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# ENABLING KNOWLEDGE FOR DISASTER RISK REDUCTION AND ITS INTEGRATION INTO CLIMATE CHANGE ADAPTATION

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## More than just data and information

The HFA indicator 1 in priority action 3, requires that critical information about disaster risk be accessible to all relevant stakeholders. This is clearly very important, albeit not enough, as will be discussed in this paper. It may be useful to start with an example that tackles one important source of information at both international and national levels, that is disaster damage databases. The debate on the value and the comparability of those databases is currently led by the European Commission. The latter initiative, open to relevant international stakeholders such as FEMA and UNISDR, has fostered a process of analysis and reflection mirrored in the JRC Report "Recording disaster losses" (De Groeve et al., 2013). The stake is revising the way current databases are developed, fed and used by a variety of actors, given the general dissatisfaction with the sometimes low data quality, low sources reliability, lack of consistency when comparing data from different databases. The need to go much beyond "data" to be able to improve the current situation and also, more fundamentally, to motivate countries to develop better national databases is a key point arising from the debate. The purpose for which disaster losses data are recorded need to be identified and known before field surveys. In fact, as suggested by Jennex (2009) whilst data and information are clearly the bricks of knowledge, you need knowledge to search for the right data and information. In the JRC report it is suggested that disaster losses data are needed for three different purposes: accounting, forensics, and risk assessment.

Whilst the first is already accomplished by existing databases, the other two require a much deeper consideration. It is recognized very clearly and to a certain extent this is a novelty, that in order to improve pre-event risk assessments, that is in order to improve the capacity to forecast expected damage for the future, a better understanding of what occurred in past-event is crucial. Both pre- and post-event damage estimates require that a clear definition of what needs to be considered as a damage, for and by whom, what types of damage are to be estimated, at what scales be univocally determined.

In the meantime, post-event damage assessment should not be limited to an account of numbers and description of losses, rather they should permit also to explain why damage has occurred. "Forensics", in line with the IRDR (2011) research line, refers to the analytical explanatory capacity to distinguish what component of damage is attributable to hazard, exposure, and/or different vulnerabilities factors.

The idea that before collecting data the problem at stake must have been understood, at least at an initial level, and framed is nothing new; however it has been a common complaint, particularly in the last decades, that the tremendous capacity provided by technological fixes has induced a much broader search and manipulation of data, often without the necessary care about methodological rigour. Along all phases of the so called disaster cycle, a relevant amount of data is available, however many times crucial information is missing, incomplete, or provided in inconsistent form.

**Box.1. Definition of data, information and knowledge**

Based on Davenport and Prusak's (2005) discussion, the following classification can be proposed:

***Data***: is a "fact", an individual event; "in general it can be said that there is no meaning in data". As an example: for the risk assessment, the data used is often a digital terrain model, rainfall data, data on historic flood events. "Data describes only a part of what happened, it provides no judgement or interpretation and no sustainable basis of action".

***Information***: "is a message, in the form of a document, audible or visible communication". In fact, in Latin it means: provide with form, with a shape. Unlike data, information has a meaning. Davenport goes on suggesting that there are 5 ways in which data can be transformed into information:

- Contextualized;
- Categorized,
- Calculated,
- Connected,
- Condensed.

The outcome of the risk assessment is information in the form of vulnerability, hazard and risk maps, tables and reports. This information must then be transferred to the users and decision-makers, making use of appropriate communication channels.

***Knowledge***: according to Davenport, "knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. Knowledge can be seen as both process and stock". There are many ways in which knowledge is created, some imply:

- Comparison;
- Consequence identification;
- Creating connections;
- Conversation.

To achieve prevention and mitigation, the output from risk assessments is used to understand where the high risk areas are and what are the best mitigation measures - either through technical measures (engineering works) or organisational measures (e.g. urban planning). Created knowledge can be partial or unsatisfactory, because for example it does not include relevant aspects, such as vulnerability assessments. Knowledge limited to the hazard factors provide less options in terms of actions that can be taken.

The case of disaster losses database provides an important example of the need to move forward, from the collection and organization of data to the concept of knowledge management systems. The Know-4-drr project does not aim at developing a full knowledge management system, but rather to explore the concept and to provide a framework for eventually building it in the future. Knowledge management systems have been introduced in the business sector as a tool to deal with stratified, articulated knowledge regarding the activities, processes, requirements, market analyses, etc. in a given firm (Alavi and Leidner, 2001). Such tools have been designed having in mind a varied set of goals, ranging from providing utilities for workers to retrieve relevant knowledge and information when needed, to storing acquired knowledge, to provide newcomers with an introduction to what has been achieved by workers of older generations. Knowledge management systems are considered as necessary in a fast evolving, increasingly complex and uncertain world.

A knowledge management system is much more than a database or an information system; in order to fully grasp the idea behind it, light should be shed on some relevant aspects and definitions. First, a workable and working definition of knowledge is needed. It condenses some of the infinite and inevitably never ending discussions about knowledge in a form that serves the purpose of learning and maintaining crucial knowledge and information when crucial decisions have to be made regarding risks and crises. In this line, Zeleny (2006) stated that «Knowledge is embodied in an organism (or social organism) and embedded in action. Knowledge is not information. Information is a description of action. As an input, information contributes to the product of knowledge (action). The value of both knowledge and information is measured by the added value of their joint product. Knowledge produces value directly through action, while information contributes to its production as one of the inputs.»

Without doubt, the increasing specialisation of scientific knowledge has led to intellectual and technological advancements in the domains of DRR and CCA. Scientific assessments – such as the Assessment Reports and the new Special Report on disaster risks of the Intergovernmental Panel on Climate Change (IPCC) – contributed to an increased understanding of the factors that lead to adverse effects. However, it became clear that in the process of establishing climate change as a global phenomenon, knowledge should not be detached from meaning. Climate facts arise from impersonal observation whereas meanings emerge from embedded experience (Hulme 2009; Jasanoff 2010).

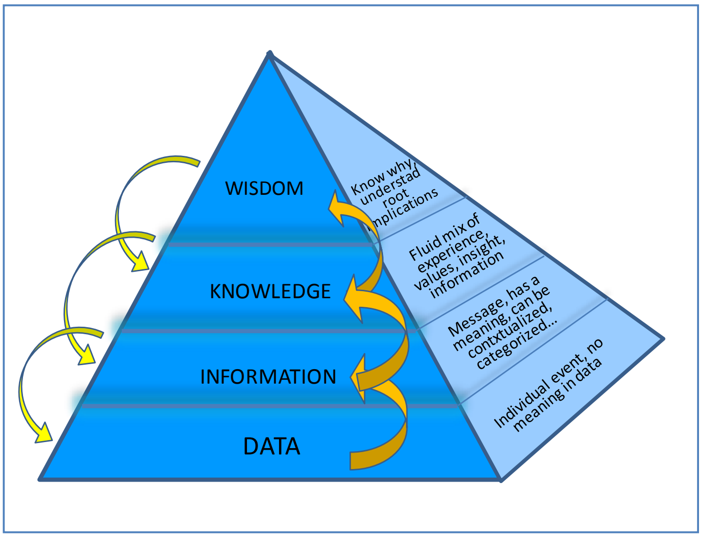


Image 1 : The "knowledge pyramid"

The neat distinction carried out by Zeleny between information and knowledge echoes the debate initiated by Ackoff in 1989 regarding the "knowledge pyramid", that organizes data, information, knowledge and wisdom in a hierarchical framework (figure 1). The initial idea has been revisited and reinterpreted by authors who suggested to break its rigidity, recognizing that there are many feedback loops in the data-information-knowledge "pyramid" (Davenport and Prusak, 2005; Frické, 2007; Jennex, 2009).Yet, the clear cut distinction between what can be intended as data, information, and knowledge is important in this discussion (see box 1).

The opportunity to propose knowledge management systems in the field  disaster risk is not new either, albeit much more recent (Seneviratne, 2010; Dorasamy et al., 2013). UN Spider (UN-Spider, 2013), for example, has developed a web platform offering several utilities and access to relevant knowledge sources in the field of satellite imagery used for emergency management and crisis mapping (http://www.un-spider.org/).

A fundamental difference exists between knowledge management systems for businesses and for organizations dealing with disaster risk reduction. In the former, the context within which the system must be developed is clearly defined, as the organisation's goals are succeeding in a given market, making profit and guaranteeing continuity in a competitive and uncertain environment. The case of organizations and stakeholders dealing with disaster risk reduction, or who have and/or can play a relevant role in making society more robust, resilient and adaptive to hazards including climate change, is rather different. First because of the multiplicity of organizations, agencies, entities, some private some public that are on the scene. Because at the very end any citizen may play a relevant role in preventing and coping with extreme events outcomes. Second, even restricting the consideration to the organizations that have a mandated role in DRR and CCA, still goals and aims may not coincide and even conflict in certain cases. Probably, as will be discussed in the final section, one has to be clear in defining what knowledge management system, for what organization(s), with what specific purpose, has to be developed.

In clarifying the context within which knowledge regarding disasters, the way to reduce, prevent and coping with them, a crucial aspect is to identify who are the key actors to be considered in such endeavour.

## Actors and stakeholders who may be interested in developing knowledge management system in DRR

As correctly stated by Merad et al. (2013), defining an actor implies that there is an observer who identifies who plays a role and who does not in a given context. This is one of the complexity inherent in the Know-4-drr project: it is not a project about knowledge in the field of natural hazards, risks, and climate change; it is a project about what we understand and know about the knowledge that is "available" or not, that should be managed (or not) differently from the way it is currently. This meta level constitutes its main challenge, as a reflection about who is producing knowledge, how, what knowledge is produced and shared are the core questions to be analysed.

In the initial project description, it was proposed to consider four main groups whose knowledge is relevant for DRR and CCA: scientists, the public and the private sectors, and the “civil society” at large.

Each group has been analysed in detail in the first deliverables of the project.

<u>Scientists</u>

The 2013 Report of the UNISDR Scientific and Technical Advisory Group (Southgate et al., 2013), after selecting the definition of science as ‘knowledge obtained through study or practice’, considers that for disaster risk reduction (DRR), ‘... scientific capacities must be interpreted broadly to include all relevant matters of a scientific and technical nature, where science is considered in its widest sense to include the natural, environmental, social, economic, health and engineering sciences ...’.

The increasing specialization of scientific knowledge while resulting in great intellectual and technological advance, also leads to increasing fragmentation.

Main issues our society is facing today, like DRR and CCA, cannot be addressed by single-discipline approaches due to its complex nature. Understanding issues such as e.g., DRR, CCA, biodiversity loss, food security, or sustainable development, requires input and expertise from a wide range of disciplines that span both the natural and social sciences. This integrated view, involving disparate disciplines, demands collaboration from problem formulation through hypothesis development, data analysis, interpretation, and application (Eigenbrode et al., 2007). These issues are essentially ‘systems’ problems (Nicolson et al., 2002). Effectively addressing systems-problems requires bridging perspectives and disciplines and dealing with complex interacting processes that operate at different temporal and spatial scales. Because collaboration is becoming so prevalent in many issues/problems of today’s societies the concept of ‘disciplines’ turn to be outmoded, i.e., administrative artifacts; as stated by Léle´and Norgaard (2005): ‘when approaching collaborative work between scientists, forget disciplines; think scientific communities’.

Progress has been made with regard to define trans-disciplinarity, to understand the differing ontologies, epistemologies, and methodologies, and to facilitate co-operation among disciplines and with non-academic knowledge holders (Hirsch Hadorn et al. 2008, Pohl 2011).

<u>Public sector organizations</u>

Organisations and institutions from the public sector play a prominent role in dealing with natural hazards across all phases of the so called “disaster cycle”, starting from the mitigation in the pre-impact phase, to emergency and crisis management, to recovery an reconstruction. An increasing number of agencies and organizations are mandated of risk mitigation and disaster response at different scales, starting from the United Nations and the European Commission as far as international organizations are concerned, to national, regional and provincial levels, down to the local one. The public sector is responsible for providing the capacity to prevent and cope with disaster events by ensuring the necessary availability of means, resources, and infrastructure. Public sector’s organizations are generally mandated to implement risk mitigation strategies and measures by directives, norms, legislation, that prescribe the scope and the limits of their intervention. Given the fact that providing safety and implementing mitigation measures are very challenging tasks, involving several organizations and agencies, the scope and limits of each one of the latter is not easy to define. This is the reason why some authors (May and Williams, 1986; Comfort, 1999) prefer to speak about shared responsibility, and the need to coordinate and cooperate, exactly as already discussed for scientists, is essential for achieving any meaningful result.

Private sector

Reported disaster losses carried by the private sector, e.g. due to damaged assets, or due to the disruption of business processes, are huge. In addition, disasters directly or indirectly affect business performance and undermine longer-term competitiveness and sustainability (GAR13, pp.iv). Even though awareness of businesses' vulnerability to disasters and to climate change consequences is still low, their contribution in DRR mainly through partnerships can be categorised as: a. companies managing or owing critical infrastructures, b. advocacy and awareness raising, c. social investment and philanthropic, and d. core business (see also UNISDR, Private Sector Activities in Disaster Risk Reduction: Good practices and lessons learned, 2008).

a. The case of companies managing critical infrastructures is somehow in between public and private sectors. In fact, for many decades critical infrastructures have been run under a regime of monopoly in the majority of countries. Deregulation and privatization trends, particularly since the Nineties, have broken such regime, even though not totally or not completely. What is recognized in any case is that even where services or networks are privatized, the service is considered as public and requires therefore specific regulations and control by public/state authorities so as to guarantee its reliability, continuity and safety (Menoni et al., 2013).

b. The private sector is an increasingly active producers of information regarding risks, hazards, and mitigation measures in advocacy and raising awareness campaigns. Web based companies for example are using the potential of the internet to make relevant information fast shared during emergencies; GIS developers are greed to provide open maps and mapping platforms for helping in logistics during crises. Private companies have been active though also in awareness raising campaigns, as testified by UNISDR (2003) and examples in GAR 13.

c. Corporate Social Responsibility (CSR) provides a good basis for business participation in disaster risk reduction. Especially for multinational companies, DRR is an increasingly important field of corporate social responsibility initiatives (UNISDR, 2008). There are many types and characteristics of CSR (ILO 2011, Twigg 2001): donations and grants in cash or in kind (goods, services, facilities) to other organisations and groups or directly to beneficiaries, contracting other organisations or groups to carry out work for public benefit, sponsorships, information and awareness raising activities, participation in committees and discussion groups.

d. Insurers have a relevant direct and indirect role in risk management, as insurance is considered as an important risk transfer mechanisms in both DRR and CCA. Particularly reinsurers have an important role in knowledge management, as they produce risk assessments at the micro, meso, and large scales. However, generally insurers and reinsurers are reluctant to make their data public, for a variety of reasons, generating a mistrust regarding their willingness to share risk knowledge sources. The other stakeholders groups also expect (re)insurers to have much better and extensive loss and risk data than is actually the case. Insurance and reinsurance companies are active sponsors of hazards and risks research. Sponsorship is an unequal partnership because the sponsor controls the funds and therefore the agenda. Research funded by insurers is on topics relevant to the industry and hence more relevant to developed countries where insurance cover is more extensive (Twigg, 2002). According to GAR2013 "A growing convergence between the insurance and risk modelling companies, governments and the international community, promises to deliver new risk information platforms that will inform investment decisions by governments, businesses and cities alike. The fact that those companies developing new tools for visualising and managing disaster risks see a key business opportunity is a potent sign of change."

Civil Society

Civil society is a heavily debated term in social sciences nowadays. In general, the term refers to the social sphere that is distinct from the state and the private sector, and this is why it is also referred to as the "third sector". In this respect, civil society is said to be comprised of the so-called "intermediary institutions" such as NGOs, professional associations, labour unions, advocacy organizations or religious groups. The MacMillan Dictionary views civil society as the social groups that lay between the state and the family. Others consider the family to be part of the civil society, the latter also including associations (where voluntarism is a key element), social movements and forms of public communication (Cohen and Arato, 1992). The reason behind the scientific community's acknowledgement of the role that the civil society plays is that voluntary or non profit organizations are playing a very important role in disaster mitigation which not only responds to the affected local communities' urgent needs but also offers a balance vis-à-vis government shortcomings in dealing with mitigation. Last but not least, civil society's involvement in DRR is also said to be important because of the specific role of knowledge is possesses. In many cases, traditional or local knowledge is said to be highly important in both mitigation and preparedness issues due to its contextualized nature. The degree to which civil society agents can collaborate with either the government or the private sector is of critical importance. Murphy (2007) argues that local government and community initiatives are interdependent (although they are separate) and that they may contradict one another, challenging the effectiveness of the total mitigation effort.

It was already acknowledged in the project proposal that this broad classification is neither exhaustive nor satisfactory. For example, scientists cannot be viewed as detached from the other groups. In fact scientists are working for both private and public institutions. In some cases they are also contracted by citizens' groups and NGO to provide an alternative perspective to "official" science on particularly controversial issues.

Each group is actually comprised by a myriad of organizations, social groups, individuals, that are not always pursuing the same goals, that are not necessarily sharing a uniform perspective about what has to be done to mitigate and respond to hazards and disasters.

Different organizations individuals, agencies, businesses, are not equally empowered nor equally able to produce and enact knowledge regarding disaster risk and climate change adaptation and prevention.

The roles of experts as mediators of knowledge has grown rapidly. As scientists expanded their role as consultants and advisers concerning policy and society, the scientific advisory process became so pervasive and influential that Jasanoff (1990) has called it "the fifth branch". By merging legal and institutional analysis with social studies of science, she challenges the conventional assumptions that science guaranteed truth and that science experts' advice was unbiased, fail-safe, and thus indispensible to policy-making: how can scientists ensure the objectivity of science and "how can they maintain their authority as neutral experts, especially when challenged in the media or the courts?" (ibid. 1990, p. 9). Jasanoff articulates a social construction model that outlines the problems of objectivity and neutrality in science policy and how science became increasingly vulnerable to the other actors in the network.

Last but not least different organizations, agencies, individuals are acting at different stages of a disastrous event, ranging from pre-impact to emergency and recovery.

Despite those severe limitations, the four-group classification has served as a rough instrument to advance in the understanding of what knowledge is relevant for whom, to what extent it is shared and managed across groups and within each group.

## Knowledge management across stakeholders and social groups along the disaster cycle in twelve case studies analysed by the know-4-drr project

Twelve case studies (table 1) spanning over ten countries have been analysed in the know-4-drr project to understand what have been the major issues in data, information, and knowledge production, knowledge fragmentation or sharing among stakeholders across spatial and temporal scales.

It may be interesting to examine how some of the countries to which the case studies pertain have reported on the advancement achieved thanks to HFA 1. Out of ten, six countries have complied with the requirement to provide such an assessment in the period 2011-2013. Regarding the indicator of concern, all countries except for Germany responded positively to the following questions: b. whether information is proactively disseminated, whether there are established mechanisms for dissemination, whether information is provided by proactive guidance. To the first question, related to the existence of a disaster information system publicly available, Italy responded "no", whilst all other countries including Germany responded "yes". More interesting are perhaps the detailed narrative that accompany the key indicators. Germany suggests that much has still to be done in coordinating the various stakeholders and in making them share information across governmental levels. This is in line with what has been observed in the Elbe case study, where several problems of information exchange, particularly in the very first days of the emergency, were reported between the local, regional and federal levels. Similarly Italy pointed at the too varied situation differentiating the existence, quality and access to information in different regions. France reported to be rather advanced on the issue of information sharing and dissemination: a local information system available for all citizens and the Gaspar database regarding disasters that occur each year have been developed. Since 2006 disclosure of hazard information is mandatory in the real estate sector; finally in the HFA1 Progress Report, France highlights the newly established National Observatory for Natural Hazards (ONRN) platform. Mexico has set within the Civil protection institution (CENAPRED) a virtual library of the Mexican system of civil protection regarding all issues related to risks and disasters. Similarly to the Gaspar database, a report is published annually reporting occurred disasters, including their socio-economic impact.

A three dimensional framework has been developed as represented in figure 2 to compare and analyse the case studies. The framework is structured by disaster phases (distinguished between pre-impact mitigation, early warning and preparedness to an imminent event, emergency, recovery and reconstruction in the x axe), according to the components of the knowledge pyramid (ranging from data to knowledge as shown in the y axe), and by stakeholders groups (in the z axe).

| **Case Study Site** | **Type of hazard** | **Date** | **Brief description of the case study** |
|---|---|---|---|
| Umbria, Italy | **Flood event** | Nov. 2012 | The event striking Umbria on November 2012, starting on the 12th and ending on the 16th, depending on exact location and river basin, was the consequence of a widespread high intensity storm. The latter provoked floods and landslides in large zones in Central Italy, including besides Umbria also the Lazio and the Toscana Region, totalling 250 million Euros first order costs covering emergency response, recovery of infrastructures and first response to restart economic activities and public services (such as schools). The case study reports in particular the post-event damage assessment activity. |
| Ilia, Greece | **Forest fires** | August 2007 | The synergistic effect of fuel accumulation and weather conditions can explain the occurrence of the large and catastrophic wildfires of 2007 in Peloponnesus. In the period between the 24th -28th August 2007, the Ilia Province faced the most serious forest fire problem of all areas in Greece. Tens of losses of human lives and 6.000 homeless people; 168 municipal districts or 1.994 km2 declared as disaster areas -i.e. a territory representing 76% of the total area of the Prefecture; tens of thousands of hectares of burnt forest land representing 39% of the total forest land of the Prefecture. |
| Kalamata, Greece | **Earthquake** | Sept. 1986 | On September 13th 1986, at 20:24 local time, the city of Kalamata (Southern Greece) and the surrounding villages were devastated by a shock of a Ms=6.0. Out of 9,800 inspected buildings, 22% had collapsed or were damaged beyond repair, 21% suffered heavy structural damages and 26% light structural damages. In the historic centre around the Castle about two thirds of the buildings suffered damage beyond repair and about 80% of historic buildings and monuments were severely damaged. Substantial steps forward in earthquake protection policies and practices well as in reconstruction policies followed the Kalamata disaster. |
| Greece | **Sea level rise** | Recent past – present and future | The Greek coastal zone has a total length of approximately 16,200 km, being one of the longest coastal zones among European countries.The risk of coastal flooding is limited, however, during December 2009-January 2010, the coastal areas of the South-eastern Aegean islands were severely flooded (up to 1 m. Sea Level Rise is estimated to be in the range of 0/+1 mm/year, if only trends and rates of eustatic SLR are considered. Most big urban centre and economic activities are located on or nearby the Greek coasts, including about 80% of industrial activities, 90% of tourism and recreation, and 35% of agriculture, fisheries. |

Table 1 : Case studies examined in the first deliverable of the Know-4-DRR project

| Case Study Site | Type of hazard | Date | Brief description of the case study |
|---|---|---|---|
| Lorca, Spain | **Lorca earthquake** | May 2011 | The Lorca earthquake on 11th May 2011 M 5.2 at 18:47 was preceded by a M 4.0 foreshock at 17:05. It caused 9 fatalities and more than 300 injured. 1164 buildings were seriously damaged. Damage concentrated in several areas in the city where around 40% of buildings were damaged. In the historical centre of Lorca around 16% of buildings were affected. Historical heritage was severely affected, including old churches and medieval wall towers. A year later, on the 28th of September 2012, Lorca was affected by flooding. |
| Elbe catchment, Germany | **Flood event** | August 2002 | The combination of heavy rainfall and sealed surfaces resulted in one of the most disastrous flood events ever observed in the Elbe region, between the 11th and 13th of August 2002. The flood severely affected eight European countries; the case study has analysed the impact and the response in Germany. Along the main river course of the Elbe, 21 dike breaches occurred, inundating more than 300 km² and affecting, amongst other things, more than 25,000 residential buildings. 21 people were killed. Economic losses amounted to more than 11 billion Euros in Germany alone. |
| Salzach catchment, Austria | **Flood event** | June 2013 | In June 2013, a 100 year return period flood affected large areas of Austria and Germany. The water gauge in Salzburg City measured 8.51 meters and was thus 15 cm higher than the catastrophic floods of 2002. The floods had a major effect on transportation networks, although the total damage was much less than in 2002. This has to do with mitigation measures implemented since then. Although major advances to DRR have been made in recent times, and Salzburg Province can be regarded as a forerunner of successful DRM, there are still many areas in need of improvement. In June 2013 what did not function as expected was the early warning provided to citizens. |
| La Faute sur Mer, France | **Xynthia storm surge** | Feb. 2010 | In February 2010, the French Atlantic coast was hit by storm Xynthia, causing over forty fatalities and direct losses of more than 2.5 billion Euros. Total public expenditure amounted to 467 million Euros; insurance pay-outs came to 690 million Euros to cover damaged infrastructure. The municipalities of La Faute-sur-Mer, L'Aiguillon-sur-Mer, and La Tranche-sur-Mer (Vendée department) suffered severe damage. Among the reasons contributing to the fatal impacts: resistance of communities to adopt risk prevention plans, uncontrolled spatial planning as concerns flood risk management, lack of maintenance and failure of risk defence measures, and inappropriate risk considerations by the real estate market. |
| Alpine Area | **Climate change adaptation** | Recent past – present , future | The effects of climate change and the induced hazards, such as avalanches, landslides, flash floods, and forest fires, are very evident in the Alpine area. The process of adaptation in the area, which is shared by different European countries is the object of some projects, and in particular the results of the the ongoing C3- Alps interreg project are reported in the case study. |
| Central Vietnam | **Typhoon events** | 2006 and 2009 | Vietnamese coastal areas are prone to tropical storms/cyclones every year (average 5-7), but at the time of Xangsane (2006), Chanchu (2006) and Ketsana (2009) typhoons, the capacity of preparedness and warning was low. In May 2006, the Cyclone Chanchu that developed in the China Sea on an east-west track hit the Vietnemete Province of Quang Nam, provoking severe damage. The number of destroyed houses was reported as 15,200, after having been downsized by public authority in a first estimate. In 2012-2013, the Ministry of Construction launched the Programme 716 to support families to build safe and resistant shelter in high flood areas, with the support of DWF (Dipecho funding project). |
| Padang, West Sumatra, Indonesia | **Tsunami event** | Dec. 2004 | After the Indian Ocean Tsunami event in December 2004, the city of Padang, West Sumatra, Indonesia, was one point of concern, due to its important seismic hazard potential and the dense population and infrastructure of its low-lying coastal areas. The scientific project that was used as a basis for this case study focused on the conditions at the community and household levels that determine their response to the early warning and capability of conducting evacuation, and addressed the topic of how urban planning may contribute to enhance this capacity. |
| Mexico | **Stan hurricane** | Oct. 2005 | The Stan tropical storm hit Mexico between the 3rd and 6th October 2005. It cause extended damage, particularly on infrastructures in different states, however the most severe damage was suffered in Chiapas. In the cities of Tapchula dn Motozintla floods occurred, affecting various neighbourhoods. In Chiapas the Stan tropical storm caused 86 deaths and more than 490.5 million UDS, representing about 40% of total damage recorded in Mexico. |

Table 1 – cont. : Case studies examined in the first deliverable of Know-4-DRR project

Results of the performed analysis will not be described in detail, rather the following questions will be discussed: whether or not knowledge that is produced by different stakeholders group is useful or not; if knowledge is shared among stakeholders within and across the identified groups; if knowledge is enacted and decisions actually implemented.

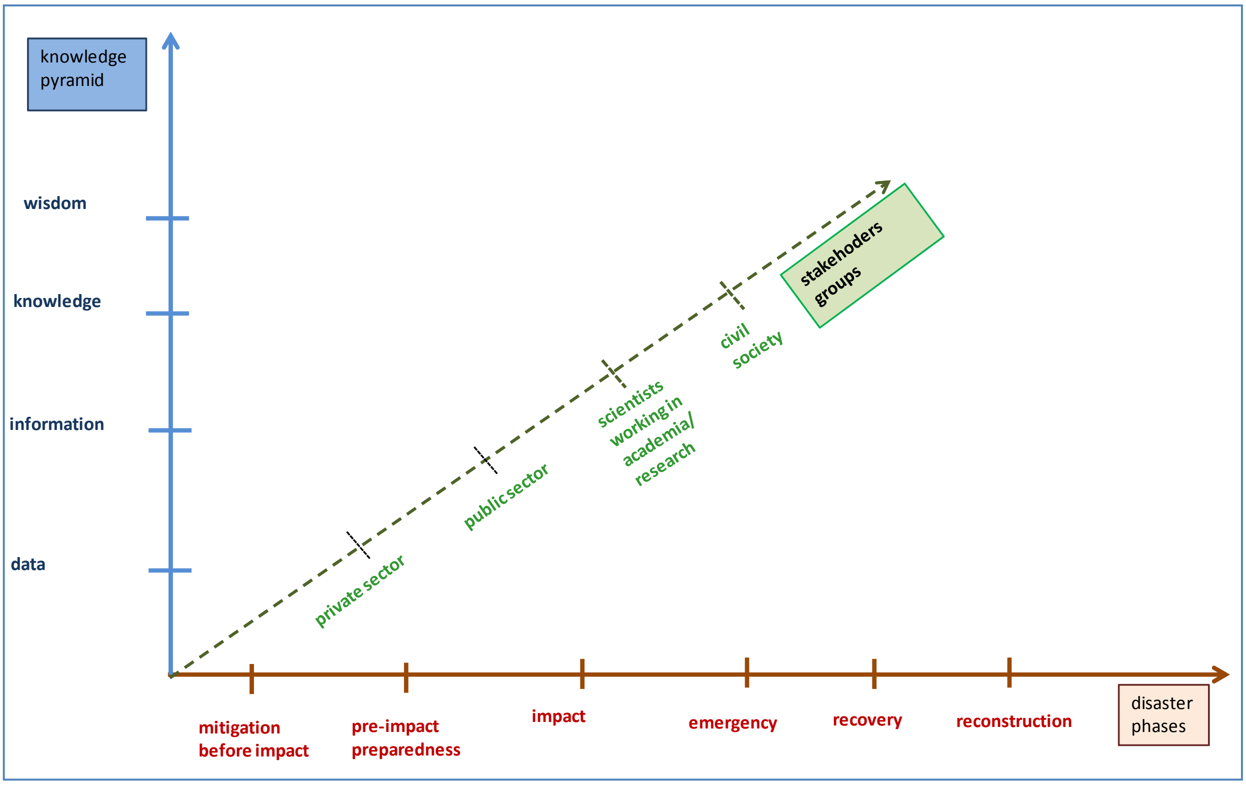


Image 2 : Framework adopted for the analysis of the case studies

## Is knowledge produced by different stakeholders group useful?

Most reflections provided in literature rotate around the question whether or not knowledge produced by "scientists" is useful and usable by other stakeholders. The same know-4-drr project answers a call asking why knowledge that is available in drr and cc is not reaching decision and policy makers. Already in the project proposal, the idea that knowledge is a "commodity" out there to be transferred from one community to another has been challenged, suggesting that the key question to be asked is another one, that is what are the conditions at which produced knowledge is used and usable, by whom and how it can be better shared, produced and co-produced. This way the question of whether or not produced knowledge is useful incorporates also the question of whether or not it is sufficiently shared.

More specifically, it can be stated that scientists have progressed significantly in understanding many aspects related to hazards, including their interconnectedness and the possibility to have enchained and cascading natural and technological incidents. Components of the risk function, like vulnerability and resilience, rather neglected in the past, have gained significant room in the last decades. Tools for measuring and assessing vulnerability and resilience of assets and communities in practice have been developed.

Steps towards operationalization of concepts like vulnerability and resilience are crucial for both achieving usable knowledge and for sharing it across stakeholders groups. Being able to map vulnerability for the private sectors, as perceived by local communities is as crucial as providing assessments for regional and local governments with the responsibility to act according to such assessments.

Progress has been made in identifying problems that hinder the use of vulnerability and resilience 'knowledge'. This includes difficulties of developing consensus on the methodologies used by different stakeholders; slow delivery of products that could enhance resilience to change, and the time-consuming process of coming to a negotiated understanding in science-practice interactions Vogel et al. (2007). The KNOW-4-DRR project confirms these problems, but also provides evidence that knowledge sharing is taking place, in particular at the:

a. local level between scientists and responsibilities with regard to data acquisition and improvement;

b. national level between different responsibilities and administration units with regard to the use of scientific data; and

c. international level between specific groups of scientists and actors with regard to the development of mitigation activities (Kienberger et al. 2013).

The analysis carried out for the twelve case studies highlighted that the different stakeholders groups are not equally active across the disaster phases. For example scientists are more active in the mitigation and in the recovery phase, whilst their contribution in the imminence of a disaster or in the emergency is far less pronounced.

Usability of knowledge depends on the phase and on the actors that are considered: a total co-sharing and participation of all stakeholders in all phases is unrealistic as for the present situation. However, what clearly emerges from the case studies and reinforces what has been already discussed in literature, is that co-production across stakeholders group has the highest possibility of successful outcomes, as the demands and the supply of knowledge from both sides are compared, understood and eventually met (Sarewitz and Pielke, 2007). For example, in the case of scientists working together with public administration officers in damage recording in the aftermath of a disaster, analytical and descriptive frameworks produced by scientists are tuned to the knowledge regarding procedures and processes to be followed in order to achieve a certain result (compensation to victims and restoration of normal conditions for life and work) that are hold by governmental bodies.

In fact, in the recovery and the reconstruction phase a far greater number of bridges facilitating knowledge sharing have been identified in the case studies, as the event acts as a catalyst (Elbe, Stan, Umbria, and Lorca). Specific funds were allocated for dedicated programmes on Risk Management Knowledge (Elbe, Stan, Umbria) including the development of knowledge for the improvement of the management procedures or establishing different stakeholder partnerships (university-scientists - civil society) that volunteer to conduct studies (Ilia). After the 2007 fires, the Greek General Directorate of Development and Protection of Forests and Natural Environment worked in co-operation with international specialists to address post-fire impacts and to protect burnt areas from secondary effects such as landslides and floods.

Automated procedures for data assessment, use of new information and communication technologies (ICT) in early-warning systems, establishing improved procedures of communication in all reporting during the emergency phase, and interlinking scientists and administrative personnel in advisory committees and joint research programmes have been witnessed in the quoted case studies.

An incremental body of literature has been dealing with vernacular and local knowledge hold by communities about risks and evidences of climate change, as this knowledge is very context specific and sometimes more relevant than highly formalized but detached from context science produced in laboratories. Whilst some case studies suggest that participation of citizens and local groups to the development of knowledge is important for overcoming lack of mutual comprehension and understanding of the implications of forecasts and norms, others show also that vernacular knowledge is today challenged by both natural and social factors. As for natural ones, fast changing environmental conditions are threatening what has been learnt for generations; as for social factors, rapidly evolving economic and market conditions are transforming habits and cultures, thus requiring new forms of adjustment and perhaps more sophisticated ways of knowing the context in which a community is living and operating.

## Is knowledge enacted?

The case studies show that knowledge is enacted, but only partially, mostly in the aftermath of a disaster, and that the translation of what is known in what is decided and actually done not so straightforward. This has to do with the fact that mitigation is per se made of a set of different structural and non-structural measures. Selecting the best mix and combination of measures is not easy and requires a much higher degree of cooperation among actors and stakeholders than the current situation allows for.

Measures that are enacted are often sectoral and piecemeal, reflecting the level of sharing and co-production of knowledge among the variety of organizations, agencies and individuals that have been recognized in section 2.

Barriers that have been identified in the co-production and sharing of useful knowledge are somehow similar to the ones encountered in translating knowledge into practice, in conveying the information about how to implement a given decision.

The enlargement of disaster-related research and the increase of scientific activities so far had little impact on reversing the upward trend in disaster damage, precisely expressed by White et al. (2001) as "knowing better and losing even more". Obviously, there are gaps between what is known about disaster risks, on the one hand, and how research findings are translated into policies and programmes, on the other.

In European hazard research, institutional and constitutional constraints are often ignored; social resilience and adaptive capacities are only poorly investigated and risk education as specific strategies of social capacity building is not highlighted (Kuhlicke et al. 2011). Deficits also exist with regard to practical applications of conceptual thinking in vulnerability assessment, operational methodologies relevant for and applicable by practitioners, concrete measures that address the systemic underlying causes of vulnerability, and assessing the substantial costs of implementing vulnerability reduction strategies (Newton and Weichsel-gartner 2013). Existent scientific results and assessments of risks are frequently not used because they have been defined and framed to meet the needs of science rather than the needs of those making decisions. Various studies point to different institutional settings and standards, differing cultural values, divergent understanding, and mistrust as critical factors hindering efficient transfer of knowledge into action (Weichselgartner and Kasperson 2010; Moser and Ekstrom 2010, Lövbrand 2011, Dilling and Lemos 2011).

The prescriptive approach of postnormal science (Funtowicz and Ravetz 1993) is particularly relevant for DRR and CCA since aspects of problem-solving are considered that were often neglected in traditional accounts of scientific practice: uncertainty, value-loading, and the plurality of legitimate perspectives. In these sorts of issue-driven science, particularly with regard to complex systems, "typically facts are uncertain, values in dispute, stakes high, and decisions urgent" (ibid. 1993, p. 744). In such contexts, 'normal science' in the sense of Kuhn (1962) is not an adequate knowledge production mode, since the traditional scientific mindset fosters expectations of regularity, simplicity, and certainty. Where uncertainties are crucial, value-loadings critical, and less information available than desired by political decision-makers, there can be no single privileged perspective for measurement, analysis, and evaluation. Thus, invoking 'truth' as the goal of science is a distraction from real tasks. It is argued that quality is a more relevant and robust guiding principle – understood as a contextual property of scientific information. By bringing 'facts' and 'values' into a unified conception of problem-solving in these areas, and by replacing 'truth' with 'quality' as its core evaluative concept, postnormal scientific practice provides a framework for extended participation in decision-making and a path to the democratisation of science.

Among bridges that can facilitate the sharing and co-production of knowledge the existence of organizations and individuals that are able to build and provide interfaces are often cited and identified in the twelve case studies. Pracademics, boundary organizations working with and between scientists and public administrations, public and private sectors, academia and NGOs or citizens groups are indicated as examples of bridges that may work and have actually worked well in some cases. A relevant example of boundary organization is provided by the French ONRN case. The latter is a unique public-private-civil as well as societal-academic partnership agreement that was signed in May 2012 by major stakeholders, including State Authorities, the Mayors Association, the Insurance Market Association, and the CCR (the Central Fund for Reinsurance). The ONRN is an example of what Godfrey et al. (2010, p.5) called "institutionalisation of knowledge brokering": "establishment of new, closer and cooperative relationships between government, science and society actor clusters" (ibid., p. 1).

The creation of bridges is not enough, though, incentives have to be given to cross and maintain them at various societal and territorial levels. Speaking about "pracademics" or about meetings and workshops for stakeholders of different groups to share and discuss together topics that are relevant to all, even though tackled in different ways and through different paradigms, specific conditions must be provided. For example, Ackoff (2006) was already complaining about the fact that in the board of scientific journals, practitioners and professionals are not present; academic reward is higher for incremental achievements regarding problems that are sometimes very marginal in the practical world (Posner, 2009), whilst the fuzzy and inevitably spurred results of the co-work of mixed scientists and practitioners, or of scientists with different disciplinary backgrounds are often labeled as lacking rigour and not meeting "scientific standards".

On the other side, actors of public administrations as well as of private businesses may see as a waste of time contributing to workshops or meetings with academics. In this regard, it may well be that the financial crisis that some European countries are facing may provide some positive incentives. In fact, as public administrations and governments shrink due to budget constraints, the need to be more efficient, adopting a framework to address the search of data and the production of information becomes more evident and pushes practitioners and officers to look for methodological frameworks produced by and in conjunction with scientists.

Examples of production and co-production of useful and usable knowledge can be found among the Know-4-drr case studies. After the Lorca earthquake, the Murcia Regional Administration prepared a brochure compiling all available actions for recovering economic activities, that constituted an important tool for informing and mobilising the public.

After the Kalamata earthquake, various studies and research projects explored a wide range of aspects relating to earthquake protection from engineering and planning to social aspects. The outcome of the scientific studies and research projects was not simply more knowledge in various fields. Of far greater significance is the connection that was developed between different disciplines dealing with the Kalamata earthquake disaster and individuals involved in the reconstruction of Kalamata through different roles and positions (field studies, consulting, usability and damage inspections, emergency response, issuing building and repair permits, supervision of the construction of infrastructure works, control and design of reconstruction of the historic centre and of historic buildings, management of transitional housing etc). This created a basis for communication and exchange that functions even today. In this way, common experiences in a disaster situation have created a bridge between various disciplines and different roles that could be maintained overtime.

## Learning, unlearning, and innovating in DRR in integration to CCA

Knowledge management systems prove to work if individuals and organizations are able not only to share and maintain relevant information and knowledge but also to acquire new knowledge by learning and innovating. Learning takes place also when stakeholders share their knowledge as by doing so they create the opportunity to learn from each other. Learning must occur at a much larger scale, as knowledge is by definition dynamic, growing on the shoulders of previous achievements and discoveries. Even though there are similarities between the way individuals and organizations learn, there are also fundamental differences, given that within an organization learning is not just the result of summed individual efforts, but is also the integrated outcome of a collective effort. In the field of disaster risk, there are many organizations and entities involved and also what needs to be learnt is not straightforwardly defined. In fact, when new knowledge is available regarding given hazards or on the way risks are assessed, new facts and methodologies must be acquired.

However not just learning about facts and new methods or tools are of use for organizations, but also regarding how things are done within the organizations and in concert with others. In particular, the management of prevention strategies and of crises requires significant learning about how things are done or could be done better. Actually when talking about "lessons learnt" from past disasters what is generally referred to are lessons about behaviours, conducts, tools that could have been used or managed better than actually occurred. However, what the twelve case studies of the project suggest is that a much more complex type of knowledge is required in order to face the challenges related to disaster risk and potential effects of climate change. In fact, organizations, individuals, citizens would need a much more complex and rich level of learning, including how things need to be done, about new facts, about new, and more elaborated ways of understanding, assessing and analyzing risks. Even the apparently "simple" task of collecting data in the aftermath of a disaster has proved to be much more difficult and requiring much more knowledge, understanding and expertise than suspected, as we have mentioned at the beginning of this paper. This task entails the recognition of the different uses and purposes for which data collection is carried out and requires a new type of collaboration among the different agencies that have direct responsibility and also indirect interest, like universities and research centres. The Umbria and the Salzach case studies provide a relevant example in this regard.

The learning process within organizations, and specifically within organizations with responsibilities in disaster risk has been studied for long time and from different angles (Roux-Dufort, 2000; Guilhou and Lagadec, 2000; Pahl-Wostl, 2009). Studies on the issue suggest that learning is not necessarily cumulative and progressive, as there may well be steps forward and backward and whilst new things are learnt and introduced in the routine of organisations, some other, even crucial, are forgotten and lost. As correctly put in the European Commission Report (2007) *Taking European Knowledge Society Seriously*, «the development of a body of knowledge is usually accompanied by a corresponding process of 'unlearning' other forms of knowledge. Even if these are not in equal measure, what is lost can be important. Likewise as knowledge is acquired, new forms of ignorance are also created, or mobilized».

When talking about learning and innovating in the field of disaster risk management, the possibility of unlearning, or forgetting has to be kept in mind. Many times what is presented as real novelty is in fact re-discovery of concepts and tools that were already at hand in the past. This occurs also as a result of the fragmentation of knowledge mentioned above. Notions like "resilience" for example are not new even though sometimes considered such in recent debates on disaster risk. In fact, as well described in Norris et al (2008), resilience as understood in the field of disasters owes a lot to the same concepts as used in psychiatry and psychology since several decades. The lack of dialogue between scientists and practitioners in the fields of disaster risk reduction and climate change adaptation and mitigation may open the floor for significant possibilities of unlearning or ignoring knowledge that has been already produced and that can be of significant use in both domains (Mercer, 2010; Tearfund, 2008).

Referring to innovation what is meant is often the introduction of new tools and in particular of new technologies. The same idea of knowledge management systems in the form of platform to facilitate access to and sharing of relevant pieces of knowledge is made possible by the significant changes the new media, the cloud computing and storage facilities offer. However, new technologies can be used in old ways, without actually innovating how things are done or the content of what is stored. In this regard, the "risk communication" and to a larger extent the "science communication" is still in its infancy. Despite large volumes written on the topic, too often authorities are reluctant to inform citizens about existing risks in their neighborhoods, getting to the harsh contradiction highlighted by Parker in Mitchell (1999): on the one hand it is stated that citizens are the primary response line in case of disasters but on the other they are not given the right information ahead in the fear they will panic or react against the authorities who have informed them.

In a similar fashion also the capacity of scientists to disseminate the results of their projects and research is still very limited and narrowly understood as presenting to conferences or publishing in a refereed journal. Whilst the European Commission has reinforced progressively the requirement to disseminate the results of project granted European funds and to have an "impact", it is still too little understood what "having an impact" really means. In the know-4-drr project an attempt is being carried out to work with professionals in the field of communication, working for web-tv and a national radio, to understand how project's results need to be communicated to the external world, by diversifying the messages and the key arguments tuning them to a rather differentiated panel of potential audiences, that are much more articulated than the four stakeholders groups identified initially in project proposal. What professionals of the communication sector are telling us is that old and new media must be understood in their potential, in their functioning, so as to provide a valid bridge across different communities to permit actual sharing of relevant knowledge and information. In some of our case studies significant advancement in the way risks and impacts are communicated have been achieved.

For example, in Vietnam, since the 2006 and 2009 typhoon disasters, information provided by TV and radio has improved with detailed warning. TV documentaries about how to prepare for disasters were also broadcast. Improvements were made to the information delivery on the websites by the local and national civil protection authorities. The media has been trained in the past five years to increase the capacity to deliver relevant information before and after disaster events.

The National Centre of Disaster Prevention (CENAPRED) in Mexico published a socio-economic study showing information about hurricane Stan: cost, numbers of communities affected, infrastructure, roads etc. To improve the transfer of information across institutions and borders, the provinces (Länder) in Germany established a common early warning website.

Finally, as suggested by various authors (Pahl-Wostl, 2009), innovation is pursued by changing organizational procedures and processes. However, a couple of points deserve further discussion. The first is the need to balance innovation with stability: innovation can take place only against practices and procedures that are kept stable in the fore or in the background and in the meantime enough time needs to be allocated for verifying the results of introduced changes. In this respect, it has to be reminded that significant changes in organizations will take at least a decade to become apparent and provide results, whist often issues are brought to the front line in much shorter time, that is measurable by years if not less (Lee, 1993). This creates a very strong tension between the requirement for innovation and change and the actual possibility and opportunity to provide for change; a situation that may lead either to immobility (there is no need for change if the latter is already old by the time it has been introduced in the organization) or to chaos (it cannot be that everything changes all the time without any control about the results of the changes that have been introduced).

In this regard an increasing literature is proposing the need for more "adaptive" organizations (McLain and Lee, 1996), that are flexible enough to provide room for experiments that will provide the opportunity to test changes and innovative practices.

## Conclusions: proposing a more comprehensive interpretation of informational and knowledge needs in HFA2

In the HFA 1 the third general priority for action is aimed at "Using knowledge, innovation and education to build a culture of safety and resilience at all levels" identifying four sub.-areas: information management and exchange, education and training, research, an public education. From the reflections and discussions carried out to build the Knw-4-drr proposal and the first deliverables, a more dynamic view of knowledge is arising, one in which different stakeholders groups should attempt build together a common vision and understanding about risks and ways to cope with them more effectively. In HFA 1 it is still assumed that research is going to provide the answers to most questions, and then the matter is how to disseminate and share with others the results of experiments carried out in laboratories or of assessments developed on the base of sophisticated modeling. Even though interdisciplinary work is considered essential, little emphasis is given on the fact that a much larger cooperation among different scientific communities, even among those that are only loosely connected to risks and hazards should be pursued, so as to make results obtained in resource management, in adaptive ecological management, in sustainability science flow and inform also disaster related sciences. Little if anything is mentioned about the need to strengthen the links between the disaster and the climate change communities, who until now have made just few and hesitant attempts to share and integrated methodologies and concepts on risks, vulnerability, coping capacity, adaptive capacity, resilience. Yet this situation is not helpful in a condition where governments may be asked to shrink because of budget constraints and the same officers are responsible of both risk mitigation strategies and climate change adaptation.

A more dynamic perspective of how knowledge is produced, shared and eventually co-produced, requires to abandon the idea of "knowledge transfer", but rather to enhance the cooperation and the coordination capacity among different stakeholders and social groups, particularly when they are working in the same geographical context on the same problems. Also the reference to more user friendly instruments to allow for the treatment and the dissemination of maps and data has to be rethought of in the light of web 2.0 and perhaps in a near future web 3.0 technologies. The digital earth concept (Craglia et al., 2008), the experiences carried out in Haiti (Harvard Humanitarian Initiative, 2011) demonstrate that unexpected forms of co-production of knowledge may emerge using the potential of internet based technologies. Yet how to design effective forms of web based knowledge and information co-production and sharing is still a matter to be explored and much better understood. For example maps embed knowledge, they represent thematic features that derive from analyses and assessments. To draw maps and use at best the potentialities of

GIS knowledge and capacities are required too. If the possibilities provided by interactive mapping on web platforms are added, even larger capacities and knowledge are required. And it is not just a matter of skilled computer scientists interviewing "domain" experts for eliciting requirements: such traditional view seems somehow outmoded in the light of the many limitations that tools developed insofar have encountered (Harvard Humanitarian Initiative, 2011).

In the same vein any attempt to improve statistical analysis of disasters and disaster risk related data requires that knowledge exists and is shared between data providers and users regarding what are the relevant indicators to survey and monitor. Before databases are made public and open, there must be a clear understanding regarding what are the objectives to be achieved, in line with the current reflection discussed in the introduction to this paper.

Knowledge related issues, however are not confined to the third priority action area; instead they encompass the entire Hyogo Framework. There is the need to enhance knowledge regarding effective and successful governance tools to address the complementary challenges of "sustainable development, poverty, disaster risk reduction". Knowing what works and what does not in which context goes far beyond a list of "best" or "good" practices, it requires that procedures and processes of bureaucracies and institutions be correctly understood, particularly if changes have to be proposed. As discussed in the paper the emphasis should not be only on the identification of the problems and on establishing a decision making process to address them, but also on how implementation, compliance with norms and decisions can be achieved. Knowledge on organisations' behavior, on states and institutions functioning is required not less than knowledge about the variables characterizing hazards, exposure, and vulnerabilities. Actually, institutions and bureaucracy can provide both weak, maladaptive and strong and positive responses to environmental stresses.

We suggest that knowledge management is actually needed in all key areas for action of HFA 1. In particular, regarding the second priority line, "Identify, assess and monitor disaster risks and enhance early warning", our analysis of the twelve case studies suggests that knowledge is required to produce risk assessments tailored for different purposes, such as early warning. Knowledge about the stakeholders involved in the process, about their way of working, about the exposed systems, about the specificities of the context within which assessments are developed.

Similarly, regarding the different measures to be taken to reduce risk factors as described in the fourth key set of actions, experience has shown that embedding the results of research and/or risk assessments in mitigation strategies or in what could become risk mitigation strategies has been rather ineffective. For example, land use planners are simply unable to embed risk mitigation as they often lack even fundamental understanding of hazards dynamics and cannot figure out the potential impact of hazards in the territory they are planning. What would be needed is therefore a much deeper consideration of how practitioners and scientists with different background and often acting in different forums can together develop or at least share understanding of risk assessments results fitting specific needs.

As suggested by McGlade and van den Hove (2013, p. 415): "It is unsurprising that planning and management institutions have been unable to respond to crises or change, as in many instances, the organizations are suffering from a chaotic mix of information, analysis and interpretation with not paradigmatic structure in which to incorporate all the various forms of scientific, interdisciplinary, and indigenous knowledge. In the pre-modern environment, knowledge was rich and adapted to the requirements of living locally. Individuals today are just as knowledgeable but they receive information from an enormous number of sources, some technical, some cultural. In this way we can see a form of second-order science emerging in which individuals must rely on other peer groups and experts to be able to evaluate the information within their own domains of expertise". The latter condition, so well described by McGlade and van den Hove requires that new forms of cooperation and coordination of knowledge be encouraged and developed.

## References


Adger, W.N., Barnet, J., Brown, K., Marshall, N. and O'Brien, K. 2012. Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change,* Vol. 3 issue 2: 112-117.

Ackoff, R. 1989. From data to wisdom. Presidential address to ISGSR, June 1988. *Journal of Applied Systems Analsyis*, vol.16.

Ackoff, R. 2006. Why few organizations adopt systems thinking. *Systems Research and Behavioral Science*, vol.23, pp. 705-708.

Alavi, M. and Leidner, D. 2001. Review: Knowledge Management and Knowledge Management Systems, Conceptual Foundations and Research Issues. *MIS Quarterly*, vol.25, Issue 1: 107-136.

Cohen, J.L. and Arato, A. 1992. *Civil society and political theory*. Cambridge, MA: The MIT Press.

Comfort, L.K. 1999. *Shared Risk. Complex Systems in Seismic Response*. The Netherland : Pergamon, Elsevier Science Ltd.

Craglia, M., Goodchild, M.F., Annoni, A., Camara, G., Gould, M., Kuhn, W., Mark, D., Masser, I., Maguire, D., Liang, S. and Parsons, E. 2008. Next Generation Digital Earth. A position paper from the Vespucci Initiative for the Advancement of Geographic Information Science. *International Journal of Spatial Data Infrastructures Research*, 3: 146-167.

De Groeve, T., Poljansek, K., Ehrlich, D. 2013. Recording disaster losses, JRC Scientific and Policy Reports. (available at:
http://publications.jrc.ec.europa.eu/repository/handle/111111111/29296)

Dorasamy, M., Raman, M., Kaliannan, M. 2013. Knowledge management systems in support of disasters management: A two decade review. *Technological Forecasting & Social Change.*

Eigenbrode, D., Sanford, O'Rourke, Michael, Wulfhorst, J.D., Althoff, M. David, Goldberg, S. Caren, Merrill, Kaylani, Morse, Wayde, Nielsen-Pincus, Max, Stephens, Jennifer, Winowiecki, Leigh, Bosque-Perez, A. Nilsa, 2007. Employing philosophical dialogue in collaborative science. BioScience, Vol. 25, Issue 1: 55-64.

European Commission, Taking European knowledge society seriously. Report of the expert group on science and governance to the science, economy and society directorate, Directorate-General for Research, European Commission. EUR 22700, 2007.

Frické, M. 2007. The knowledge pyramid: a critique of the DIKW hierarchy. *Journal of Information Science*. Vol. issue.pages

Funtowicz, S.O. and Ravetz, J.R. 1993. Science for the post-normal age. *Futures,* vol.25, Issue 7: 739-755.

Godfrey, L., Funke, N. and Mbizvo, C. 2010. Bridging the science-policy interface: a new era for South African research and the role of knowledge brokering. *South African Journal of Science,* vol.106, Issue: 5/6: 1-8.

Guilhou, X. and Lagadec, P. 2002. *La fin du risque zéro*. Paris: Les Èchos, Eyrolles Editeur.

Harvard Humanitarian Initiative 2011. Disaster Relief 2.0: The Future of Information Sharing in Humanitarian Emergencies. Washington, D.C. and Berkshire, UK: UN Foundation & Vodafone Foundation Technology Partnership.

Hirsch Hadorn, G., Hoffmann-Riem, H., Biber-Klemm, S., Grossenbacher-Mansuy, W., Joye, D., Pohl, C., Wiesmann, U. and Zemp, E. (eds.) 2008. *Handbook of Transdisciplinary Research*. Berlin:Springer.

Howell, R.A. 2013. It's not (just) "the environment, stupid!" Values, motivations, and routes to engagement of people adopting lower-carbon lifestyles. *Global Environmental Change*, vol.23, Issue 1: 281-290.

Hulme, M. 2009. Why we disagree about Climate Change: Understanding Controversy, Inaction and Opportunity. Cambridge: Cambridge University Press.

ILO, International Labour Organization 2011. Multi-hazard business continuity management. Guide for small and medium enterprises. Programme for Crisis Response and Reconstruction (ILO/CRISIS), Geneva.

IRDR (Integrated Research on Disaster Risk), 2011. Forensic Investigations of Disasters: The FORINProject (IRDR FORIN Publication No. 1), Beijing: Integrated Research on Disaster Risk.

Jasanoff, S. 1990. *The Fifth Branch: Science Advisers as Policymaker*. Cambridge, Mass.: Harvard University Press.

Jasanoff, S. 2010. A new climate for society. *Theory, Culture and Society* vol.27, Issue 2-3: 233-253.

Kienberger, S., Spiekermann, R., Jimenez, M.-J., Garcia Fernandez, M., Dandoulaki, M., Valkanou, N., Pigeon, P. and Briones, F. 2013. Analysis of main fragmentation issues within different stakeholder groups. Deliverable 2.1. KNOW-4-DRR Project Report.

Kuhn, T.S. 1962. *The Structure of Scientific Revolutions.* Chicago University Press: Chicago.

Lee, K. 1993. Greed, Scale Mismatch, and Learning. *Ecological Applications*, vol.3, Issue 4: 560-564.

Lélé, S. and Noorgaard, R. 2005. *Practicing Interdisciplinary*. BioScience, Vol.55, Issue:11: 967-975.

Lövbrand, E. 2011. Co-producing European climate science and policy: a cautionary note on the making of useful knowledge. *Science and Public Policy* vol.38, Issue 3: 225-236.

May, P. and Williams, W. 1986. *Disaster policy implementation. Managing programs under shared governance*. New York-London: Plenum Press.

McGlade J.,S. van den Hove, 2013. Ecosystems and managing the dynamics of change. Late lessons from early warnings: science, precaution, innovation. EEA Report 1, 2013, pp. 407-428.

McLain, R. and Lee R. 1996. Adaptive management: promises and pitfalls. *Environmental Management*, Vol.20, Issue 4: 437-448.

Merad, M., Dechy, N., Llory, M., Marcel, F. and Tsoukiàs A. 2013. Towards an analytics and an ethics of expertise: Learning from decision aiding experiences in public risk assessment and risk management, HAL-00874392.

Mercer, J. 2010. Disaster risk reduction or climate change adaptation: are we reinventing the wheel? *Journal of International Development*, Vol.22, pp.247–264.

Menoni, S., Pesaro, G., Mejri, O. and Atun, F. 2013. Interface between public and private treatment of «public goods». Background Paper prepared for the 2013 Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: United Nations Office for Disaster Risk Reduction (UNISDR). Available from: http://www.preventionweb.net/gar. Accessed 2013 Nov 20.

Moser, S.C. and Ekstrom, J.A. 2010. A framework to diagnose barriers to climate change adaptation. *PNAS,* Vol.107 Issue 51: 22026-22031.

Murphy, B.L. 2007: Locating social capital in resilient community-level emergency management. *Natural Hazards*, 41: 297-315.

Naustdalslid, J. 2011. Climate change: the challenge of translating scientific knowledge into action. *International Journal of Sustainable Development and World Ecology*, Vol.18, Issue 3: 243-252.

Newton, A. and Weichselgartner, J. 2013: Hotspots of coastal vulnerability: a DPSIR analysis to find societal pathways and responses. Estuarine, Coastal and Shelf Science. http://dx.doi.org/10.1016/j.ecss.2013.10.010.

Nicolson, C., Starfield, A., Kofinas, G. and Kruse, J. 2002: Ten heuristics for interdisciplinary modelling projects. *Ecosystems* 5: 376-384.

Norris, F., Stevens, S., Pfefferbaum, B., Wyche, K. and Pfefferbaum, R. 2008. Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. *American Journal of Community Psychology*, Vol.41, Issue 1-2: 127-150.

Pahl-Wostl C. 2009. A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change*, Vol.19, pp. 354-365.

Parker, J. 1999. Disaster response in London. In: *Crucibles of hazard: megacities and disasters in transition*. Mitchell J. (ed.). United Nations University Press.

Pohl, C. 2011. *What is progress in transdisciplinary research?* Futures 43 (6): 618-626.

Posner, P. 2009. *The pracademic: an agenda or re-engaging practitioners and academics.* Public Financial Publications, Inc..

Roux-Dufort, C. 2000. *La gestione de crise. Un enjeu stratégique pour les organisations*. Paris-Bruxelles: DeBoek Université.

Sarewitz, D. and Pielke Jr. R.A. 2007. The neglected heart of science policy: reconciling supply of and demand for science. *Environmental Science & Policy*, Vol.10, pp. 5-16.

Seneviratne, K. 2010. *Knowledge Management for Disaster Resilience: Identification of Key Success Factors.* Paper School of the Built Environment, University of Salford.

Southgate, R.J., Roth, C., Schneider, J., Shi, P., Onishi, T., Wenger, D., Amman, W., Ogallo, L., Beddington, J. and Murray, V. 2013. *Using science for disaster risk reduction*. Available from: www.preventionweb.net/go/scitech. Accessed 2013 Nov 20.

Tearfund, 2008. Linking Climate Change Adaptation and Disaster Risk Reduction. London.

Twigg, J. 2001. Corporate social responsibility and disaster reduction: a global overview. Benfield Breig Hazard Research Centre.

Twigg, J. 2002. *Corporate social responsibility and disaster reduction - conclusions and recommendations*. University College London.

UNISDR 2008. Private sector activities in disaster risk reduction: good practices and lessons learned. Geneva, Switzerland: United Nations Office for Disaster Risk Reduction.

UN-Spider 2013. Connecting knowledge- UN-Spider's knowledge management, Newsletter, February 2013.

Zeleny, M. 2006. Knowledge-information autopoietic cycle: towards the wisdom systems. *International Journal of Management and decision Making*, Vol. 7, Issue 1.

Weichselgartner, J. and Kasperson, R.E. 2010. Barriers in the science-policy-practice interface: toward a knowledge-action-system in global environmental change research. *Global Environmental Change* Vol.20. Issue 2: 266-277, 2010.

Know-4drr website: http://www.know4drr.polimi.it/