimited verbal information about the hazard, its threatens and

possible consequences. This dissemination can be supported by formal reports giving all the particular details about the expected emergency and agency recommendations.

Since by the presence of a direct two way contact between the personnel of the both agencies, it reduces the data interpretation process by the emergency managers due to the immediate assistance of any misunderstood or doubtful data about the impending hazardous event. In the other hand, there will be a time loss bound between the detection of the hazard and informing the emergency management agencies. The time loss will vary according to the distance between the locations of the organizations and, and it can be worse in case of the cooperation between a local and regional organizations.

As for public warning, the message content can be brief but limited due to time limitations. The message will include nothing about the hazard details, some small remarks only can be notified like its time and exposure area, though. These verbal notifications can be supported by some pamphlets and leaflets which can include pre-conducted information about the general guidelines for emergency response and life saving, which can help reducing time spent in explaining these procedures at the real occurrence of the emergency.

Like in warning the emergency management, door to door communication technique can help to give also some verbal specific information about the upcoming emergency for the public, and also it allows immediate answers for their questions and doubts. However it is considered very time consuming especially in dense populations and wide areas. Experiences had revealed that it can take four to six minutes to perform a complete warning to a single house, depending on the day and the day time. Moreover, type of hazard also can play an important aspect to determine the effectiveness of this communication tool,

since Door to door communication cannot be appropriate in hazard which will not give an long time for preparedness at flash floods or Na-tech hazards, while it can show a great success in hazards which can be early determined as hurricanes or tsunamis.

2. Residential route warning:

This message dissemination method is considered as a bulk version of door to door communication, where municipal cars like police, ambulance, etc. are equipped with public address system which is simply an electronic sound amplification and distribution system with a microphone, amplifier and loudspeakers, and these vehicles will move around the targeted region with life or pre-recorded announcements.

The context of the warning messages in public alerting using this tool can eliminate the disadvantages of door to door communication, where residential route warning will help in sending the warning notifications in much faster ways than door to door one. This in return can also give more availability of time to contain more details about the hazard but still it should be brief and simple as much as possible. However, it provides only one way of communication, where public will have the possibility for requesting any additional information, but this drawback can be mitigated by including a notice to follow more information through second level communication means like mass media.

The main advantages of residential route warning bounds in its effectiveness despite its simplicity, where with a cheap and simply assembled system, credible and flexible messages can reach high number of people even those who are indoors if the voice is wide enough. On the other hand, like in door to door, this communication tool requires an accurate pre-planning about equipping and

organizing the personnel to avoid a huge time loss for initiating it. In addition, it cannot be effective in some conditions like road narrowness of roads, high density of traffic and the existence of tall and giant buildings which may block the sound coming from the speakers of sirens. Finally, it will be so difficult to assure and control the reception of the warning message by public and their responses.

2.4.2.2.2 Indoor dissemination tools

The biggest challenge is to warn people who are situated indoors. Buildings can easily block out sound and visual warnings. Indoor warning systems rely upon technologies that are:

1. capable of penetrating inside spaces
2. wide spread enough to ensure that they can reach any space where people are residing
3. sufficiently disruptive to capture undivided attention
4. capable of disseminating messages at any time of day or night
5. preferably independent from external electrical power sources at least for a limited time

All indoor warning devises from the less to the most sophisticated rely on external sources as a trigger. Televisions and radios rely on functioning broadcasting systems and electrical power. Depending upon which kind of activity people are engaged in at the event of a warning it might be necessary to use different methods that cater to different senses (eg. hearing or sight). The special requirements of disabled persons (e.g. blind, deaf) should be taken into consideration as well. Some methods provide limited, one way delivery capacities; others support two ways or interactive messaging (e.g. telephones or HF-radio). These features become important when an action like a confirmation of the

reception of the warning message through the recipient is required. However, experience shows that common telecommunication systems tend to break down after earthquakes due to destruction of infrastructure and/or overload through increased communication needs. [15]

The tools of indoor message dissemination are:

1. **Radio**

Radio is considered the most common communication tools within the world of mass media. In fact, this communication method can be considered an indoor and outdoor (to be explained later), since the warning dissemination can be received by the radio receivers turned on by people at houses, or the ones turned on by people at Journeys with their vehicles or other means of transport. This technology provides a wide distribution scale of warning notifications and in a possible high repetitive frequency. Radio system components are simply bounded in a broadcasting component located at the local or regional broadcasting center, and a receiver which is located on simple home or car radio set which is almost possessed in any household or a car.

The public warning message content will be remotely sent to the whole public who are tuning their radio stations on at the same time, so these messages can have the advantages to be descriptive, up to dated and almost overcoming any time limitations, Moreover, the warning credibility can be assured by conducting interventions with some monitoring or management officials members who can validate the hazard situation and provide guidelines for emergency mitigation by the public. Finally, unlike the personal dissemination tools, it doesn’t need a huge time of planning to initiate this tool for warning, since it doesn’t require any assembly or distribution emergency management

personnel, it only requires the ability to understand how to operate and control these messages which can be done by usual broadcasting center employees.

On the other hand, there are some drawbacks of radio communication tool. First, there is no guarantee that people will be already tuning on the radio stations that will announce for the impending emergency, especially at some times of the day like the working hours or at late evening to midnight. This issue can be overcome by using earlier means of communication like personal tools to aware people to tune into the radio stations to get the more detailed information about the hazard. For that reason, radio or mass media disseminations should be considered as second level message dissemination tools. Moreover, some hazard details cannot be perfectly described in radio message dissemination due to the unavailability of usage of some illustration figures like maps, graphs, etc. which can cause a misunderstanding or confusion for the message receivers. For example, the description of flood exposed area can be described as being 10 km along the river banks, this information can cause confusion for people, where some people at the exposed area can believe that they are away from the flood affected zone and vice versa. Finally, most of the radio receivers are electricity based devices, which can make this communication tools not effective in some hazards like earthquakes or tsunamis due to the possible loss of power in case of their occurrence.

2. Television

Television is considered as an indoor application of mass media communication tools. The message can be disseminated through the local and regional broadcasting centers to the television receiver devices mainly located at households or commercial offices. Like in radios, this communication tool can assure warning message dissemination with a high repetitive frequency and with

a high distribution scale. In addition, using televisions can overcome some of the drawbacks mentioned in radio tool televisions can assure a wider distribution of warning notification than radio. First since its technology provides the possibility to broadcast its channels to levels that can reach overseas. Also, the ability to inform about the hazard facts in more illustrative ways like graphs, maps, live photos will decrease or even eliminate the public confusion. For example, people can be easily got aware about the exposed area by hazard by showing a detailed map of the city subjected to an impending emergency with color discrimination over the probable areas of exposure.

Television communication has the general telecommunication tools advantages and drawbacks, where the advantages are that it is widely available and almost possessed by all households and commercial places, and allows an instant and up to date communication as long as it is turned on. Also, it doesn't need a long time initiating planning and can be operated by normal personnel at broadcasting centers. In addition, there is an ease of assurance of message credibility by the intervention of emergency management and monitoring officials. On the other hand, the drawbacks bound on the unavailability of this communication tool in case of loss of power, and that it is considered as a second level message dissemination tool.

3. Phone

Phone notification is one of the tools that can be used for the mentioned two link of communication. There are two possible ways to use telephone in message dissemination. The first one consists of normal direct calls and inform about the expected hazard through two way communication. This type has the advantages of the assurance of the particularity of the information and allow share of information and inquiries. However, it is considered so time consuming

since only one person or group of people can be notified in each call, several lines can be installed but still it cannot be considered as a mass dissemination way. This way can be used in the case of communication between the monitoring and management subsystems since the specificity of the warning message has a higher priority than the time of targeted dissemination. The second way can be ringing list of predefined numbers stored at service carriers and transmit unified recording messages. The installed systems for this way provides the possibility sending these messages simultaneously, with the option of redialing any numbers which didn't pick up the calls. Experience show that it can take at least 50 seconds to deliver a recorded message of 30 seconds, which can increase according to the time spent for telephone users to pick up the lines and for the number of cycles of redialing used till there is a call response. This method can be used in the communication between the management organizations and public, where it saves much more time in sending the warning to the targeted people in a much less time than normal calls, but the drawbacks will be bound in the low specify of the messages and it will not provide a two way communication to monitor public response.

The main advantage of using telephone is its availability among the most of the population, especially for later generations. Studies show that over 90% of the population in some developed countries like United States, Germany and Italy and even in some developing countries like Morocco, Egypt and Guinea [17]. This makes it one of the main ways of warning message dissemination when deciding the possible way of public warning. Moreover, they act as an ideal way of informal warning dissemination between management officials and public, and between the people within the public which will help in a faster awareness about expected hazards.

On the other hand, each of the two approaches in telephone warning cannot satisfy the aspects of message particularity and dissemination scale. Also, in their services are vulnerable to later stages of some which can affect the infrastructure or cables such as floods or earthquakes. Finally, the effectiveness of the service can be subjected to a rapid decrease when they are congested

4. SMS

SMS or short messaging services are considered one of the most common options that cell phones can provide. It is based on written short message that they are about 250 characters long that can be sent between SMS applications to phones or between the phones themselves. The use of SMS as a complementary method for multi hazard warning can be a good option. A great number of people, especially in urban and densely populated areas are using hand phones and are familiar with SMS. SMS sometimes can be more reliable than cellular voice transmission. During 9/11 mobile phone networks in New York lost most of their voice transmitting ability but SMS still came through. Short messages share the same advantages and disadvantages of telephone for being both considered as telecommunication systems. But in addition, SMS differentiate from telephone communication in terms of ease and wider distribution of the warning message [15]. However, it has two main drawbacks. First, SMS technology provides tiny limit for message content as mentioned before, the fact which limit the specificity and details of the targeted hazard information to be sent. Second, in telephone, it can be guaranteed that the recipients had received and read the message content when he respond to the call, which is not the case in SMS where the message is just sent to people without being assure if the messages had been either read or not.

Like in telephones, there are two possible ways for using SMS as a warning dissemination tool. The first one can be in terms of customized messages that can be sent to the emergency managers with an advantage of the ability to send the same message for large number of people at the same time. However, the specify of the message will decrease due to the absence of the direct contact between the organizations members and the shortness of the message content. The other way is to pre reoccurred messages to predefined lists of numbers of specific public group or a whole public with some basic facts about the hazard and maybe a notification to follow other means of communication which can provide more details.

5. Internet

Internet itself includes a numerous of applications depending on it. In this part, two applications used in warning message dissemination will be mentioned which are Email and websites.

Beginning with Email communication, the very basing email message consists of descriptive, usually unlimited amount text which is sent from one email address to one or more email addresses where the maximum number of email addresses that a single message can be sent at once is specified by the service provider. By the development of programming and the increasing demand on the usage of this service, several options now can be used in one single email messages, there are many common options than attaching pictures, graphs, multimedia and general files in one email with the only limit of message size specified by the service provider.

There are many advantages that make the decision to use email in hazard warning is an adequate one. These main advantages are:

- Email is an easy way to disseminate information, ranging from text files to maps, sound and video files.
- Every computer with internet access features usually also an email programme
- Large amounts of information can be sent out to a large number of people in a very short time if bandwidth is sufficient by the service provider
- Distribution lists can be predefined.
- Email can also be used to send messages to hand phones in SMS format.
- Email is widely supported on all computer operating systems and can be easily
- Interfaced with other warning dissemination tools.
- It is easy to track whether a mail has been opened or not.
- Very low cost

As mentioned in table 2.1, email warning notification in both warning system communication links can be used. However, it is not considered as an alerting device, where there is no direct notification of a sent messages but it requires the activity of the recipient, that is, to be opening the email inbox and so reading the received message. For that reason, email notification is is proffered in the communication between hazard detectors and managers since it is easier to send them a notification message and check their emails for a detailed hazard information using other communication tools such as telephone or SMS. As for public, Email messages can be effective more at piece times for sending general periodical emergency guidelines and hazards awareness contents, since this stuff doesn’t require an immediate reception and response of the message.

The second internet application to be considered is the development of the websites. Websites can be quickly updated and supply an almost unlimited number of users with a large variety of information but they don't function as an efficient alerting or notification tool. Websites can only be categorized as supplementary. Users have to actively open the website. To do so they have to know the web address. To change the content of a website requires expert knowledge. Websites are merely useful as long as a computer is running and connected to the internet. Websites can be useful information sources during the response phase of a catastrophe. Information can be centrally stored and access rights for restricted information given to relevant stakeholders like fire-fighters or emergency operation centres.

6. Formal reports

Formal reports are not considered as an alerting tool; It is used in systematic monitoring performed by the monitoring and detection organizations and reports containing deeply detailed hazard information are sent to the management officials in regular basis. As a result, although these reports may not provide an intermediate warning at the occurrence of a hazardous event, it helps the decision makers a lot in forecasting the possible event that can occur to make future risk mitigation plans and raising public awareness about the expected future hazards with their consequences.

Rather that fact that the formal reports are not considered as warning message dissemination tool, another main disadvantage which can be found is the difficulty of understanding of the reports content by the emergency managers if they had been written in deep scientific means which cannot be understood except by scientists and personnel of the monitoring and detection

agencies. Writing these reports in a common language requires the knowledge of each of the organizations about the nature of the field of each other.

2.4.2.2.3 Outdoor dissemination tools

Outdoor dissemination refers to the warning for targeted recipients who are located outdoors. These recipients can be pedestrian public, people at vehicles or other transportation means or even warning system personnel. The different tools for outdoor dissemination share the same possibility to provide a wide scale of alert distribution. On the other hand, these messages are completely brief and unspecified; some of the tools cannot be either defined as message carriers but just critical alerting devices. These messages will contain no details about the hazardous event itself. They will just notify the people about unwarranted conditions, and in some tools, it can illustrate some particular guidelines. In addition, outdoor tools cannot provide communication in double ways. As a result, outdoor warning message dissemination tools are ideal to give alerting notifications to public rather than to emergency management officials.

There are four outdoor dissemination tools that can be considered, which are:

1. **Sirens**

   Sirens are considered one of the most popular emergency alerting tools used. They can be easily and cheaply installed in wide populations or even in isolated areas. They act as a best option for cases when using other message dissemination tools cannot be used. The huge technology development had come out with a variety of sirens with improved coverage areas and additional options like light indicators for people with special disabilities or sirens attached with

channels that can allow verbal communication between officials and public. However, gaining an adequate knowledge for the possible hazards is require to avoid over or underestimation the types to be installed. Sirens are ideal for alerting purposes. However, their messaging capacity is limited unless they are combined with an announcement function since the output warning messages from sirens will be just alerting without any information or updates about the hazard or any step forward guidelines to assist public with the right emergency response so, like in personal dissemination tools. They can be used to advise people to turn to information sources like radios or TV sets to seek further instructions.

The main aspect that address the effectiveness of using sirens as a main public warning alerting tool, is the extent of understanding and awareness of public the public about the mean of its disseminated message. People should be educated previously about the means of the sounds that they can hear from sirens. Otherwise, a huge confusion and unwanted panic can take place. An example for that is the false tsunami alarm that occurred in Indonesia at 2007, where a false alarm caused the sirens to produce alert sounds for about one hour and the population didn't have an adequate education to be able to understand the message behind these sounds. As a result, the sirens infrastructures had been destroyed by the angry residents, beside the needless public panic which could lead to wrong actions and cause unfavourable consequences like the loss of trust between the public and their alerting system, thus, increasing the social vulnerability.

2. Signs

Signs are also considered only alerting message dissemination tools, usually consist of some –to the point- information to indicate banned roads or diverted

route directions due to the hazard occurrence. Signs are installed just after the knowledge of the impending hazard since they are useless in peace times, or in some cases they are permanently installed with an attached siren light that starts to light when it is activated. In cases of emergencies, signs can be ideal to be used in public warning communication link, especially for those who are using means of transport.

The advantages of this communication tools is the same like in sirens that it is an ideal solution when there is no possibility to disseminate the warning in other ways. However, using signs can be not a good idea, especially in cases of hazards associated with low preparedness time like flash floods or nuclear plant explosions, since an accurate management about the content the signs and their targeted locations, where installing sign with incorrect messages or in locations that were not assigned to them can cause a huge case of public confusion or disastrous consequences. For example, installing signs to assist vehicles for diverted routes in wrong locations or in unclear way can cause unwanted congestions or accidents. Also, the only two options of warning using signs is either to place or remove them, and there is no remote way to automatically broadcast any new information that are desired to be sent, so there is no efficient possibility to disseminate updated emergency information or guidelines.

3. Flags

Flags can be raised to indicate that there are unwarranted conditions and so warning has to begin. Different flags can be assigned to different simple messages; they will only work if the public is educated about their meaning. Flags can only carry very limited information since like signs, it cannot carry any details about the expected hazardous event, it just has the function to raise aware people about its evolution. Flags are only making sense where they can

be seen, so their range is limited. For example, they can be used on beaches that are frequented by tourists or locals in cases of expected storms or high sea waves. Another limitation for using flags is that this type of communication its warning content will not be broadcasted, so it is useful only for the people who can notice it. For that reason, it will show any reliability when it comes to assure the public response towards emergency warning.

4. Variable message signs (VMS)

The last outdoor communication method to be considered is an electronc version of warning signs. These signs consist of electronic boards that can be modified by a control canter to show brief messages about an expected emergency and also provides assistance to the public outdoor to stay safe through the different hazard stages. VMS are mostly effective in transportation emergency management, where they can show brief information about damaged or dangerous roads, routes changes and all available alternative routes. The main advantages of these electronic signs that makes it favourable over normal ones is the easiness of information update, where these signs can be turned on, off, changing their message contents remotely with simple and short processes.

On the other hand, these signs provide a small space to place the warning messages. In fact, some electronic boards can give the options of producing more than one message; each one will be shown independently. Also some of them assess the option of scrolling text which can add more space message content. However, these options are not always suitable to be used, the decision to place them will depend on their locations and the targeted categories of people to whom their messages will be targeted. For example, the additional mentioned options can be suitable for small local roads where there is a small vehicles flow and a low limited speed, while for highways and wide local roads,

there are only few seconds available for the drivers to check the content of the messages in these signs, if they are longer, it requires a slowing down or the stops of their vehicles which can lead to congestions or accidents.

2.5 Evaluation of message dissemination tools [4][15]

By studying all the advantages and limitations of the different tools that are used for disseminating warning messages mentioned the previous section, it can be concluded that there is no single tool that can provide options enough to satisfy all the needed characteristics of a warning message. As mentioned before, that's why decision making of choosing the content and way of warning message dissemination reflects a main challenge of a successful warning system. This section will focus on the main aspects that are considered in sending an emergency alert for both communication links to emergency managers and alerts. Moreover, a representation about the extent in which that each communication tool can fulfil those aspects will be briefly discussed.

2.5.1 Main aspects of warning messages

There are many common warning messages aspects to be considered in the communication between detection and management, and management and public. However, their priorities may differ. For example, the specificity of the warning message to be sent is one of the most important factors that should be focused when sending an alerting message from the detection to management organizations to ease the process of decision making for the emergency managers. This is not the case at the communication between the management and public entities, where it is more beneficial to provide the public with a short hint about the hazard nature and related threats and to provide brief guidelines for emergency preparedness than to spend much time in explaining for them the detailed information about the hazard itself. For the sake of simplicity, the following lines will briefly explain the most

important aspects that should put into account when disseminating the warning message for the both communication lines.

2.5.1.1 between detection and management

As mentioned before, the first process that takes place at the management subsystem of an integrated warning system is the interpretation of the received information about the impending hazard from the detection subsystem. The rate of success of this process is responsible for the success of the later ones from the decision making to public informing. As a result, some main aspects should be satisfied when taking the decision to disseminate a warning message. The following represent the most common aspects from the recipient point of view.

1. **Message specificity:** As stated in the early beginning of this chapter, to reach the data for a wisdom stage, it requires an increasing level of its understanding. Members of management subsystem are in the need of full knowledge and awareness about the impending hazard and its possible consequences to be able to decide the public areas to be notified, the content of the warning alerts and the possible tools of communication to be used. By taking a flash flood as an example, detection and monitoring subsystem officials need to send data about the available time that make it still safe and enough to warn the public. Moreover, by sending the information about the predicted hazard affected area by the flood with the relevant expected water depth and velocity, management officials can decide which tools that can disseminate the warning message in the assessed time and with the brief guidelines for the public located at the hazard affected area to assure their safety.

2. **Availability of two way communication:** As already discussed before, the difference between the specializations of the detection and management

subsystems requires a creation of common language of communication between detection and management organization personnel, which will help the latter to achieve the best knowledge possible when receiving the hazard information. In fact, it is hard to develop a language that will assure this issue completely, there will be always the need for the emergency managers to request assistance and more clarification of the received information from detection and monitoring centres. For that reason, the availability of option of the warning message dissemination tool for providing lines of double way communication plays an important prioritised aspect when deciding the possible communication tools to be applied within the warning system.

3. **Reliability:** Reliability is bound in the extent of ability that the warning message dissemination tool can be used under unfavourable conditions. The reliability can be measured within many variables in the communication link between the warning system detection and management subsystems. For example, the time of sending message can be an important factor, where sending an email with a warning content cannot be reliable at times of day when the receiver will not be available to be aware about the message delivery like beyond working hours or midnights. Another measure of reliability can be in its ability to work under abnormal conditions due to some hazards or phases of hazards, like as mentioned before, some hazards like hurricanes or flash floods can cause a power loss which can lead to a stop of functioning of many communication tools that are electricity bases like radios and televisions.

4. **Timing to disseminate the message:** Timing can be considered the aspect that has the least priority. This fact is not due to the lack of the importance of the speed in which the warning message is going to be disseminated

between the two warning system parties, but due to that communication doesn't have to be held between the all people within the both subsystems; it can be shared among selected members or representatives of each of the both organizations. As a result, it is almost assured that different tools of communication between monitoring and management subsystems can provide the warning messages within an accepted time. However, when it comes for the need of a permanent communication within the emergency for any changes or updates, the reliability of the communication tools will vary from one tool to another. For example, using formal reports can be adequate in the first warning for providing as much details as possible about the hazard and its consequences. However, using the formal reports in asking for further or updated information will be effectiveness due to the long time needed to wait for the response of the detection and monitoring centre, in addition to the non assurance of the delivery of the warning message with the exact requested details.

By combining all of these main aspects with the characteristics, advantages and disadvantages of the different mentioned tools of communication for this communication link, the next table is summarizing the degree of fulfilment that each of the communication tools can achieve for each aspect.

Table 2.2 detectors to managers communication link tools and their concluded degree of fulfilment to the mentioned aspects

Warning message aspect	*Dergree of fulfillment*				
	Door to door	*Phone*	*SMS*	*Formal reports*	*Internet (Email)*
Message specifity	MEDIUM	MEDIUM	LOW	HIGH	HIGH
two way communication effeciency	MEDIUM	HIGH	LOW	MEDIUM	MEDIUM
Reliability — *In hazards with related power loss*	HIGH	MEDIUM	MEDIUM	HIGH	LOW
Reliability — *In inactive times during day*	HIGH	HIGH	LOW	MEDIUM	LOW
Time of message dissemination	MEDIUM	HIGH	LOW	LOW	MEDIUM

2.5.1.1 between management and public

The communication between the warning system management and the public is considered more complex. As stated at earlier parts of this chapter, it is hard to monitor the public response and establish an interactive way of communication between emergency managers and public members. Moreover, a balance between warning message specificity and briefing should be maintained which is a hard task to be accomplished by a single communication tool. The following lines will briefly reveal the most important factors to be accomplished when disseminating a warning message from the management point of view.

1. **Distribution scale:** The most important factor that is needed to be fulfilled is the sufficiency of a tool of communication to disseminate the warning message to the targeted scale. By studying the characteristics of the different mentioned means of communication, it can be revealed that the scale of message distribution increases by the development of more advanced technologies. For example, televisions can be more used when there is a

need to conduct a regional scale warning, which cannot be achieved when using more classic tools like sirens and flags for example.

2. **Duration of message dissemination:** According to the time available for preparedness and warning about an impending hazard after its detection, the possible duration to spread the needed information about it to the public will vary. From that point, the decision to choose the communication means to disseminate the warning message should be done according to their estimated duration to fulfil a complete targeted distribution of the emergency notification. Some hazards like tsunamis or hurricanes can be expected several days before its occurrence which can the emergency managers to use means of communication that can take longer time in means of sending and delivery to the public like SMS and Emails. As for other hazards that allow a real short preparedness time like nuclear power explosions and flash floods will force the managers to activate communication tools with less warning message specificity but assuring fast sending and delivery like all outdoor and personal communication tools in addition to other indoor tools like radio and television.

3. **Credibility:** Credibility in the public point of view is referred to the extent of trust that they can gain upon the received alert message received from their responsible officials. Emergency managers should establish means of communication to disseminate the warning message that give exact information based on exact decisions and with a proof of formality. As a result, message credibility can be addressed from two factors. First, in the hazards that can result an uncertainty about its occurrence, management subsystem should apply communication tools that can give them a space to provide an updated and little detailed information about the hazard to avoid

the point of false alarm. This factor cannot be fulfilled by all the alert communication tools. For example, as stated before, depending on sirens in a tsunami warning, which assess an uncertainty of non-occurrence can associate a problem of a false alarm due to the lack of space to provide any updated emergency information or changes in the management decisions, which will result a severe increase of social vulnerability due to the less lack of public truthfulness about the future warnings sent from their officials. For the second factor, credibility is also providing the public the trust that the message they have received is sent from official and truthful sources. This can be achieved by the communication tools that can be only initiated and controlled by the local or regional officials and that ones which can provide the intervention with representatives or heads of the detection or management subsystems. Here, sirens can show a high degree of credibility due to the known fact that siren messages cannot be initiated or controlled except by management or detection organizations. Unlikely, phones for example cannot fully fulfil that aspect. Where making calls or sending SMS can be initiated by any of the device holders, which will result a wasted time by people who received the warning messages via these communication in checking the truth behind these alerts.

4. **Reliability:** The reliability aspects in the communication between management and public are exactly the same as those in the detection and management communication. But in addition, reliability in the communication between management subsystem and public depends also on the availability of the rate of users for the particular message dissemination tool among the public. It is meaningless to use the communication latest technologies but due to lack of awareness or the non possession of message receiving devices, these warning notifications will not be delivered, though.

As a result, the most effective communication tools in overcoming these factors will be those which don't acquire special receiving devices in order to assure the warning delivery. For example, in some mountain or small villages, it is more guaranteed that the alerting messages will be received to public by the initiation of the tools that can provide a direct delivery of the messages without needing receivers like outdoor and personal message dissemination tools, while for other tools like internet or phones, which require the possession of landlines, cell phones or computers with internet connections in order to receive the disseminated warning messages sent through these communication tools, the thing that cannot be common.

5. **Dialogue communication:** the double way of communication effectiveness in public warning can be measured on the bases of the extent of interactivity that the communication tool can provide. This aspect fulfilment provides the best ability to track the public response and offering immediate assistance.

By combining all of these main aspects with the characteristics, advantages and disadvantages of the different mentioned tools of communication for this communication link, the next table is summarizing the degree of fulfilment that each of the communication tools can achieve for each aspect.

Table 2.3 managers to public communication link tools and their concluded degree of fulfilment to the mentioned aspects

Warning message aspect		*Dergree of fulfillment*										
		Door to door	*Residential route warning*	*Television*	*Radio*	*Phone*	*SMS*	*Internet (Websites)*	*Sirens*	*Signs*	*Flags*	*VMS*
Distribution scale		LOW	HIGH	MEDIUM	HIGH	LOW	MEDIUM	MEDIUM	HIGH	MEDIUM	MEDIUM	MEDIUM
Duration of message dissemination		LOW	MEDIUM	HIGH	HIGH	LOW	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
Credibility	*Overcoming false alarm*	LOW	MEDIUM	HIGH	HIGH	MEDIUM	HIGH	HIGH	LOW	LOW	LOW	MEDIUM
	Officiality of the disseminated message	HIGH	HIGH	HIGH	HIGH	LOW	LOW	MEDIUM	HIGH	MEDIUM	MEDIUM	HIGH
Reliability	*In hazard with related power loss*	HIGH	HIGH	LOW	MEDIUM	MEDIUM	MEDIUM	LOW	HIGH	HIGH	HIGH	HIGH
	In inactive times during the day	HIGH	HIGH	MEDIUM	LOW	MEDIUM	LOW	LOW	MEDIUM	LOW	LOW	LOW
	in rate of possession of the message reveiving devices	HIGH	HIGH	MEDIUM	MEDIUM	LOW	LOW	LOW	HIGH	HIGH	HIGH	HIGH
Dialougue communication effectiveness		MEDIUM	LOW	LOW	LOW	MEDIUM	LOW	MEDIUM	LOW	LOW	LOW	LOW

To conclude, among all of these message dissemination technologies, there is no single one that can satisfy all the considered aspects concerning the warning message to be disseminated. For that reason, the decision of choosing the warning message dissemination tools should always come out by the establishment of more than one communication tool for warning notifications in order to reach the highest degree of fulfilment of all the aspects and doubts that come into consideration in the times of emergencies.

Chapter 3

Warning system in social media era

3.1 Introduction to the social media

In the previous chapter, a variety of different communication technologies that are used for warning message dissemination for the emergency managers and public had been represented. Each of them possesses a set of advantages, disadvantages and main aspects to be considered while being used. A most two common conclusions that had been observed are, first, the inability for each single communication tool to fully satisfy all the main aspects that should be taken into account when disseminating a warning message between emergency detectors and managers, and between the emergency managers and public. Second, for most of the mentioned communication technologies, there is a difficulty in monitoring the message receiver response due to the lack of efficient ways to maintain a double way communication especially in the second communication link.

From what is mentioned before about the framework of public warning using the represented typical communication tools, it can be shortly concluded that they are basically based on mostly one way communication warning message dissemination, where the authorities give information to the impending hazard's affected public prior and during its occurrence, and the possible hazard consequences afterward. However, the emergency management authorities will not be able to conduct a public response to these warnings and it will be difficult to inform them about any plan or decisions changes. As a result, they perform their work with the assumptions that provide an ideal warning system model in case of their fulfillment. First, their information and guidelines will be exactly followed by the warned people. Also, it will be assumed that their first stages decisions will be adequate for an effective emergency preparedness. Finally, the use of the different

communication tools will be able to disseminate understandable, action oriented and it is confirmed through different information sources.

However, the reality doesn't reveal these ideal conditions. Public warning had been seen as a separate task for each authority or each administrative region, instead of a coherent social capability of the whole community or region. For example, although a fire chief, a flood plain manager, and a public health official have common public warning concerns, separate research, regulations, and routines for public warning had sprung from each of these domains. As one result the mentioned set of warning communication technologies are currently used to warn of particular hazards. However, experiences and best practices from one authority's domain or jurisdiction do not easily transfer to another's [18].

By performing a deeper survey among the latest maintained technologies that can be used for warning communication, a noticeable method that it is witnessing an increasing demand by the multi hazards warning systems, is the usage of the different social media applications. Social media refers to a combination of three elements: content, user communities and Web 2.0 technologies [19]. Social media eliminates the main limitation of the processes separation found in the typical warning communication tools since its main idea is the interactive information sharing among their users, which when applied in the field of crisis and emergency warning, can lead to a great advantage of the ease of information flow between the different emergency stakeholders.

Social media, which began as a mode through which individuals may communicate with others has now evolved to critical element in emergency and crisis response. The recent political unrest in the Middle East, earthquake in Japan, and mass shooting at Virginia Tech are clear demonstrations that social media are a force that cannot be ignored. In times of crisis, social Media gives the ability to communicate

quickly and effectively revolutionizing the manner in which people communicate and gather information about stories and topics that are of interest to them. Organizations are increasingly implementing Social Media strategies as a part of their crisis management planning. With the right tools in place, there's no doubt that Social Media can play an important role in crisis communication. [20]

3.2 Types of social media

The concept of social media had come out numerous numbers of applications, which together provide almost all the means of information illustration, starting from short texts (twitter) to image sharing (flickr) and also videos with unlimited durations (YouTube). The next table represents a set of the most common types of social media, the available service for their application and the description of the options allowed by each type.

Table 3.1, The variety of social media types and applications [20]

Type	Examples	Description
Social networking	Facebook, MySpace, LinkedIn, Google Plus, Ning, Bebo	Allows users to add friends, send messages and share content. People on social networking sites group in communities of like-minded interest
Social bookmarking	Digg, Delicious, Yahoo! Buzz, StumbleUpon, Reddit,	Allows users to share their favorite online content with one another while also creating online bookmarks.
Blogs	Wordpress, TypePad, Blogger, livejournal, Tumblr	Online journals where the author can write (blog) about any interest he wants. The blogger can also use the blog to share content picked up from other Social Media sites (YouTube, Issuu) by taking advantage of the simple embedded codes offered by those content hosts
Micro-Blogging	Twitter	Allows users to send short 140 character message in real time to large audiences
Collaborative Projects/Wikis	Wikipedia, Google Docs	Online content created as a result of multiple users working on the same content, but at different times, from different places

Type	Examples	Description
Photo Sharing	Flickr, Photobucket, Picasa	Allows users to upload photos, share either privately with only selected other users or publicly
Video/Music Sharing	YouTube, Spotify,	Allows users to upload or watch video content or listen to music to a site for sharing either privately or public
Presentation Sharing	Slideshare.net, Scribd, Issuu	Allows users to upload files as PDF's and convert to work with the online presentation applications. The presentation tools include embedded codes and email options to share the content online
Intellectual Property Sharing	Creative Commons	Licensing rights and permissions for others to use the photos by simply embedding the codes in their blogs
Meetups/Events	Evite, Facebook events, foursquare	Allows users to promote and display where people are at that moment
Questions and Answers	Yahoo questions, Facebook Q & A, formspring	Allows users to ask random questions, and anyone can answer and start a conversation

The most three common types of social media used to disseminate the warning messages are the social networking (mainly Facebook), Micro-blogging (mainly Twitter) and multimedia sharing (mainly YouTube). Each one has its own possible options to provide and related advantages and drawbacks. However, their disadvantages be eliminated by the usage of more than one application in a single warning system.

3.3 Social media versus traditional communication technologies

The use of social media in a warning communication system is mainly more useful in the communication link between emergency managers and public rather than between emergency detectors and managers. There are many reasons that made the emergency management authorities shift into the decision of choosing social media as a primary tool for warning message dissemination to public among the traditional communication technologies mentioned before.

The use of social media in a warning communication system is mainly more useful in informing public rather than informing emergency managers. So the following lines will explain the. Their variety of tools and options had been helping in

achieving high degree of fulfillment of the most main aspects to be considered when producing a public warning notification stated before. The following lines will explain how the social media is providing the high satisfactory levels for the main considered aspects for the warning communication between the emergency management organizations and public stated in chapter 2:

1. **Distribution scale:** The decision of using the social media tools for warning message dissemination is a total guarantee for the distribution of a warning message to a numerous number of receivers and to a distance that can vary from local level to oversee one. By 2014, statistics show that the number of registered users on Facebook, Twitter and YouTube are reaching around 1.35 billion, 284 millions, and 300 million users respectively [21]. Moreover, past experiences are showing the effectiveness of social media as a primary tool for communication to and between public before and during the crisis. For example, archives show that the number of tweeter users who participated in posting messaged including the special hash tag "#qldfloods", which is made exclusively for any posts that assess or require info information about Queensland report at the period of 10-16 January 2011, had exceed more than 15.500 users, with total tweets of more than 35,000 tweets [22]. For these reasons, social media are increasingly playing one of the most important roles in sending warning notifications in a local to global scale.

2. **Duration of message dissemination:** As mentioned in chapter 2, the main to considerable points to measure the effectiveness for warning message dissemination tool are the time taken for initiating the communication tool and the time spent between the message sending and being received by the recipients. Social media tools are providing a great efficiency for both measures. First, sending a warning message through tools of social media

like Facebook or twitter doesn't need any special operating devices or long processes; It just need an internet connection to login to the website and sending the message, the process that can be done even from personal computers or smart phones, Moreover, posting on Facebook, blogging at Twitter or uploading illustrative videos at YouTube assures that the message will be sent to millions of people in the same time, where their default options allow any registered users to be able to see and interact with the updates that any other user can write down.

3. **Credibility:** Credibility is considered is one of the most challenges that come out when depending on social media in notifying the public about the hazard, where as it will be discussed later on, the main problem in the social media applications is the complete freedom for any user to initiate posts and updated in any desired topic. This cause the problem in terms of much fake and unverified information that can lead to a severe public confusion and points of chaos [20]. The control of this limitation varies from one tool to another. For example, the concept of usage Facebook is by establishing a unique profile page, which can be announced in earlier stages through other means of communications like TV or pamphlets, related to the management authorities with a limited access to people who possess the profile's login information which are relatively only the members within the organization, so only officials or emergency management representatives can post available hazard information with the allowance of public interaction but only through comments or information sharing which can be not so difficult to control. This is not the case in twitter, where the idea of this tool is to generate a special hash tag related to the hazard where any user can bring their own information and updates about the impending emergency, the fact that can make it very difficult to control and monitor all the information

posted unofficially by public members due to the large number of posts including the unique hazard hash tag which can reach to tens of thousands like in case of Queensland flood case stated before.

On the other hand, social media tools provide a high level of fulfillment for the second measure of credibility related to the possible continuous information about the upcoming emergency that can eliminate the uncertainty of false alarm. Social media tools provide a space for posting the hazardous information with unlimited capacity, lots of illustrative ways like graphs, sound files, and videos and in a very rapid time, so public can be always up to dated within almost the same level and time with the emergency management authorities.

4. **Reliability:** As stated in chapter 2, the main three measures that define the extent of the effectiveness of a communication tool to fulfill the reliability aspects are bound in their ability to reach notify the public at the inactive times during the day like midnight and early morning, the amount of public position of the message receiving devices and their effectiveness to be still operating during hazards with power loss consequences. Beginning with the first two measures, the message through social media doesn't need except very common devices like personal computers, laptops, smart phones and tablets with active connection through the internet and social media servers. There is no need to mention that at least one of these devices is possessed by each household or even each person. San Francisco substantiated this by listing empowerment of people via connected mobile devices as the mega trend of the 21st Century [23]. This fact assures the delivery of the warning message for people who are within different activities and in different times during the day. For example, people who are at households or work will be

able to access their social media accounts through the different receiving mentioned devices. Moreover, people who are outdoor will be able to keep online through their smart phones and tablets. Finally, the options of sound communications that smart phones provide once receiving a notification from facebook, twitter, etc. can grab people's attention even when they are not active at these sites at the time being.

As for the last measure, social media are mainly internet based. So they behave exactly like websites communication tool, where they show no usage in case of hazards that have a high impact on regions of high systemic vulnerability in the form of the damage of the infrastructure including the internet cables. However, the fact that social media can work on a variety of devices which depends on more than once internet source (For example, desk computers depend mainly on cabled connections, while smart phones and tableds are mainly depending on cellular data packages or satellites) can decrease the probability of a complete service failure. A real case that can illustrate this fact is at the Egyptian revolution on 2011, where despite of the cutting of all communication services by the authorities for crisis controlling, still a large number of people could still communicate and access the internet through direct satellite connections [24].

5. **Dialogue communication:** This is considered the main advantage of social media over any other traditional warning message dissemination tools, the main idea of social media is held on the exchange of information, updates, and thoughts between people worldwide. Using social networking sites adds a human connection to communications about the disaster. The new media adds visuals and interactivity to a topic [25]. In one study it was discovered that during an emergency, people affected by the event would post to social

media and provide information about the emergency including a detailed location of the event. Sometimes these posts are accompanied by images of the disaster. The images provide a firsthand assessment that can be placed with other eyewitness accounts to create a more complete view of the disaster. It is useful at all stages of an emergency including warning, impact and recovery stages.

3.4 The role and challenges in warning communication

As stated before, the social media communication tools are mainly used in the communication line between emergency managers and public; authorities can establish their official pages on the different social media applications and with the adequate informing and controlling, all the aspects to be considered in warning dissemination message can be achieved. Another important role that social media play is in the informal warnings initiated between the members within the public.

3.4.1 Communication between emergency managers and public

In times of crisis, Social media plays an important role in the providing fast and an updated source of information to feed the public. The massive earthquake that rocked Japan in March 2011 is a good example to demonstrate how individuals, groups, and tech giants mobilized their existing Social Media resources. Social Media not only guided first responders and victims, but also served as a forum to express the concern and debate over the issue of nuclear power in an earthquake-prone country like Japan. Global voices, an international community of volunteer bloggers, offered links, resources, and translations in multiple languages for users, within minutes after the earthquake struck. Japanese citizens used social networks to exchange information and reach out to their family and friends. Voice services were disrupted but people were able to text and use data services. Social networks like Twitter and Facebook also came to the rescue. They posted an information

guide offering tips and other resources in Japanese and English. Google introduced People Finder, within minutes after the earthquake to help the victims find their family and friends. Social networks demonstrated their social responsibility by adopting these measures to help and guide the victims of the earthquake in Japan. [23].

As stated before, the most used social media application in crisis communication are Facebook, Twitter and YouTube. The decision of choosing one or more of these applications will come from the decided contents in a warning message to be broadcasted. In an ideal case, the three applications will be used, where:

1. YouTube will be used in graphic and animated illustrative information where videos with unlimited duration can be uploaded containing interactive maps, animated guidelines or live videos. Moreover, there is a possibility to perform an online live streaming for local or regional mass media channels located in TV or Radios. This option is an ideal solution in the case of power loss or if the channels broadcasting scale are not reachable for targeted people to be warned.

2. Facebook and twitter are used for a continuous and up to date information headed to the public, where Facebook is providing the possibility to exchange unlimited statuses, images or even videos, these posts can also include other external links for further or more detailed hazard information, the same applies for twitter, except of the limitation of 140 characters for each message, so it is more favorable to be used within later stages of emergency where there is no more space for preparedness and general

information but for brief and to a point updated emergency state and guidelines for public safety.

So the very basic procedures to initiate a warning message through these application are easy and short, just an access to an internet connection and profile page personal information are enough to be able to start disseminating the messages. However, these procedures can face more complexity according to the extent of effectiveness the authorities want these tools to reach and reliability of these tools. For example, when using twitter as a primary source of hazard information to public, there will be a need of well established controlling and monitoring system especially for messages disseminated by public, where true information should be verified and false ones should be eliminated [20]. Also, by integration of these social media tools in warning message dissemination, a guarantee for specific, up to date and detailed warning messages will be obtained, since people can have more than one source of information, of course this can make a case of confusion, but still it will be better than performing actions which rely on false information, the fact that can cause undesired consequences later on.

The previous part shows the way that the emergency authorities can communicate with the public for an impending emergency. For the reverse communication line, for all of these social media tools, there is a number of tools that can allow their users either to share or repost the received information at their personal profiles or to exchange them with others (sharing into a friend's account in Facebook, or retweeting in Twitter) or to interact with the posted information through comments or posting on the official organization's pages, which if it is well controlled, it will help to grab people who need more clarifications about the upcoming hazard or the preparedness guidelines in prior emergency stages, and to catch people who are needing special assistance or help in later stages. This helps

also the emergency management organizations to track the public understanding and response towards the disseminated hazard messages.

One other important opportunity in using social media as a warning communication tool is the possibility to disseminate more detailed warning information from different emergency control agencies experiences. In most of the traditional media tools like Radios or telephones, the content of the warning message is always containing the brief and unified message that has a form of a summary of the wide lines decided by each agency [20]. For example, in the case of Na-Tech disasters, a warning message can inform that the chemical leakages or radiations can make health problems and fires at public properties. However, due to the time limitation, medical experts for example cannot describe the nature of health problems associated with these disasters or if there are some special categories of people who are more subjected to severe injuries or health complications. In the usage of the rapid message dissemination characteristic fulfilled by social media, each agency can establish their own official pages and providing people with more valuable information and special guidelines to cope with the upcoming hazard.

3.4.2 Informal alerts

Another paramount usage of the social media in crisis communication is the possibility for the public to establish unofficial lines of communication between each other, the fact that can give them an ability to share some information which may not be covered by the messages sent by the emergency management authorities. In times of crisis, Social Media provides the opportunity for people to participate and contribute their ideas, experience and knowledge. They participate personally in Social Media because they value and identify with the purpose. Their post experiences can be possessed by other information sources like individual calls from the emergency management members to people, or by direct observations. Moreover, the informal communication between the people can help in quicker

response towards people who need special help during the emergency, a perfect example can be in 2008, where during the Mumbai terrorist attacks; Twitter was a source for breaking the news and sending out emergency contact numbers and locations of hospitals that needed blood donations. Local Mumbai bloggers used their blog sites to get the word out and let people know what was happening. [26].

On the other hand, the allowance of public exchange of emergency knowledge and information can result a high level of uncertainty regarding messages credibility. First, their messages can over or under estimate the description of the real cases. H. Jenkins describe that the consumers are missing practicality over their own information. By applying on the public warnings, due to panic and the overestimated feel of danger, some people can write down hazard information with some personal points of views additives or in means of exaggeration to grab the attention of public and authority members even with the absence of real danger but just in sake of more warranted safety. A message example can be when police publish an identification photo with a criminal wearing a hat, some people can post that they've seen this criminal each time they can observe someone walking on the street with a hat. [27]

Another issue that contributes in the lack of message credibility is the establishment of fake accounts or establishment or broadcasting completely false alarms without any referenced sources. The fact that social media accounts especially twitter and Facebook are hardly and not directly controlled by the authoritities provide a space for any gossip or rumor makers to publish any information that not relates to the reality at all. Author Donya Curie furthers this observation by stating, "A major challenge of Social Media, however, is a lack of confidentiality and a danger of non-verified information flashing around the globe at lightning speed. A common barrier to adopting Social Media in communications strategies can be the fear that

too much information too soon will create panic." [28]. According to the American Red Cross, "Use of publicly available data in times or a place of crisis raises issues of authenticity, privacy, veracity and ownership." [29]

To avoid the lack of message credibility concerns when using social media as a main source of emergency warning dissemination tool, three approaches are proposed. The easiest approach is to oblige people to add some identification information attached to any posts related to the existing crisis and setting penalty laws in case of concluding any misleading or false warning information. Despite of the easiness of this approach, its effectiveness is far from happening due to the need of time and investment to establish a controlling and investigation system especially at post emergency stages since that he main aim of the authorities at this time is to estimate losses and starting emergency relief processes, and the elaboration of other uncertainty that people will follow these rules and put their contact information when disseminating public warning messages. The second approach, which is considered a main challenge of the usage of the social media, is establishing a whole formal system for monitoring conversation. This approach can guarantee much better results than the previous one but it eliminate the advantage bound in the rapidity of initiation time of this message dissemination tool. In his article, A. Stone (2009) states that "The biggest investment in Social Media comes in the form of time: Setting up accounts, broadcasting updates and monitoring conversations." The last and most effective approach upon all, is the role of NGO's. NGO, which is the synonym of "Non-governmental organizations" are defined as "the term commonly used for an organization that is neither a part of a government nor a conventional for-profit business. Usually set up by ordinary citizens, NGOs may be funded by governments, foundations, businesses, or private persons" (Humanrights.gov, 2012). NGOs are considered as the warning message mediators between the emergency management authorities and public. Through the official announcements

of their links through the pages of social media applications, they can initialize unique points of communications like pages in Facebook or unique alert hashtags in twitter, the organization members are responsible to inform the public about the continous fed hazard information broadcasted by the official authorities to provide the public with trusted sources of information to take responses in place, and on the other hand they are responsible to control the public information and evocations to the authorities using social media or any other effective means of communication like mass and telecommunication ones. By increasing the number of these organization, a more guarantee of an adequate control and awareness about what public inform will be available. For example, recent studies had revealed that the numerous number of NGOs in India is reaching the availability of one organization for each 400 citizens, which had shown its effectiveness of awareness and public control in many crisis events. [30].

The emergency authorities can assure two main benefits from the public informal alerts. First, it guarantee a much higher scale of warning message distribution, since people will be more aware about the extent of the crisis when they receive its information from their friends or family members present on their profile's friends list. Second, if they are an adequate control about the credibility of the information posted by public, they can be considered a powerful source of information to help in adequate responses and plan changes since these information are coming from the actual calamities rather than depending on plans based on probabilities and past experiences.

3.5 Real social media application (Twitter alerts)

3.5.1 Introduction to Twitter alerts

The micro blogger, Twitter, is considered the most vital and reliable application to be used as a social media tool for warning communication during

hazards and crisis. According to the article of B. Coyne [31], the official and unofficial organizations recently are using twitter as a main critical and timely information and engagement with public tool in the cases of massive crisis like the examples in Sandy hurricane, tsunami in Japan and more.

In general, the idea of Twitter is allowing the option of its registered users to create their own profiles and to post and read unlimited number of brief messages, named tweets, with 140 characters length limit for each. The default settings provide the visibility of members tweets within all the service's registered members across the world. For that reason, twitter became the main source for celebrities, organizations and even governments for posting their timely updates and engagement with their followers. Moreover, the unique twitter option "hash tagging" had provided a smart information sorting technique. These hash tags are considered as common keywords for information relevant to the same topics, so any tweets including similar characters following the hash tag symbol "#" can be sorted and listed within one page, so the users can have the easy possibility to possess all the information regarding a relevant topic at the same place.

The previous facts reveal the generalized service that twitter offers for its users, for the sake of more specialized uses for this social media tool, there had been the set of new services that sorts the twitter messages according to the type of activities related to the tweets. For example, twitter sport service had been established for providing the users to contribute with their sports idol, getting continuous real time updates about football matches and so on. Much other kind of services are available like Twitter Government to update public about Governmental announcements, elections, etc. and Twitter news for posting latest news in local and global scales.

On the field of emergency and crisis management, twitter has recently launched the service of "Twitter alerts" which is considered one of the most recent

effective emergency informing tool and a reliable source of information when other official sources are not available. This service provides a closer level for helping communities in receiving critical and updateable information at the times of the impendence of emergencies and crisis as a result of environmental and natural hazards. [31]

The differentiation of this service from the general twitter posting system is found in the way of the message dissemination, where twitter alert service sends the warning messages through multi channels of communication and into different message communication tools. When users subscribe into this service independently from their normal account, they will be able to receive the warning message disseminations in a variety of ways. First, twitter surfers upon their computers will be able to see unique alert messages discriminated from normal tweets, where these messages will be visible in a special identification with orange bell icon like in figure (3.1). Second, users of regular phones will be able to receive the warning messages directly into their phones by short messages service (SMS). Finally, users of smart phones and tablet devices with installed twitter app will receive a push notification about the warning content. To activate this service, the users can use their already signed up Twitter profile in addition to entering a main additional inquiry which is the phone number for opening the channel for communication by SMS. [32]

Figure 3.1 the interface of the unique twitter alert message [32]

The service of twitter other is applicable for usage by the municipal or regional emergency management organizations, as stated in the article of [32], the list below provides examples of the parties that can get the advantages of this service:

- law enforcement and public safety agencies;
- emergency management agencies;
- city and municipal governments, as well as their agencies and representatives;
- county and regional agencies, providing services to cities and municipalities;
- Select state, federal, and national agencies and NGOs.

3.5.2 Twitter alert participants

The twitter alert message is not considered as the original warning message disseminator but only allows a communication channel for broadcasting it. For that reason, organizations and authorities need to register for the services of twitter alert to be able to send their warning messages through it.

The planned scale for this service is a worldwide one; the main aim is to make Twitter alerts a common and main tool for crisis communication line between emergency management organizations and their public. Currently, a number more

than 100 agencies and NGO's had already considered twitter alerts as a main warning message dissemination tool for their public. In this section, three examples will be mentioned from these organizations to understand the service's roles and methodologies of usage.

3.5.2.1 Ushahidi

Ushahidi is a nonprofit organization specialized in software solutions that provides free and open source applications that provides a variety of options including information gathering, illustration and interactive mapping. The organization uses the concept of crowd sourcing for social activism and public accountability [33]. The services of Ushahidi are proposed to share information about crisis of any kind. Examples are after Kenya presidential elections violence in 2007, Queensland flood in Australia in 2011, and Forest fires in Italy at 2010.

The crowd sourcing is defined as the process of obtaining needed services, ideas, or content by soliciting contributions from a large group of people, and especially from an online community, rather than from traditional employees or suppliers. Ushahidi applications are serving as an initial model for what has been coined as "activist mapping", the combination of social activism, citizen journalism and geospatial information. Ushahidi offers products that enable local observers to submit reports using their mobile phones or the internet, while simultaneously creating a temporal and geospatial archive of events [34].

For allowing a greater distribution for the crisis information among public, Ushahidi uses the information gathered at their website and applications and post them through twitter alerts service in the form of tweets. This reveal the high extent of public engagement with their authorities to share their information regarding emergencies in increasing the distribution scale of alert information dissemination, where in this case, the Ushahidi organization had collected the data gathered

through their crowd sourcing services after information verification, and sent it to other sources of direct communication which will by turn help in the delivery of the messages to a bigger range of public members.

3.5.2.2 Crowdmap

Crowdmap is considered one of the most popular applications implemented by Ushahidi software Solutions Company. The concept of crowdmap is also depending on the public journalism where people are having the opportunity to share any knowledge, illustrations and inquiries about the impending emergencies. However, this application add a step more into information message clarity and illustration in terms of social mapping, where people's post will be accompanied with geotagging techniques which will help in determining the location of the sender and post it into an interactive map that shows the exact locations of the disseminated message with all of its contents. [33]

The Figure 3.2 illustrates an example of map for warnings towards Floods in central Europe from the crowdmap application. The location icons represent the location of the tweets and information sent by users, by expanding each icon, all the content of this message will be revealed. In addition of the more clarity of the disseminated message accompanied with this technology, another important option can be found is the assistance of public to graphically getting awareness about the most flood prone areas and by personal wisdom they can come out with the risk severity of these areas, the fact that can help them to take corrective actions in terms of safety seeking.

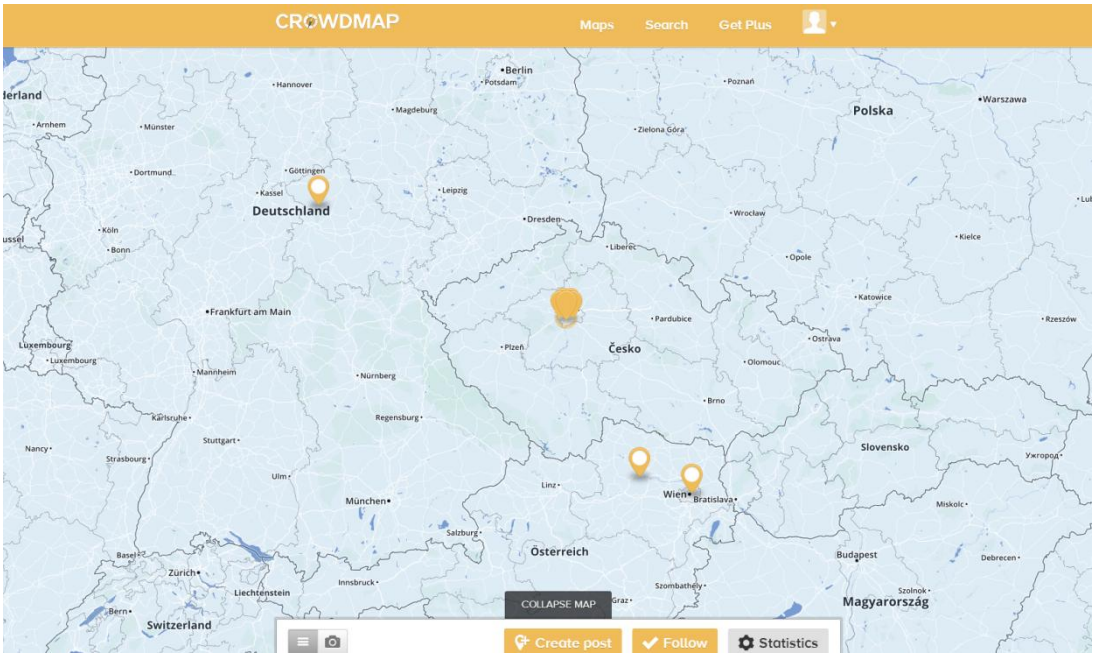

Figure 3.2 Social interactive map floods in central Europe

Twitter alerts in this case also reflects the importance of the double way communication between emergency management authorities and public sector, where also in this application provide an assurance of more message dissemination scale by opening the opportunity of warning communication through more communication channels, where all the information posted by public can be gathered by the regional authorities and transformed to official warning for other public members through twitter alert service, which in turn will automatically disseminate the warning message through the communication tools of SMS, internet, and notifications through smart phone devices.

3.5.2.3 UNOCHA

The United Nations office for the coordination of humanitarian affairs is a direction of the United Nations organization that is responsible for establishing a contribution framework with the response of complex emergencies and crisis. The main objectives of this office is to

- Mobilize and coordinate effective and principled humanitarian action in partnership with national and international actors in order to alleviate human suffering in disasters and emergencies.
- Advocate the rights of people in need.
- Promote preparedness and prevention.
- Facilitate sustainable solutions.

During emergencies, UNOCHA basically was depending on reports and publication's based warning message dissemination, the fact that was making it hard and time consuming for public to gain the awareness of the impending emergency, where the communication line was consisting of the receive and Understanding of the warning contents though the reports then the warning message was being disseminated by local emergency management organizations using other common message dissemination tools to public, or by the direct understanding of these reports by public which is so hard to maintain. However recently, the UNOCHA had participated in the Twitter alert service for the assurance of a global dissemination of the impending emergencies with a larger scope over people subjected for danger due to the impending crisis and in a much shorter communication line, where by using this service, a direct and brief warning message content could be sent by social media users from public so they have thr adequate crisis preparedness without waiting the alert notifications from the authority's emergency management sector. [35]

3.5.2.4 WHO Europe

The World health organization (WHO) is an agency branched from the United Nations organization that is tasked for the mitigation of the World threatening diseases and epidemics such as HIV, malaria and recently Ebola. It is responsible for providing leadership on global health matters, shaping the health research agenda, setting norms and standards, articulating evidence-based policy

options, providing technical support to countries and monitoring and assessing health trends.

From the above lines, it can be observed that the WHO organization responsibilities were bound in scientific health researches and providing only information about their findings and conclusion. However, by taking the European branch as an example, WHO Europe had started their operations for taking their findings into a further step and transforms them into brief hazard messages and alerts that can be directly sent to public through the services of Twitter alerts. This process is severely important when then there is a need for public cooperation to eliminate the risk of distribution of the recent diseases or epidemics in case of starting signs of occurrence. An example can be in case of the appearance of Ebola symptoms over one or more persons within a region, by the direct twitter alert messages to public, people can gain more preparedness and precautions for preventing the transmission of this virus for others by following the safety instructions learnt, the fact that will eliminate the disaster of the large epidemic distribution in the local or beyond local scales. [36]

Chapter 4

Case study: Expo 2015 event in Milan, Lombardy region

4.1 Introduction

This chapter will briefly explain an application of the integrating the different tools of warning message dissemination for multi-hazard emergencies in the case study of the Expo exhibition event carried in the city of Milan, Lombardy region, Italy. This chapter will reveal a brief introduction about the study area, the management and policies referring to the processes of civil protection and emergency management. Moreover, it will explain some facts and details about the nature of the Expo event with all the possible threatens that can take place to the event participants and region visitors. Finally, a presentation about the possibility of usage of latest communication technologies in designing a unified media for using different tools of warning communication lines between emergency detection and management subsystems, and between the management subsystems and public in the form of web applications technologies for disseminating alerts regarding hydrogeological risks

4.2 Introduction to Lombardy region

4.2.1 Geography

The Lombardy (Italian: Lombardia) is one of the 20 regions of Italy. It is located at the Northern Italy with total area of 23,844 Km^2 and bordered by the country of Switzerland from North, the Italian regions of Trentino-Alto Adige/Südtirol and Veneto at East, The region of Emilia-Romania at South, and Region of Piedmont at West. Figures (4.1) and (4.2) illustrates the location of Lombardy within Italy and it's main map.

Figure 4.1 Location of Lombardy region on the Italian map

Figure 4.2 Lombardy main map

The region is characterized by the plenty of water sources. First there is an existence variety of natural lakes that are originated from the glacial zones of

Alpine mountains which are mainly located at the Italian south borders. By heading from west to east directions, the lakes are Lake Maggiore, Lake Lugano (shared with Switzerland), Lake Como, Lake Iseo, Lake Idro, then finally the Lake Garda which is considered the largest one in Italy. Moreover, A large number of rivers, all direct or indirect tributaries of the Po, cross the plains of Lombardy. Major rivers, flowing NW to SE, are the Ticino, the outlet of Lake Maggiore, the Olona, the Lambro, the Adda, outlet of Lake Como, the Mincio, outlet of Lake Garda, and the Oglio, the Lake Iseo outflow. [37]

4.2.2 Tourism

In general, the economy of Italy is mainly based on the annual arrival of regional and international tourists across the whole country, with the variety of Natural, historical, cultural and mountain activity attractions, Italy had been ranked the 5th for the annual tourists' arrivals in 2013 with the number of 47.7 millions arrivals obtaining a revenue of €33,064 millions with an average daily expenditure of € 102.77 per tourist, exceeding the year of 2012 by the number of 1.3 million tourist arrivals, and revenue of €1008 million [38]. The distribution of tourism arrivals and country's revenue across different divisions are shown in the figure (4.3) and (4.4) below:

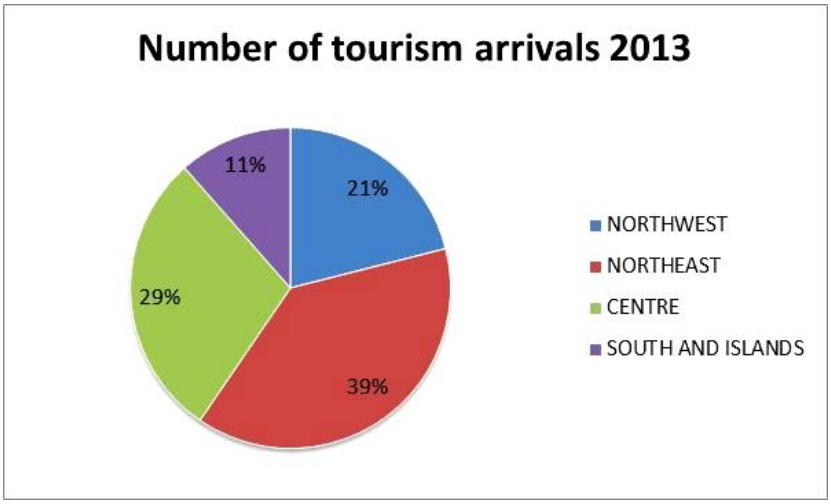

Figure 4.3 Division of tourism revenue across Italian regions

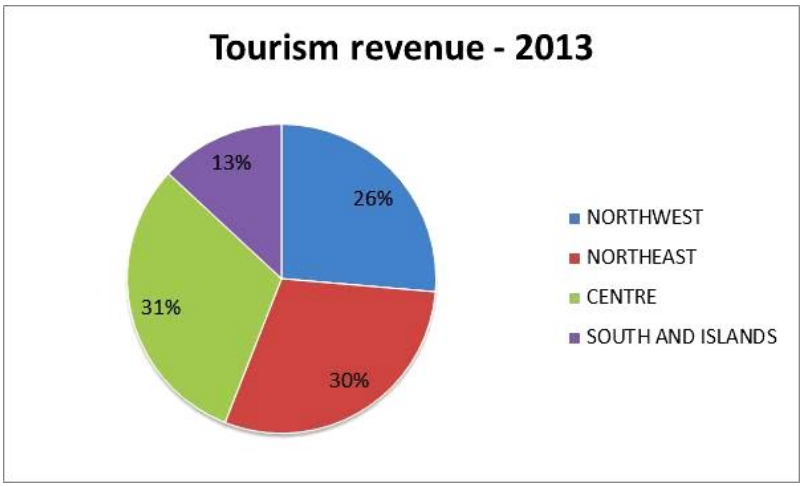

Figure 4.4 Division of tourism arrival across the Italian regions

By a deeper focusing on Lombardia, The tourism in the region had achieved a number of tourism arrivals of 6.9 million arrivals. As stated in table 4.1, Tourism in Lombardy region represents 67% of the total tourism in the North-Western part of

Italy at 2013, which in turn represents over 14% of the whole country tourist arrivals [38]

Table 4.1 Total tourism arrivals in North-western Italy

North-West Regions	*Number of tourist arrivals*	*Percentage*
Lombardy	6883106	67.08%
Liguria	1463312	14.26%
Valle d'Aosta	337626	3.29%
Piedmont	1577733	15.37%
Total	10261777	100.00%

4.2.3 Administrative divisions

The Lombardy regions is mainly divided into 12 provinces, table (4.1) show the different characteristics of each province in means of Total area and number of population by mid 2014 [39]

Table 4.2 Characteristics of Lombardy provinces [39]

Province	*Total Area (Km^2)*	*Population*	*Code*
Bergamo	2,723	1,096,972	BG
Brescia	4,784	1,250,817	BS
Como	1,288	594,973	CO
Cremona	1,772	362,098	CR
Lecco	816	339,752	LC
Lodi	782	226,586	LO
Mantua	2,339	411,911	MN
Milan	1,575	3,128,232	MI
Monza and Brianza	405	856,936	MB
Pavia	2,965	542,579	PV
Sondrio	3,212	181,490	SO
Varese	1,199	878,941	VA

Figure 4.5 Provincial division of Lombardy region

4.2.4 Capital

The Capital of Lombardy region is Milan, which is considered the second most populated city after Rome, and the fifth largest Urbanized European city with an estimated population over 5 millions capita within the active day time [40]. While Rome is considered as the political capital of Italy, Milan is considered the economical city of the country which is a home for large and international business in a variety of sectors mainly on banking, fashion, mass production and construction industry sectors in addition to international Trading exchange and Logistics services.

Apart from the center of Milan, the center region of the city includes main 9 zones in addition to a large area of districts outside the borders of the main city, forming a sophisticated metropolitan area. Figure (4.6) and (4.7) represents the main maps of the center of Milan and all the districts of the city metropolitan areas.

Figure 4.6 Map of Milan metropolitan area

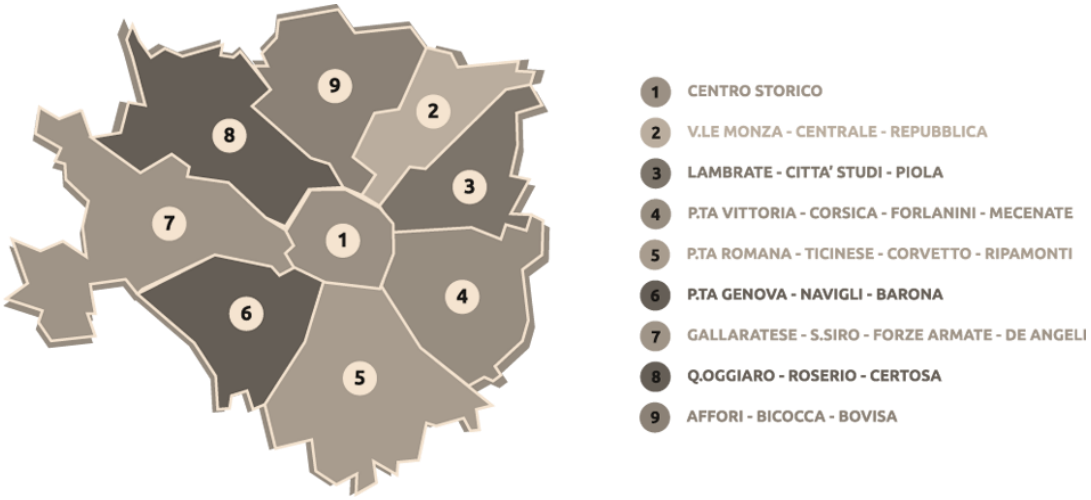

Figure 4.7 Map of main zones of the city of Milan

With Milan metropolitan area, the city had been achieving a €132.5 billion GDP by 2010, the city of Milan contains over 45% of the economy of Lombardy region including three of the richest 500 –based on revenue- international companies according to Fortune magazine ranking lists, and about 8% of the Italian economy. Moreover, by a GDB of $115 billion for the provincial area, Milan is considered the 26th most expensive city according to its purchasing power, and 11th most expensive city for expatriate employees. [41]

The city's Exhibition Center and Trade Fair complex is one of the most important in the world. Abroad Fiera Milano is a prestigious window for the Country's National products of the world and has 43 offices in 67 foreign countries. Fiera Milano has two fair areas: fieramilanocity and fieramilano in Rho, which is a new fairground in the north-western suburb (opened in April 2005). This is Europe's largest open construction project and makes Fiera Milano the largest trade fair complex in the world. Fiera Milano organizes exhibitions and conferences while hosting multiple different promotional shows for the industry. The Fiera Milano city

exhibition center had achieved hosting over 100 international exhibitions with total of 35,000 exhibitors and rented about 1.8 net m^2 of exhibition space (Erbusco, 2013). The new Fiera Milan It is the biggest industrial city of Italy, situated in the area of the ex refinery of Rho Pero. Because of its size, more than one exhibition display at the same time. The New Fiera has many different industrial sectors such as: manufacturing of textiles and garments, car manufactory, chemistry, mechanical tools and heavy machinery. Another important industry is tourism and of course fashion. [41][42].

4.2.5 Transportation

The region of Lombardy is supported a sophisticated transportation network that serves a good number of alternative and frequent transportation solutions within the region and into and out of it. For that section, a more focus will be conducted on the available transportation means and networks inside the capital Milan and into and out of the city.

4.2.5.1 into and Out of Milan

For reaching and leaving the capital of Lombardy within the region, the main two means of transportation are the by regional and highway road networks and the usage of regional and sub urban railway networks. The following lines will explain the two transportation systems into more details

1. **Road network:** The is a variety of types of roads in Lombardy region that together form a sophisticated and efficient road network connecting all the regional provinces and communes with each other. The traffic and emergency management is mainly performed by the traffic Police “polizia traffico stradale” and the roads construction and maintainance is done by the National Autonomous Roads Corporation (formerly, ANAS, Azienda Nazionale Autonoma delle Strade) [43]. The next figure (4.8) and table (4.3)

represent a brief road network map within Lombardy region and the different types of roads in Italy

Figure 4.8 Road network in Lombardy region

Table 4.3 Types of roads in Italy [44]

Road type	***Prefix***	***Description***
State	SS	Double carriage not tolled roads connecting between cities or town centres
Regional	SR	The same type of State roads which are controlled by the regional authorities
Provincial	SP	
Municipal	SC	Multiple lanes roads that are connecting different regional municipalities
highway	A	Double carriageway, tolled roads connecting different cities or regions

2. **Railways:** The railway transportation is considered one of the most vital means of transportation in Lombardy region as a result of its accessibility to all the region provinces and most of their inner cities. The railway network and services in Lombardy region are managed by "trenord" which is established by the main Italian railway management company "trenitalia" and "Ferrovie Nord Milano". and their services are divided into the regional and suburban railway services, where the first concerns about the railway transportation within the different provinces and inner cities within the region while the latter is based on the 10 underground railway lines connecting 106 stations within the Milan metropolitan area. [45]

   The capital Milan is considered as the central destination for the whole railway network within Lombardy regions, containing alone a number of 22 railway stations considered as arrival and destination points for both railway transportation services mentioned above. [46]

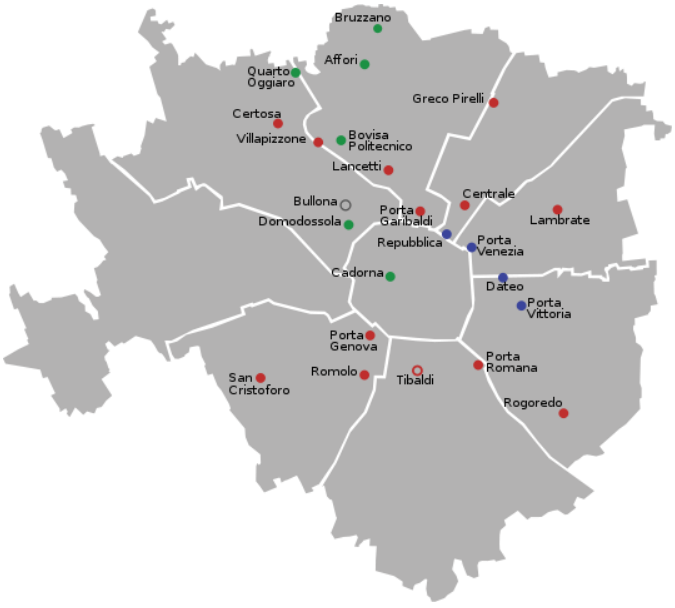

Figure 4.9 Spatial locations of railway stations in Milan

4.2.5.2 inside Milan

The main organization for the operating, controlling and managing the transportation system in the city if Milan is “Azienda Trasporti Milanesi (ATM)” which is a public company, responsible for public transportation in Milan city and some surrounding municipalities. It operates tram lines, urban Bus lines, Trolleybus lines, interurban Bus lines, and underground lines (Metropolitana di Milano), carrying over 734 million passengers in 2010. [47] In more details, the available transportation systems within the capital are:

1. **Underground Metro:** The Milan Metro is a rapid transit system, running mainly underground, serving Milan and other surrounding cities. The network consists of 4 lines, identified by different colors and numbers. Those different lines assure the accessibility of a wide number of districts within the city and some of the extra urban areas. A representation of the metro lines across Milan is shown in figure (4.10)

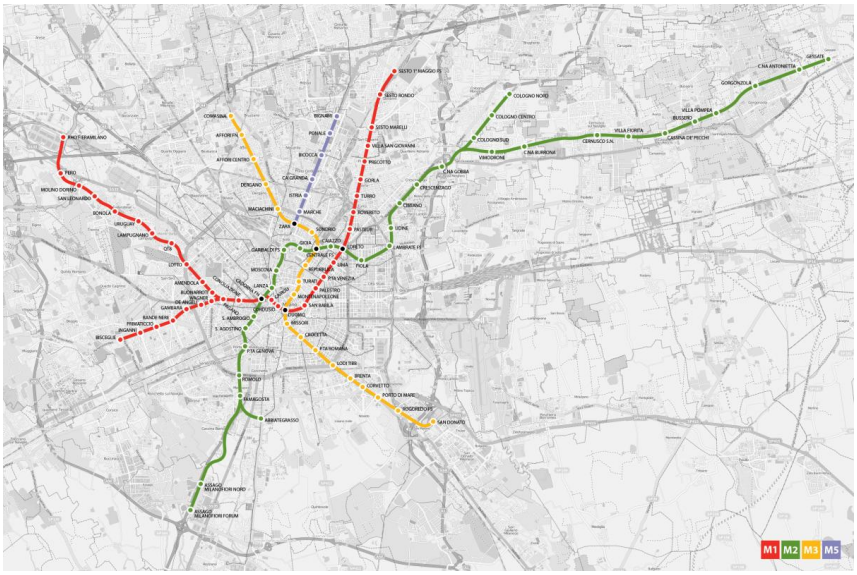

Figure 4.10 Spatial locations of railway stations in Milan

2. **Busses:** There are 82 bus and 5 trolleybus lines in Milan Most of the routes do not run during the night, however, bus services on demand are available in the weekend at night. New night bus lines during weekends have been introduced since 24 September 2011, running from 2 am to 6 am on Fridays and Saturdays. The new network was considered a success, with more than 8,000 people using the lines every weekend. In addition, the transportation service offers 35 interurban bus lines for transportation across the Milan metropolitan area and nearby regional provinces.
3. **Trams:** The Tram network comprises 17 urban lines and 1 interurban line (Milan - Limbiate). The system is more than 115 km long and is the biggest network in Italy.

4.3 Lombardy region risks

A risk is a situation that poses a level of threat to life, health, property, or environment due to impending hazards. Most hazards are dormant or potential, with only a theoretical risk of harm; however, once a hazard becomes "active", it can create an emergency situation. A hazardous situation that has come to pass is called an incident. Hazard and possibility interact together to create risk.

4.3.1 Risk homogenous sections

Before explaining the details about the possible hazards that can occur at the Lombardy region, it is worth to mention that while the region is divided into administrative provinces as stated before, the region is divided into homogeneous zones of alert for the purposes of addressing the zones including the same level of subjectivity of a certain impending hazard. These sections are territorial substantially uniform about the effects on the ground, that is the risk, which consider. The distinction in areas derives from the need to enable consistent and appropriate responses to address the risks for the population, for the social and the

natural environment. Because any risk depends on several external causes, which are of course dependent on factors of Meteorological, geological, hydrographic and administrative, to every risk considered associated with specific zoning districts.

4.3.2 List of possible regional risks

In Lombardy Region in Italy, the weather changes and their related events are the most main reasons for creating risks that plays a negative effect on lives and property, where the region faces regular heavy rain and snow periods which in their turns can cause snow avalanches, landslides, floods and flash floods.

4.3.2.1 Hydrogeological

The geological risk is related to the probability of the occurrence of natural disasters such as floods and landslides, which cause damages to the environment and to humans. Normally hydrogeological phenomena are triggered by meteorological events also concomitant as temperature changes, frost and thaw and heavy rains, which determine, in more serious cases, the transport to the valley of the large volumes of solid material. Each person or movable and immovable, hit by these phenomena, can be subjected to serious damage which are sometimes irreversible. [48]

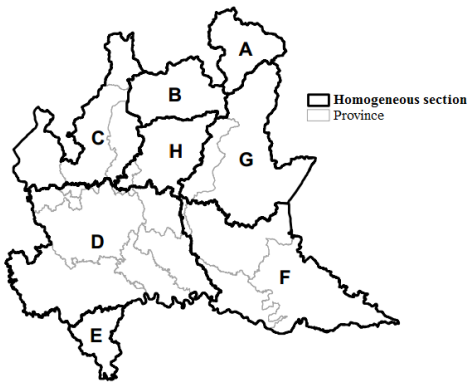

Figure 4.11 Homogeneous sections for hydrogeological risks [48]

4.3.2.2 Hydraulic risks

The hydraulic risk refers to the phenomena of transfer of flood waves in the sections of valley ground and plains that are not contained within the natural locus or levees. The water invades the outdoor areas with natural water levels and variable speeds depending on the intensity of the phenomenon and the conditions of the terrain. Any person or movable and immovable, exposed to these phenomena, can suffer serious consequences. In general, these phenomena are also very extended, which in doing so may generate serious damage. [49]

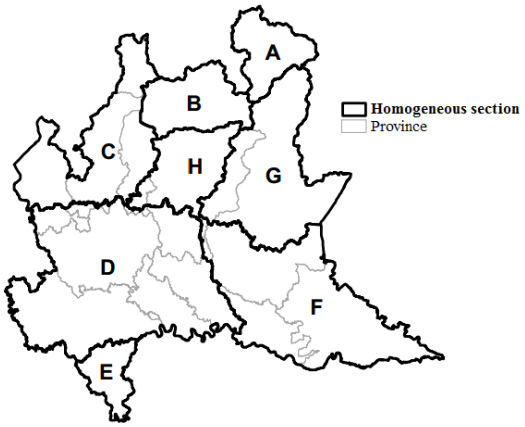

Figure 4.12 Homogeneous sections for hydraulic risks [49]

4.3.2.3 Severe thunderstorms

The risk is related to the intense phenomena thunderstorms occurrence, which is accompanied by other severe consequences as rain showers, often hail, lightning, gusts of wind and sometimes tornadoes, however not should be always at the same time. From these phenomena, different types of damage direct and indirect, for the people and property in the area affected may arise. [50]

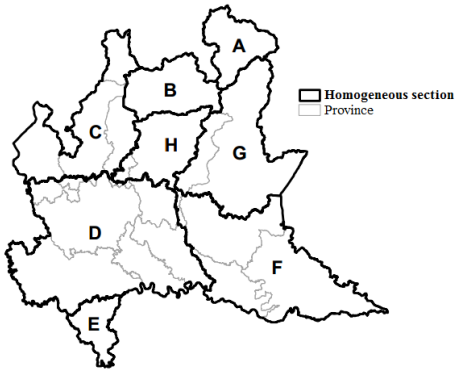

Figure 4.13 Homogeneous sections for severe thunderstorms risks [50]

4.3.2.4 Strong winds

This risk considers the consequences induced by wind conditions particularly intense. The arc Alpine, in Lombardy, is a barrier that significantly limits the possibility that events typically assume catastrophic proportions; for which the direct risk refers to the action exerted on the stability of scaffolding, billboards, trees and temporary structures. Also the strong wind causes difficulty to traffic, especially for heavy vehicles and is an aggravating factor for other risks. [51]

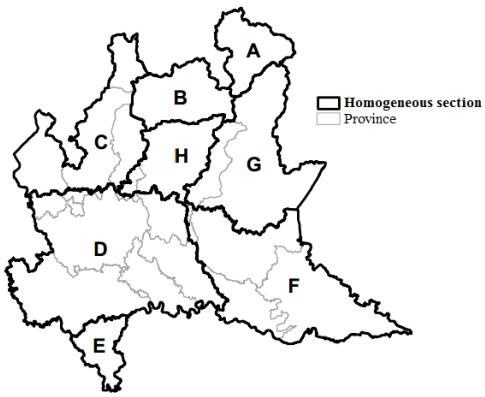

Figure 4.14 Homogeneous sections for strong winds risks [51]

4.3.2.5 Snowfall

The snow risk refers to the consequences induced by snowfall on ground in quantities that lead to difficulties in the activities normally performed by the population, delays and disruption of public transport and private line services, (electricity, water, gas, telecommunications, etc ..) as well as damage to structures. [52]

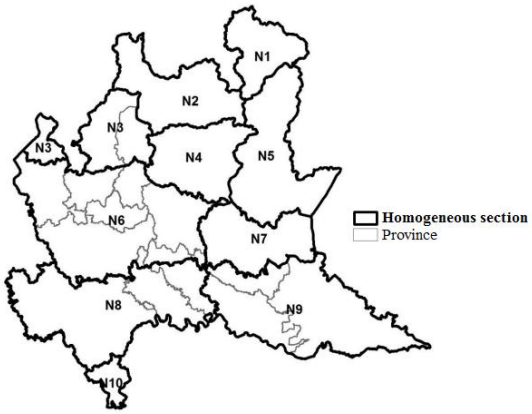

Figure 4.15 Homogeneous sections for snowfall risks [52]

4.3.2.6 Snow avalanche

The avalanche risk refers to phenomena of instability of the snow masses, which can cause the movement of the snow masses to the valleys, generally at high speeds, causing serious damage. Usually, this risk is taking place on the mountain valleys at high elevation levels. [53]

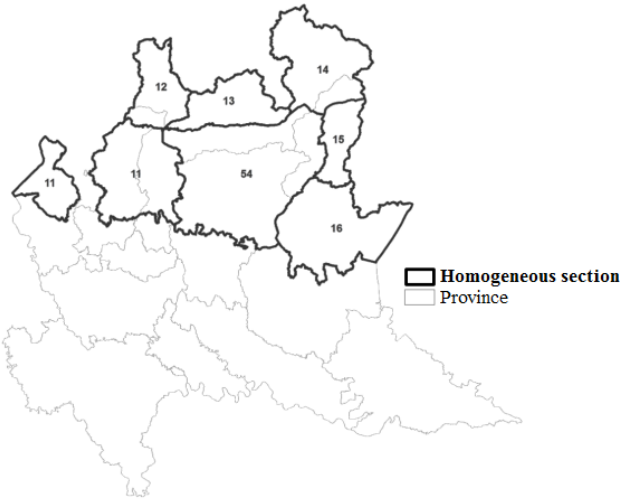

Figure 4.16 Homogeneous sections for snow avalanche risks [53]

4.3.2.7 Forest fires

This risk refers to phenomena related to the onset and extent of fire outbreaks that may expand on wooded areas, bushy or arboreal, including any structures and infrastructures populated placed inside of the aforementioned areas, or on cropland or pastures and fallow to these neighbors. [54]

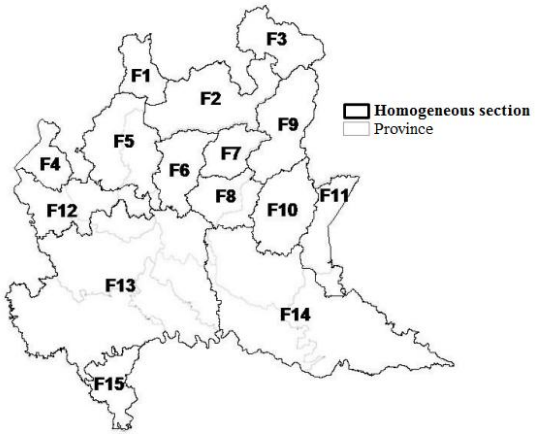

Figure 4.17 Homogeneous sections for forest fire risks [54]

4.4 Lombardy region risk alerting policies

For the above mentioned hazards, there had been a need for an efficient system for monitoring and expecting the upcoming hazards in terms of technological and statistical means. In addition, the need to have pre-assessed emergency plan and control procedures including placing different thresholds that help in knowing when to realize the need of attention and taking appropriate actions in the appropriate time. A brief explanation of the system of emergency preparedness taken by Lombardia authorities and different agencies and parties is going to be mentioned in the next lines. [55]

4.4.1 Regional normative

4.4.1.1 Roles and responsibilities

There had been many updates of the rules regarding the main roles and responsibilities assessed by the Mayor in case of emergencies. Where the rule 142/1992 states that The municipalities become holders of its functions to them attributed to the State and Regions. And the act No. 225/1992 states that the Mayor become the main responsible for his own municipality. These rules had been extended at year 1993, where the act informs that Among the essential services of the municipalities is also part of the Civil Defense, not only as an aid, but as well as prevention. Finally, the mayor acts the head of all civil protection activities as stated in act no. 16/2004.

These rules sum up the importance of the roles and responsibilities of the Civil defense department ruled by the Mayors, where they are the main heads of the civil protection activities at their municipalities; Their main responsibilities to address the risks of the territory and to provide and organize all essential skills and

resources to mitigate the impacts that can take place due to the expected hazards. Their roles are only bound in the rescuing processes but only for prevention.

In addition to the law 265/1999 the Mayor has also duty to inform and warn people about the risks active on its territory and the rules of prevention. In accordance with current regulations cited above, the Mayor plays in triple opportunities which are:

1. head of the Administration
    - Ensures municipal services indispensable in the Civil protection.
    - Performs the functions of art. 2 the L.r.16 / 2004 and art. 6 of L. 225/92.
2. Official Government
    - Ensures the delivery of services that meets the pre defined measures
3. Municipal Authority
    - Conducting the first rescue actions
    - Activation and coordination of Civil protection
    - Alerting and regularly informing the population.

In addition to all the stated roles that mainly focus in the role of the civil protection department of each municipality, headed by its mayor, Lombardia region had placed set of strict punishment regulations in case that the Mayors had failed to take their assigned responsibilities in case of incidents occurrence. These regulations could be found for example at article 328 which indicates punishments in case of rejecting the alert notice from the functional monitoring system or delaying the response. In addition, article 40 c.2 puts an equivalent accusation of non preventing an informed event as causing it. From this brief analysis of the legislation in force, shows that the Mayor before any obligation to know and recognize the risks present on their territory and to be the point of reference in case of emergency within its municipal area.

To secure the services of Civil Defense, the Mayor will have the following roles in both peace time and emergency phases:

- **Peace time phase**
  - Conducting an emergency plan to be used in anytime any event will take place
  - Establishing a department of civil protection for his own municipality, or to make agreements with already existing civil protection associations
  - Providing an efficient communication means to assure alerting the civil protection department members at the least time in case of event occurrence.
  - A ceaseless tracking and following the evolution of any events that will lead to risks at his own territory, which in turn required keeping in touch with the functional monitoring center of Lombardia region.
  - To provide an educational background for the population about emergency preparedness and the most appropriate actions to be taken into account in case of hazardous events.

- **Emergency phase**
  - Activating the pre-conducted emergency plan (as stated before).
  - Immediate informing to the municipal civil protection department and all stated involved parties in the emergency plan, including voluntary services.
  - Keeping the contact with Lombardia region functional monitoring center for a regular update about the hazard situation and evolution.

- Informing the population about the excpected event, with primary guidelines of actions to be taken.
- Reporting the situation of the municipality including the imposed losses and damages to both property and humans within 7 days after the event. Ra.S.da which stands for “Raccolta Schede Danni” which is a damage data sheet special for Lombardia region which has its unique forms and procedures in order to assure a proper documentation and archiving of the event occurred for the certain municipalities.

4.4.1.2 The emergency plan

To play an effective civil protection service in the territory, there is need to prepare to deal with critical situations, through a good emergency planning. For this L.r. 16/2004, art. 2, letter b) refer the matter to the municipalities in the preparation of municipal plans and / or inter-municipal emergency and also taking advantage of the associative forms of cooperation provided for by Law 267/2000. The goal of a municipal or inter-municipal Emergency Plan is the identification of risks and related different scenarios in the municipal and inter-municipal and resources available in the event of an emergency, the organization of the emergency procedures, the activity land monitoring and assistance to the population. Therefore it is essential for the analysis of hazardous phenomena or the potential sources of danger to the lives and property in the area.

The rules at the region obliges the provinces that are bounded at the region as areas subjected to hazardous events at any time and others which are already stated D.G.R. n. 8/7374/2008 Annex 13, Table 3 to conduct their own emergency plans for different types of risks. In addition, These mentioned municipalities can inquire association and cooperation with other ones to have plans in a wider scale. At the end, the conducted emergency plans are sent and submitted to the Province and the

whole region to help in facilitating the actions of the subsidiary agencies at the time of the real event occurrence

4.4.1.3 During and after emergency

The Mayor, first of all, is required for providing relief to the population, so actions and plans must be activated immediately and do not wait to be rescued. However, if certain events, or by gravity extension, exceed the possibilities for action level municipality, the Mayor may request the intervention coordinated more bodies in the ordinary way, or even the operation with extraordinary powers by the State. The Civil Protection system in fact operates according to principles of subsidiary it is able to integrate, at Depending on the intensity and extent of the event, the different levels of intervention envisaged in the organization. As a result, events are classified into three types:

- Type A: Types of the events that can be handled by the facilities and resources provided by the Mayor to his own municipality.
- Type B: The event nature had been exceeded the abilities and resources for the municipality and needs a multi-agency cooperation. For that reason, the Mayor reports the situation to a wider spatial scale, That is for prefectures, province, region, etc .In addition, he sends requests of needed reinforcements.
- Type C: Event Intensity and extent must be met by extraordinary means and powers. The Prefect requires the intervention of the regional Department of Civil Protection.

The occurrence of an event of type B or C does not exempt, in any event, the Mayor of the responsibilities envisaged for law. In addition, the Mayor, will enlist the help of several entities that are involved in monitoring and supervising the territory. For example, you can refer to the STER monitoring of the hydraulic network, the

Weather Service ARPA for regional weather information, for AIPO for information regarding the flooding of the river Po, the Centre Monitoring Geological ARPA of Sondrio and the Center Nivometeo ARPA Bormio, respectively monitored landslides and avalanches in the Alpine area.

4.5 Alert system stakeholders

The alert function is ensured by: Lombardy Regional Council, territorial offices of government, provinces, municipalities, and territorial Deans ARPA Lombardia. In this study, a deeper focus will be established for the main organizations which forms the integrated warning system mentioned in chapter 2. Figure (4.18) shows the main processes of alerting system in Lombardy regions and the organizations which operate each of them.

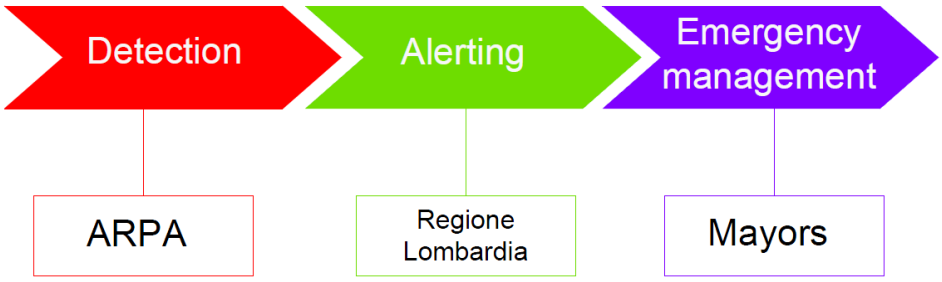

Figure 4.18 Alert process and responsible stakeholders

4.5.1 ARPA

ARPA (which is the abbreviation of Agenzia regionale per la protezione ambientale) is a regional environment protection agency and it is specialized in the Regional Meteorological Service, in addition of making information and forecast directed to public to be better informed and prepared to face the adverse weather conditions. Moreover, it supports the Functional Risk Monitoring Centre (in the role of Competence Centre for Meteorology) in the prediction and observation of intense

rainfall and abundant, storms, snow, high winds, heat waves, with the publication of specific products, available also on the directions of civil Protection. [55]

The information products to ARPA for alerting consist of the following: [56]

- Surveillance regional weather bulletin.
- Adverse weather conditions notification.
- Weather forecasting.

This service refers to the "Normative for the regional management of the organizational and functional warning system for natural hazards for Civil Protection" (dgr No. 8/8753 of 22.12.2008). [55]

4.5.2 Regione Lombardia

Regione Lombardia is the organization that includes the civil protection in Lombardy region. When Regione Lombardia receives an Adverse weather conditions notification from ARPA, the working group of the Functional operating room in the organization's processes the prediction of ground effects, classifying the information in it according to different levels of criticality which is issued to the mayors in the form of "notice of criticality" report sent in daily basis. [55]

4.5.3 The Mayors

The communes compete to implement all the activities in their emergency plans once a warning had been sent by the civil protection department of Lombardy region organization, and initiate monitoring and security services based on their own networks of hydraulic monitoring systems, when there is an active alert level criticality with at least moderate. The Municipalities are also required to establish lines of communication with the nearby provinces in case of resources or services requests. [55]

4.6 Alert reporting

After the reception of the adverse weather conditions notification from ARPA, the civil protection department at Regione Lombardia is responsible for the analysis of the weather data and translates it into an easy form of warning notification to the heads of municipalities' emergency management which is the job task of the Mayors. The Lombardy region uses synchronous techniques in warning disseminations since he main way of communicating the weather conditions is a unique form of reports named "alert of regional critical conditions" which is sent usually in daily basis including brief information about the general weather conditions across the different regional sections, with a specific warning notification by the increase of the levels of specific hazards over the unified thresholds.

4.6.1 Unified criticality levels

For the variety of hazards expected on the region of Lombardy, a unified way of categorizing the risk is established for all of the risks by measuring the degree of risk over 5 levels divided by the unique thresholds given to each of the possible hazards and differentiated by means of numeric codes and colors. Figure (4.17) represents the different levels of risk defined by the Lombardy region while table (4.4) gives some details about each level of risk. [57]

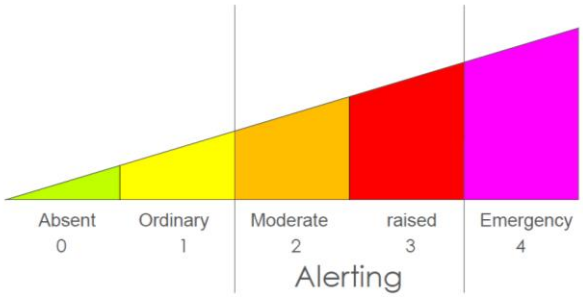

Figure 4.19 Risk levelling system in Lombardy region [57]

Table 4.4 Description of risk levels [57]

Risk level	***code***	***Description***	***Colour code***
Absent	0	There are no natural phenomena (external forcing) that could generate the risk considered	
ordinary	1	There are natural phenomena that may arise situations of risk manageable locally	
Moderate	2	There are natural phenomena that can generate serious risks of a substantial part of the territory alerted.	
Raised	3	There are natural phenomena that can generate serious risks so widespread in the area alerted.	
Emergency	4	This phase prevail relief actions addressing the population. Furthermore, the work of forecasting, monitoring and supervision also aimed to support the relief efforts.	

4.6.2 Report components

In the next set of figures, the different components of the "alert for regional criticality conditions" which is sent to the mayors by Regione Lombardia will be briefly described. The shown report had been issued at 16/3/2013 for regular daily risk conditions with a critical notice for rainfall in some areas of the region. [58]

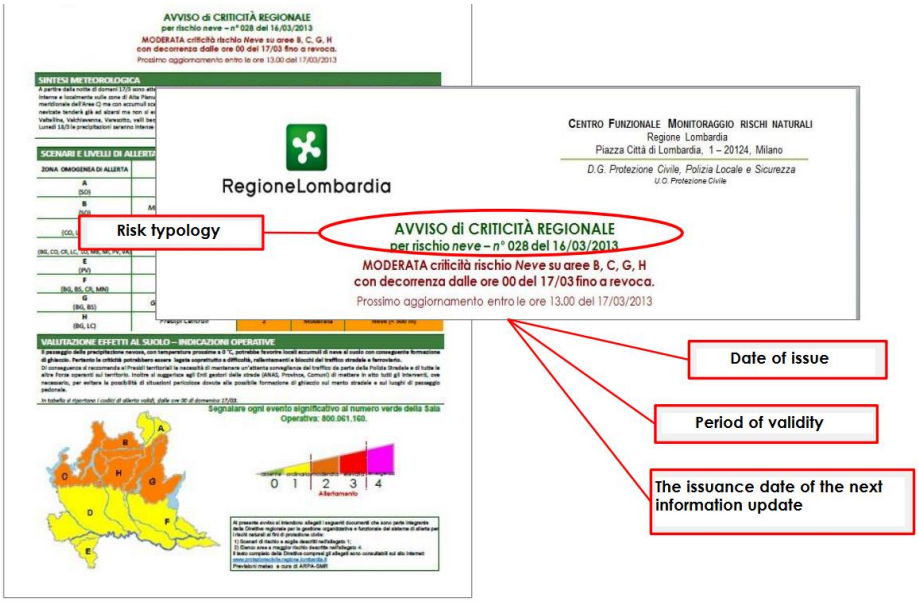

Figure 4.20 Criticality report, part 1 [58]

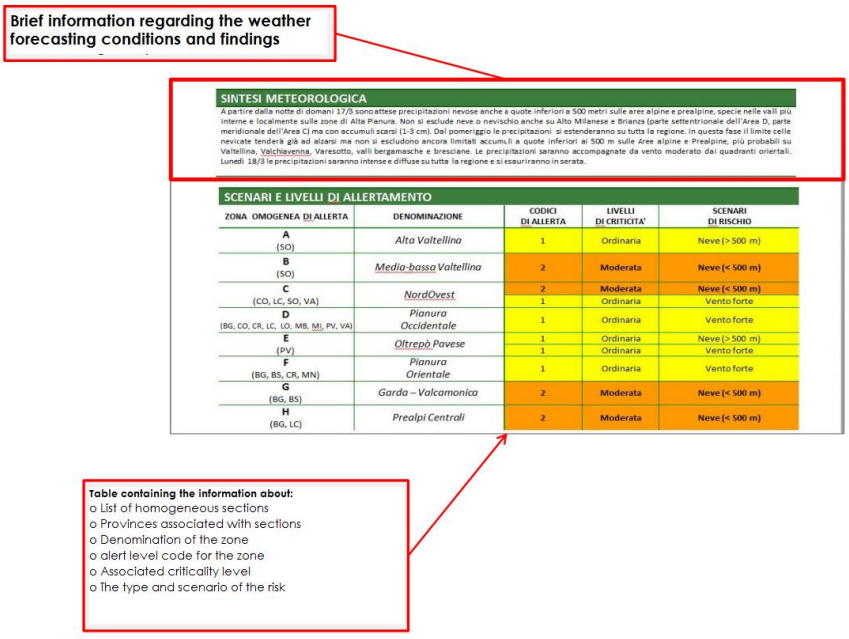

Figure 4.21 Criticality report, part 2 [58]

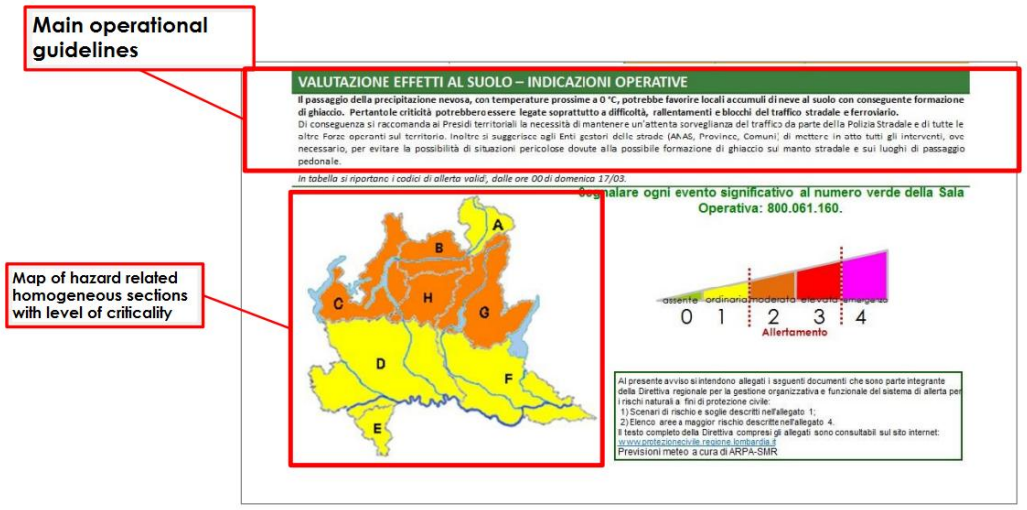

Figure 4.22 Criticality report, part 3 [58]

4.7 EXPO event, Milan 2015

4.7.1 Introduction to EXPO event

The world expo is an event involving, in a network of institutional relations, the governments of the countries around the world, the International Organizations, the Civil Society. Expo 2015 is the next scheduled Universal Exposition after Expo 2012, and will be hosted by Milan, Italy, between 1 May and 31 October 2015. This will be the second time Milan hosts the exposition, the first being the Milan International of 1906. On November 23, 2010, the event was officially announced by the International Exhibitions Bureau (BIE). The BIE General Assembly in Paris decided in favor of the Milanese candidature on March 31, 2008. Expo 2015 will be held under the theme Feeding the planet, energy for life

Having selected Milan as the city to host the Universal Exposition, Italy also chose Feeding the Planet, Energy for Life as its central theme. Expo Milano 2015 will talk about the problems of nutrition and the resources of our planet. The idea is to open up a dialogue between international players to exchange views on these major

challenges which are relevant to everyone. The theme chosen for the 2015 Milan Universal Exposition is feeding the Planet, Energy for Life. This embraces technology, innovation, culture, traditions and creativity and how they relate to food and diet. Expo 2015 will further develop themes introduced in earlier Expos (e.g., water at Expo 2008 in Zaragoza) in the light of new global scenarios and emerging issues, with a principal focus on the right to healthy, secure and sufficient food for all the world's inhabitants.

The concerns of many futurologists about the quality of food in the years to come are compounded by forecasts of increasing uncertainties regarding the quantities of food that will be available globally. These concerns, expressed early on in studies by MIT for the Club of Rome, were largely ignored at a time when it appeared that increases in resource availability would outstrip increases in consumption. However, the rapid depletion of agricultural surpluses has clearly manifested the urgency of the problem of how to Feed the Planet and prevent hunger.

The giant mentioned exhibition areas located in Milan had been chosen to be the main venue of this exhibition, containing a number of huge pavilions that will be hosted by the large number of the event participants. The number and types of participants will be mentioned in later parts in this chapter.

4.7.2 Key facts

The EXPO 2015 is planned to be the biggest universal exhibition in the history from the establishment of this event since 1897. The following key facts describe the characteristics of this event is going to fulfill this target. [59]

1. **Duration:** The exhibition is spanned for whole 6 months in the duration from May 1st to October 31st 2015.

2. **Number of visitors and attendees:** The expected number of exhibition visitors along its duration is reaching 20 million visitors, with an expected foreigner participation percentage of 30%, in addition to an expected number 1 billion citizens to be reached around the globe from 2012-2015 through Cyber Expo and the Expo Global Communications program.

3. **Number and types of participants:** The exhibition will be a home to a wide number of participants bounded in 144 countries representing 94% of the globe, 3 international organizations, 13 Non-governmental organizations and finally 4 international companies placed in special 3 corporate pavilions.

4. **Exhibition site area:** The event will be covered by 1.1 million square meter exposition site including 60 self built exhibition spaces for Official Participants; 5 theme pavilions; theatre and performing arts center**.**

5. **Number of events:** Over 2000 events will be held within the exhibition duration including world debates, conventions & policy meetings, cultural & gastronomic events - forecasted during six months on-site and in surrounding territory and more events all over Italy.

4.7.3 Main activities

Exhibition and tourism are going to be the main two activities done during the EXPO duration. The both activities are going to be explained briefly in this section.

4.7.3.1 Exhibition

The main exhibition area will be divided into three explorations, each containing different types of events, activities and participants. These main explorations are:

1. **Clusters:** They are one of the new attractions of Expo Milano 2015: for the first time the pavilion communities are grouped, not by geographical area, but by a common theme and food group to which they belong. This approach applies the theme Feeding the Planet, Energy for Life in its broadest sense, instilling these spaces with the spirit of sharing, dialogue and interaction for which they were created.

2. **Thematic areas:** The main theme will be expressed through five Thematic Areas. In this section, visitors will be able explore and reflect on matters relating to the it. The Thematic Areas are situated close to the main entrances and other key points around the Exposition Site, Comprising exhibition routes with attractive elements sure to engage both adults and children alike. These areas will provide the visitor with insights through a host of multi-sensorial and educational experiences.
3. **Exhibition site:** This area, extending across approximately one million square meters, was designed by internationally renowned architects, Stefano Boeri, Ricky Burdett and Jacques Herzog. It is built on the Cardo and the Decumano perpendicular shape of a typical roman town and enriched by a breath-taking green space that is evocative of an island surrounded by water. [59]

Figure (4.21) represent a general model for the whole exhibition area, while Figure (4.22) shows the main three explorations with their different sections.

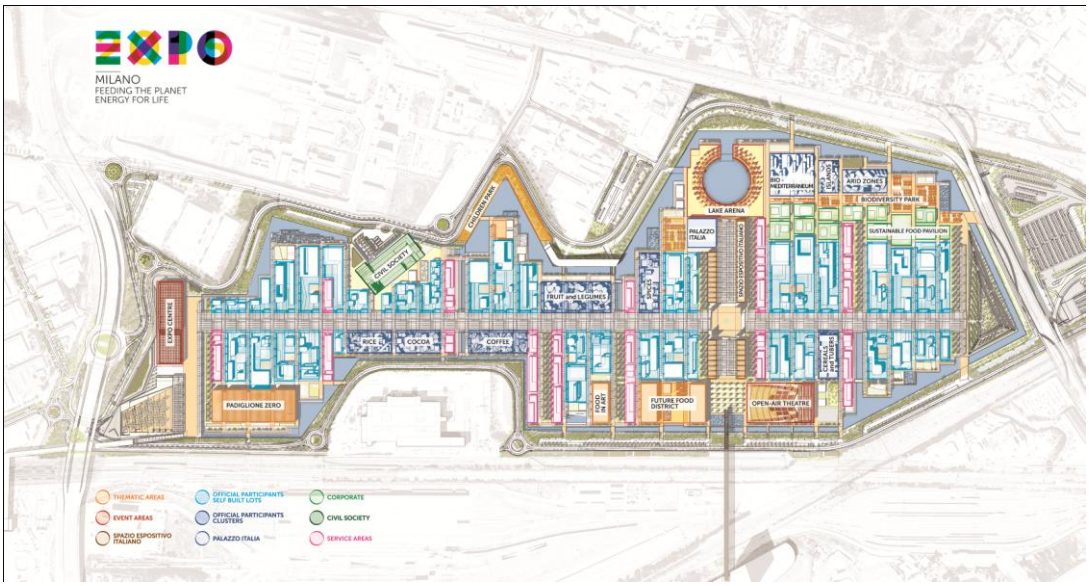

Figure 4.23 Model for EXPO exhibition area

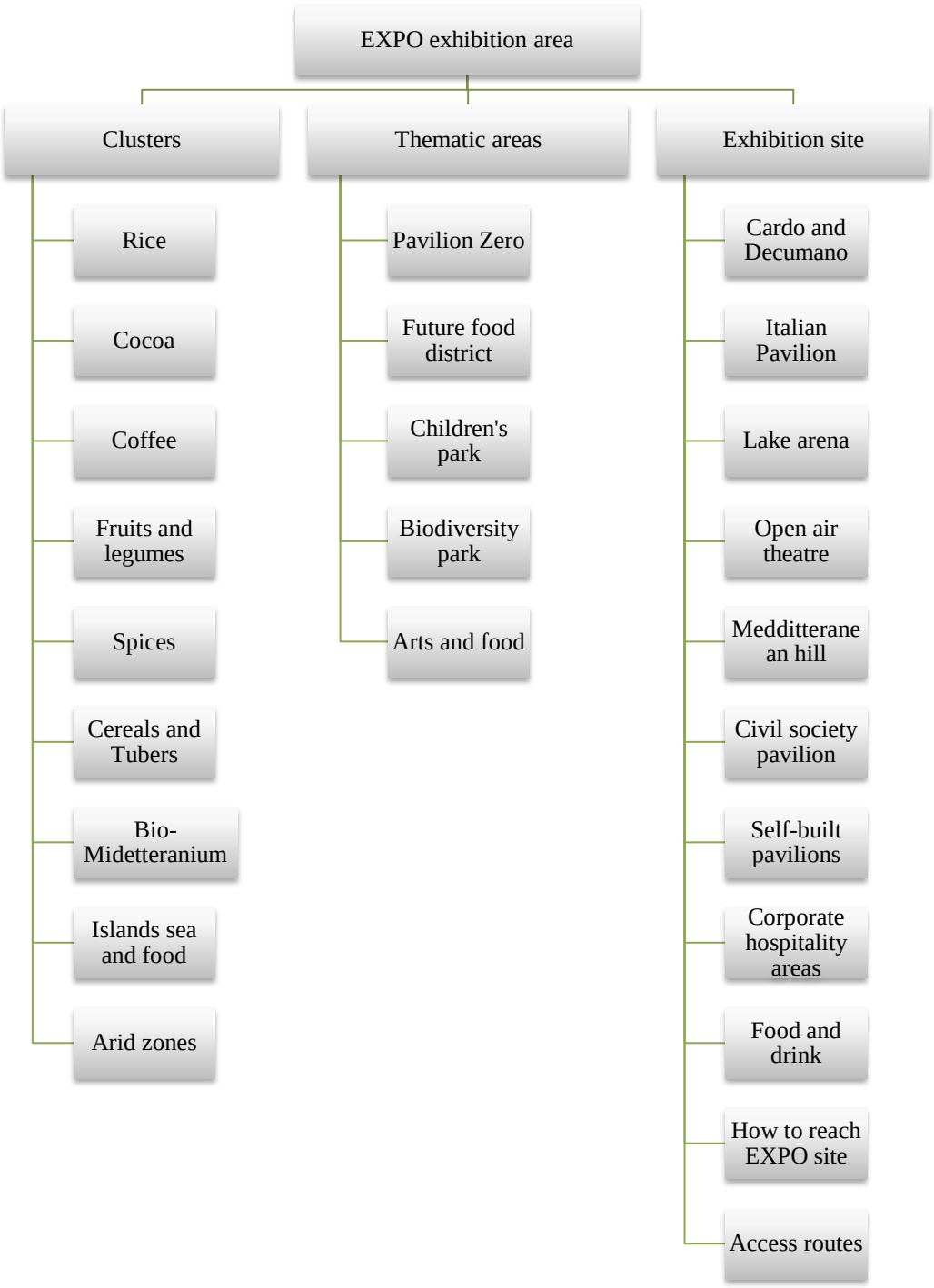

Figure 4.24 different explorations of the exhibition area [59]

4.7.3.2 Tourism

The region contains an enormous variety of touristic attractions. First, visitors will be able to find many historical places from the medieval to modern historical eras bound in variety of museums and landmarks like the kingdom castle bounding the old Milan era, the castle of Lecco, white war museum in Brescia and more. Lombardy region is considered a home for fancy and prestigious architectural design with a unified renaissance, Baroque, and Gothic architecture found in all the region's buildings and churches. Moreover, the north of Lombardy regions is the ideal place for nature and heavy sports people, where there is the Lake of como laid by the provinces of Como and Lecco which is nominated the most attractive lake in the world in addition to the region of the most famous mountains in Alpine series including the St. Martin and Resegone mountains between Como and Lecco which are considered an ideal place for hiking and snow sports Practitioners. Another cultures, cuisine, fashion, and shopping attractions can be easily found in Lombardy regions with a large number of theatres, fashion houses and most elegant and exotic fashion names, in addition to the existence of many fancy restaurants serving high quality national and international cuisines. Finally, the province of Mantua is considered as a main UNESCO heritage center with a large number of landmarks and monuments that reveal and illustrate many knowledge about the past Italian history.

For the purpose of purposes of encouraging the tourism within the region of Lombardy and to decrease the condensation of residents inside the capital Milan, the authorities had decided to locate the participants delegations around the different regional provinces to provide accommodation spaces for the tourists visiting the capital and for encouraging the delegates and visitors to discover the other attractions apart from Milan. [38]

4.8 Alert communication lines

As mentioned in earlier parts of Chapter 2, the main communication lines present in an integrated alerting system is bound in the communication between the emergency detectors and the emergency managers, while the latter is expressed in the communication between the emergency managers and public, each of them achieve higher levels of effectiveness by the right decisions for selection and diversity of the means of alerting message dissemination technologies in order to fulfill the main aspects that measure the adequacy of the message content according to the sender and receiver needs.

This section will mention on these main communication lines for the case of Lombardy region, where first, a study of the present communication methods performed between Regione Lombardia and the Mayors with stating their facts and limitations, and a focus on the challenge of warning the EXPO visitors throughout the exhibition duration that will be faced by the region's emergency management will be presented, with a special addressing of the impending hazards affection on the region's transportation means.

4.8.3 Communication between Regione Lombardia and Mayors

At section (4.6.2), a presentation of the daily weather criticality notification report which is sent by Regione Lombardia to the provinces emergency managers represented by their mayors. These reports are sent based on ARPA forecasting center in the both cases of normal or adverse warning conditions.

By focusing on the ways of warning message disseminations used by Regione Lombardia, the Regione Lombardia when the regional functional center notices an event of exceeding more than moderate thresholds, they directly send notice of criticality to the Mayor directly and to his office manager in order to assure the delivery of the notice. This notice can be transferred through SMS or

direct phone call. The aim of this step is to aware the Mayor about the expected risk at his own municipality. At the same time frame, the Functional center provides extended information about the event through the designed specific web database for alerting. Figure (4.23) summarizes the communication path and tools used between Regione Lombardia and the Mayors.

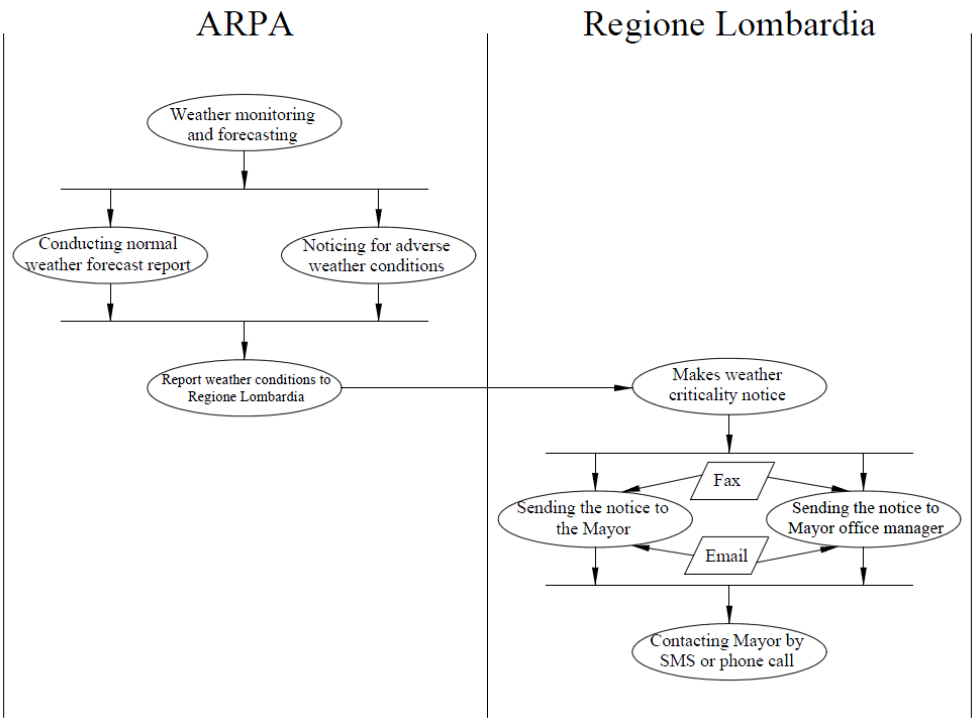

Figure 4.25 Communication path between Regione Lombardia and Mayors

By observing both the criticality notice report and the flow of communication between the Regione Lombardia and the municipalities Mayors, some main limitations could be included, these limitations are:

1. **Synchronous warning:** The criticality notice reports conducted by Regione Lombardia and the Mayors are sent in fixed daily basis, the fact that makes

a state of ineffectiveness in terms of updatable and frequent information at the times of risks with raised criticality levels.

2. **Long communication path:** From the communication flow between the two stakeholders, which is shown at figure (4.23), it can be observed that the tools used for raising the awareness of the Mayor and the office managers are not considered as direct warning message dissemination tools, where Regione Lombardia announces by phone calls, Fax or SMS for only notifying the Mayors about the existence of risks with raised criticality levels and to announce about the receipt of the daily criticality notice report , which is the only source for the warning content.

3. **Single-hazard based:** By studying the first part of the criticality report present at figure (4.18), it can be observed that the daily reports are carried out based on the notification of awareness about a single hazard, with assigning different levels of criticality among the homogenous map related for the hazard. This fact show ineffectiveness in the case of the occurrence of multi-hazard events which is frequent in Lombardia region since all the risks subjected to the region are sourced from a single cause which is the adverse weather conditions.

4. **Low level of notifications for provinces Mayors who are out of high hazard criticality levels areas:** While the priority to raise the alert notification level is obviously the highest for the Mayors responsible for the provinces subjected to high criticality level hazards, still it is necessary to raise the awareness of the Mayors within the areas which are not subjected by it. This necessity is present for the reasons of maintaining the preparedness of the Mayors in high risk near by areas to offer assisctance

for these risk subjected areas in terms of resources and planning. Also, for raising public awareness about the hazardous event for helping in public alerting and preventing them to reach those areas during the high risk phases.

4.8.4 Communication between Mayors and public

For the communication between Emergency management represented in public members, including the numerous number of region's foreign visitors for the Expo event, there are challenges can be concluded in the case the occurrence of the hazards related to the region.

The first set of challenges are bound in the fulfilling the main aspects for disseminating the alert messages to public. By revising those main aspects mentioned before in Chapter 2 and degree of fulfillment of them by the common message communication tools, it can be observed the absence of that tool that can achieve high levels of fulfillment for all of the main aspects to be considered when communicating the risk notifications and guidelines with public members. As a result, finding a solution which can offer integrating the main advantages of these different tools should be conducted for reaching high aspect fulfillment levels.

As for the other sets of challenges, it will be specified for the large number of foreign tourists reaching Lombardy region for a long time bound in the duration time of the exhibitions which is around 6 months. These challenges can include the unawareness of the region's language, where it can be difficult for the foreigners to ask for assistance and help from locals during the occurrence of emergencies. Moreover, those visitors will be conditions by unawareness about their areas located in which can cause adverse consequences in cases of emergencies. For example, at cases of Flood in province of Como, public will have a spontaneous awareness about the dangerous areas which are mainly those lied on the Como lake, which will

not be the case for foreigners who are having much less knowledge about the city's areas and directions. Last challenge can be in the lack of knowledge by the foreigners about the systems of public emergency alerting and the right reactions to perform to get away from possible dangers which can cause also adverse consequences, especially in the case of usages of hazard only notifications devices as sirens and flags, which are the tools that requires public education about the right decisions and reactions to perform after they had got notified.

4.9 Introduction to Lombardia emergency disseminator (LED)

Lombardia emergency disseminator (abbreviation: LED) is a proposed solution for providing a space that can integrate the advantages of different message disseminating tools for conducting Alerts about Lombardy region's risks, serving the both main lines of communications in the Form of an App installed in Smart phones and tablets. By the variety of options available for all the risk stakeholders, this app can assure the dissemination of the warning messages that can achieve high levels of achievements for the mentioned aspects to be considered when communicating the message between emergency detectors and management organizations (ARPA, Regione Lombardia and the Mayors), and between the emergency management subsystem and public (Mayors, public, EXPO visitors). Moreover, the app had been designed to overcome the challenges regarding the cope of the emergencies by the large number of foreigners present at Milan international exhibition duration.

4.9.1 Advantages

The advantages of LED can be classified into two categories. First, the app had been designed to provide an alternative and improved way for communicating the alert between Regione Lombardia and the Mayors, with eliminating the mentioned limitations regarding the communication flow presented in figure (4.23)

and the content of the warning message represented in the daily criticality report sent by Regione Lombardia to Mayors. The following characteristics provide supporting facts which make LED is a way for improving this communication line:

1. **Asynchronous warning:** Unlike the fixed intervals of sending the daily criticality reports, LED provides an asynchronous way of reporting the hazards to the Mayors, where Regione Lombardia app users can have the ability to post a detailed form of reports at the same time of receiving any updates from ARPA about the adverse worse conditions. Hence, providing a detailed and up to dated hazardous data. Moreover, the reports are supported with interactive hazard related homogeneous maps which provides a single and organized space for visualizing any hazard records or updates.

2. **Double-way communication:** For assuring the rapid reactions and decision making processes by the Mayors, the App is providing integrated two ways for communication with Regione Lombardia representatives, where in the case of assistance need by the Mayor from Regione Lombardia, he/she can directly choose direct calling or Instant messaging communication which directs him/her to the representatives of the civil protection department of Regione Lombardia, providing a direct and rapid assistance between the both hazard stakeholders.

3. **Multi-hazard based:** As mentioned before, daily reports are carried out based on the notification of awareness about a single hazard, with assigning different levels of criticality among the homogenous map related for the hazard. This fact show ineffectiveness in the case of the occurrence of multi-hazard events which is frequent in Lombardia region since all the risks subjected to the region are sourced from a single cause which is the adverse weather conditions. This limitation can be eliminated by the app by the fact

that the simple and rapid procedures for conducting new hazard records and updates can give the advantage of assigning more than one hazard type for more than one homogenous zone. As a result, an effective alerting notification will be achieved in the cases of multi hazard occurrence.

4. **Short communication flow:** While the present Regione Lombardia alerting policy includes sending the alert content and notification separately, The Smart reporting integrated in the app assures the occurrence of both processes at the same time, since the App logic is to send Automatic notifications for all the provinces Mayors regarding the entry of a new hazard record within the system, with a higher notification level for the Mayors who are responsible for provinces subjected by the hazard impact area. The latter option can eliminate as well the limitation of the low level of hazard awareness for the Mayors who are in provinces located in hazard impact free locations.

It worth to mention that these advantages can also include the Transportation companies who are considered as management stakeholder users for LED, where the logic of the app allows an automatic sending of the provincial risk notifications once entered by the Mayors, where these notifications are in the same form as that those which will be sent to the public members, However, the notification content is designed to assure to provide enough data to help in decision makings by those companies in terms of addressing their transportation services changes according to the impending hazards notified by the provincial Mayors.

The second set main advantages of the LED is bound in the communication between the emergency managers whom are bound by the Mayors and Transportation companies in terms if the adequate fulfilling of the aspects to be considered when disseminating alerting messages to public members. Where:

- The clear fact about the increasing number of smart phones and Tablet holders around the globe provides a wide scale of distribution for the alerting communication, since the only requirements to receive alerting messages is the assessment of Smart phone or tablet devices with installed and registered LED app on it. Also, with warning messages are created in a form that doesn't require any prior special knowledge. Respectively, providing a warning message with clear content for both local and foreign app public users.

- The options of the app provides an automatic publishing of the hazard records once entered by the emergency managers on their official social media pages, which by turn can increase the distribution scale of the warnings and owe the advantages of the outcomes of the public informal warnings, Moreover, the app gives the possibility for creating a space for public reporting, where normal public members will have the option of conducting their own hazard reports with attaching any supporting sources like media ones, while the credibility problem associated with social media can be eliminated by the direct receipt of these warns to the province Mayors to verify these records and discriminate verified info from rumoured ones.

4.10 LED Operations

As mentioned before, the app is directed to different type of users, which all together will result complete operations for both alerting system communication lines. The App users are summarized in figure (4.26).

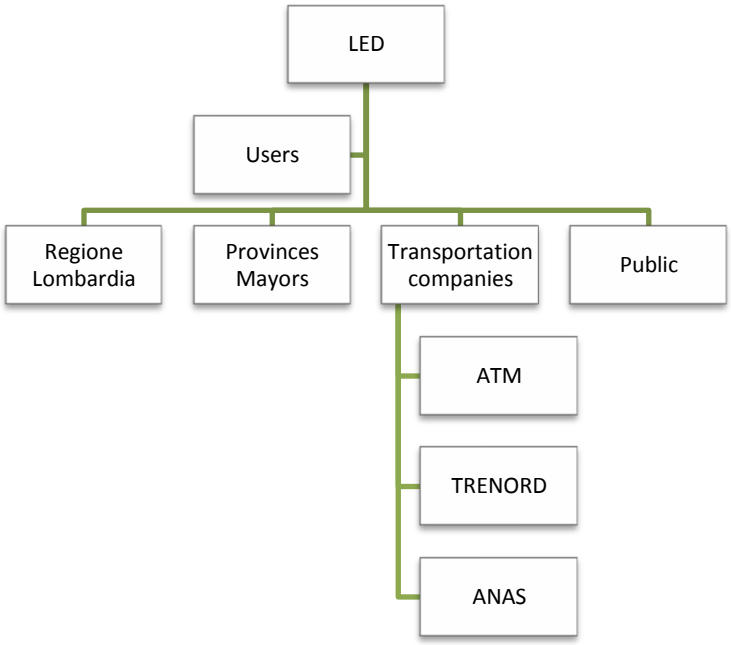

Figure 4.26 LED app users

This section will focus on the different operations that can be done by each user type.

4.10.1 Regione Lombardia

The LED main menu associated to Regione Lombardia users sector is providing the possibilities for adding new hazard records, which is saved as a main record with specific hazard type, with the option to add unlimited number of hazard updates with assigning them to the number of zones located in the homogeneous maps related to the selected hazard. For the app operation logics and database content, refer to the activity diagrams (2.1), (2.2), (2.3). And entity relationship diagram (1.1).

Figure 4.27 Regione Lombardia LED main menu

4.10.1.1 Add new hazard record

This option allows the users of Regione Lombardia to add new hazard records once notification of adverse weather conditions is received from ARPA. The app will open the list of hazards loaded from the Regione Lombardia alert lists database which is mentioned in earlier parts of this chapters.

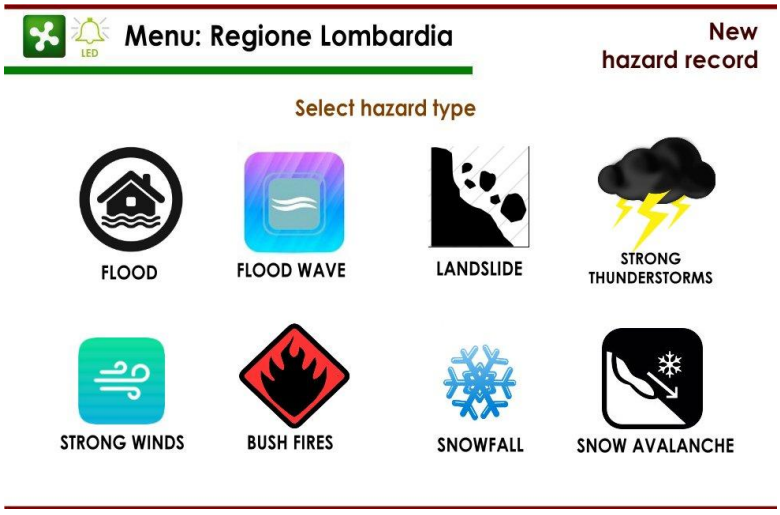

Figure 4.28 new hazard menu

After the hazard had been chosen, the user will need to fill the “new hazard form” generated by LED entering the information as shown in the figure below (4.27).

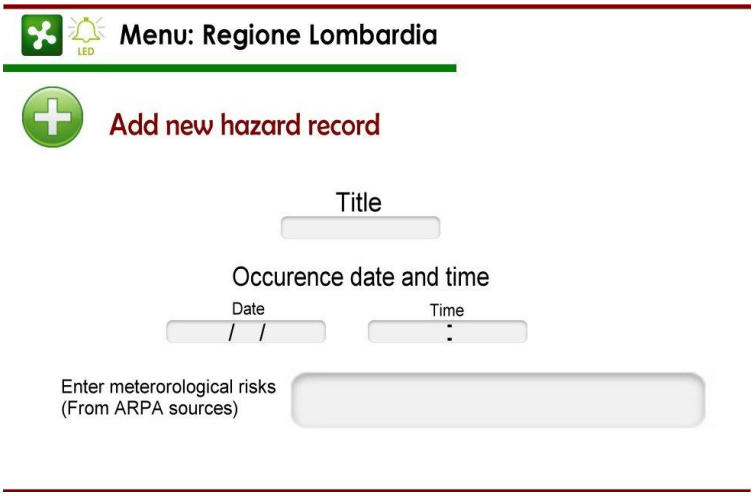

Figure 4.29 Regione Lombardia LED main menu

Once the hazard new record form had been filled and submitted, the app directly asks about the desire for entering an immediate new hazard update, once selected, the user will follow the operations which are the same of those related to the option of “Update existing hazard record”, it will be explained in the next section.

4.10.1.2 Update existing hazard record

Once this option had been chosen, the app will require the user to select the hazard to be updated. This process will not be present in the case of choosing to update the new hazard record directly as mentioned before.

Once the hazard had been chosen, the app will automatically generate the homogeneous map related to the selected hazard. These maps are fed from the database of the list of hazards homogeneous maps conducted priory by Regione

Lombardia and they were mentioned in earlier parts of this chapter. Figure (4.30) provides an example of the app showing the Snowfall homogeneous map.

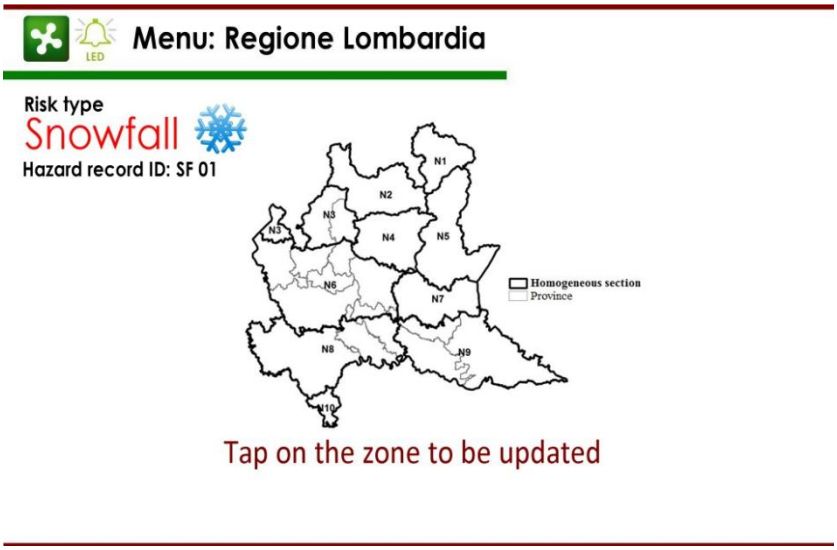

Figure 4.30 Hazard related homogeneous map

After the user had tapped on the desired homogeneous section to be updated, the app will automatically open the form for entering information about the new hazards. It is worth to mention that the form fields are conducted to include all the firms included in the official Regione Lombardia criticality reports for the purpose of following the region's emergency management normative. The fields are shown in the figure below (4.29).

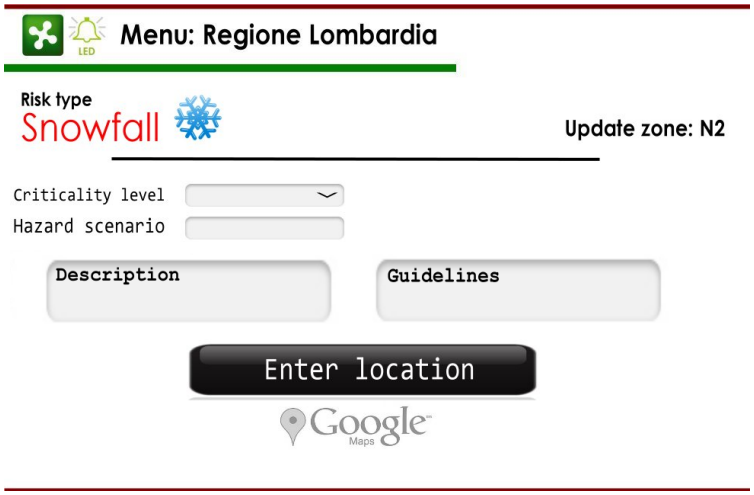

Figure 4.31 New hazard update form

By focusing on the "Enter location" field, the App is integrating the services of Google maps for visualizing and searching for the exact positions of the hazard impact locations according to Regione Lombardia risk analysis and ARPA information. By tapping this field, the user will be able to search and locate the hazard related impact areas, with the possibility to enter the impact radius in case of the impact wide zone scale.

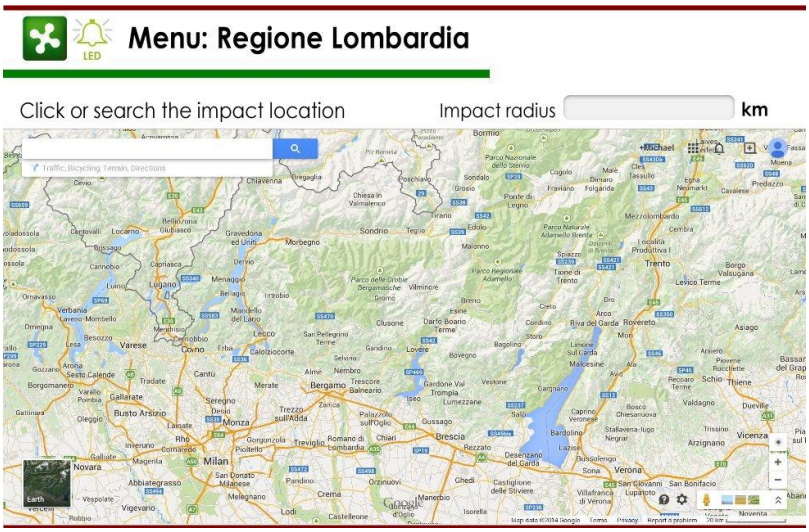

Figure 4.32 Locating hazard impact

By completing the form of the new Hazard update, the app automatically generate the new hazard update info to the associated hazard record database. Afterwards, LED will generate alert notification to the mayors after specifying the provinces present within the homogeneous sections associated with hazard update entries. There are two levels of notifications assigned in the app, which are:

1. **Notification Level 1:** This level of notification is directed to the Mayors located in the provinces outside the alerted homogeneous sections. The notification content will be bounded in a sound alert and a notification located in the notification bars in the Mayors' devices.

2. **Notification Level 2:** This notification level is directed to the Mayors located in the provinces inside the alerted homogeneous sections. It had been designed to assure the optimum attraction of the Mayor's attention, where it consists of a full screen image with a continuous sound alert that will be stopped only by the Device holder response. An example of this notification is shown in figure (4.31).

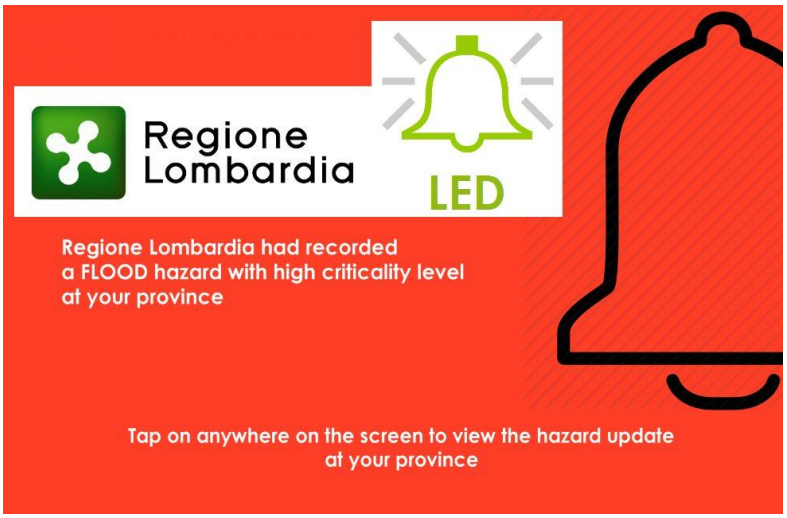

Figure 4.33 Notification of level 2 to Mayors

4.10.2 Mayors

The main menu for the Provinces Mayors user sections is offering the possibilities of visualizing the hazard updates in more than one view type, where they can choose between list views or homogeneous map view. Moreover, LED gives the mayors the possibility to translate the hazard updates received from Regione Lombardia into provincial risk notifications that will be automatically sent to the public users and the Transportation companies to take the correct actions. For the app operation logics and database content, refer to the activity diagrams (1.1), (2.3), (3.1), and entity relationship diagram (1.2).

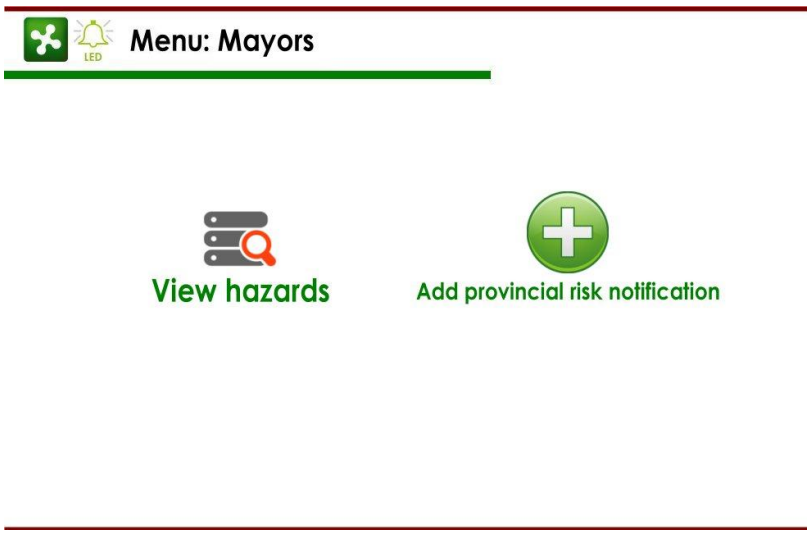

Figure 4.34 Mayors menu

4.10.2.1 Select hazard update view

Once the Mayor had selected the hazard record, the application will ask about the preferred hazard update view. There are two possible views in LED app which are:

1. **Homogeneous map view:** This view visualize an interactive hazard related homogeneous map showing the criticality level color code of the last update entered for the each zone in addition to the number of updates present within each zone. By tapping on the zone, a list of all zone hazard updates will be shown. This view is shown in figure (4.33).

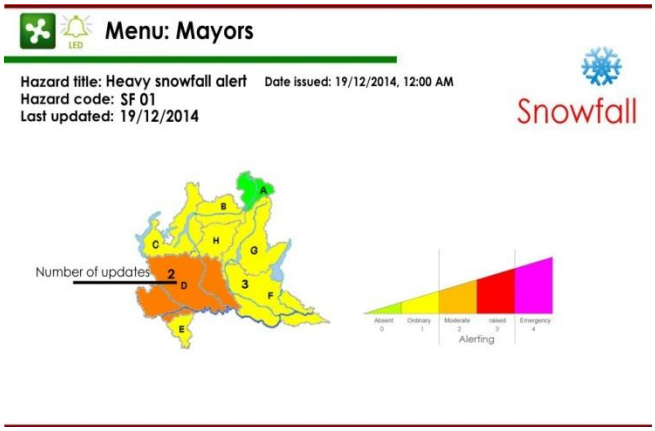

Figure 4.35 Hazard update homogeneous map view - Mayors

2. **Hazard list view:** This view will visualize all the hazard updates sorted by ascending order of the last updates. The user can show the update details simply by clicking on the desired hazard update record.

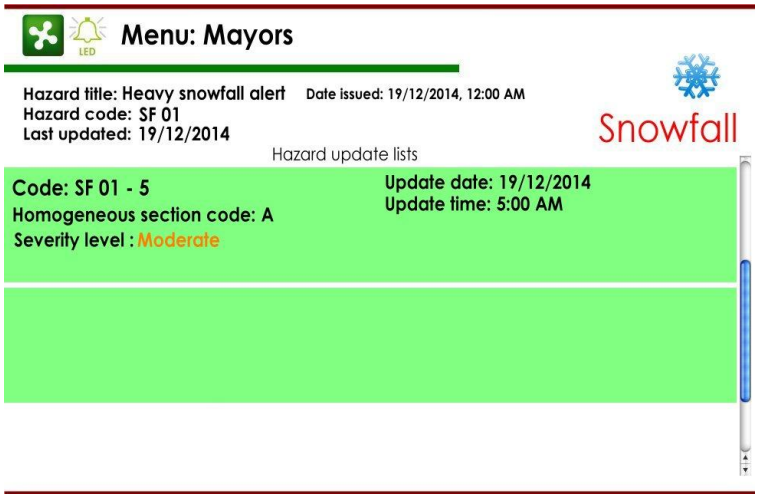

Figure 4.36 hazard update list view - Mayors

So by clicking on the desired hazard update record from any of the both views, the application will directly show the hazard update details as shown in figure (4.37). It is worth to mention the user will be directly directed to this page in the case of responding the notifications sent by LED through Regione Lombardia

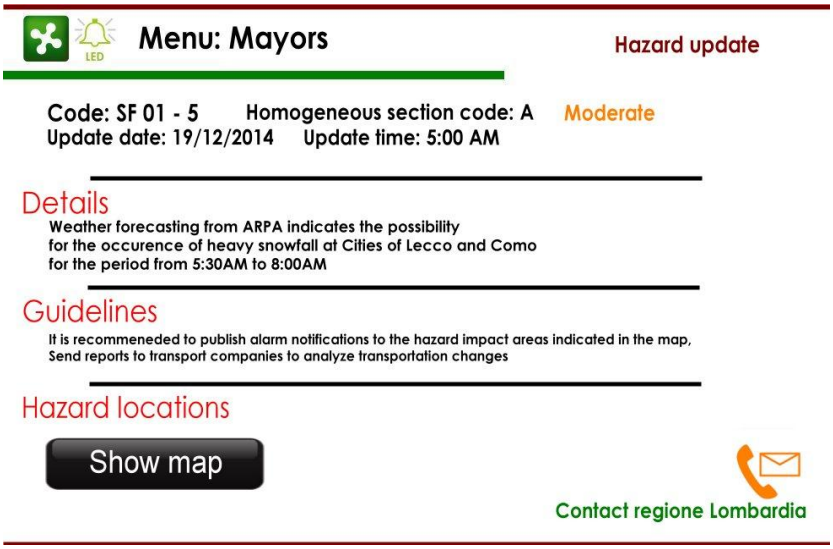

Figure 4.37 hazard update record details – Mayors

As seen in the previous figure, the app provides the possibility for visualizing the list of locations that will be directly affected by the hazard occurrence and by clicking any of the records, information about the spatial coordinates and the impact radius will be appeared as in figure (4.38)

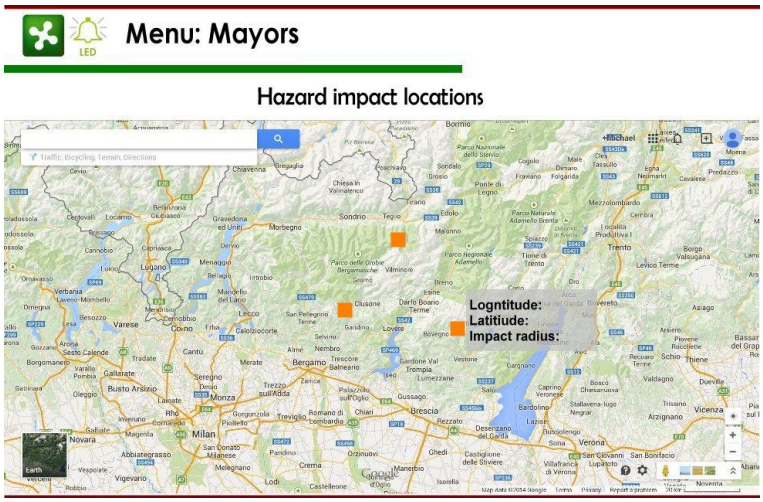

Figure 4.38 hazard update record details – Mayors

4.10.2.2 Contact Regione Lombardia

By looking at figure (4.35), the LED app is providing an option that can allow direct contact between the Mayors and Regione Lombardia in cases of assistance needed upon the hazard record details. The user can choose either direct phone call which will automatically direct a call for Regione Lombardia civil protection department representatives by the app, or the option of instant messaging for opening an open conversation page with Regione Lombardia for a continuous communication.

4.10.2.3 New provincial risk notification record

The last option offered to Mayors user sectors is the possibility to add new risks notifications related to their own province, where these notifications will be

automatically notified to the public and transportation companies' users. After the Mayor and emergency team had analyzed the risks and damage scenarios that can be subjected by their provinces, the Mayor can choose this option where the app will first ask to enter one or more locations with the associated impact radius where the risks can be present due to the hazard notifications sent by Regione Lombardia. After finishing the locating risks, the app will open the provincial risk notification form where the Mayors will enter the data as shown in the next figure:

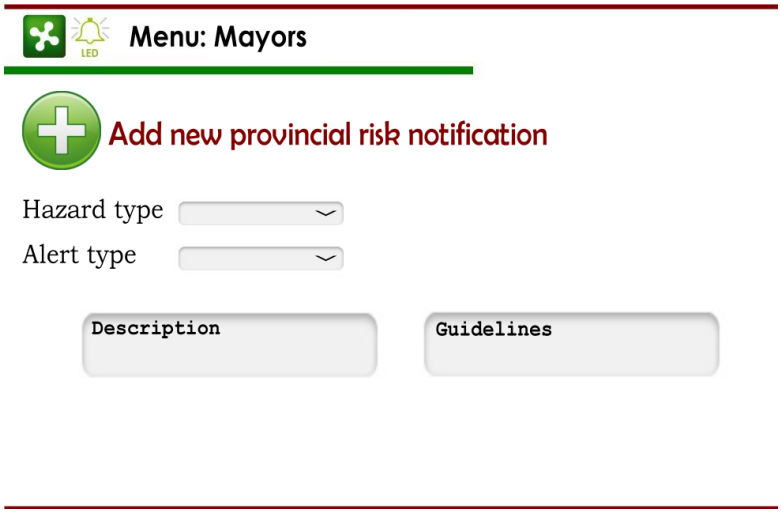

Figure 4.39 New provincial risk notification form

After generating the new risk notification record, the app will automatically send a notification to 3 destinations which are:

1. **Public:** using geo locating engine within the LED app, it will determine the locations of the app public users, where the users within the risk area will be notified using notification level 2, while it will assign level 1 notifications for public members who are out of these areas. The characteristics of the both notification levels are the same as those mentioned previously in the hazard new update records one.

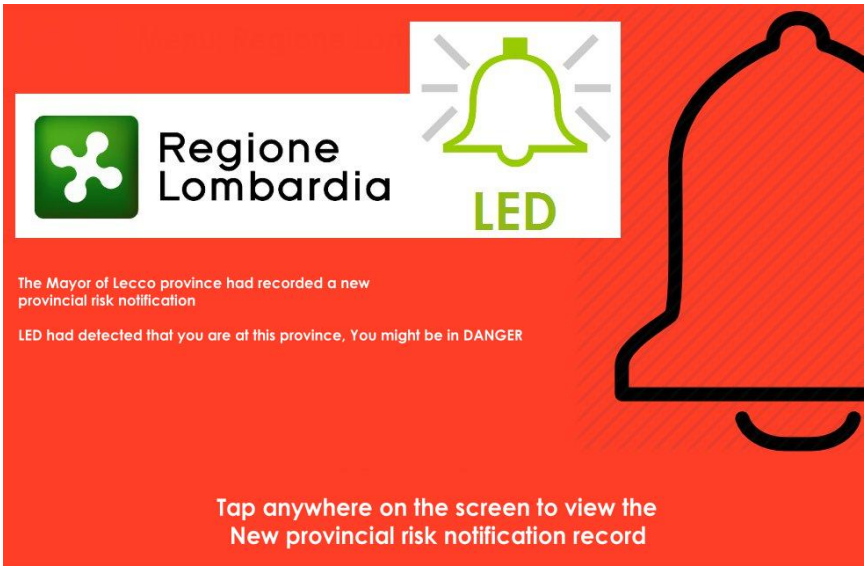

Figure 4.40 Level 2 notification – Public members

2. **Social media:** The app will automatically detect the official provincial Facebook and Twitter pages for posting a brief information about the hazard.

3. **Transportation companies:** A notifications will be sent to the different Regional transportation companies in order to help them in deciding any essential changes for their services. The notification will be bound in an entry in the user device's notification bar and a sound alert.

4.10.3 Transportation companies

The different options offered by LED to the different transportation company users sections are almost similar to those offered to the Mayors, where they will have the possibility to view the provincial notification records done by Mayors in map and list views. Moreover, they will be able to enter new records regarding any changes in their transportation services as a result of the impending

hazards. For the app operation logics and database content, refer to the activity diagrams (1.2), (4.1), (4.2), (4.3), and entity relationship diagram (1.3).

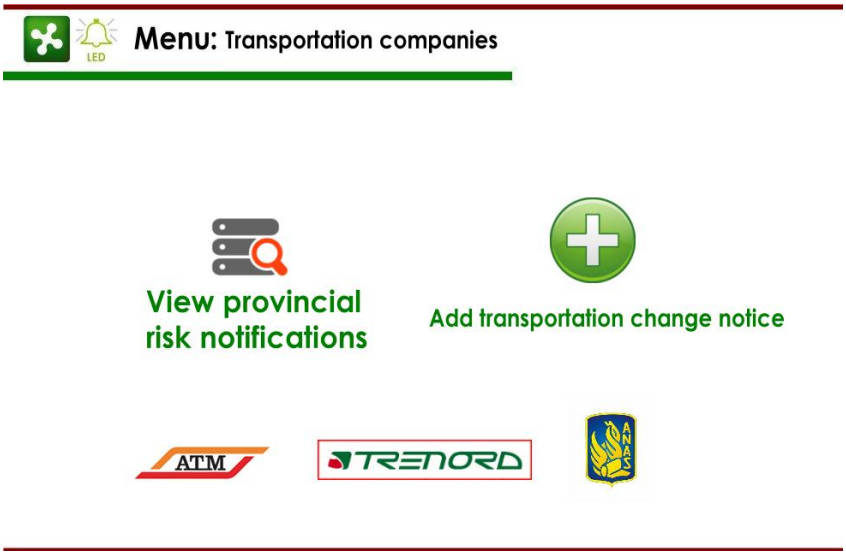

Figure 4.41 Transportation companies main menu

4.10.3.1 Select provincial risk notifications view

By choosing the "view provincial risk notification" option from the main menu, the users will have the possibility to choose between the list and map views, where:

1. Choosing map view will load a map taken from the Google maps database, with the landmarks of the locations where the risk notifications are being posted, the land marks will be in the form of icon representing the type of hazard that will occur.

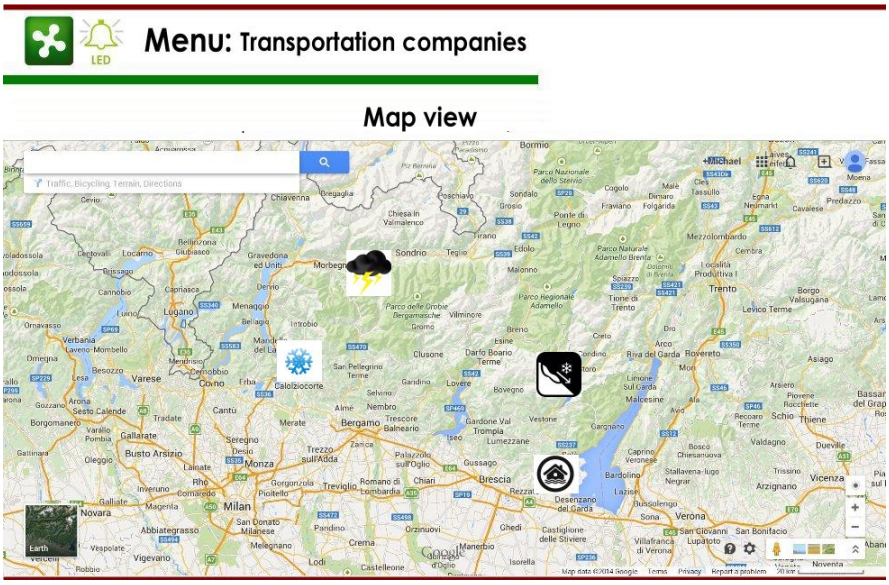

Figure 4.42 Map view – Transportation companies

2. The list view provides a list of provincial notifications sorted by ascending order according to last updates. They are differentiated by codes and hazard identification icons.

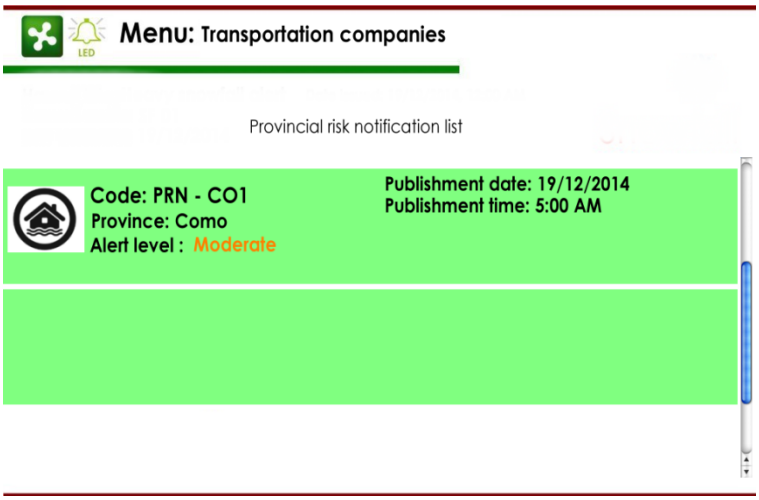

Figure 4.43 List view – Transportation companies

For the both views, by choosing the desired notification, LED will direct the user to the detailed risk notification record. It should be mentioned that this page will be directly viewed if the user had been directed through notifications sent from the Mayors. The detailed notification page is shown in figure (4.41). By showing the map, the app will direct the user to a map loaded from Google map database, with viewing a landmark of the hazard location and associated impact radius, an example had been already shown in figure (4.36)

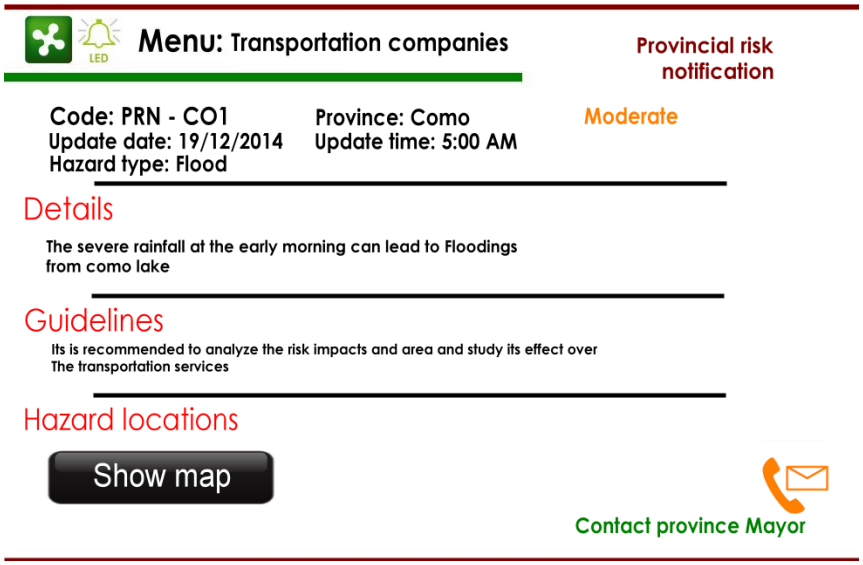

Figure 4.44 Province risk notification page

4.10.3.2 Contacting the Mayors

The processes and options of contacting the Mayors are similar to those mentioned in section used in the communication with Mayors and Regione Lombardia, where the transportation companies can have the ability to reach Mayors through direct calls or instant messaging in case of needing more clearance about the notifications sent by the Mayors.

4.10.3.3 New transportation change

After the transportation companies had analyzed the impact of the impending risks to their transportation services, the option of recording transportation changes allow them to notify the public about any delays, cancellations or line changes for their means of transportations. Since each company is responsible for totally different means of transportation and networks, a unique transportation change form had been conducted in order to serve the different possible changes done by each company. The content of each company's form is as follows:

1. **Trenord:** Since the only possible changes that can be done by the company are trains delays and cancellations, the program provides a form including entering the information regarding the train which is subjected to the change. These information include train number, journey starting and ending stations and actual departure time. Then, the type of change will be entered whether it is a delay or cancellation; if delay had been chosen, the user will enter the delay duration. As for cancellation, the user will enter the date and time of the next available train. The risk type responsible for the train change will be also added from the list risk notifications

2. **ATM:** whole there is the similarity of the changes types present in Trenord, the difference is bound in the availability of more than type of transport managed by ATM, and the more flexibility in finding out possible alternative solutions for allowing public to reach their destinations. The LED form for ATM transportation change include the insertion of the type of the transportation means (Tram, bus, metro, etc) and their associated service number. Then, the change of transportation type is inserted whether it will be subjected to delay, cancellation or route changes; for the first two

types, the alternative solutions are similar to those mentioned in Trenord form. As for the latter, the program provides text field including the possible alternative transportation routes and means that can be used by the public users to reach their desired destinations if possible. The risk type responsible for the train change will be also added from the list risk notifications.

3. **ANAS:** Since this company doesn't offer transportation means but management services over the different types of Region's local and regional roads, the program provides a short form that allows the company to locate restricted roads due to hazard from Google maps database, with providing a field for specifying alternative routes to be followed by the public users to reach their desired destinations.

All of the records posted by the different transportation companies will be automatically announced by LED to public users through level 1 notifications, in addition to an automatic generated posts for the official Facebook and Twitter pages associated with the transportation change record inserter company.

4.10.4 Public members

The different options offered by LED to public members include the possibility of viewing Mayor's provincial risk notifications records with similar view modes offered to the transportation company app users. Moreover, LED is providing the advantages of social reporting, where public users will have the accessibility to report their own hazard records, supported by mentioning the information sources and uploading options of Images and videos. For the app operation logics and database content, refer to the activity diagrams (1.2), (5.1), and entity relationship diagram (1.4).

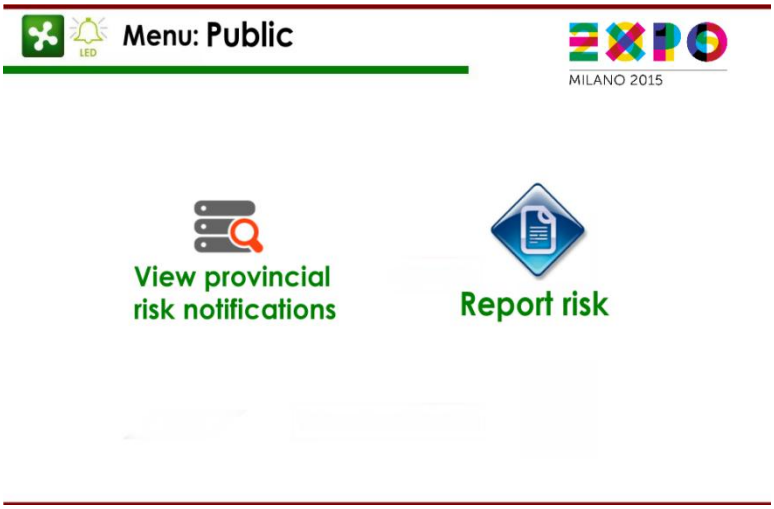

Figure 4.45 Province risk notification page

4.10.4.1 Select provincial risk notifications view

The same procedures and views are exactly similar with those related to the transportation companies' users. The only main difference is found in the provinvial risk notification details page, where the guidelines will be conducted to assist the public members and the absence of contacting Mayors possibilities to avoid the congestion of communication lines, which will be eliminate the problems of chaos in trying to handle numerous number of public assistance.

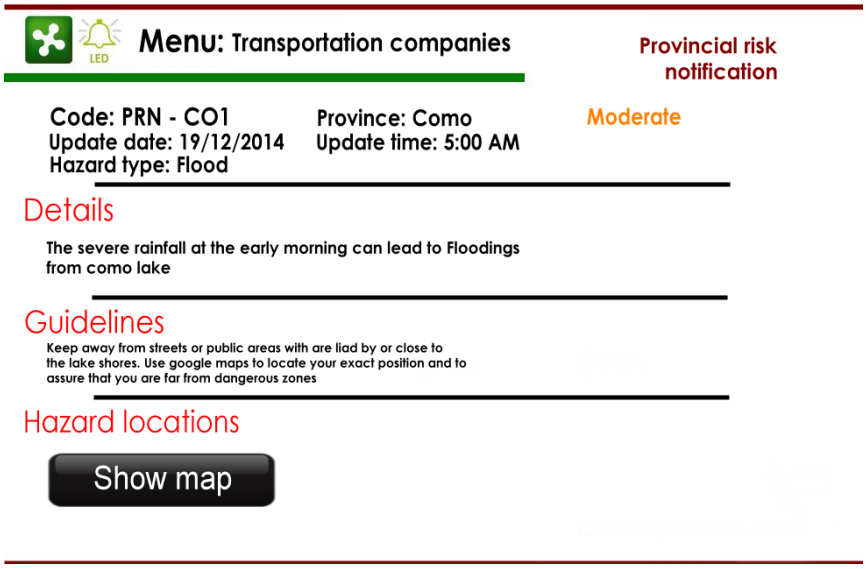

Figure 4.46 Provincial risk notification details – public

4.10.4.1 Report hazard

The public members will have the possibility to report risks based on their own observations or depending on external sources of information. Their reports will be checked by the Mayor to decide to validate the report information or to consider them as rumored report. The report form fields is shown in Figure (4.44)

Figure 4.47 Public hazard reporting form

Chapter 5
Conclusions

By studying the main components and processes related to the main subsystems of an integrated warning system, it had been concluded that to ensure an effectiveness of the whole system of alerting, the system's authorities shoule be able to provide an adequate combinations of communication within the main two communication lines within the intergrated alerting system, where their effectiveness will be measured in the terms of the fulfillment levels for the aspects to be considered in a warning message as shown previously in chapter 2.

With applying those aspects on the case of Lombardy region, it had been concluded that the Region's policies provide some limitations in the communication between the detecting subsystem authorized by ARPA and Regione Lombardia. The first limitation is bound in depending on synchronous way of alerting, where the criticality notice reports conducted by Regione Lombardia and the Mayors are sent in fixed daily basis, the fact that makes a state of ineffectiveness in terms of updatable and frequent information at the times of risks with raised criticality levels. Second, From the communication flow between the two stakeholders, which is shown at figure (4.23), it can be observed that the tools used for raising the awareness of the Mayor and the office managers are not considered as direct warning message dissemination tools, where Regione Lombardia announces by phone calls, Fax or SMS for only notifying the Mayors about the existence of risks with raised criticality levels and to announce about the receipt of the daily criticality notice report , which is the only source for the warning content. Third, by studying the first part of the criticality report, it can be observed that the daily reports are carried out based on the notification of awareness about a single hazard, with assigning different levels of criticality among the homogenous map related for the

hazard. This fact show ineffectiveness in the case of the occurrence of multi-hazard events which is frequent in Lombardia region since all the risks subjected to the region are sourced from a single cause which is the adverse weather conditions. Finally, The dissemination tools doesn't provide a high notification levels for the Mayors located outside the zones subjected to the hazards; it is essential for them to gain a higher level of awareness regarding the hazards occurences to be able to warning their announce these zones to the public within their regions for preventing them to move to zones containing high danger levels, and to raise the preparedness level in the case of assistance needs from nearby provinces mayors in terms of resources and planning.

Regarding to the second line of communication between the Mayors and the public members, it had been observed that two main challenges had been found. The first set of challenges are bound in the fulfilling the main aspects for disseminating the alert messages to public. By revising those main aspects mentioned before in Chapter 2 and degree of fulfillment of them by the common message communication tools, it can be observed the absence of that tool that can achieve high levels of fulfillment for all of the main aspects to be considered when communicating the risk notifications and guidelines with public members. As a result, finding a solution which can offer integrating the main advantages of these different tools should be conducted for reaching high aspect fulfillment levels. As for the other sets of challenges, it will be specified for the large number of foreign tourists reaching Lombardy region for a long time bound in the duration time of the exhibitions which is around 6 months. These challenges can include the unawareness of the region's language, where it can be difficult for the foreigners to ask for assistance and help from locals during the occurrence of emergencies. Moreover, those visitors will be conditions by unawareness about their areas located in which can cause adverse consequences in cases of emergencies. For example, at cases of Flood in province of Como, public will have a spontaneous awareness

about the dangerous areas which are mainly those lied on the Como lake, which will not be the case for foreigners who are having much less knowledge about the city's areas and directions. Last challenge can be in the lack of knowledge by the foreigners about the systems of public emergency alerting and the right reactions to perform to get away from possible dangers which can cause also adverse consequences, especially in the case of usages of hazard only notifications devices as sirens and flags, which are the tools that requires public education about the right decisions and reactions to perform after they had got notified.

Seeking for providing an alternative solutions to eliminate the limitations and challenges found in the both communication lines within the Lombardy alerting system, a new app with the name of Lombardia emergency disseminator (abbreviation: LED) is a proposed for providing a space that can integrate the advantages of different message disseminating tools for conducting Alerts about Lombardy region's risks, serving the both main lines of communications in the Form of an App installed in Smart phones and tablets. By the variety of options available for all the risk stakeholders, this app can assure the dissemination of the warning messages that can achieve high levels of achievements for the mentioned aspects to be considered when communicating the message between emergency detectors and management organizations (ARPA, Regione Lombardia and the Mayors), and between the emergency management subsystem and public (Mayors, public, EXPO visitors). Moreover, the app had been designed to overcome the challenges regarding the dealing of the emergencies by the large number of foreigners present at Milan international exhibition duration. The app's provides set of different possible operations directed to all the stakeholders that are responsible for the interventions of hazard and risks mitigations for the Lombardy region, where LED provides set of options for all of Regione Lombardia, provinces mayors, transportation companies and public members. Each of them is granted by the possibility for viewing the hazard records and updates in map and list views, which

is chosen by the user according to their point of view in viewing the hazards in the most easy and informative ways. Moreover, the app provides the possibilities for all sector of users to publish their hazard records which is automatically notified by the program with different levels according to the receiver's location from the hazard zones. Where Regione Lombardia will be able to generate new hazard records with associated unlimited number of updates which are directly notified to the Mayors with giving a more critical notification level to the mayors located in the provinces within the warned hazard related homogeneous zones. The same options can be used by the other 3 user types with a difference in the record forms to address the needed notification contexts by the receivers and to fulfill the mentioned aspects for the warning message. The LED app provides a space for double communication line for the Mayors and transportation companies in the case of unclear or incomplete information received by the hazard records senders or in the case of assistance need. By this, the aspect of providing a double communication line had been assured. Finally, the app uses the advantages of social media in disseminating the hazards notifications by providing the public members with the option of reporting their own hazard records based on their observations or sources. At the same time, the main credibility problem associated with the usage of social media in emergency warnings by the automatic direction of these reports to the Mayor at the province where the public user had located his hazard record, so by the adequate risk analysis performed by the emergency management, the Mayors will be able to control the credibility of the received information with listing them in either the verified or rumored emergency records database.

5.1 Recommendations for further studies

Further researches recommended by this thesis is bound in the study of the ICT and programming logics to be able to implement the proposed app to serve the

emergency stakeholders including EXPO visitors by the time of the exhibition initiation.

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APPENDIX