SECTION 4- ACTORS RESPONSE AND INTERACTION

1. Organizational culture in Disaster Risk Reduction

In crisis response, an increasing number of individuals, groups, organizations and jurisdictions need to coordinate their actions in order to deliver effective operations.

Organizational culture and disasters
Organizational culture plays a crucial role in DRR by affecting the way different actors give an interpretation to the critical situation. Organizational culture could affect the way different actors perceive the interaction network – e.g. polycentric, hierarchical, star-shaped, etc. – influencing the process of seeking, trusting and interpreting emergency information. Developing effective emergency management strategies requires a clear understating of the differences among cultural organizations and agents' understanding of the interaction networks.

Organizational culture is emerging as a crucial aspect to be considered in assessing the performance of an organization. In emergency, organizational culture affects the way different responders interpret the situation, organize tasks and interact with the others.

How do you analyse organizational culture to enhance resilience?
The implementation of information management and communication technologies, even innovative (e.g. internet-of-things, smartphone, smart city cameras and traffic lights, etc.), failed in many situations because of the oversimplification of the social processes at the base of emergency information management. The key steps in the process of transforming risk information and warning into actions – i.e. hearing, understanding, believing, personalizing and deciding – are mediated through social structures. Exposing all individuals to the same information in the same way, without accounting for the different social structures and organizational culture, is likely to negatively affect the ability to generate novel ideas and interpretations of the emergency situation.
This section of the handbook aims at supporting emergency managers in enhancing the interaction processes among actors involved in emergency management and response, through a better understanding of the complexity (ramification) of the interaction network, and ambiguity in problem framing and understanding the situation.

1.2. Organizational culture in emergency management

The same Greek origin of the word 'crisis' entails the concept of judgment, implying the crucial capacity to make sense and disentangle the clues of a rapidly evolving situation. Evidences demonstrate the danger of lack or delayed decision making during crisis. Decision making and its enactment demands the coordinated involvement of experts and organizations from several fields.
As social systems become increasingly more interdependent with physical and technical systems acting at interconnected spatial and temporal scales, the range of possible interactions among individuals, groups, and organizations, and the context in which these all function increases. Also the number of factors that influence the potential actions and outcomes in constructive or destructive ways also increases. This interconnectedness among the different elements of the system could lead to what we call/are called interdependent crisis. That is, the disruption of one element in the system (e.g. an infrastructure) causes appreciable impact on other elements, which in turn cause further effects on other parts of the system. The extent to which these effects propagate, and how serious these effects become, depends on how tightly coupled the components of the system are, how strong is the original cause, and whether or not adequate counter-measures are in place.
The core activity of taking decisions and implementing actions in this complex and highly dynamic environment often exceeds the ability of a single centralized entity to cope. No single entity can have

complete control of these multi-scale, distributed, highly interactive networks, or the ability to evaluate, monitor and manage these emergencies in real time. It's becoming crucial to overcome the classical emergency management approaches in which institutional organizational structure tends to follow stable boundaries, established authority figures, and protocol driven actions. Nowadays the response to crises becomes an emerging, large-scale system consisting of individuals, groups, organizations and jurisdictions that need to coordinate their actions for delivering effective operations. In crises, a "temporary multi-organisation" as defined by Cherns and Bryant (1984) needs to be deployed, implying several difficulties of coordination and shared management of the situation(s). Cooperative response actions need to be carried out in a network form (Abbasi, 2014), and can benefit or be impaired by the connectivity patterns of the different emergency responders (Vespignani, 2011).

Enhancing the coordination effectiveness in case of emergency among the different responders is the main scope of several studies aimed at overcoming the main organizational factors hindering cooperation. Up to now, most research has been carried out on what happens within a single organisation under stress, while knowledge is still limited on what happens when multiple organisations need to coordinate in unison to make the best of their capacity in a highly stressful environment. That is, lack of cross-sectoral structures, lack of common goals, lack of common concepts, lack of distribution of information, lack of trust, competitive practices and lack of situational awareness (. Although most of the efforts carried out in order to enhance cooperative emergency management have been focused on technological innovation for information sharing, we need a shift toward enhancing the interactions among the different actors in emergency management.

Existing formal protocols of interaction ignore how cultural diversities, with specific reference to organizational culture, influence the way different actors perceive the topology of their own interactional network, and, consequently, their strategies to cooperate with other entities. Empirical evidences demonstrate how some actors assume a strongly hierarchical structure of the interactions (Sorensen & Stanton, 2013). Other actors consider the multi-central structure as the most effective one to allow the rapid exchange of information and cooperation within each level of the organizational structure and between different levels (Smart & Sycara, 2013). Neglecting these differences could lead to the development of ineffective procedures for emergency management, because the actors will not recognize the network through which they collect the information and cooperate as trustable.

The dynamic and complex nature of crisis situations does not allow for a static framework of the crisis responses. Interaction networks change dramatically during an emergency. Some actors could assume the role of informal leaders, whereas the official responders could be characterized by a low level of trust. The existing institutional protocols for information management in case of emergency seem incapable of adapting themselves to this changing interactional situation.

Finally, the process of interpreting the emergency information (i.e. sensemaking) has to be considered as a social process aiming at selectively focus on certain stimuli and responses (attentional selection), and at generating a shared understanding for coordinated action. This requires a perspective in which the negotiation of meaning of information that is embedded in emergency management become visible. This allows emergency managers to unravel the impacts of differences in institutional and cultural backgrounds and to consider those diversities as a factors enabling/facilitating the collective sense-making. Nevertheless, cognitive diversity is not always a virtue when it comes to collective cognitive processes. On the one hand, evidence suggest that cognitive heterogeneity is useful in mitigating against the cognitive biases that are associated with collective sense-making (e.g. confirmation biases) (Smart & Sycara, 20. On the other hand, different background knowledge and belief can represent a barrier to collective cognitive processes (Smart & Sycara, 2013).

The experiences in EDUCEN demonstrate that in order to shift cultural diversity from a barrier to an enabling factor for cooperative emergency management,requires methods and tools to enhance the

understanding of the dynamic processes influencing the interactions among different actors in the different phases of the DRR.

Organizational culture in L'Aquila, Italy

The city of L'Aquila experienced a disastrous earthquake in 2009. Different barriers hampering the cooperation among the different actors were registered during the three main phases of the DRR. The communication limits in the preparatory phases and during the recovery gained a lot of

attention.

1.3. Organizational culture in L'Aquila (ITA)

We mapped the network of interactions among the different emergency responders, both institutional and non-institutional to analyse the flow of information and cooperation activated during the different phases of the 2009 earthquake emergency.

The Case Study looks into the disastrous Magnitude 6.3 earthquake which struck L'Aquila city and its province at 3.32 a.m. on 6 April 2009. The event killed 308 people and injured 1500. Although the physical event was relatively moderate (moment magnitude 6.3), its impacts were particularly great, mainly due to the very high vulnerability of lives, livelihoods, building stock and institutions i
n the Apennine Mountains.

This event highlighted several limits in the information sharing protocols, and specifically between the institutional actors and the community. These limits had a very negative impact on the level of trust local community had in the emergency managers, with consequences on the acceptability of emergency management and recovery measures. After the earthquake, the local community was forced to abandon the city center. New towns were developed in safer places, disaggregating the original socio-cultural networks. New networks emerged after the disasters, showing different cultural aspects.

In order to cope with emergencies, the official protocol of interactions among the different actors can be represented as in figure 52.
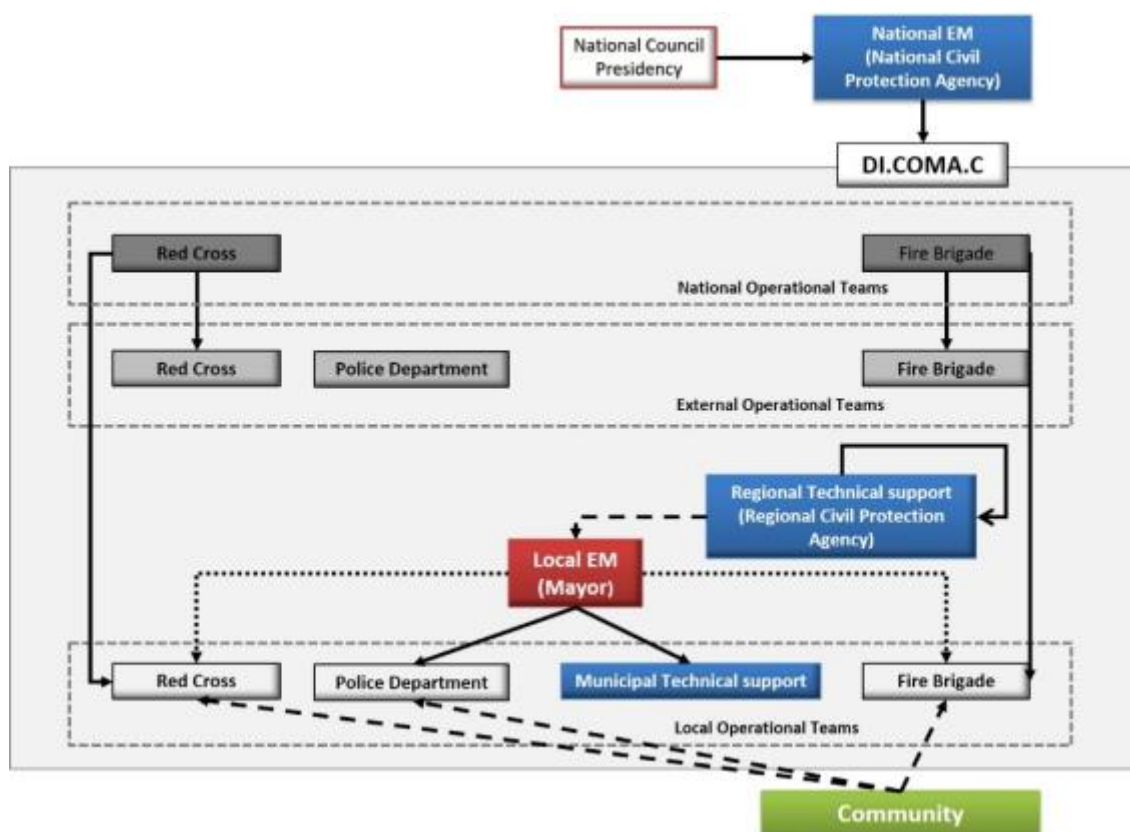
Fig. 52: Official protocol of interaction

As shown in the figure, the protocol is strongly hierarchical and pemits little information sharing between actors at the same level in the process. The analysis of the interviews carried out in the case study, involving both official responders and members of the community, allowed to map the actual network of interactions, as shown in the following figure.

Table 3: List of stakeholders involved in the L'Aquila CS.

Name	Role	Type	L'AQUILA
L.EM	Local Emergency Manager	Individual	Mayor
N.EM	National emergency management	Organization	Di.Coma.C.
L.TS	Local Technical Support	Organization	Technical Municipal office
R.TS	Regional Technical Support	Organization	Regional Civil Protection agency
N.TS	National Technical support team	Organization	National Civil Protection agency
L.OP1	Local Operational Team #1 (Health assistance)	Organization	Local Red Cross team
N.OP1	National Operational Team #1 (Health assistance)	Organization	External Red Cross teams (coordinators and operators)
L.OP2	Local Operational Team #2 (Fire Brigade)	Organization	Local Fire Brigade team
N.OP2	National Operational Team #2 (Fire	Organization	External Fire Brigade teams

	Brigade)		(coordinators and operators)
L.OP3	Local Operational Team #3 (Police Dept.)	Organization	Local Police team
N.OP3	National Operational Team #3 (Police Dept.)	Organization	External Police teams (coordinators and operators)
C	Community	Individual	Members of the community
CL	Community leaders	Individual	Representative of the community

The comparison between this network and that representing the official protocol of interactions in case of emergency demonstrates the inadequacy of the protocols to fully capture the complexity of the interactions. The actual network is far less hierarchical and accounts for informal interactions taking place even among institutional actors. That is, during the knowledge elicitation phase we learned that, besides the official interactions, in case of emergency the institutional actors activated personal relationships to gather important information.

The combination of the different networks allowed to map the complex interactions among the main elements activated during the flood emergency, i.e. agents, knowledge and tasks (see Figure below).
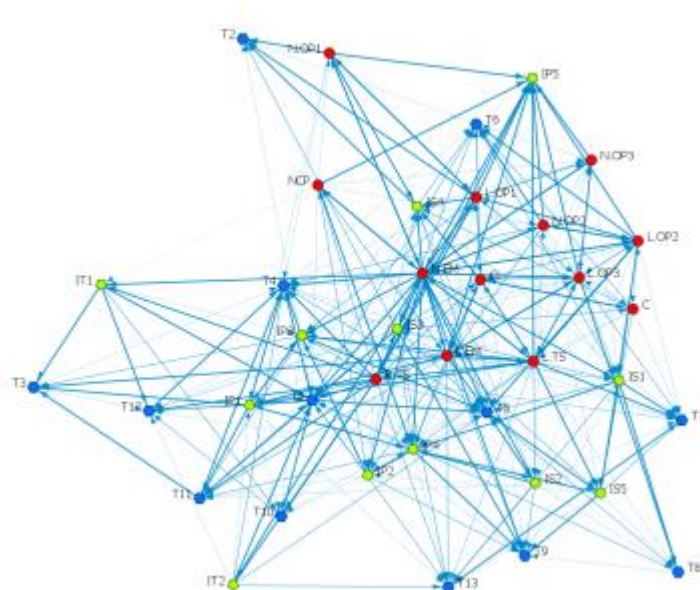

Figure 53. Network of interaction among Agents, Knowledge and Task according to both experts and local knowledge.

The Figure shows the actual complexity of the interaction mechanisms supporting the emergency management. Failure in this network – lack of an information, missing cooperation for task implementation, etc. – could provoke uncontrollable cascading effects leading to the failure of the whole emergency management process. Therefore, it becomes crucial for the emergency managers to enhance their comprehension of this complexity, in order to implement actions aiming to increase the effectiveness of the emergency management network and to reduce its vulnerability.

The experiences carried out in the L'Aquila CS demonstrated how the organizational culture influences the way the different organizations perceive the interaction network in which they have to operate in case of emergency. Some institutional actors, such as local emergency managers, considered the multi-central structure as the most effective structure to enable a rapid exchange of information within each level of the organizational structure and between different levels. These levels seem capable to adapt their information collection strategy to different conditions, showing resilience to failures in official protocols of information sharing. Institutional actors with a dense network of interactions – regional emergency management – seemed capable to shift from the formal to the informal network in order to gather the information needed. But the official responders, such as the national civil protection and the fire brigades, assumed a strongly

hierarchical structure for information exchange. These actors exclusively trusted information flowing from the top through intermediary, and easily recognizable, levels. This is because they needed to reduce "noise" in information collection. Neglecting these differences can lead to ineffective strategies for information sharing for emergency management. Integrating Murcia's emergency management into a hierarchically structured network could negatively affect its role as response coordinator. To the contrary, increasing the number of information centres in the responders' networks could paralyze their activities. The experiences gained in L'Aquila suggested that developing effective emergency management strategies requires a clear understating of the differences among agents' understanding of the interaction network.

Finally, the adopted methodology allowed us to emphasize the role of the community in the emergency management phases, and to make the institutional actors aware of the need to account for the community's understanding of the emergency situation. Specifically, the analysis of the community network allowed us to better comprehend the reasons why the level of trust in institutional information is so low. The community network is strongly polycentric, allowing community members to select the more suitable information sources and activate informal networks of information sharing, as the information provided through institutional channels is not easy for them to comprehend. The analysis of the network allowed to define the central role played by the community leaders in facilitating the flow of information. They represent the actual information centres for the community. This result was considered as crucial for the definition of potential improvements of the emergency management procedure.

Organizational culture in Lorca, Spain

The Lorca municipality has historically suffered serious disaster episodes. The St. Wenceslas Flood (2012) caused several fatalities and damages to buildings and infrastructures. This experience showed some bottlenecks in the "formal" channels of information and data sharing. In particular, the capability of the institutions to provide community with accessible and understandable information on flood risk was strongly questioned and leaded to some conflicts involving community and institutions.

1.4.Organizational culture in Lorca, Spain

The methodology described was implemented to analyse the interaction network supporting the flood emergency management in Lorca and Puerto Lumbreras municipalities, located in the autonomous region of Murcia in Southeastern Spain. The area is highly disaster prone, mainly floods, but also droughts and earthquakes. Lorca is the third city within Murcia and the main one in the shire of Alto Guadalentín, a large valley that has become a key agricultural area in Spain. Paradoxically, the area is characterised by a semi-arid climate.

The area has historically suffered serious disaster episodes. Specifically, Lorca's Puerto Lumbreras area is more prone to hazard: major events include the Puerto Lumbreras flood in 1973 and St. Wenceslas Flood in 2012. These events caused several fatalities and damages to buildings and infrastructures (e.g. Puentes dam was destroyed twice by flooding).

The flood episodes typically occurring in the area may be extremely dangerous due to their quick onset: the flow rate can increase up to 2000 m3/s within minutes, conveying in two hours approximately the same volume of water that is normally expected in a whole year. Specifically, in the flash flood event of the 2012, the Nogalte wadi, a tributary to Guadalentín river, changed from a dry riverbed to a wide and fast-flowing river in less than 20 minutes (Figure 54).

Fig. 54: The St. Wenceslas Flood of 2012

In order to cope with flash flood emergencies, a protocol of interactions was developed aiming at facilitating the coordination and the flow of information among the different institutions and official responders. Figure 55 schematizes the official protocol of interactions in case of emergency in the Murcia autonomous region.
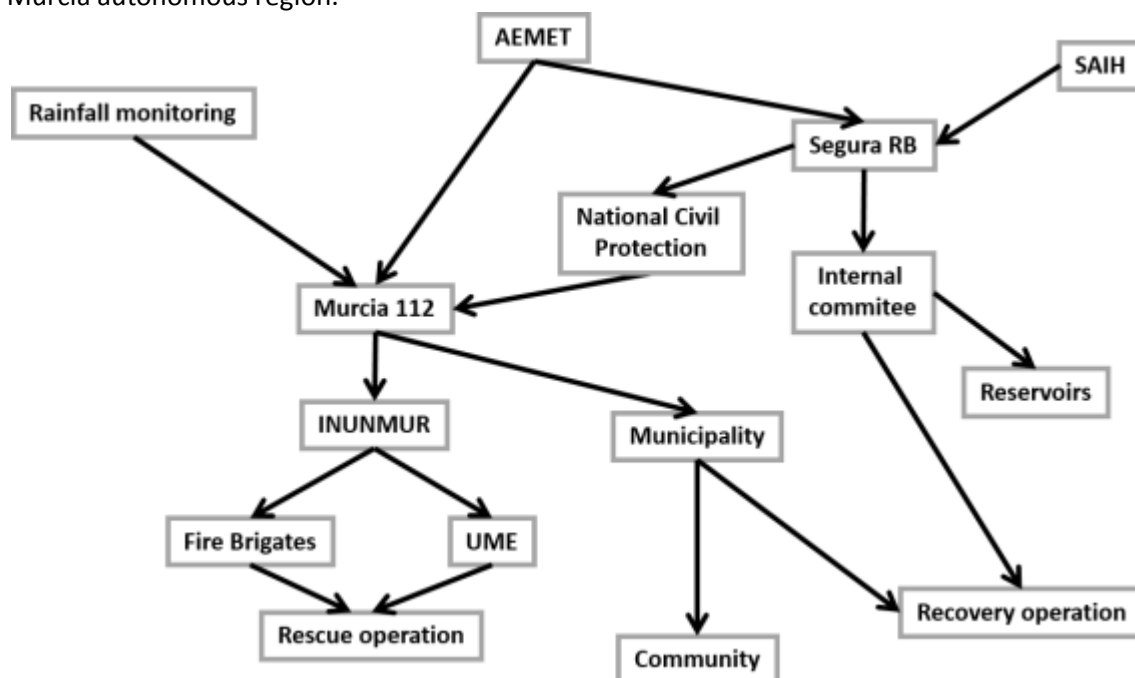

Fig. 55: Protocol of interactions and information flow among the institutional actors in case of emergency

As shown in the figure, the protocol assumes a hierarchical structure concerning the flow of information. The Spanish Meteorological Institute (AEMET) is responsible for disseminating the early warning based on the weather forecasts. According to the level of warning - red, orange and yellow - actions should be taken by Murcia's emergency management unit (Murcia 112). During flood events, two independent monitoring networks collect data:

- the rainfall monitoring system provides real time data to Murcia 112.
- the SAIH, the Segura River Basin monitoring system, provides accurate and updated data on rainfall, the level of the water in the riverbeds and the level in the reservoirs.

These two monitoring systems do not exchange information. According to the protocol of interaction, Murcia 112 plays the central role in the emergency management. It coordinates the rescue activities of the first responders through Murcia's flood response committee, INUNMUR. On the other side of the interaction network, the Segura river basin authority, in case of warning, activates its internal monitoring and decision-making committee whose main scope is to adopt the needed actions for managing the water in the reservoir according to the flow of water in the riverbeds.

The Municipality represents the interface between the emergency management authority and the local community. According to the existing protocol of interventions, its main role is to facilitate the flow of information to the community and to implement the decisions taken by Murcia 112 at local level, e.g. the evacuation of the local population.

Previous experiences had shown bottlenecks in the "formal" channels of information and data sharing. In particular, the capability of the institutions to provide community with accessible and understandable information on flood risk was strongly questioned and leaded to some conflicts involving community and institutions. Moreover, ineffective communication among institutional agents was registered, both between the Segura river basin authority and Murcia 112, and between Murcia 112 and the Municipality. Based on these experiences, negotiations were started to revise the operative protocol. Our analysis aims to support this revision and adaptation process through the analysis of the formal and informal networks of interaction, and the detection of the vulnerable elements in the network.

The following pages describe the results obtained through the implementation of this methodology. The official protocol of interactions to be activated among the institutions in case of emergency was used in this work as a starting point for the definition of the set of actors to be involved in the knowledge elicitation phase. Table 2 shows the list of the institutional actors involved in the cognitive mapping interviews. A main role was assigned to the institutional actors as well, which can also be useful to generalize the methodology. The acronyms were selected in order to facilitate the development of the network maps, as shown in the following.

Name	Role	Acronym
Spanish meteorological Agency (AIMET)	National technical support	N.WF
Segura river basin authority	Regional technical support	L.TS
Murcia emergency management	Local emergency management	L.EM1
Fire brigades	Local operational team	L.OP1
Military emergency unit (UME)	National operational team	N.OP
National civil protection	National EM	N.EM
National Government	National coordination	N.GOV
Municipality	Local emergency management	L.EM2
Media	Information provider	MC
Other Municipalities	Local emergency managers	L.EM3
Local Police	Road functionality	L.OP2

| Network managers | Road functionality | R.OP2 |
| State police | National emergency unit | N.OP3 |

Table 2: List of institutional stakeholders involved in the flood emergency management

The aggregation of the collected narratives allowed to develop the complex maps of interaction, as shown in the following figure.
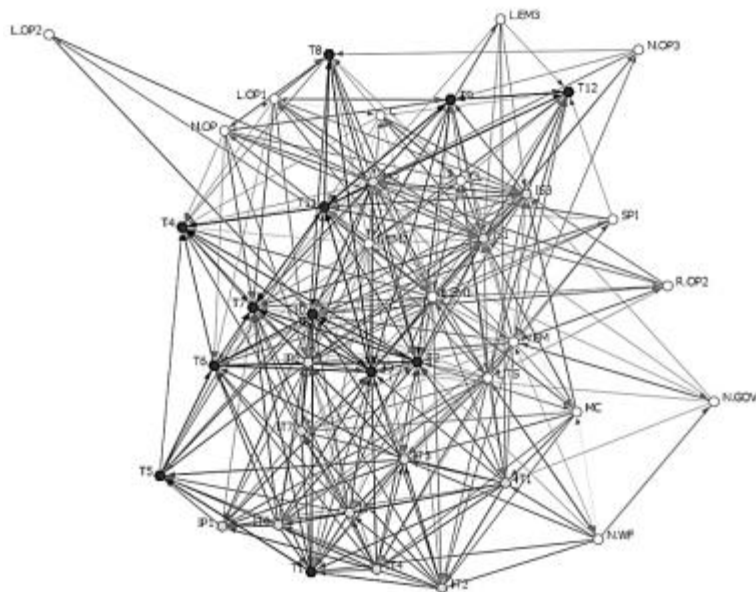

Fig 56. : Network of interaction among Agents, Knowledge and Task according to both experts and local knowledge

Figure shows the actual complexity of the interaction mechanisms supporting emergency management. Failure in this network – lack of an information, missing cooperation for task implementation, etc. – can provoke uncontrollable cascading effects leading to the failure of the whole emergency management process. Therefore, it becomes crucial for the emergency managers to enhance their comprehension of this complexity, in order to implement actions aiming to increase the effectiveness of the emergency management network and to reduce its vulnerability.

To this aim, graph theory measures described previously were implemented in order to identify the key elements and the main vulnerabilities of the network. Table 4 shows the results of the analysis aiming at identifying the key agents in the network.

Measures	Key actor	Meaning
Total centrality degree	National civil protection Municipality	These actors are characterized by a high number of connection (both in- and out-) with most of the other agents in the network.
Betweennes Centrality	Municipality Segura RBA Murcia 112 Community leaders	These actors occur on many of the shortest paths between other agents. This means that these actors can easily move information from one part of the other of the network.
Hub centrality	Segura RBA Murcia 112 Community leaders	Individuals or organizations that act as hubs are sending information to a wide range of others each of whom has many others reporting to them. Therefore, they act as hub of information within the network.
Most knowledge	Segura RBA Murcia 112 National civil protection Media	These actors have access to important pieces of information.
Most task	Murcia 112 Municipality	These actors are called to perform the most important tasks.

	National civil protection Segura RBA	

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Table 3. Key agents in the Lorca flood emergency network

The analysis allowed us to identify the most crucial agents in the network accounting for the complexity of their relationships with the other agents, which affects their capability in moving information from one side of the network to the other. Moreover, the adopted approach assumed that an agent is crucial in the network performance if she/he brings important knowledge and if she/he cooperates in performing important tasks.

The results of analysis demonstrate the importance of the three most influential institutional actors at local level, i.e. the Segura river basin authority, Murcia's emergency management and the municipality. These actors had a dense network of interactions with the other agents (centrality measures), and had access to a wide set of crucial information allowing them to carry out crucial tasks. Beside these results, the analysis of the network emphasizes the actual role in the emergency management of the community leaders and the media. These actors were not mentioned in the official protocol of intervention. Specifically, the community leaders could easily act as an interface between the institutional system and the local communities. Their high value of the betweenness centrality and hub centrality demonstrate that these actors could facilitate the sharing of the emergency information.

Similarly, the network analysis showed that role the media could play during an emergency. Most institutional actors were in direct contact with media. Therefore, they had access to important information.

The developed network was also analysed in order to identify key vulnerabilities, i.e. those elements that could lead to failures of the emergency management operations and/or to decreasing effectiveness of the responding actions. The graph measures mentioned in Table 5 were implemented. The key vulnerabilities are described in Table 5 below.

Type of elements	Key vulnerability	Meaning
Agent	Community leaders	This actor has a high degree of centrality but a low degree of "most knowledge": s/he has access to limited knowledge impeding their role as information providers. They represent a barrier rather than a bridge to information sharing.
	Municipality	This actor has a high degree of "most task" and a low degree of "most knowledge". This is mainly due to the limited capacity of the municipality to understand the technical information provided by the other actors. As result, the effectiveness of its actions is limited.
	Media	This actor has a high degree of "most knowledge", because it receives information directly from the institutional actors. Nevertheless, its low centrality degree reduces its capability to effectively share the information with the community.
Knowledge	Flood emergency	This information should play a crucial role

	management plan	since it has a high level of 'most task" (it supports a large number of tasks). Nevertheless, it is poorly shared among the different agents (low degree of most knowledge).
	River flow monitoring and forecasting	This information represents a key vulnerability because it has a high betweenness centrality in the *knowledge x knowledge* network (i.e. it could activate other information), but it is not easily accessible to most actors.
Task	Preparedness activity with community	This task is characterized by a high degree of centrality in the *Task x Task* network: it could facilitate the implementation of numerous other tasks. However, only the municipality is responsible for the correct implementation of this task.

Table 5. Key vulnerability in the network of Lorca flood emergency management

The results of the analysis were used as basis for the discussion with the local decision-makers and stakeholders. At the beginning of the process, they were aware that improvements in the protocol of interactions were needed. Nevertheless, they were focusing exclusively on the interaction among the institutional actors. The analysis carried out in this work increased their awareness about the role played by the informal interactions, taking place within the institutional system and between institutional actors and the members of the community. Using the results of the key vulnerabilities analysis, participants started discussing about suitable strategies to improve the flood emergency management plan, accounting for the complexity of interactions. Specifically, the discussion initially focused on the role of the media. Most institutional actors agreed that enabling a more effective bi-directional communication with the community members through the social media would be beneficial for sharing emergency information. The institutional actors were interested in enhancing the capability of the current media channels to collect, store and analyse the feedbacks from the community. The capability of local communities to contribute to the monitoring of the emergency evolution was deemed important by the participants.

In order to enhance the preparedness for flood emergency management, the need to improve the cooperation between institutional actors and the local community was considered crucial. According to the results of the discussion, this activity could improve the capability of local population to react in case of emergency in cooperation with the official responders. To this aim, suggestions were made to train the community leaders to be referred to as "agent of change". Participants referred to the results of the "key agents" analysis in order to identify this potential improvement.

Therefore, the first and most important positive result of the methodology concerns the increased awareness of the institutional actors about the need to shift the focus from investing economic and human resources in developing innovative emergency information collection tools, to enhance the capability of the different actors to co-operate in case of emergency.

2. The role of culture in multi-organizational emergency management

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2.1. Challenges with information sharing and coordination in emergency response

One of the most pronounced key challenges in emergency management concerns how to adequately share information and coordinate the rescue efforts of different emergency response organizations. In emergency response various organizations with different backgrounds, specialized operational expertise, and professional jargons try to develop a shared understanding of the situation. In order to do so, they must bridge their jurisdictional and organizational boundaries. This is challenging because each response organization has operational field units at different levels, different functional command structures, and separate back offices for information and resource management. Consequently, emergency management literature often describes failing information management due to problems of information overload, difficulties with information technologies and validation of information, and insufficient attention for data sharing (Comfort and Kapucu, 2006; Kapucu, 2006; Moynihan, 2009; Netten and Van Someren, 2011).

Recently scholars have started to address the *cultural dimension* in emergency response operations. For example, Morris, Morris and Jones (2007) describe that the success of the US Coast Guard rescue operations in the aftermath of hurricane Katrina was based upon being able to speak the different professional languages of many different stakeholders. In a different analysis of the response to Hurricane Katrina, Moynihan (2012) shows how the Department of Defence performed a culture-switch to adopt to a new multi-stakeholder operational logic. Similarly, Tsai and Chi (2012) argue that cultural distance is the missing link in explaining the gap between desired and perceived effectiveness of Incident Command System in Japan and Taiwan.

Yet, a coherent perspective on the cultural dimension of multi-organizational response operations is missing. The main focus of this chapter is, therefore, to explore the cultural dimension in multi-organizational emergency response coordination. We propose a coherent cultural model, which builds upon and integrates several years of empirical studies into Dutch emergency response organizations (Boersma et al., 2010; 2012; 2014; Wolbers et al., 2012; Wolbers and Boersma, 2013; Treurniet et al., 2016; Wolbers, 2016).

2.2. Introducing a culture model: the trading zone

Organizational culture has been described as a pattern of (a) basic, shared assumptions, (b) invented, discovered, or developed by a given group, (c) and instrumental for organizational members to cope with problems and uncertainties (Schein, 1996; Giorgi et al., 2015). It is seen as the social glue that holds the organizational members together. In the case of emergency responders this means that the fire department, police and ambulance services each have distinct cultural characteristics that give the professionals an unique identity, but at the same time can also cause misunderstanding between them as soon as they have to work together.

However, the description of culture as a static set of shared assumptions is an oversimplification of the actual situation. Stories of first responders provide us with a far more complex and dynamic picture, showing that tensions can develop because of cognitive and normative diversity within a particular response organization. The attribution of meaning (an important part of the cultural process) is complicated and can lead to fragmentation as well as integration, diversity as well as unity. In line with JoAnne Martin's organizational cultural analysis (2002), we argue that a monolithic approach that sees each response organization as having an own 'culture', neglects the complexity of the cultural dimension. In order to understand the role of culture in the multi-organizational, and dynamic environment in which emergency responders operate, we propose a model that adheres to

that complexity. We do so, by addressing the practices of emergency responders from an interpretive perspective, which considers organizational culture:

1) *to be a layered phenomenon*, which including the values and the deep assumptions within the organization,

2) *to be multi-dimensional* since it is not a static, monolithic phenomenon in which each organization has a distinctive culture (i.e. are integrated). Instead, these cultures can also be differentiated (i.e. have subcultures) or be fragmentized (i.e. different perspectives can exist within one subculture) and they can change over time,

3) *to be an outcome of sensemaking and sensegiving* in which organizational members (de/re)construct reality based upon these processes to find out what is going on in times of uncertainty.

In the actual practice of emergency response operations, we have often witnessed professionals from the different response organizations in discussion with one another about the characteristics of the emergency, their actions, and the consequences of the actions for the response operation. This interaction is characterized by a process we regard as *negotiation*. We propose a model of cultural-in-practice to capture the recurring processes of negotiating actions and interpretations between emergency responders. The negotiation between emergency responders take place in *trading zones*: situations in which local coordination of ideas and action take place despite differences in the (professional) backgrounds, norms, and routines the first responders (see for this concept: Galison, 1997). A trading zone as a setting that embodies coordination efforts, is an ongoing accomplishment in which diverse groups interact across their boundaries, by agreeing on the rules of the trade, while the objects traded can mean different things to both groups.

The trading zone has four dimensions. First, groups that interact in the trading zone have different professional backgrounds, a phenomenon that we call: *epistemics*. Second, by developing their own professional knowledge and standards these groups create an own *identity*. Third, the groups confront their different interpretations by initiating in a negotiation process across their professional boundaries through *boundary work*. Fourth, this negotiation process occurs by sharing the interpretations of a particular situation by *storytelling*. We have placed these elements on two axes in a culture model (figure 57).
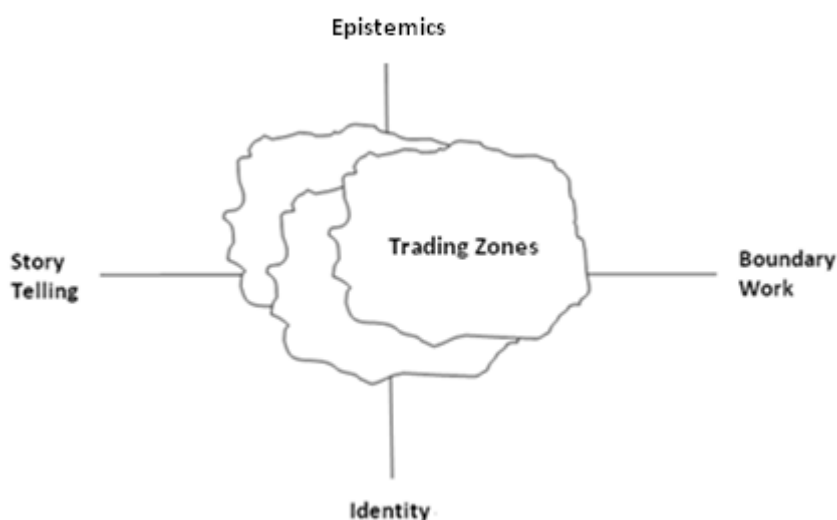

Figure 57 : a layered cultural model for understanding first response organizations in-action.

The vertical axe in our culture model shows the diverse nature and backgrounds of emergency responders interacting in the trading zone, through their *epistemics* and

identity.

Epistemics refers to the *jargon* of different professional languages in relation to the organizational practices in which this professional knowledge is developed (Knorr Cetina, 1999). The connection with actual practices is important to understand the relations between the concepts in our layered culture model, as epistemics are made up of patterns of activities that are constructed in daily interaction, that demarcate the existence particular professional fields. By interacting with artifacts the professionals generated knowledge that is seen as particular to that field, which also creates a boundary between different epistemics. In this way the epistemics can be directly related to processes of brokering ideas between different communities.

Identity refers to professionals who tend to identify themselves with their own organization; especially in situations in which they are confronted with other professional organizations (Tajfel and Turner, 1986). We acknowledge the necessity for the strong identification and loyalty of the members with their operational field. At the same time, in the dynamics of emergency response operations the context in which identification occurs often changes to result in 'identity work' (Alvesson, 2000). This leads to the situated nature of identity, which means that in one context one identifies with being an emergency responder working together with other emergency responders, while in another context one might identify him or herself with being a police officer who has to work together with a fire officer.

The horizontal axe in our culture model focuses on the action and practices of emergency response in-action, in which *storytelling* and *boundary work* takes place.

Boundary Work describes the process of sharing information across the boundaries of organizations (Star and Griesemer, 1989) to negotiate actions and interpretations (Kellogg et al., 2006). Boundary spanning occurs when emergency responders interrelate on the basis of understanding each other's needs and requirements for coordination. Learning how to bring together each other's complementary skills, learning from the experience of others and closely examining information is a key asset for developing cross-boundary coordination. Boundary objects are part of coordination mechanisms by representation, which offer a common referent that people can use to interact, align work and create shared meaning.

Story telling conceptualizes the process of sharing and making explicit the interpretations of emergency responders, in which they describe the situation and their actions (Feldman et al., 2004). The stories told by the first responders have a plot (the main message), characters (what are the relevant actors in the story) and a narrative (what is the story about and how is the story presented). Through sharing their stories implicit, problem conceptualizations are made tangible by signalling potential problems, clarifying misunderstandings and exchanging information.

2.3. On methodology and methods: a research agenda

Our trading zone model aims at unravelling the cultural dimension by exploring and understanding sensemaking and sensegiving practices of emergency response professionals (Weick, 1995; Weick et al., 2005; Maitlis and Lawrence, 2007). As sensemaking is a process that describes how actors perceive and enact their environment, we adhere to an interpretative, constructionist perspective (Yanow and Schwartz-Shea, 2006). This perspective focuses on collecting and analysing data in which the stories of the actors involved are central. Storytelling (narrative analysis) as a method enables the researcher to uncover the otherwise hidden assumptions of the emergency responders, as well as

their organizational values. Through stories actors implicitly, and sometimes explicitly, negotiate their interpretations and actions. The ethnographic approach (Hammersley and Atkinson, 2004) is very useful in unravelling trading zones since it enables the researcher to follow the real-life conversations and the negotiation of the interpretations of the emergency responders. A typical cultural study based on our model takes place by adopting three methods: observations, interviews and document analysis to come to a triangulation of data.

2.4. The emergency responder as reflective practitioner

Negotiation in the trading zone is not a neutral process; it involves power and interests. A such, for emergency response to engage in a trading zone, a stance is required that increases their *reflexivity*. Reflexivity and *knowing in-action* (Schön, 1987; Thompson, 2008) can make differences, power, and interests that are embedded in interpretation processes explicit. Increasing reflexivity can be achieved by telling stories about the bottlenecks that emerge in the response operation. This often makes the different interpretations of the situation the actors adhere to explicit. Yet, is not only important to tell the story from one perspective, but it is especially important to include the other professional perspectives as well. Reflexivity allows the emergency responders to make their different professional backgrounds visible to themselves and others, and find new creative solutions to traverse their professional boundaries. This, of course, is a learning process that (literally) needs training and education, in order to let professionals recognize the constraining and enabling characteristics of multi-organizational work. Reflexivity starts with the recognition of the problem, and continues with the development of affective responses and empathy. Therefore, a multi-organizational operation in emergency response involves asking and answering the questions (Yanow, 1997): *What do I do? Why do I do it? What does it mean for me, as a professional, and for the other professionals I work with and for?* In this way, first responders can create a trust in each other's skills and routines, and work towards a shared process of sensemaking and sensegiving.

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3. Networks of responders

3.1.Introduction

Crisis decision-making and its enactment demands the coordinated involvement of experts and organizations from several fields. In crises, a "temporary multi-organisation is deployed, which brings difficulties of coordination and shared management of the situation(s). Up to now, much more is known on what happens within the same organisation under stress, than n what happens when multiple organisations need to coordinate in unison to make the most of their capacity in a highly stressful environment. > A dense network of interactions – formal and informal – emerges during a crisis, involving both institutional and non-institutional responders in information sharing, collaborative task performance, etc. The topology of the network (i.e. the structural patterns of relations) of responders has a significant impact on how actors actually behave. > Once we understand the actual topology of the emergency management network, we can formulate suitable strategies to make it more effective.

3.2.Network topology and emergency management

The patterns of interactions effect different processes at the basis of the network performance in case of crisis, i.e. knowledge transfer, information sharing, collaborative actions, etc. One of the main characteristics is the density of the social ties: the more social ties, the more possibilities for collective action, for collaboration and for the developing a common understanding (Shared Situational Awareness). The degree of *cohesion* of a network describes to what extent the network "hangs together" instead of separating it into separate sub-groups. The existence of sub-groups can pose challenges for joint action. Yet, only a few subgroups with relatively strong ties between them can ensure that the network is managed, in a ' polycentric' way. This kind of network can facilitate bridges between disparate views and help formulate a shared understanding and framing of the problem, leading to a sounder management strategy.

Network analysis in L'Aquila CS

We interviewed key responders in order to map the interactions among the different responders during the 2009 earthquake emergency. When we analysed the map we noted the crucial role of the local emergency management team in facilitating the information sharing process.
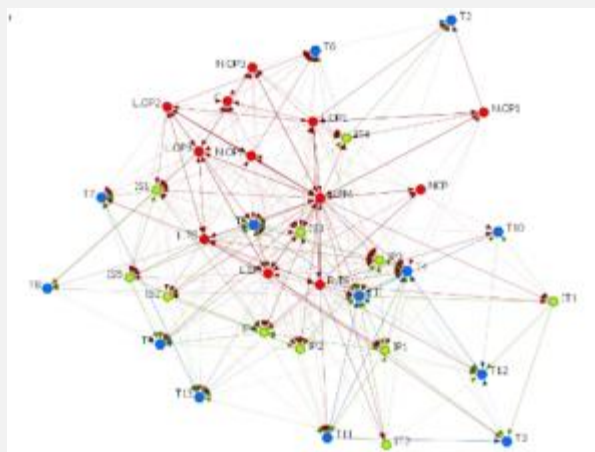

Figure 58. Map of interaction of responders in L´Aquila earthquake, 2009

3.3.Network analysis in Lorca CS

We also mapped the interaction network of both institutional and non-institutional responders in Lorca, Spain in the San Venceslao flood episode of 2012. The map highlights the crucial role played by community leaders. Suggestions were made how better to integrate community members in information sharing.
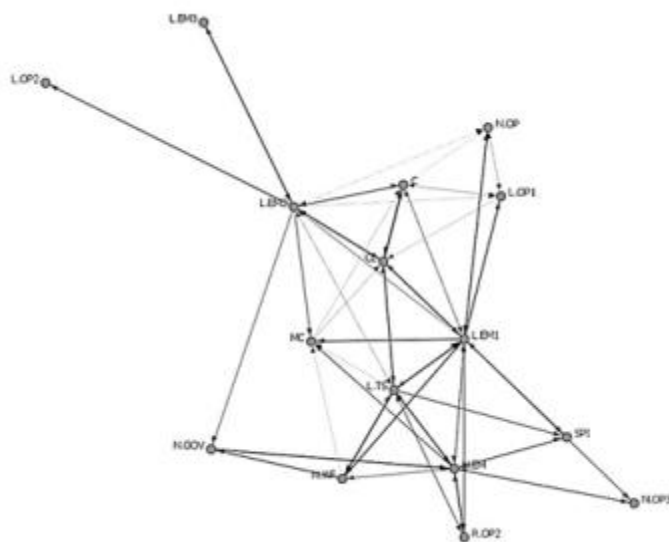

Figure 59 . Map of responders in Lorca, in the San Venceslao flood episode, 2012

3.4.Coordination, communication and decision-making

How can we make coordination among the different responders more effective, when a fast and efficient response is required? Different barriers can hamper the coordination and communication among different responders, i.e. lack of cross-sectors structures, lack of common goals, lack of common concepts, lack of distribution of information, lack of trust, competitive practices and lack of situational awareness. Most of the efforts carried out for enhancing coordination effectiveness were meant to innovate the information technology for internal and external communication, information production and sharing, task information and allocation, coordinated decision-making process and analytical tools. > Evidences show that effective coordination support system should account for the cultural diversities among the responders, which affect the way actors search and interpret the situational information, and interact with others.

The Greek origin of the word 'crisis' entails the concept of judgment, implying the crucial capacity to make sense and disentangle the clues of a rapidly evolving situation.

The core activity of taking decisions and implementing actions in a complex and highly dynamic environment, such as the emergency management, now often exceeds the ability of a single centralized entity to cope. No single entity has complete control of these multi-scale, distributed, highly interactive networks, or the ability to evaluate, monitor and manage these emergencies in real time. Nowadays the response to crises becomes an emerging, socio-technical system of individuals, groups, organizations and jurisdictions that need to coordinate their actions for delivering effective operations. In crises, a "temporary multi-organisation" needs to be deployed, implying several difficulties of coordination and shared management of the situation(s).

Up to now, much more research has been carried out with respect to what happens within the same organisation under stress, while knowledge on what happens when multiple organisations need to coordinate in unison to make the best of their capacity in a highly stressful environment is still limited. That is, lack of cross-sectoral structures, lack of common goals, lack of common concepts, lack of distribution of information, lack of trust, competitive practices and lack of situational awareness. Among those factors, the capabilities of organizations to overcome the fractured nature of information in distributed system, where the state of the system itself can be perceived indirectly, through an effective information exchange by collaborative agents is considered crucial (Sorensen & Stanton, 2013).

Most of the efforts carried out for enhancing coordination effectiveness were meant to innovate the information technology for internal and external communication, information production and sharing, task information and allocation, coordinated decision-making process and analytical tools.

Among the different available information systems, Operational Picture (OP) has gained the interest of different researchers and practitioners. This is because these systems facilitate the access to real-time, spatio-temporal information on the evolution of the emergency and matching responses, in other words, situational information. An OP aims at supporting Situational Awareness (SA) of the different actors involved in the emergency management operations. SA is a key concept in emergency management and in the whole cycle of Disaster Risk Reduction (DRR), being related to the fast reconnaissance of the extent of affected areas and the potential number of victims, the damage magnitude and the consequent needs that may be expected. Further, this picture of damage and needs as well as the unravelling of the disaster situation itself will change with time, also in direct connection with the dynamics of the surrounding environment and the effect of actions. Shared situational awareness (SSA) is further defined as the degree to which different actors involved in the disaster response activities are characterized by a shared understanding of the subset of information that is necessary to achieve their goals. An OP provides data and information feeding evidences about what is happening, who is intervening and where things are happening. Common Operational Pictures (COP) are further development of the OP systems, enabling all actors involved in the emergency response to achieve and share situational information in a geographically distributed environments.

Examples of COP systems

Several COP systems are currently available for supporting emergency responders. The below are just few examples of information management systems aiming at creating a broad situational awareness by combining Geographic Information System (GIS) data with changing, real-time event data through the integration of different information sources, and supporting coordinated control and communication:

Disaster Management Information System (DMIS) (https://www-secure.ifrc.org/DMISII/Pages/00_Home/login.aspx),

SAHANA (https://sahanafoundation.org/), the NC4's Emergency Operations Center (EOC) software solution E Team (E TEAM) (http://nc4.com/Pages/eteam.aspx), the Department of Homeland Security (DHS) COP system (https://cms.geoplatform.gov/node/574),

The COBRA Emergency Management Information System platform (http://cobra2020.com/products/cobra-platform/),

Rhe ArcGIS for Emergency Management solution (http://solutions.arcgis.com/emergency-management/situational-awareness-overview/),

VIEW POINTE 4QTRS (http://www.viewpointe.info/),

SENTIO (http://c4ic.com/products/sentio/),

IBM Intelligent Operations Center for Emergency Management (http://www-03.ibm.com/software/products/it/ioc-emergency-management) a

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Traditional approaches to COP development, conceived as systems for collecting and representing information, are now considered indequate for enabling the development of a common understanding of the emergency situatio. These systems seem to be oriented exclusively towards emergence management teams, neglecting the role of the community, as key (potential) responders to the emergency. Moreover, these systems ignore that, even if common collaboration tools are available, actors do not share their information and knowledge without trust. These systems neglect the differences in terms of goals and actions among the actors involved in a response to the emergency. The same information might not be relevant for every actor. Exposing all individuals to the same information in the same way might affect the team's ability to generate novel ideas and interpretations.

Moreover, existing COP systems ignore how cultural diversities, with specific reference to organizational culture, influence the way different actors perceive the topology of their own interactional network, and, consequently, their strategies to collect useful information. Empirical evidence demonstrates how some actors assume a strongly hierarchical structure of the information

exchange process. That is, they will exclusively trust information flowing from the vertex through different intermediary levels. Other actors consider the multi-central structure as the most effective structure in allowing the rapid exchange of information within each level of the organizational structure and between different levels. That is, actors tend to adjust their interpretations in ways that consider the information their "network neighbors" provide. Neglecting these differences could lead to the development of ineffective COP for emergency management, because the actors will not recognize the network through which they collect the information as trustable.

Information management and sharing procedures within a responding organization and/or among different organizations might be jeopardized by the need to alter the organizational structure and roles, procedures and use of information in order to meet the demands of an exceptional event, such as an emergency situation. Moreover, the dynamic and complex nature of crisis situations does not allow for a static framework of the crisis responses. Interaction networks change dramatically during an emergency. Some actors may assume the role of informal leaders, whereas the official responders could be characterized by a low level of trust. The existing COP systems and the institutional protocols for information management in case of emergency seem to be incapable to adapt themselves to this changing interactional situation.

Although emergency management agencies put great efforts on building complex information system architectures, these evidences challenge the understanding of the COP as a technological mean aiming at reducing information incompleteness by making information better and more widely accessible. Enhancing the capability to capture information using different, even innovative, sources (e.g. Internet-of-things, smartphone, smart city cameras and stoplights, etc.) and put it in a shared system where it can easily be accessed represents a partial solution for supporting emergency management. The implementation of communication technologies has failed in many a situation because of the oversimplification of social processes.

Last but not least, current COPs have been often developed to deal with specific types of emergencies, which makes it difficult to adapt them to different types of crises, particularly when the spatial and temporal features of the latter are taken into consideration. What is urgently needed is a novel environment in which current applications and systems may be intelligently retrieved and adapted to respond to different types of scenarios, making interoperability a key condition rather than an afterthought arrangement that often does not fulfil the expectations and the real needs of people acting on the ground.

The evidences previously mentioned, the increasing awareness of the complexity of the emergency responses situations allow us to affirm that enabling the process for SSA development for coordination and decision-making requires a shift from innovating information production and management technologies towards enhancing the interaction processes among the different actors in emergency management. Interaction represents the mechanism allowing the different actors to interpret their environment, to achieve a satisfactory shared understanding of the situation, and to cope with the organizational and individual improvisation needed to deal with extreme events. Moreover, interactions allow to mitigate the conflicting interpretation of information about emergency due to differences in knowledge belief, customs and assumptions. Stressing the role of interactions in emergency management puts knowledge co-production, sharing and regeneration at the core of the SSA development and coordinated emergency management. Knowledge and interaction are strongly intertwined. Knowledge is distributed in social systems and is continuously processed and regenerated via interactions between teams and among members of the same team with different background.

COP systems for Situational Awareness should allow the different actors to create a common ground for communication and interaction, based on insights contributed by different members of the team with different background and disciplinary perspectives. SSA should be conceived as the results of a collective intelligence process. Therefore, an effective COP should be defined as a tool capable to

enhance connection/interaction among the different responding organizations and communities so that – collectively – they act more intelligently than individuals or groups in case of emergency. The basic assumption is that the capability of a collectivity of actors to perform some tasks is a property of the group itself, not just of the individuals in it. That is, collective intelligence seems to go above and beyond what can be explained by knowing the abilities of the individual group members, and it notably depends on the way group members interacts.

An innovative COP systems for effective coordinated emergency management are conceived as a human-computer environment, designed in such a way that the collective processes characterizing intelligent systems – sensing, sense-making and decision-making – would be more or less automatically structured to be optimal for emergency management tasks. This approach looks at group sensing as a process activated through the development of a shared system that individuals in a team use to collectively encode, store and retrieve information or knowledge in different domains. Finally, this approach conceptualizes the effectiveness of collective decision-making processes as a property associated with eliciting the relevant information and combining it appropriately in order to take the right collective actions. For an SSA to be effective, two-way relationships between sensing/sensemaking/decision-making have to be supported. Sensing, through sense-making processes, provides information that feeds decision-making. Conversely, decision-making often stimulate the surprises and confusion that create occasions for sensemaking and, thus, innovation in sensing the environment.
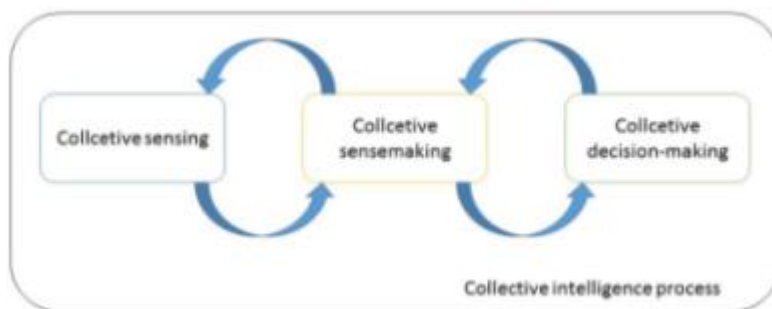

Figure 60: The three main phases of the collective intelligence process.

In order to enhance coordination and communication for improved decision-making in emergency, three interrelated layers of innovation need to be implemented.

The first layer of innovation concerns the collective sensing. The current commonly adopted perspective of COP as a platform for collecting and storing "institutional" information about the emergency situation, making it accessible for the different decision actors, need to be overcame. Tools to integrate "official" and "unofficial", as well as "private" and "public" sources of data, into a common pool, adopting the entitlement approach to manage access and an open semantic framework to promote data interoperability are needed. This applies to past experiences and current trends as well as emergency and recovery situations, to build a collective territorial awareness capability, similarly to what is currently done by the well-known Ushahidi platform for crowd-mapping emergency data. These tools should support the creation of a shared system for encoding, storing and retrieving knowledge (group memory). Narrative approaches as a way to manage knowledge co-production process become important. According to this approach, organizations are perceived as storytelling systems. Narratives organize individual thoughts and, thus, help people to comprehend and communicate their experiences.

The second layer of innovation concerns the collective sensemaking, which is particularly critical in dynamic and turbulent contexts, such an emergency management situation, where the need to create and maintain coherent understandings that sustain relationships and enable collective action is crucial. The process of sensemaking is a social process, aiming to selectively focus on certain stimuli and responses (attentional selection), and to generate a shared understanding for coordinated

action. This requires a perspective in which the negotiation of meaning of information embedded in emergency management and situational awareness creation become visible. The innovative COP system should be capable to unravel the impacts of differences in institutional and cultural backgrounds and to consider those diversities as a factors enabling/facilitating the collective sensemaking. Nevertheless, cognitive diversity is not always a virtue when it comes to collective cognitive processes. On the one hand, evidence suggests that cognitive heterogeneity ("two minds are better than one") is useful in mitigating against the cognitive biases associated with collective sensemaking (e.g. confirmation biases). On the other hand, different background knowledge and belief can represent a barrier to collective cognitive processes. To handle diversities in sensemaking process, a collective sensemaking system should be capable to address the two main dimensions describing the process of organizational sensemaking, i.e. animation and control. Animation is a powerful element that brings diverse understandings of an issue into discussion, but it is most likely to result in consistent actions when the sensemaking process is also relatively controlled.

Through animation and control, sensemaking system could be designed as a virtual trading zone, in which the different interpretations and narratives about the emergency are co-created and negotiated. Collective sensemaking is subject to conflict between the participating stakeholders (because of equivocality). That is why crisis management has to invest in situations and moments in which the stakeholders can come together to negotiate the relevance and meaning of information shared through the COP.

In order to enhance the effectiveness of the coordinated emergency management, systems need to be developed capable to support the collective decision-making and action implementation. That is, systems go beyond the idea of coordinated actions. Emergency management requires institutional and non-institutional decision-actors to collectively develop actions in response to damages and needs of affected communities. Innovative decision-making framework that goes beyond the limits of collaborative framework for emergency management. Collaborative work in group decisions and negotiations requires actors to have enough information about the others' preferences. Evidences demonstrate that the complexity and dynamic nature of the emergency management decision environment makes it hard to access to such information. The aim here is to create the conditions under which different actors are going to cooperate for reasons going beyond their institutional obligation to do so. For this purpose, effective cooperation needs to expand existing methodology and technology in order to include the whole process: scanning, communication and information sharing, collective problem structuring and definition, dynamics of the problem situation, generation of alternatives and options, socio-emotional interaction etc.

3.5.Key actors and key vulnerabilities

The analysis of the interaction ties in the network allows comprehending the actual role of the different actors in the network. That is, besides the institutional roles described in the protocols of intervention, the actors could impact the effectiveness of the network performance. The complexity of the surrounding network, both in-coming and out-going, allow us to identify the most central actors in the network, that is, those actors who are capable to collect information from different areas of the network. These actors are "in the know". Crucial for the network performance is the "information hub" , that is, actors that can act as interface in the information sharing process, moving information from one part of the network to the others. Similarly, the network analysis brings out the most important information in the network. That is, information whose availability is crucial for performing most of the tasks in emergency management.

Network analysis allows us to detect the main aspects of vulnerability in the network: those elements that could lead to failures of the network, lower performance, reduced adaptability, reduced information gathering, etc. Network management strategies need to be implemented in order to reduce these.

3.5.1. Policy suggestion: key actors and key elements of vulnerability

The map of the interactions allow to better comprehend the actual role played by the different actors in supporting the emergency management. That is, besides their institutional roles, the different actors could enhance/reduce the effectiveness of the emergency management by enabling/hampering the interaction and the flow of information during the different phases of the emergency management.

The map of the network could be used to analyse and unravel the complexity of interactions, allowing to identify the key elements in the network and the main vulnerabilities. To this aim, graph theory measures are implemented. The description of the different measures implemented in order to analyse the network of interaction are described in a different section of the handbook.

The results of this analysis can be used to support the development of strategies aiming at improving the emergency management through the enhancement of the network performance. Two different groups of actions can be implemented to this aim:

actions putting the key elements at the core of emergency management protocols, e.g. enhancing the sharing of key information, emphasizing the role of key actors, etc.

actions reducing key elements of vulnerability, e.g. increasing the speed of information by increasing the capabilities of the central agents to have access to crucial information.

For sake of clarity, the following sections describe how the network analysis was used to support the definition of actions for improving the emergency management in the Lorca case study.

3.5.2.The network analysis and the dialogue with the decision actors

A series of workshops were organized in order to discuss the results of the analysis with both the institutional actors and the community leaders of the L'Aquila case study. The aim of this phase was twofold: we intended validating the results of the analysis. To this purpose, we tried to compare the results of the network analysis with the personal experiences. And, to identify potential strategies to improve the emergency protocol together with the actors, accounting for the results of the analysis carried out in this work.

For what concerns the validation of the results, the key elements and the key vulnerabilities were discussed with the already involved institutional and non-institutional actors. Referring to the key elements, participants agreed with the obtained results, and seemed aware of the centrality of the community leaders. Moreover, the institutional actors found it useful that the adopted methodology can provide detailed information about the role played by each actor in the network of interaction. Specifically, the institutional emergency managers were interested in learning more about the meaning of some graph measures, directly connected with the information sharing process. These measures were used as a basis for starting debating about potential improvements of the emergency management procedure.

Participants were also interested in learning more about the key vulnerabilities of the network. At the beginning of the process, they were aware that improvements in the protocol of interactions were needed. Nevertheless, they were focusing exclusively on the interaction among the institutional actors. The analysis increased their awareness about the role played by the informal interactions taking place within the institutional system and between institutional actors and the members of the community. Using the results of the key vulnerabilities analysis, participants started discussing about suitable strategies to improve the flood emergency management plan, accounting for the complexity of interactions. Specifically, the discussion initially focused on the role of the media. Most of the institutional actors agreed that enabling a more effective bi-directional communication with the community members through the social media would be beneficial for sharing emergency information. The institutional actors were interested in enhancing the capability of the current media

channels to collect, store and analyse the feedbacks from the community. Local community members thought it important to be able to help monitoring how an emergency evolves.

In order to enhance the preparedness for flood emergency management, the need to improve the cooperation between institutional actors and the local community was considered crucial. The analyses performed allowed to identify the 'key' agents within the network, identifying the most crucial ones in terms of relationships with the others and capability to move information. According to the results of the discussion, this activity could improve the capability of local population to react in case of emergency in cooperation with the official responders. To this aim, suggestions were made to train the community leaders as "agents of change".

Therefore, the first and most important positive result of the implemented methodology **was that institutional actors were more aware** about the need to shift the focus from investing economic and human resources in developing innovative emergency information collection tools, toward enhancing the capability of the different actors to cooperate in case of emergency.

3.5.3. Interpreting complexity and ambiguity in relation to the emergency management

The analysis of the results allowed us to demonstrate that the oversimplification of the interactional structure at the basis of the development of formal protocols of intervention, characterized by a strongly hierarchical and inflexible structure, represented a barrier to the enabling of an actual collaborative emergency management process involving the different actors. This was mainly because of its incapability to account for the actual role played by the different actors and for the resources required for supporting the cooperation among them. The official protocol described only a small part of the complex network, that is, the institutional and formal interactions. The collected knowledge demonstrated that, during an emergency, informal interactions were activated even among institutional actors, based on personal and already established relationships. Moreover, the set of information exchanged within this informal networks is often broader than the one defined by the official protocols of information exchange.

The methodology allowed us to map the complexity of the interactions and, through the selection of a set of graph theory measures, to better comprehend the interaction mechanisms influencing the effectiveness of the cooperative emergency response. That is: what information needs to be shared, what task needs to be cooperatively implemented. Moreover, the analysis allowed to us to define the actual role played by each actor, according to the information they bring in the network, and their role in performing the emergency management tasks. The results of the analysis were used by the local stakeholders to inform the debate and to identify potential improvements of the protocol of intervention and cooperation.

The methodology accounted for the differences in organizational culture and to analyse how those differences could lead to different management of emergency information. On the one hand, some institutional actors – e.g. the Murcia emergency management – considered the multi-central structure as the most effective structure in allowing the rapid exchange of information within each level of the organizational structure and between different levels. These actors seemed capable to adapt their information collection strategy to the different conditions, showing resilience to failures of the official protocols of information sharing. Institutional actors with a dense network of interactions – i.e. the Murcia emergency management – seemed to be able to shift from the formal to the informal network in order to gather the needed information. On the other hand, the official responders – e.g. the UME and the fire brigades – assumed a strongly hierarchical structure of the information exchange process. These actors trusted exclusively information flowing from the top through intermediary, and easily recognizable, levels. This is because they needed to reduce the "noise" in information collection. Neglecting these differences could lead to the development of ineffective strategies for information sharing for emergency management. Integrating the Murcia emergency management in a hierarchically structured network could negatively affect its role as

response coordinator. Contrarily, increasing the number of information centres in the responders' networks could lead to the paralysis of their activities. The experiences carried out in Lorca suggested that developing effective emergency management strategies requires a clear understating of the differences among agents' understanding of the interaction network.

Finally, the adopted methodology allowed us to [[emphasize the role of the community in the emergency management phases, and to]] make the institutional actors aware of the need to account for the community **members**' understanding of the emergency situation. Specifically, the analysis of the community's FCM and the related network allowed us to better comprehend the reasons of the low level of trust toward the institutional information. The community's network has a strong multi-centre structure, allowing community's members to select the more suitable information sources and activate informal networks of information sharing. This is mainly due to the limited comprehensibility of the information provided through the institutional channels. The analysis of the network allowed to define the central role played by the community leaders in facilitating the flow of information. They represent the actual information centres for the community. This result was [[considered as]] crucial for the definition of potential improvements of the emergency management. Community members, generally not mentioned in the official protocol of intervention, should be instead explicitly taken into account. Specifically, the community leaders could easily act as an interface between the institutional system and the local communities, supporting information sharing in emergency.

4. The armed forces and civil-military interaction

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4.1.Introduction

"While retaining its primary role of safeguarding the country from external threats, the military has become one of the main partners of federal, state, and local agencies in disaster response operations, providing its available resources, logistical capacity, and operational services effectively used against both man-made and natural disasters." (Kapucu 2011, p. 7)

In studying the role of the armed forces in domestic disaster response operations, most attention has been paid to homeland security or counter terrorist activities, in particular in the aftermath of the terrorist attacks on New York, Washington, Madrid, and London.

Relatively little attention, however, has been paid to the role of the armed forces in addressing domestic natural disasters.[2] In such a context, the involvement of the armed forces can be manifold and may include a variety of activities. Sylves (2008, p. 172) lists a great number of these activities including: search and rescue; emergency medical care; emergency transport of people; mass feeding; in-kind distribution of food, clothing, and other necessary commodities; epidemiological work and disease control; decontamination (in hazardous materials or radiological circumstances); temporary sheltering; firefighting; help in restoration of electric power and other utility services; debris removal to reopen roads; and bridge repair or temporary bridge replacement, as well as offer security and property protection aid. Armed forces are frequently requested to contribute to disaster response operations: are usually well organized, trained, mobile, well equipped, and available (Clark, 2006, p. 1). Kapucu (2011, p. 9) stresses that armed forces

- have manpower with specific qualifications, skills and expertise;
- forces are capable of a strategic and rapid mobilization;

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[2] A notable exception to this is the research on hurricane Katrina in 2005 in the US (see e.g., Takeda & Helms, 2006).

- have a variety of equipment (e.g. helicopters, aircraft, earth-moving machinery, respirators, medical supplies, power and lighting equipment, under-water capability) that most other emergency organizations lack.

Moreover, "the military's relative autonomy and efficient bureaucratic structure with hierarchical rules; which are effective in command, coordination, and control of manpower, authority, and regulations, is beneficial in providing effective response actions". (Kupucu, 2011, p. 9)

4.2. Requesting military support

When civilian agencies request military support, there are three guiding principles according to Salmon et al. (2011, p. 141):

1. "Military aid should always be the last resort, with the use of mutual aid, other agencies and the private sector all having been considered as insufficient or unsuitable;
2. The civil authority lacks the required capability to fulfill the task and it is unreasonable or prohibitively expensive to expect it to develop one; and
3. The civil authority has a capability, but the need to act is urgent and it lacks readily available resources."

Additional factors that should be taken into consideration when requesting military support are (e.g. Kapucu, 2011; FEMA, 2008; Schrader, 1993):

-1 Legality: whether the legal basis of military involvement aligns with the national laws and regulations that are in place (Kapucu, 2011). Most, if not all, European countries have specified the conditions under which armed forces may support in disaster response operations.

-2 The potential cost of military involvement and its impact on the budget of the Ministry of Defence must be determined. Military assets are more costly than similar assets of civilian emergency responders in light of the reliability, security and robustness of military assets. Wiharta et al. (2008, p. 43), however, also stress that "because military assets are usually kept in a state of readiness for quick deployment, defence ministries already cover their procurement and basic running costs, whether the assets are being used or not. Thus, the idea that deploying military assets is much more expensive than deploying civilian assets should be regarded with caution".

Most western countries have mechanisms in place for sharing the costs of military involvement in assisting to disaster response operations. In the US for example the Federal Emergency Management Agency (FEMA) reimburses the Department of Defence for some of the costs that occurred in disaster response operations (Schrader, 1993).

-3 Lethality: this defines the possibility of the use of lethal force while providing assistance. Although lethality is mainly an issue in cases of homeland security or counter terrorism, it may be important in the context of natural disasters as well. Several historical cases such as the aftermath of Hurricane Katrina have shown that maintaining law and order is an essential task to which armed forces also may contribute.

4. Potential risks that may threaten the armed forces. Although the armed forces are trained to operate in unsafe places, natural disasters may pose severe risks to the soldiers that are being deployed. These risks may include the collapse of buildings, the danger of asphyxiation in case of (forest) fires or the breaching of dikes.

5. The extent to which military services and resources are appropriate for providing assistance. Some practitioners and researchers involved argue that just because the military has the capacity to perform a task, it may not necessarily be the most appropriate entity to do so, since most militaries do not often train their personnel in disaster response. For example, the militaries apply different

standards. They are expected to provide high-quality water to small populations rather than adequate water to large populations, as is needed in a natural disaster response (Wiharta, 2008). Also, in case of medical care militaries are mostly equipped to treat young men that are physically fit, while natural disasters may lead to many injuries (e.g. fractured bones) or patients (e.g. elderly, children) that the military is not used to deal with.

6. The readiness of military forces to provide assistance that will not harm the primary mission of the Ministry of Defence (Kapucu, 2011; Buchalter 2007). In most countries the primary mission of the armed forces is safeguarding the country from external threats. Moreover, the armed forces of many western countries are heavily involved in overseas operations such as in Afghanistan, Iraq or Mali. This focus limits the readiness of the armed forces to get involved in domestic disaster response operations.

4.3. Civil-military coordination

Due to the growing diversity, complexity, and scale of many disasters, there is an increasing requirement for the military and civilian organisations to adequately coordinate their activities during disaster response operations (Salmon et al., 2011). For example, Hurricane Katrina, the BP Oil Spill in the Gulf of Mexico and the 2007 floods around Gloucestershire in the UK are all recent examples of disaster response operations in which military and civilian organisations worked alongside each other.

Despite its importance, civil-military coordination during disaster response operations remains a neglected research area (Chen et al., 2008). The two tables below illustrate the wide variety of issues emerging when civil and military organisations attempt to work closely together, for two recent cases as well as the recommendations and lessons that were learned during their evaluation.

Issues	Recommendations & lessons learned
- Lack of an organisation responsible for surface water flooding; - No clear coordination structure; - Lack of coordination between Meteorological (Met) Office and Environment Agency; - Lack of communication & sharing of key information between agencies; - Lack of mutual aid agreements between civil organisations; - Lack of clarity regarding roles and responsibilities of different organisations; - Ad-hoc systems, structures and protocols; - Lack of leadership at Gold (i.e. strategic) command level; - Instances where Silver (i.e. tactical) command was activated instead of Gold;	- Should be a single national organisation with an overarching responsibility for all types of flooding; - Information must be readily shared between agencies in a form that can be used; - Joint warnings issued by the Met Office and the Environment Agency; - Enhanced IT, real time mapping and visualisation tools should be available to every Gold command; - Mutual aid agreements should be established between organisations; - Roles, responsibilities and capabilities of all agencies should be clearly defined and communicated; - Preparedness of HQs (e.g. accommodation, IT and comms systems) should be regularly tested; also purpose built HQs are required; - Communications procedures between agencies should be clarified.

• Lack of appropriate command HQs.	

2007 UK floods, summer of 2007, Gloucestershire region, UK. *(Pit, 2008; adapted from Salmon et al., 2009)*

Issues	Recommendations & lessons learned
• Complete loss of communications hindered the response significantly; • Lack of an appropriate incident command structure; • Lack of coordination between agencies e.g. Urban search and rescue and civil search and rescue; • Lack of a process for a unified response (National Incident Management System (NIMS) & National Response Plan (NRP)) inefficient for large scale catastrophic events); • State and local authorities lacked the ability to communicate with one another; • Command centres had unclear roles and responsibilities; • Secretary of Homeland Security had difficulty coordinating the activities of federal departments and agencies – he lacked situation awareness, both of the disaster and of the response; • Key decision makers at all levels were not familiar with plans or NIMS.	• Need to establish a National Operations Center to coordinate national response and provide situation awareness and a common operation picture for federal government; • Interagency team should review and revise NIMS and NRP; All agencies/departments should align responses to NIMS; • There should a formal NIMS training program for all those responsible for incident management across agencies; • There should be an interagency planning and execution system; • Need to establish a National Information and Knowledge Management System; • Need to establish a National Information Requirements and a National Information Reporting Chain; • Need to establish mutual aid agreements; • Need to establish a national crisis communication system to support information exchange from the President, across the Federal government, and down to the State level; • Need to establish a deployable communications capability; • Need to clearly define roles, responsibilities and capabilities of different agencies.

2005 Hurricane Katrina, New Orleans (Banipal, 2006; adapted from Salmon et al., 2009)

At a meta-level, Salmon et al. (2011, p. 153) have distilled and structured the issues that influence civil-military coordination during disaster response operations. They have grouped the issues into the following categories: the organisation, information management, communication, situation awareness, equipment, cultural issues and training.

Organisation	Information management	Communication	Situation awareness	Equipment	Cultural issues	Training
Lack of clear and effective leadership	Poor information management	Lack of communication	Inadequate levels of distributed situation awareness	Inadequate communications technology	Incompatible procedures	Lack of multi-agency training exercises
Unclear command and control structure	Lack of an appropriate common operational picture	Communication of inaccurate or incomplete information	Inadequate levels of meta-situation awareness	Incompatible communications technology	Lack of understanding of military concepts, processes and procedures	Lack of experience in working with other agencies
Inadequate or inappropriate command and control structure	Lack of clarity regarding MACA requests	Lack of clear communications links between agencies	Lack of understanding of each agency's roles and responsibilities	Poorly equipped command centre	Lack of understanding of civilian concepts, processes and procedures	
Lack of clarity regarding each agency's roles and responsibilities		Lack of a common communications structure	Lack of understanding of each agency's capability and resources			
Inadequate multi-agency response frameworks, or procedures Conflicting goals			Lack of understanding of each agency's contributions			

Issues limiting civil-military during emergency responses (Salmon et al., 2011, p. 153). In the table MACA stands for "Military Aid to the Civil Authorities."

4.4 Experiences with civil military coordination in domestic disaster response

For EDUCEN, the Netherlands Defence Academy (NLDA) explored the experiences with civil military interaction in two domestic disaster cases. In May 2016, the NLDA team interviewed several people who had been engaged in the disaster response after the April 2009 earthquake that hit the city of L'Aquila Italy. In November 2016, the NLDA team was present during an exercise in Marken, the Netherlands, which aimed, among others, to enhance interaction between civil and military actors involved in disaster response in the Netherlands.

For both cases, the following research questions were used:

1.   In what phases and how do military and civilian organizations interact in domestic operations and what problems and opportunities can be identified?

2.   To what extent and how were military actors confronted with culture? How did they deal with it?

The preliminary research findings can be found below. The more extensive results will be published in an academic paper.

Experiences with civil military interaction in L'Aquila

In L'Aquila, NLDA -in cooperation with EDUCEN partner CNR IRSA- conducted five interviews with six persons who were employed with response organizations during the April 2009 earthquake. Interviews were held with personnel from the Red Cross, the military, fire brigade and the police. We asked them about their experiences working together with the military or civilian organizations and if and how they encountered culture.

The Italian armed forces were involved in two main tasks:

•   Providing logistical support

•   Controlling the damaged area (or 'red zone') and preventing theft

Despite the broad presence of the armed forces in the area, which was extended until 2014, interactions with civil organizations were arranged through the national civil protection services. This

entailed that 'on the ground' interactions were rather limited according to our respondents. Nevertheless, the respondents did identify problems and opportunities regarding the presence of the armed forces. An important advantage that was mentioned was the fact that military actors could work for long hours whereas civilian organizations often lacked the capacity and man-power to work uninterruptedly (also due to restrictions on consecutive working hours). The main challenge that was mentioned was the risk of 'military arrogance', or 'militarization' of the city. To moderate this, the military actors received special training which focused on interacting with citizens. Another beneficial factor that moderated the impact of military presence was the deployment of local military actors.

The advantage of having local responders was mentioned by several respondents. Local responders were for example able to assist outside forces in getting around, shortening the arrival time of emergency response. Moreover, they spoke the same dialect as most of the affected inhabitants, enabling them to provide a sense of familiarity and understanding. The local division of the Red Cross for example provided psychological help to people in the shelters. The fact that their personnel spoke in dialect and was trusted by the local people proved beneficial. Obviously, despite this advantage, the fact that they were local also entailed that the disaster impacted them personally, making the experience psychologically and emotionally challenging for them.

Read more on experiences with civil military interaction in Marken

On 2 November 2016, NLDA was present at a two day simulation of a flood emergency exercise in Marken, the Netherlands. A dike breach was simulated requiring massive evacuation of residents. A total of 35 organizations were able to test their emergency plans and learn from the interaction with other partners. NLDA was present during the exercise to observe the interaction between military and civilian actors and spoke with 15 participants about their experiences.

Figure Evacuation of citizens

The military actors were involved in the following activities during the exercise:

• The evacuation of citizens

• Dike strengthening

• Providing a pontoon for transport of civil equipment

The interaction between civil and military actors started in the preparation phase which commenced nearly a year before the actual exercise. This proved to be very helpful in 'getting to know each other' but it also revealed the first differences in organizational culture. It was for example mentioned by military respondents that the meetings with the civilian counterparts could have been

more efficient. Being used to a rather strict script whilst exercising, they had to adapt to a more flexible approach and non-binding commitments. The civilian actors on the other hand named the language, or jargon, used by the military actors as confusing and difficult to grasp. It was however mentioned by both the civilian and military respondents that the exercise helped to enhance mutual understanding and understanding of each other's capacities. Moreover, several additional collaborations between organizations arose due to the exercise.

Figure Civil military coordination at the incident command location.

Although the respondents noted that the experiences with civil military interaction during the exercise were positive, remarks were also made regarding information sharing between agencies. It was for example found during the exercise that there was a lack of (technical) information on each other's material. Moreover, during the evacuation, which was a collaborative effort between military and civilian actors, a lack of clarity regarding roles and responsibilities appeared. Both situations were resolved but point to the importance of considering these issues during the preparation phase.

A total of about 1000 civilians participated in the exercise. Unique for this exercise was also the participation of several locally based organizations (who work on a voluntary basis). This meant that there were opportunities for interaction with the local population and culture. It was for example

noted by our respondents that the strong social cohesion that characterizes Marken was very helpful in engaging the local population and securing public support for the exercise.

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5.Multi-stakeholder participation and community engagement

In order to manage risks in complex urban settings, collaboration between stakeholders, understood in the EDUCEN project as actors that can affect or are affected by an event, is crucial to reduce, prevent and minimize risks. This is a process that involves sharing knowledge and experiences; identifying barriers and opportunities to address risks in an integrated way (e.g. differences in mandates, administrative, organizational, political and operational cultures of organizations and communities of practice tasked with different aspects of DRR); and understanding why existing knowledge (e.g. on the risk, experiences, and strategies to address it) does not always make a difference in generating the kinds of actions needed to make desired changes at the appropriate (local, national, regional) scale (Matten, 2004).

The EDUCEN project recognizes the cultural (institutional, social and ethnic) perspectives as determining factors in the pursuit of effective DRR plans and strategies. Culture influences how we

define and perceive risk but also the kind of actions deemed appropriate in a particular context. In order for actors to collaborate successfully and engage in a learning process, they need to be receptive to changing their own mental models. This starts with the recognition of problems and interests of all the people involved. Insight is gained between one's own problem and problems of others. In other words, problems are put in a new broader perspective or frame (Aarts & van Woerkum, 2002). By collaborating closely to examine the success of different responses to risks, actors jointly learn which strategies and policies show the most promise.

The cultural learning component in the EDUCEN project has facilitated a learning process to identify enabling and disenabling factors for culture and social dynamics to be recognized in DRR. The process has led to the identification of volunteers and gatekeepers important to strengthen current DRR strategies and plans in Europe.

Figure 61.Culture and learning workshop at SEI headquarters in Stockholm

5.1.The role of volunteers in DRR

Volunteering can mean different things to different people. Here we refer to volunteerism as the planned voluntary behavior intended to benefit others, taking place within an organizational setting, for a prolonged period (Cumming, 2012). Volunteerism is a fundamental source of community strength and resilience that exists in all societies. It is expressed through a wide range of activities, including traditional forms of mutual aid and self-help, formal service delivery, campaigning and advocacy, as well as other forms of civic participation (UNV, 2011). button: [read more about the role of volunteers](the role of volunteers in DRR)

The role of volunteers in DRR
The role and contribution of volunteerism is well recognized and highlighted in the Sendai Framework for DRR Reduction as crucial for adopting a more people-centered preventive approach to disaster risk. When a disaster happens, volunteers are often the first to act (UNV, 2011). However, the integration of volunteers and civil society organizations throughout the disaster management cycle varies between different contexts. The form and extent of volunteers' integration into formal DRR activities, as well as perceptions on what their role differ greatly.
During a workshop with stakeholders from five different European cities in Spain, Italy, Sweden and the Netherlands, participants highlighted the role of volunteer organizations as important for mobilizing society, for communicating across sectors and groups, for negotiating amongst competing demands, and for advocating solutions that benefit groups rather than individuals.

Better training and more resources necessary to support the work of volunteers. Training and lack of resources are key challenges for developing the network of volunteers in Italy and Spain, and coordination as the main barrier for making volunteers' work more efficient. Despite the high level of dependence on volunteers during emergencies, there is no political will to finance and improve training for volunteers.

Figure 62.Brainstorming on the role of volunteers in DRR

While gatekeepers (discussed below) were seen as crucial for reaching particular social groups, volunteer organizations were considered important for mediating between different social groups. Despite positive developments towards increased civil society participation through volunteer organizations, there remain several challenges related to their integration and coordination, as well as level of trust from civil society. "Sometimes volunteers may be a burden and create additional problems. The timing is crucial to determine who should be involved when. If there are too many without having a clear role they will create problems and require resources for food and accommodation" argued a participant. "In the Spanish case, the lack of coordination and proper training of volunteers can create additional problems. The large, organized associations have their own structure and division of roles, however, coordinating between organizations and the 'frugal' volunteers that show up in face of emergency and the government institutions is complicated and very challenging" argued another participant. "Sometimes people do not trust volunteers: in Spain volunteers are a very heterogeneous group, some are professionals and many know what they are doing, but not all of them. There is a perception that they don´t have the knowledge/capacity which is not accurate" argued a participant.

Less vulnerability coupled with high levels of trust in institutions limits the role of volunteers in DRR

The Netherlands and Sweden have a different experience on the role of volunteers in DRR than the Southern cities in Italy and Spain. The fundamental difference is linked to the fact that neither Sweden nor the Netherlands have much recent experience in disasters. As a result the role of civil society and volunteers remains unclear. During the workshop representatives from Sweden and the Netherlands shared that a key factor that they believe has limited the role of volunteers and civil society in general has to do with trust. In Sweden and the Netherlands there is high level of trust associated with government agencies and people tend to seek information from government as opposed to civil society.

Stakeholders identified volunteers as a heterogeneous group with different capacities, levels of training and availability. These organizations ranged from well-established volunteer organizations with internal structures such as the Red Cross to more spontaneous volunteers that showed up during an emergency. Authorities often lack knowledge about the different capacities and strengths of voluntary groups and individuals, which can put people at risk. It is a complex task to find where the different capacities fit and at what time. When a group is organized it is easy to collaborate with them otherwise it adds a level of complexity.

Figure 63.Brainstorming about communicating DRR

Participants highlighted the need for governments and volunteers to co-develop a long term plan and a strategy to have the right people ready at the right time throughout the DRR cycle, and not only during an emergency. In Italy for example, there is often much focus on the emergency phase, but volunteers are needed to work with awareness rising and public opinion as well, for building understanding amongst youth and assessing other groups in society. For this, volunteers

would need a different type of training than the one available today, for instance to build capacity on existing legislations for DRR and emergency response.

The experiences in Spain and Italy of past and present hazards have led to continuous improvements on strategies and action plans in DRR and DRM and was believed to be an important factor to engage volunteers as an important group in DRR and DRM. An attempt to improve coordination of volunteers was made both in the Spanish and Italian cases by creating a contact database to keep track of individuals. In Spain, this database only contains contact information of the persons volunteering. In L'Aquila, the database also specifies their main skills, experiences and capacities. However, neither of the countries has established quality controls, assigned budgets or personnel in charge of maintaining and updating the databases. Thus, the databases are often unreliable and are not used.

We learned that Sweden has extensive experience both nationally and internationally with a long-standing tradition of preventive policies and has a continued presence in supporting international management of disasters (Björngren Cuadra, 2015). However, despite an increasing topicality internationally, volunteer work in Sweden can be said to have a relatively undeveloped role and function in the context of disasters as well as in serious events and crises. There are two potential explanations for this. The first is that in an international comparative perspective, the serious events that Sweden faces are fairly limited in scope. Sweden is geologically and geographically situated in a region that is struck by neither earthquakes nor tsunamis, even though floods, droughts and forest fires have recently caused significant damage. The second is due to that the state assumes all social responsibilities through an encompassing welfare state system which is believed to have hampered the establishment and role of voluntary organizations in DRR and DRM.

In Sweden, while rescue services have the legal mandate to request help from civil society in case of an emergency, there is a stark contrast with the levels of organization and integration of voluntary work in Italy, where the national organization and coordination of voluntary work in the country has evolved over several decades of experience in handling disasters. Today civil protection is a complex, surprisingly non-hierarchical, and highly organized agency composed by various voluntary groups across the country and with a clear mandate and jurisdiction to respond to society's needs during times of crises.

By contrast, Italy has long-time experience of a well-developed voluntary organization that operates across the country, and which in times of crises can function better and be more reliably than the government itself. Similarly to Italy, Spain has a long history of different disaster events. Civil society has an important role in DRR. The formal inclusion of voluntary organizations into DRR in Spain has been traced to 1982 following the Tous dam event, which is considered one of the most significant socio-natural disasters in the history of the country during the twentieth century. That event triggered a paradigm change in the way disaster risks were perceived and managed locally and at multiple levels of governance. A concrete result from these changes was, amongst others, increased public participation particularly of voluntary groups to establish a warning system (Serra-Llobet, Tàbara, & Sauri, 2013). In Lorca for example, local associations together with voluntary organizations and the private sector currently cooperate to create new warning systems through for instance new technologies.

5.2. The role of local leaders and gatekeepers in DRR

The concept of local leaders or gatekeepers can be traced back to ethnographic methods where it is understood as an individual who directly or indirectly provides access to key resources, be those resources logistical, human, institutional, or informational (Campbell, Gray, Meletis, Abbott, & Silver, 2006). Engaging with gatekeepers entails the establishment of an ever-evolving relationship which has deep implications for how a researcher or practitioner understands a particular context and interacts with stakeholders. The opposite is also true. If gatekeepers are key individuals to access

people or resources, they can also be obstacles, particularly in contexts where power relationships are reversed, but also in communities where traditional authority structures are in place (Campbell et al., 2006).

The concept of gatekeepers is used in a wide range of disciplines including geography, anthropology, management, urban planning, medicine, but also in disaster studies. In DRR, the concept of gatekeepers is sometimes understood as people who are in positions of power and possess large amounts of information on certain matters in a group. Gatekeepers in this context are deemed important individuals who maintain interactions with other group members in order to transfer information.

The definition of gatekeepers is not static; it is subjective to context, time, location, relation, and type of risk.

They act as mediators between culturally or linguistically diverse communities, and between communities and managing institutions. Their role is crucial because people with culturally or linguistically diverse backgrounds often prioritize social networks and informal sources of information, particularly in cases where language barriers exist or when communities mistrust the government (Shepherd & Vuuren, 2014). The role of gatekeeping has not been adequately investigated in the context of disasters and emergency risk communication. However, some studies (Shepherd & Vuuren, 2014) suggest that incorporating gatekeepers in DRR activities could contribute towards better emergency management preparation, but this requires an understanding of the cultural constructions of risk.

Stakeholders from L'Aquila highlighted the importance of gatekeepers as "cultural mediators" especially in marginal communities and refugee and immigrant populations: "The differences in social networks/groups/vulnerable people could be better taken into account in plans and emergency activities through a better inclusion of gatekeepers in planning activities." In contrast, the group from Lorca discussed the importance of gatekeepers in rural vs urban areas, arguing that gatekeepers are particularly important in rural areas as they can act as bridges and canalize information to the population and inform back to the authorities. For instance, "farm owners can help evaluating damages, risks and canalizing the information and local needs to the authorities", explained a participant.

In both Lorca and L'Aquila, gatekeepers were only made visible following a disaster event. The role of gatekeepers didn't exist until the disasters occurred and there was a need to know about the others and inform neighborhood associations without the traditional communication channels which were destroyed or seriously disturbed after the disaster. Both groups agreed that the challenge now is how to include gatekeepers in formal DRR plans and prevention work. They both spoke about the importance of developing and maintaining databases or applications that facilitate communication with gatekeepers. At the same time they argued that the cost of such action would be too high and that local authorities would not see the importance of investing on this action.

All cases agreed that it is important to plan in advance how to identify gatekeepers. The challenge is how to do this. Crises are different and happen in different ways. For instance, in Lorca leaders during the floods were farmers, but farmers had no responsibility or leadership role during the earthquake. Different disasters gave place to different leaders, because people were affected in different ways. Lastly, the role of leaders can change over time, and the process of identification needs to be continuous. A leader today might not be a leader tomorrow. Moreover, a positive leader able to unify individuals from a particular group, mediate between them and authorities, and communicate with other groups could also turn into a negative one. This dynamic role of gatekeepers highlights the need for maintaining close contact with cultural leaders (e.g. persons officially or unofficially representing an ethnic or occupational group), religious leaders, and key actors within age groups (e.g. elderly or young); while at the same time remaining flexible for possible new actors.

Figure 64.Brainstorming on the role of gatekeepers in DRR

Participants from the cities in Spain and Italy highlighted how following a series of disastrous events, there has been an increased recognition on the role of key individuals in civil society to act as mediators or information nodes between some social groups and managing institutions. In these two countries, DRR approaches are starting to change towards more inclusive management structures due to the realization that civil society participation could fill the vacuum that state agencies have failed to fill. For instance, in cities like L'Aquila, where trust for key members of civil society might be greater than for some governmental institutions, having a mediating actor that enjoys support from both society and the government might be necessary to communicate and mobilize groups; or in Lorca where there are large minority groups with different cultural and linguistic backgrounds. For some of these minority groups, a gatekeeper or leader might play an important role for giving the group visibility and voice. This is important in order to communicate the group's particular needs as may be the case with refugee groups or certain ethnic groups.

In Spain for instance, the history of integrated risk management is more recent than in Italy, with the failure of the Tous dam in 1982 which triggered a more inclusive approach. Despite this, effective civil society participation remains a challenge, and interest to reach society varies greatly within and across managing institutions. In Lorca, for instance, some of the managing institutions have increased and improved their contact with local leaders through the EDUCEN project. This in turn gave institutions better understanding of the problems, needs and wants of citizens in the area, but also an overview of available capacity amongst individuals which could be crucial for preventing fatalities during risk situations. However, the process driving this change has been met with lack of interest and resistance from some of the institutions, and skepticism from some of the members of civil society in Lorca.

In contrast to the Italian and Spanish experiences, the Swedish and Dutch cases admitted there is very little contact with social groups. In fact, participants were not aware of whether there are local leaders, who these might be, and whether they have a role in DRR. The role of local leaders or gatekeepers to build community resilience seems to be a concept often associated with the poorer corners of the world. In an international context, this is reflected in two ways: first, there is far less academic literature on the role of leaders and gatekeepers in countries like Sweden and the Netherlands, than in countries like Bangladesh or Nepal. Studies assessing cooperation across sectors in emergency management typically focus on the role of formal state and non-state institutions, but leave out "informal" leaders like gatekeepers (see for instance Nohrstedt, 2016; Nohrstedt & Bodin, 2014). In fact the only instance where civil society is represented in these studies is through "formal" voluntary associations, which play a minor role in Swedish disaster management, as explained in the section above. Second, donor countries, like Sweden and the Netherlands, have a strong focus in building resilience through local participation in recipient countries but not at home. Despite this, participants from both cities admitted seeing the value of connecting with gatekeepers, but like participants from Spain and Italy, thought it was difficult to identify and contact them.
(End of read more on the role of local leaders and gatekeepers)

5.3.Working with volunteers and gatekeepers in DRR: recommendations from five European cities.

A list of concrete recommendations to improve the work of volunteers in the DRR cycle, and increase participation of gatekeepers in formal DRR work was produced by participants from the cities of

L'Aquila (Italy), Lorca and Valladolid (Spain), Kristianstad (Sweden), and Dordrecht (Netherlands) during an EDUCEN stakeholder workshop. During the workshop representatives with different occupational backgrounds within DRR identified, described and reflected upon the role of volunteers and gatekeepers in DRR in their own cities. The conclusions emerging from this encounter can help DRR authorities improve their work with awareness raising and public participation, and for building social capital across sectors (public-private) and social groups with different cultural or ethnic backgrounds.

The interaction between stakeholders from different cultural and professional backgrounds demonstrated the importance to share experiences and identify similarities and differences in work on DRR between cities in Europe. The participants confirmed the need for greater attention to the role of volunteers and gatekeepers to build awareness in current policy planning for DRR.

A common message from all the cities is the need for improved involvement of volunteers in DRR. However, the ways to achieve this differed in each of the contexts. Whilst the role of volunteers is to a higher degree institutionalized in DRR in Southern Europe, cities representing Northern Europe shared that the government is the leading agent and civil society continues to play a marginal role. Thus, the potential to improve the role of civil society in Northern European contexts should be further assessed.

Figure 65.Stakeholders present potential actions for improving DRR work in their cities

The role of gatekeepers seems to be often disregarded in DRR work, despite the recognized benefits of engaging with this type of stakeholders. There is a need to allocate time for local government to identify and work with local leaders and other respected individuals in the community, particularly to build awareness and improve ways to ensure effective communication before and during an event. The workshop showed the differences between Lorca and L'Aquila where frequency in disasters have influenced improved communication and led to more sophisticated ways to communicate. For instance, civil society and the private sector in Lorca and Spain have played an important role to develop new communication gadgets. By contrast, the lack of cultural memory in Sweden and the Netherlands of flood events were emphasized as a limiting factor among communities to demand information and efforts to share information from the government.

Feasible and priority actions for improving DRR work in the Italian, Swedish, Dutch and Spanish contexts

After acknowledging the benefits and challenges in volunteer and gatekeeper inclusion, workshop stakeholders produced a number of recommendations to improve the DRR work. The picture below shows a country-based assessment of recommendations, their feasibility and importance in relation to contextual institutional and cultural factors.

Workshop participants collectively made the following recommendations to enhance understanding and action on the role of volunteers and gatekeepers in DRR:

- Increased participation of volunteers during the preparedness phase can be one of the most important and feasible actions for improving DRR work. Besides from creating risk awareness amongst volunteers, this can also enhance trust towards volunteer organizations, as volunteers establish a continuous relation rather than a one-time intervention.
- Improve the existing contact databases of volunteers and complement it with information on individual capacities (e.g. skills, experience, specific training). The main responsibility of

managing this action would be on local authorities who would need to designate a budget to identify the different volunteer groups, develop and maintain the database and support the coordination with civil protection.

- Improve training for volunteers to include actions important for the whole DRR cycle, not only the emergency phase, like for instance basic legal and policy knowledge related to DRR; and to diversify sources of funding for training volunteers through for instance the private sector.
- Create one strategy for identification and inclusion of both volunteers and gatekeepers and to have a plan on how to use spontaneous (volunteers/gatekeepers) in the best way.
- Engage older people, like the retired, who often have more time to participate in issues concerning their communities. They are also a particularly vulnerable group who might have a personal interest in engaging in DRR questions
- Include religious leaders who often have a well-established relation of trust to a group of the population. They can act as informants and mediators between managing agencies and civil society and between interest groups.
- Improve communication and cooperation with the private sector, particularly insurance companies, who have a good understanding of people's assets and vulnerabilities. In some countries, insurance companies are already integrated in DRR work. In others insurance companies and managing agencies continue to operate in silos. Increased cooperation and information exchange could be beneficial for the government, the companies involved, as well as the clients.
- Establish contact with local or thematic journalists who may hold important information and in some places might have good relations with local populations. They could act as mediators between civil society and managing institutions. Often, information coming from local journalists has higher credibility and reaches society faster than the official information disseminated by official government channels.
- Design a strategy for institutional-stakeholder engagement. Some governmental agencies might have better relation with society than others due to their role and jurisdiction. For instance it is probably easier for civil protection to access and contact gatekeepers than it might be for an organization like the water managing institutions (Confederación Hidrográfica in Spain) which might be perceived as a "water police" than a civil society advocate. With good communication structures in place across managing institutions, several actors might be able to access the information gathered by institutions that lie closer to society.
- Women groups could provide with a window of opportunity to access marginalized or foreign groups. However, these groups might not always be labelled "women group", but could take the form of knitting groups, yoga groups, reading groups, or religious circles. In other places there might be a "gender" organization or political party.
- Sport organizations can provide a link to youth but also provide with "space" in times of a crisis, for instance by providing access to football fields to build temporary camps, or gyms to provide for temporary shelter. Sport organizations are often used to work in teams and could therefore also provide with organizational skills during an emergency.

5.4. Suggestions for further reading

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6. Mapping the people and the organizations in DRR

6.1. Introduction

Enhancing the coordination effectiveness in case of emergency among the different responders, when a fast and efficient response is required, is the main scope of several studies aimed at overcoming the main organizational factors hindering the cooperation. Up to now, much more research has been carried out with respect to what happens within the same organisation under stress, while knowledge on what happens when multiple organisations need to coordinate in unison to make the best of their capacity in a highly stressful environment is still limited. Most of the efforts carried out for enhancing coordination effectiveness were meant to innovate the information technology for internal and external communication, information production and sharing. Empirical evidences demonstrate the need to shift from innovating information production and management technologies towards enhancing the interaction processes among the different actors in emergency management. Interaction represents the mechanism allowing the different actors to interpret their environment, to achieve a satisfactory shared understanding of the situation, and to cope with the organizational and individual improvisation needed to deal with extreme events. Moreover, interactions allow to mitigate the conflicting interpretation of information about emergency due to differences in knowledge belief, customs and assumptions. Therefore, a better understanding of the complex network of interactions activated during the different DRR phases is of utmost importance.

6.2. Interaction network and DRR

Most of the efforts carried out in the field of organizational studies demonstrate that the network of interactions influencing the performance of a certain organization is more complex than the simple network involving the different agents. An organization can be modeled and characterized as a set of interlocked networks connecting four key entities operating within the organization, i.e. people, knowledge, resources and tasks. Therefore, in order to better comprehend this complex network of interaction, analytical methods are required capable to conceptualize not only the attributes of these entities, but also the set of relations and ties among them. The Meta-matrix conceptual framework could be implemented to this aim. This approach conceives the organization as composed by: social network, knowledge network, resources network, assignment network, information network, resources requirement and knowledge requirement.

6.3. How to map and analyse the map of interactions

The map and the analysis of the network requires collecting data about how the different agents interacts with each other, how they accessed the information and used it in order to perform some tasks. Two kinds of approaches can be implemented to this aim, i.e. the quantitative and the qualitative approach. The former requires numerical assessment about the different interaction. That is, how many times agent A interacts with agent B; how many times the information C is used by agent A, etc. Collecting this data is often difficult when the interaction is not leaving a tack − e.g. interaction via email, database access, etc. The qualitative approach is based on the elicitation and structuring of experts' experiences and knowledge. It allows to overcome the limits due to the lack of data. The integration among social mapping and the critical event analysis facilitates the interaction with the experts and, thus, the knowledge elicitation phase.

Most of the methodologies aiming at mapping the network of interactions among people limit their analysis to the social network, that is, to map "who talks to, works with, and reports to whom". According to the common formulation social network are developed in terms of ties among persons. The improvement of emergency management requires the adoption of an organizational perspective for what concerns the information sharing processes and the cooperative task allocation and performance. Specifically, temporary multi-organizations are created for improving the coordination efforts during the emergency management. This composite agent has to be considered as a network whose behaviour is a function of complex processes for combining and generating collective outcomes. In this perspective, networks are more ubiquitous than those simply social network, and entities besides agents can be networked together.

The adopted methodology for mapping the interactions during an emergency is based on the conceptualization of an organization as a set of interlocked networks connecting entities such as people, knowledge resources, tasks and groups. This meta-network representation effectively combines the knowledge level perspective, the social network perspective and the coordination management perspective.

The following table shows the meta-matrix approach.

	Agent	Knowledge	Tasks
Agent	*Social network:* map of the interactions among the different institutional actors in the different DRR phase	*Knowledge network:* identifies the relationships among actors and information (Who does manage which information? Who does own which expertise?)	*Assignment network:* defines the role played by each actor in the DRR phases

		Information network: map the connections among different pieces of knowledge	Knowledge requirements network: identifies the information used, or needed, to perform a certain task in the DRR
Knowledge			
Tasks			Dependencies network: identifies the work flow. (Which tasks are related to which)

Table 7: Meta-matrix framework showing the connections among the key entities of social network (adapted from (Carley, 2005))
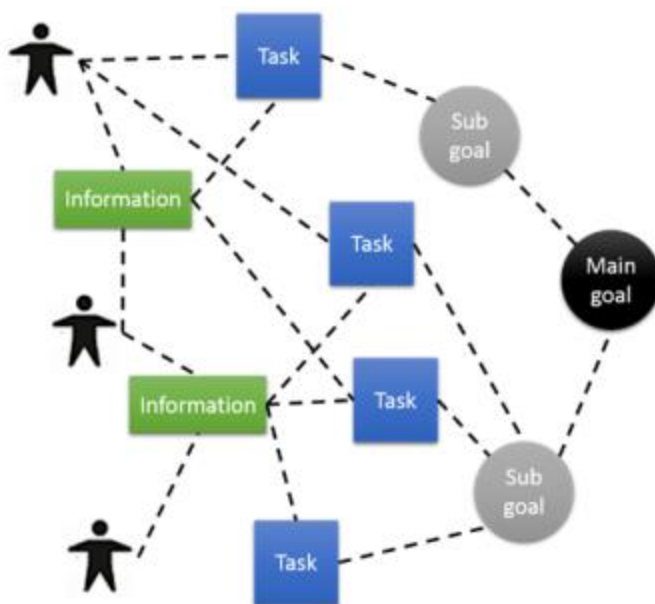
The details of the methodology for mapping the interaction among the main entities – i.e. agent, knowledge and tasks – is described in the following.

The first entity to be analysed is the *Agent x Agent* matrix, at the basis of the social network. Table 2 shoes an example of the social network.

	A1	A2	A3	…	An
A1	0	W12	W13	…	W1n
A2	W21	0	W23	…	W2n
A3	W31	W32	0	…	W3n
…	…	…	…	0	…
An	Wn1	Wn2	Wn3	…	0

Table 8: *Agent x Agent* matrix

In the previous matrix, W_{ij} represents the importance of the interaction between the agent A_i and the agent A_j as perceived by the agent A_i. Similarly, the value of W_{ji} refers to the strength of the interaction between the agent A_i and the agent A_j as perceived by the agent A_j. The weights can be assessed accounting for the experts opinion. In this work, we use the term "experts" to indicate policy-makers and official responders involved in the emergency management. The experts' knowledge was elicited through a series of individual semi-structured interviews. A storyline approach (SA) was implemented. Referring to a specific episode of emergency management, participants were required to describe the sequence of actions implemented in order to achieve their goals in the emergency management, the information used and the other agents with whom they interacted.

The first issue to be addressed concerned the selection of the experts to be involved in this phase. In order to minimise the selection bias and the marginalization of stakeholders a top-down stakeholder identification practice, which is referred as "snowballing" or "referral sampling",

was implemented (Harrison & Qureshi, 2000; Prell et al., 2008). The selection process started with the actors mentioned in the official protocols of intervention. The preliminary interviews carried out with these agents allowed us to widening the set of stakeholders to be involved.

The results of the interviews were structured in individual Fuzzy Cognitive Maps (FCM) (figure 66). The structuring phase allowed us to translate the narratives into useful inputs for the SNA phase.

Fig. 66: Fuzzy Cognitive Map describing the individual's understanding of the connections between goal-task-information-agents

The interactions with the other agents can be activated through both the sharing of information and the cooperation to perform specific tasks. Each link in the FCM is characterized by a weight, which describes the stakeholders' perception of the importance of that connection. The weight of the link *agent-information* describes the interviewee's perception about how crucial is the agent to obtain the needed information. Similarly, the weight of the link *information-task* represents the role played by the information in facilitating the implementation of that specific task.

The individual FCMs were also used to define the other matrices. For instance, the individual i-th *Agent x Knowledge* matrix was obtained considering the weights assigned by the i-th actor to the different *agent-information* connections. The *Agent x Knowledge* matrix for the i-th agent is represented in Table 3.

	I1	I2	I3	...	In
A1	Ki11	Ki12	Ki13	...	Ki1n
A2	Ki21	Ki22	Ki23	...	Ki2n
A3	Ki31	Ki32	Ki33	...	Ki3n
...	...	...	...	...	...
An	Kin1	Kin2	Kin3	...	Kinn

Table 9: Knowledge network matrix for the i-th agent.

The overall *Agent x Knowledge* matrix was obtained as the sum of the individual matrices. Similar processes were implemented to develop the *Agent x Tasks*, *Knowledge x Knowledge*, *Knowledge x Tasks* and *Tasks x Task* matrices.

In order to facilitate the elicitation of the participants' opinions about the importance degree, fuzzy linguistic variables can be defined. This method requires the identification of the linguistic labels used by the interviewees to describe the importance of the connections.

The weights in the matrixes are used to develop the network. They represents the strength of the ties between two entities. Figure 67 and 68 shows, respectively, the social network and the knowledge network developed for the Lorca CS.
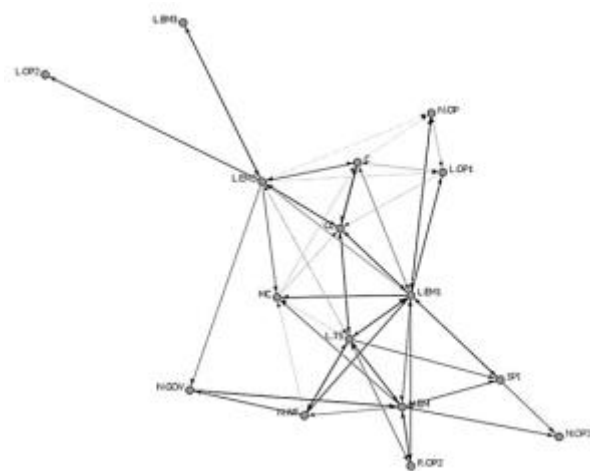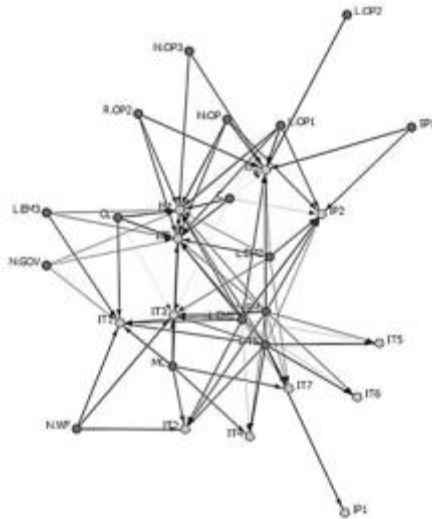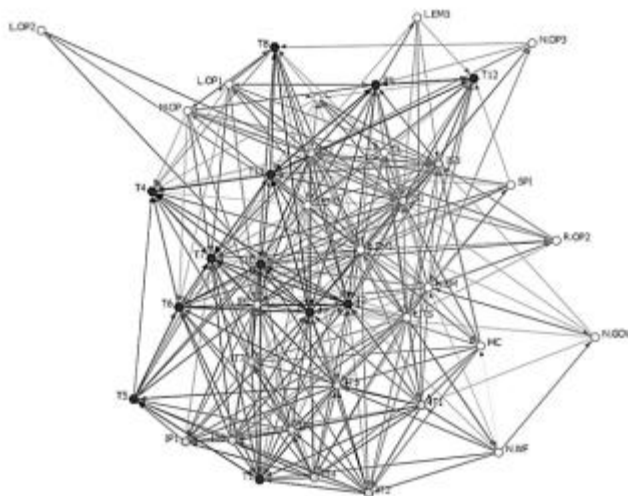
network.

Fig. 67: Map of the *Agent x Agent* interactions taking place during the flash flood emergency management in Lorca.

The direction of the links indicate which agent mentioned the interaction. For instance, the link between L.EM2 and L.OP2 shows that L.EM2 perceived itself interacting with L.OP2, but not vice-versa. The thickness of the links represent the weights assigned by the different actors during the knowledge elicitation phase.

Fig. 68: Map of the *Agent x Knowledge* network

The map demonstrates that there is no exclusivity in the *agent-knowledge* interactions, namely there is no actor exclusively owning pieces of knowledge. Therefore, cooperation among the different actors is crucial to overcome the fractured nature of the information system.

The combination of the different networks allowed to map the complex interactions among the main elements activated during the flood emergency, i.e. agents, knowledge and tasks (figure 69).

Fig. 69: Network of interaction among Agents, Knowledge and Task according to both experts and local knowledge

Figure 69 shows the actual complexity of the interaction mechanisms supporting the emergency management. Failure in this network – i.e. lack of an information, missing cooperation for task implementation, etc. – could provoke uncontrollable cascading effects leading to the failure of the whole emergency management process. Therefore, it becomes crucial for the emergency managers to enhance their comprehension of this complexity, in order to implement actions aiming to increase the effectiveness of the emergency management network and to reduce its vulnerability.

The results of the analysis can support emergency managers in different ways. Firstly, the SNA allows to identify the actors that, because of their role in the network, could play a central role in speeding up the information sharing process. These actors should have easy access to the required information. Secondly, the SNA allows identifying the reasons of potential conflicts hampering the cooperative emergency management - i.e. information that should be shared between two different actors in order to facilitate the task implementation, but it is currently owned by one actor with limited capability/willingness to share. Thirdly, the SNA allows assessing the congruence between the

information needed for performing certain tasks and the information actually accessible to the actors performing those tasks.

Concluding, the SNA results could provide useful information for improving the protocol of intervention in case of emergency.

How to analyse the map of interactions

Different kinds of analysis can be carried out through the implementation of graph network theory to the network of interactions. The results of the analysis can be used to enhance the effectiveness of the emergency management network, through the identification of key elements – i.e. key actors, key knowledge and key tasks – and main vulnerabilities, that is, the characteristics of the network that could lead to the failure of the emergency network.

Two different levels of analysis can be performed, i.e. node-level metric analysis and network-level metric analysis. The former allows for an analysis of the complexity of the network surrounding each node. This kind of analysis is used to identify the key elements in the network. The network-level analysis allows for better comprehension of the complexity of the network and makes it possible to identify key vulnerabilities. The results can be used to support the development of strategies aiming at improving emergency management through network performance. Two different groups of actions can be implemented to this aim. On the one hand, actions can be defined aiming at putting the key elements at the core of the emergency management protocols – e.g. enhancing the sharing of key information, emphasizing the role of key actors, etc. On the other hand, actions can be identified aiming at reducing the key vulnerability – e.g. increasing the speed of information by increasing the capabilities of the central agents to have access to crucial information.

The following tables describe the different measures, their meaning and how to use them to assess the performance of emergency management network.

Network	Network measure	Assessment	Meaning in DRR
Agent x Agent	Total degree Centrality	Those who are ranked high on this metrics have more connections to others in the same network.	Individuals or organizations who are 'in the know' are those who are linked to many others and so, by virtue of their position have access to the ideas, thoughts, beliefs of many others.
	Betweenness centrality	The betweenness centrality of node v in a network is defined as: across all node pairs that have a shortest path containing v, the percentage that pass through v.	Individuals or organizations that are potentially influential are positioned to broker connections between groups and to bring to bear the influence of one group on another or serve as a gatekeeper between groups.
Agent x Knowledge	Most knowledge	Assess the number of links between a certain agent and the different pieces of knowledge in the network.	An agent with a high value of most knowledge has access to a great variety of knowledge to be used in case of disaster.
Agent x Task	Most task	Assess the number of links between a certain agent and the different task that need to be carried out in case of emergency.	An agent with a high degree of most task plays a crucial role in the network due to her/his capability in performing different tasks.

Knowledge x Knowledge	Total degree of centrality	It calculates the importance of a certain piece of information according to the number of connected links.	The most central pieces of knowledge are those whose availability is crucial to make the other pieces of knowledge accessible.
	Closeness centrality	Closeness is the inverse of the sum of distances in the network from a node to all other nodes.	The closeness centrality measure allows us to identify the information that could facilitate the process of information sharing.
Knowledge x Task	Most task	Assess the number of links between a certain piece of knowledge and the different task that need to be carried out in case of emergency.	The pieces of knowledge with a high value for this measure are fundamental for the effectiveness of the network, since without them a high number of tasks will be not carried out.
Task x Task	Total degree of centrality	It analyses the complexity of the connections within the task X task network.	Tasks with high degree of centrality are those that have to be carried out in order to allow the executions of the other tasks.

Table 10: Graph Theory measures for key element detection

Similarly, different graph theory measures can be implemented in order to assess the network vulnerability. That is, those elements that could lead to failures of the network, lower performance, reduced adaptability, reduced information gathering, etc. Considering the complexity of the emergency network, in this work the vulnerability elements were identified though a combination of different measures, as described in the table 2.

Network	Network measures	Meaning in emergency management
Agent x Agent Agent x Knowledge	Total centrality degree Most knowledge	An actor with a high degree of centrality and a low most knowledge degree represents a vulnerability because, although she/he a central position in the network, she/he has a limited capability to enable information sharing.
Agent x Agent Agent x Knowledge	Betweennes centrality Most knowledge	An actor with a high degree of most knowledge and a low betweennes degree represents a vulnerability because she/he is not capable to share with the others the pieces of knowledge she/he has access to.
Agent x Agent Agent x Task	Total centrality degree Most task	An actor with a high degree of most task and a low centrality degree represents a vulnerability because, although she/he is required to carry out important tasks, she/he is quite isolated and cannot be supported by the others during an emergency.
Agent x Knowledge Knowledge x Task	Most knowledge Most task	A piece of knowledge poorly shared within the network (low most knowledge) represents a vulnerability if its access is crucial to carry out important task (high most task).
Agent x Knowledge Knowledge x Knowledge	Most knowledge Closeness centrality	A piece of knowledge with a high degree of closeness but poorly shared (low degree of most knowledge) represents a vulnerability since it could hamper the process of information sharing.
Agent x Task Task x Task	Most task Centrality degree	A task with a high centrality degree and with low most task degree represents a vulnerability because, although its importance, there is no, or very limited cooperation to guarantee its effectiveness.
Agent x Agent Agent x Knowledge Agent x Task	Cognitive load	This measure takes into account the number of other agents, knowledge and tasks an agent needs in order to perform its own task. High cognitive load represents a vulnerability.

Table 11: Measures for the detection and analysis of key vulnerability in the emergency management network

Besides the node-level analysis, the map of interactions can be analyzed at network level. Table 12 describes the measures that can be implemented in order to assess the effectiveness of the network in emergency management.

Network measure	Graph theory	Meaning in emergency management
Communication congruence	Measure to what extents agents communicate when and only when it is needful to complete tasks. Higher congruence occurs when agents don't communicate if the tasks don't require it.	Communication overload could reduce the effectiveness of the emergency management.
Knowledge congruence	Measures the similarity between what knowledge is assigned to tasks via agents, and what knowledge is required to do tasks. Perfect congruence occurs when agents have knowledge when and only when it is needful to complete tasks.	Having access to unnecessary knowledge could create "noises" during the emergency management.
Density	The actual number of network edges versus the maximum possible edges for a network N.	A dense network support the sharing of knowledge and information, leading to the creation of a common understanding.
Hierarchy	The degree to which a square network N exhibits a pure hierarchical structure.	In a hierarchical network, diversity of point of views and ideas is highly improbable. This negatively affect the richness of the knowledge co-production process,
Negotiation Knowledge	The extent to which personnel need to negotiate with each other because they lack the knowledge to do the tasks to which they are assigned.	Long negotiation processes needed to get the required information could reduce the effectiveness of the emergency management.
Speed average	The average communication time between any two agents who can communicate via some path.	Emergency management requires fast communication among the different agents.

6.4. When and where to use social network modelling

The experiences carried out in EDUCEN project demonstrate the usefulness of social network modelling in detecting the actual role of the different actors and information in DRR. The results of EDUCEN activities in L'Aquila and Lorca CS showed the inadequacy of the official protocol of interaction for describing the actual network of interaction. The official protocols fail to account for the informal interactions activate during an emergency, and for the role of lay people and local knowledge in DRR.

Guidelines for when and where to use social network modelling

Social network modelling (SNM) could facilitate a better understanding among emergency managers of the complex network of interactions taking place during an emergency. In doing so, SNM enhances the coordination mechanism among the different responders and, thus, the effectiveness of the emergency management procedure.

The SNM emphasizes the need to adopt a multi-agency approach for the analysis of the network of interactions. Therefore, the emergency management multi-organization can be conceptualized as

composed by interconnected meta-networks linking the main entities in organizational management, i.e. the agents, the knowledge and the tasks.

Starting from these premises, this section provides emergency managers and practitioners with guidelines for choosing SNM as a tool be adopted in order to enhance the emergency management process.

The experiences carried out in EDUCEN case studies, L'Aquila and Lorca, demonstrate the usability of SNM for addressing three different issues related to the coordinated interactions in emergency management:

Identify all the actors that need to be integrated in the emergency management procedures;

Assess the level of accessibility of crucial information in case of emergency;

Evaluate the congruence between the information sharing process and the cooperative tasks performance.

6.4.1. Identification of the needed actors

The official protocol of intervention describe only part of the complex network of interactions activated during an emergency. Other actors play a crucial role, although they are not officially integrated in emergency management procedures. Moreover, the results of the EDUCEN activities demonstrate that the importance of particular responders – either institutional or not institutional – is related not only to their official role in the protocol of intervention. Rather influenced by their capability to spread information within the network of interactions, and to share resources and tasks. The EDUCEN results show that the actors at the centre of the map of interaction are those that can enable the collaborative emergency management. They can increase the speed of communication, facilitating the transfer of pieces of information from one side of the network to the other. I.e. these actors could act as interface between the institutional systems of responders and the community. Due to their wide web of interaction and their access to knowledge and information, these actors represent an effective channel for information sharing. Specifically, EDUCEN results show that these actors can increase the accessibility to institutional information. Often this result is achieved through the activation of informal interaction channels. Therefore, the SNM, has to be based on the collection of narratives about how the different actors actually interacted during the emergency.

The use of specific approaches (e.g. storyline approach) increases the insight in the sequence of events during the emergency management. Particularly, it supports: i) a general description of the system being investigated (e.g. procedures/protocols and key actors involved); ii) definition of a scenario; iii) determination of the sequence of events during a storyline, focusing on actions and responses implemented by each actor, information used and interactions; iv) analysis of the impacts of the external pressure and the effects of actions of local authorities and community members.

Limit**ing** the analysis to the institutionally defined interactions could be misleading. The following table13 describes the roles that can be played by the different actors in the network.

Role of the actors	Meaning in the emergency management
Central actor	Individuals or organizations who are 'in the know' are those who are linked to many others and so, by virtue of their position have access to the ideas, thoughts, beliefs of many others. Individuals who are 'in the know' are identified by degree centrality in the relevant social network.
Information hub	Individuals or organizations that act as hubs are sending information to a wide range of others each of whom has many others reporting to them.
Authority	Individuals or organizations that act as authorities are receiving information from a wide range of others each of whom sends information to a large number of others
Gatekeeper (betweenne**ss** centrality)	Individuals or organizations that are potentially influential are positioned to broker connections between groups and to bring to bear the influence of one group on another or serve as a gatekeeper between groups. This agent occurs on many of

	the shortest paths between other agents.
Agent with most knowledge	Individuals or organizations that have more expertise or are associated with more types of knowledge than are others.
Agent with most tasks	Individuals or organizations that are assigned to more tasks or are associated with more types of tasks than are others

6.4.2. Information accessibility

The EDUCEN results demonstrate the usability of SNM to assess the actual importance of the information available within the network and its accessibility by the different actors. The basic assumption is that if crucial information is not accessible to central actors then cooperative tasks performance could be hampered. Therefore, it is of utmost importance, for an effective emergency management process, to enhance the comprehension of the actual use and accessibility of the different information. The EDUCEN case studies show that one of the most important barriers hampering the effective coordination of emergency management operations is the fractured nature of information in distributed system, where the state of the system itself can be perceived indirectly, through an effective information exchange by collaborative agents. In order to overcome this barrier, SNM allows emergency managers to have a clear idea about who has what information, where information is located in the network and how it is used. The following table shows the results of SNM analysis that can help to improve the sharing and accessibility of knowledge and information.

Knowledge and SNM	Meaning in emergency management
Central information	The central information is crucial because it allows other pieces of information to be used in the emergency management.
Most used information	The SNM allows analysing the connections between information and tasks. Therefore, the most used pieces of information are those that are used in order to perform a high number of tasks.
Most shared information	The SNM allows analyzing the connection between information and actors. I.e. who knows what. The most shared information are those with a high level of accessibility by a high number of agents.

The results of this analysis allows to enhance the information management in case of emergency: central information and/or most used information should be accessible **to** a high number of actors. This requires the timely availability, in a proper format, of the key information to agents having the trust of other agents and an important set of interconnections. The lack of this property represents a vulnerability in the network.

6.4.3. Congruence between information sharing and task cooperative performance

Finally, the SNM could be used to enhance the sharing of information, in order to improve the cooperation in task performance during emergency management. Specifically, SNM allows to identify the tasks that are shared among a high number of actors, and the tasks that require access to a high number of information.

Tasks and SNM	Meaning in emergency management
Central task	The central task is crucial because it allows other tasks to be performed. These tasks should have the highest priority in the protocol of intervention.
Most shared tasks	The official protocols of interventions often ignore the fact that actors are carrying out some tasks informally. The SNM allows **one** to analyse the actual level of task sharing and to identify the tasks that require a high degree of coordination.
Highly demanding tasks	The analysis of the Task-knowledge network allows SNM to identify the tasks requiring a high volume of different information in order to be performed. If these tasks play a crucial role in the emergency management, assuring the accessibility to the needed information should be considered as crucial.