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TOWARDS MORE EFFECTIVE FLOOD EARLY WARNING SYSTEMS:

The Italian Experience

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1. Introduction

The Hyogo Framework for Action (HFA) points at identifying, assessing and monitoring disaster risks and enhancing early warning as one of its priorities for action. In doing so, it requires to implement the outcome of the Second International Conference on Early Warning (2003). The latter concluded that effective Early Warning Systems (EWS) are comprised of four components which are strictly interconnected to each other:

- a monitoring and warning service, to monitor and forecast hazards to produce information about impending events;

- a risk information sub-system, to develop scenarios to figure out the potential impact of an impending event; this information should be incorporated in the warning messages;

- a preparedness sub-system, to develop strategies and actions required to reduce the damage from an impending event; this means that community-based emergency plans should be activated in response to warnings, to reduce potential impacts on lives and livelihoods;

- a communication sub-system, to timely communicate information to authorities and public at-risk on the approach of a disastrous event, the corresponding potential risk scenarios and preparedness strategies to cope with it.

A successful system requires integration of the four components and collaboration and coordination between multiple institutions (Kundezewicz, 2013). The failure in one component or lack of coordination across them could lead to the failure of the whole system; for this reason the development of effective EWS requires a "shift in thinking" from simple forecasting tools (as EWS were conceived up to late nineties) to a more complex system which, according to the structure identified above, should be designed to provide communities with all the capacities required to reduce expected damages from a hazardous event. In other words, the system should be designed for supporting all the decisions during the warning process.

An analysis of the current state of art at world level (see e.g. Kundezewicz, 2013; Golnaraghi, 2009; UN, 2006; Handmer, 2002) highlights that present EWS are still unbalanced with respect to the development of the four components and that the risk information and communication sub systems are the weakest points. The objective of this paper is then to document the Italian path or, more specifically, the experience of the Umbria Region (Central Italy) towards an effective EWS, as underpinned by the HFA. From this perspective the Umbria region can be considered as an interesting living-lab; lessons and best practices can be inferred from the Umbria experience. In fact, collaborations among regional officers and research centres supported the implementation of several activities towards more effective EWS, in the HFA philosophy.

The paper is organised as follow. Section 2 discusses Italian governance and institutional arrangements for EWS. Here the stress is on the multi-sectorial and multi-level (national to local levels) approach which is behind the warning philosophy articulated in the HFA. Section 3 describes the Umbria EWS with respect to the four components previously discussed. In Section 4 an ad-hoc procedure is set up to evaluate the level of development of the Umbria EWS with respect to the balanced development of the four components. Shortcomings are identified as well as lessons learnt from past experience in applying the EWS. Section 5 discusses past and ongoing initiatives to increase the system's LoD. Finally, conclusions identify future required efforts to further increase the Umbria EWS performance

This paper focuses only on flood hazard. This choice is supported by the necessity to be synthetic but, at the same time, to handle with all aspects which are relevant for EWS effectiveness. However, it is important to stress that flood early warning in Italy is embedded within a wider warning policy based on a multi-hazard approach as required by the HFA. For this reason, with the exception of the monitoring and warning service, most of considerations discussed below can be applied to hazards other than floods.

2. Italian governance and institutional arrangements (national to local levels) for Early Warning Systems

"Civil Defence" (or Civil Protection) consists of all the structures and activities provided by nations to protect the integrity of life, assets, settlements and environment from damage or danger deriving from natural calamities, catastrophes and other calamitous events. EWS is one of such activities; for this reason Italian governance and institutional arrangements for EWS are here defined within the wider context of Civil Protection activities.

In Italy, it is the law n. 225/1992 which establishes the National Civil Protection System[1], defining also its main activities as: forecasting and risk prevention, relief to people, respond to and overcoming of the emergency, and risk mitigation. Moreover, the law identifies public and private administrations and institutions, at the different levels of government, that are components and operational structures of the National Service (e.g. regions, provinces, municipalities, research centres, and utilities suppliers); for each of them, roles and responsibilities are defined according to their skills with respect to the various civil protection activities. It is worth noting that the law also appoints at individual citizens as a component of the National Service, assigning them the duty of risk prevention.

In the peace time, the components and operational structures of the National Service are committed to their different areas of expertise, with the main objective of planning risk mitigation measures (both in the short and long term). In detail, municipal, provincial and regional authorities define/update their plans (i.e. spatial plans and emergency plans) which are indispensable tools of prevention, based on the guidelines addressed at regional and national level (see next section). The network of "Competence Centres" also has a main role in this phase, by conducting research or providing services of technical and scientific nature for the purposes of civil protection.

In the emergency phase - when an event occurs – the mayor of the municipality has the task of ensuring first aid to the population, coordinating all the operational structures on the bases of the local municipal emergency plans (event type "a"). If local resources are not sufficient, the provinces, the prefectures (local government offices), and the regions are involved and activate the available resources on the territories under their jurisdiction (event type "b"). In more serious situations, at the instance of regions, the national level takes over, with the declaration of a state of emergency (event type "c"): the coordination of interventions is hired directly by the President of the Council of Ministers, which operates through the National Service.

Both in peace and emergency time, it is central the involvement of the technical-scientific community - through the network of "Functional Centres"; the latter makes every day, both at central and regional levels, forecasting, monitoring, surveillance and warning (see Section 3).

[1] www.protezionecivile.it (last access: 30 December 2013)

In accordance with the HFA, the Italian Civil Protection adopts then a multi-sectoral, multi-level approach in both peace and emergency time.

3. The Umbria flood Early Warning System

3.1 The monitoring and warning service

Umbria Region monitoring and warning service was set up in Perugia in 1985, with the development of a real time hydrometeorological network (nowadays consisting of 140 automatic stations over a territory of almost 8000 km^2 - 1 automatic station every 60 km^2) and a team of experts for stream flow measurements and data analysis. The system is made up by 72 hydrometers, 87 rain gauges, 74 weather stations, 12 Radio repeaters, 1 Doppler Meteoradar.

In 2006, the regional Functional Centre[2] (FC) was founded within the new Regional Civil Protection Centre in Foligno. The FC has been fully operative since 2010 and, according to national and regional regulations, is responsible for monitoring, forecasting and warning.

For the warning purpose the Umbria territory was divided into 6 "warning zones"; for each zone, three levels for hydrometric and rainfall thresholds were assessed, the latter according to the expected ground effects: ordinary, moderate, and high criticality. Based on these thresholds, three different phases (characterizing the progression of a hazardous event, i.e. floods and landslides) were identified: forecasting (pre-event), event and post-event. Each phase has detailed subdivisions of roles among different authorities and subjects involved. The begging/end of each phase is defined by advices (i.e. bulletins) emanation by the FC on the bases of regional forecasts, and formal adoption by regional authorities.

Regional forecasts are obtained by combining data from the regional hydrometeorological network with forecasts at national level; a link exists then between the monitoring and warning regional system and the national one. The level of forecasted criticality is formally communicated by the FC 24-48 hours in advance to territorial presidiums and regional civil protection authorities; the latter, in their turn, has to advise municipalities and other local operational structures. Figure 1 shows the FC synthetic procedures flowchart for the Pre-event and Event phases.

It is worth noting that, besides the monitoring network, for the estimation of ground effects, the FC can rely also on a real time integrated early warning modelling system for floods and landslides (Ponziani et al., 2012; Ponziani et al., 2011; Berni et al., 2009). These models are coupled: quantitative precipitation forecasts are estimated by meteorological models; the soil water content is estimated by a hydrological balance model and satellite data. The outputs of the modelling system feed a Web-GIS based open source tool for dynamic hazard/risk scenario assessment, for the decision support systems.

3.2 Risk information, communication and preparedness sub-systems

As introduced above, the monitoring and warning service in Italy is linked to emergency planning by a national law which identifies roles and responsibilities with respect to the various phases of a crisis (i.e. prevention, forecasting, emergency management and recovery). Three levels of emergency planning are foreseen: regional, provincial and municipal; however, risk management strategies are defined at the regional level: local level plans must be coherent to regional

[2] www.cfumbria.it (last access: 30 December 2013)

guidelines thus facilitating coordination and consistency among plans and actions at the different levels of government.

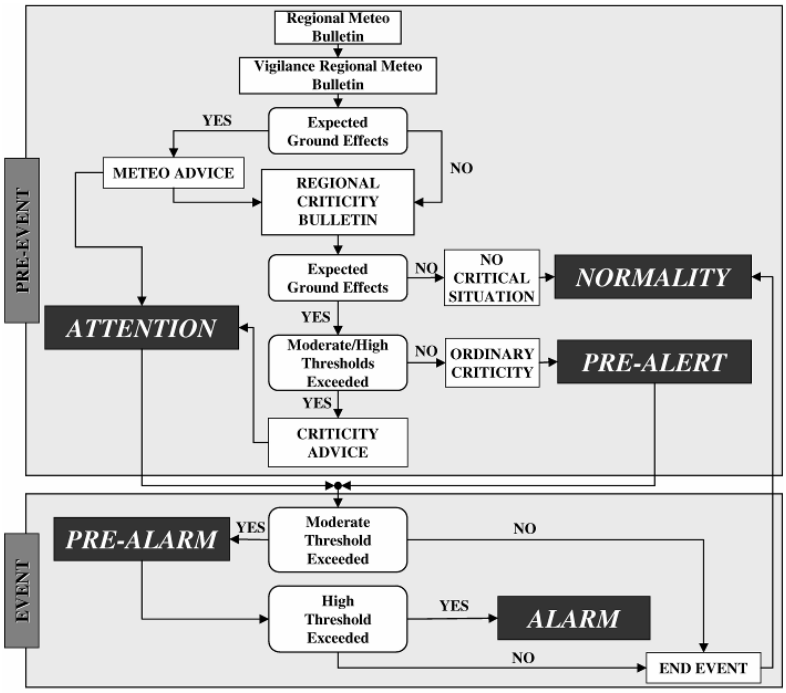

Figure 1 : Umbria Region FC procedures flowchart for the Pre-event and Event phases.

An important tool is represented by the so called regional "prevention plans" (i.e. Programmi Regionali di Previsione e Prevenzione) which describe the current level of risk(s) at the regional level (by embedding available knowledge, for example, from river basin plans) as well as the regional policy for their mitigation. In Umbria, the regional prevention plan is presently under revision. Coherently with the HFA, the new plan will adopt a multi-hazard approach and will include an analysis of historical events (both from the point of view of physical and impacts scenarios) as well as a description of hazards and vulnerability at the regional level, on which future mitigation strategies (including EWS) will be grounded. The plan will be also supported by IT tools, for the analysis and visualisation of risks, to be shared among the different levels of government.

Municipal emergency plans should be revised in the future according to the contents of the new prevention plan. Presently, they are based on several studies which since late 90's have led to the definition of flood maps for almost 1000 km of river network in Umbria by the Tiber River Basin Authority (main rivers) and regional authorities (minor rivers and streams). These studies highlight low, medium and high probability flood prone areas and are linked to planning rules.

Currently, 91 out of 92 Umbria municipalities have an emergency plan, most of all updated in 2011-2012. Such plans adopt a multi-hazard perspective; most of them share the same template to facilitate coordination among the different civil protection actors (i.e. among municipalities and at different levels of government) and specify, for each hazard:

- a hazard analysis;

- an exposure analysis, defining exposed population, critical infrastructures at risk, strategic structures or buildings at risk, high vulnerable production sites;

- roles and responsibilities in dealing with the emergency (both at local and higher levels of government);

- the warning procedure, according to regional requirements;

- resource availability.

With respect to warning dissemination, emergency plans not only specify ways of communication among civil protection actors (e.g. fax, reserved website) and among the latter and lay people (e.g. door to door, reserved telephone lines, press, media) but also the contents of the warning message, according to both the target audience and the dissemination channel. Moreover, educational campaigns are planned as well as civil protection drills. Indeed, local municipal emergency plans are continuously verified with civil protection exercises which also have the aim of training the operators and of making the population aware of the correct behaviour to be adopted during emergencies. Educational campaigns and other information activities also have the purpose of making citizens aware of the risks in the area where they live, and of making them taking part in the prevention activities. Amongst these, voluntary activity is the phenomenon which best expresses the involvement of people in safeguarding and defending their own territory.

Last but not least, the continuous updating of plans is planned according to lessons learnt from previous events, change in risk(s) knowledge, regulations, etc. As an example, a survey was conducted by regional officers after the last flood event in November 2013. The objective was to investigate the effectiveness of municipal emergency plans in dealing with emergency (Servizio Protezione Civile – Regione Umbria, 2013); in detail:

- to verify if affected municipalities had an emergency plan;

- to verify if procedures foreseen by plans were implemented;

- to check the correspondence between hazard areas identified in the plans and the areas actually affected;

- to identify parts of the plan to be updated/revised.

The survey concluded that all affected municipalities had a plan and that procedures were properly implemented; however a revision of hazard maps is required. Accordingly, such plans are now under revision.

4. Level of Development of Umbria flood Early Warning System

The level of development of the Umbria flood EWS has been here evaluated, by means of the methodology developed within the EUROflood project (Parker and Fordham, 1996). The methodology was originally conceived with the aim of defining a uniform evaluation procedure to be applied in the "quiet period" (i.e. the period between disasters): (i) to optimize the effectiveness of warning systems, in preparation for a disaster; and (ii) to compare different systems, highlighting common problems, pooling knowledge and transferring best practices.

The EUROFlood methodology originally employs 14 criteria (see table 1) which are based on those factors discovered to be critically important in designing and operating effective flood EWS. Each criterion must be assessed with respect to its level of development (LoD) that spans from 1, which means "basic", to 5 which means "advanced". The set of implemented criteria allows for evaluating both the level of development of the individual components of a EWS as well of the system as a whole. By means of this procedure the performance of a EWS can then be evaluated in a holistic way. From another point of view, i.e. by looking at the key activities set by HFA in terms of (i) national and local risk assessments, (ii) early warning and (iii) capacities, the procedure allows to evaluate their current level of implementation.

The EUROflood methodology has been here employed after being adapted to the context of the analysis (i.e. the regional context) according to Molinari et al. (2013); the adapted methodology has been already implemented in the past to evaluate other regional EWS in Italy.

Table 1 provides a comparison between the original set of criteria and the one here implemented.

EUROflood CRITERIA	**CRITERIA adopted in this work**
1. Flood warning philosophy	---
2. Dominance of forecasting vs. warning	1. Dominance of forecasting vs. warning
3. Application of technology	2. Application of technology
---	3. Redundancy
4. Geographical coverage	4. Geographical coverage
5. Laws relating to warning systems	5. Laws relating to warning systems
6. Content of warning messages to public	6. Content of warning messages to public
7. Methods of disseminating warning	7. Methods of disseminating warning
8. Attitudes to freedom of risk information	---
9. Public education about warnings	8. Public education about warnings
10. Knowledge of system effectiveness	---
11. Dissemination of lessons learnt	9. Dissemination of lessons learnt
12. Performance targets & monitoring	10. Performance targets & monitoring
13. National standards	---
14. Organisational culture	11. Organisational culture
---	12. Uncertainty management

Table 1: Comparison between original and implemented evaluation criteria (Molinari et al. 2013)

During the adaptation process, the following aspects have been taken into account:

- the regional scale; the original methodology was conceived to be applied at national scale whilst it is here implemented at regional/local scale. Consequently, some original criteria (e.g. "flood warning philosophy" and "national standards"), which refer to differences among countries, have been deleted;

- the availability of data; some original criteria have been merged because of a scarce availability of data, that limit the capacity to evaluate each of them in detail (e.g. "performance target and monitoring" and "knowledge of systems effectiveness" became a single criterion);

- the objective of the analysis; further criteria have been added in order to evaluate some aspects which are especially interesting within this work. A criterion was introduced to assess

redundancy in communication (which is crucial for warning effectiveness). Another criterion aims at analysing how uncertainty is managed within the decision making process on warning and emergency management. Scientific estimates are always affected by a certain degree of uncertainty and so are flood predictions as well as estimates of flood risk. The way in which uncertainty is managed, communicated and understood is then crucial for EWS effectiveness, given that decisions on warning are usually based on these data (see e.g. Downtown et al. 2005, De Marchi, 1995, De Marchi et al. 1993, Weick, 1988)

Moreover, again because of little availability of data, the number of development stages has been reduced from 5 to 3 (see Table 2). Table 3 summarizes the whole procedures, by specifying the meaning of each criterion and the corresponding development stages.

Level of Development	MEANING
1	basic/little development
2	intermediate
3	advanced

Table 2: LoD values (Molinari et al. 2013)

Table 4 shows the results of the application of the procedure to the Umbria EWS. With respect to each criterion, the methodology highlighted the following aspects:

1. Dominance of forecasting vs. warning (value:2): Although several improvements have been reached with respect to a balanced development of the four EWS components, the Umbria EWS is still unbalanced towards the monitoring and forecasting service on which historical efforts have traditionally focused. Specifically, the risk knowledge subsystem is presently the less developed whereas vulnerability is almost never analysed nor risk is quantified in terms of expected damages or other indicators; this could limit the suitability of emergency management, thus reducing the effectiveness of actions which should be designed on the bases of risk knowledge. However, it is important to note that this situation is typical of all Italian regional EWS. Past and ongoing initiatives were/are coherently targeted to improve the less developed subsystems (see Section 5).

2. Application of technology (value:3): Technology is well implemented within the system both with respect to the monitoring and forecasting phase (e.g. data from satellite, weather radar as well as data from real time modelling are implemented) and within the risk knowledge, warning dissemination and response subsystems (i.e. ICT tools are embedded in the system). However, last advancement in ICT which are proved to be useful in other emergency (like crowd sourcing in the Haiti earthquake) must still be tested/embedded in the system.

3. Redundancy (value:2): The system embeds a certain level of redundancy: e.g. different ways/means of communication are considered among civil protection authorities and the latter and lay people; field survey are planned to corroborate monitoring and forecasting data. However, during one of the last flood, in November 2012, the warning communication failed, suggesting that there is still room for improvement in this direction. Moreover, reliability of monitoring instruments during flood events is not always guaranteed.

CRITERIA	OBJECTIVE/MEANING	Level of Development		
		1	2	3
1. Dominance of forecasting vs. warning	To evaluate systems capacity to proper design and operate all the warning subsystems	Systems are monitoring and forecasting dominated	Other cases	All subsystems are properly designed and operated
2. Application of technology	To evaluate the level of technology implementation within the system	Basic; numerous equipments shortcomings	Other cases	Advanced, state of the art in most areas
3. Redundancy	To evaluate technological reliability; redundancy in communication networks, procedures	None to very little; need not recognised	Partially developed	Need extensively recognised and developed
4. Geographical coverage	To evaluate systems ability to warn all "at-risk" areas.	Coverage <10%	Coverage <50%	Coverage >50%
5. Laws relating to warning systems	To evaluate organisational aspects; transparency in roles and responsibility setting	No arrangements	Intermediate	Well defined
6. Content of warning messages to public	To evaluate effectiveness of warning contents	Limited; warnings are generic supplying only the likelihood of an event	Intermediate	Exhaustive; warning supplies likely intensity and impacts as well as actions to be taken
7. Methods of disseminating warning	To evaluate effectiveness of warning dissemination	Dissemination tools are generic, not targeted to people needs	Intermediate	Dissemination tools are different and oriented to people needs
8. Public education about warnings	To evaluate people knowledge of warning and preparedness to react	Non existent	Other cases	Comprehensive, regular awareness and educational programs
9. Dissemination of lessons learnt	To evaluate whether knowledge and experience are shared among researchers and practitioners	No literature or reports are available	Other cases	Full/wide spread
10. Performance targets & monitoring	To evaluate the presence of suitable performance measures	Non-existent	Performance measures focus on forecasts accuracy	Performance assessment aims at evaluating systems capacity to reduce expected damages
11. Organisational culture	To evaluate how warning management is shared among authorities (regional vs. local approach)	Regional authorities are in charge of both forecasting and emergency management	---	Forecasting is responsibility of regional authorities whilst local authorities are in charge of emergency management
12. Uncertainty management	To evaluate how uncertainty is managed within the decision making problem.	Problem not recognised	Uncertainty is supplied only with respect to forecasts accuracy or uncertainty is not explicitly taken into account	Decisions are taken according to uncertainty in physical and impacts scenarios

Table 3: Evaluation criteria guidelines (Molinari et al. 2013, adapted from Parker and Fordham, 1996)

CRITERIA	LoD [-]
1. Dominance of forecasting vs. warning	2
2. Application of technology	3
3. Redundancy	2
4. Geographical coverage	3
5. Laws relating to warning systems	3
6. Content of warning messages to public	2
7. Methods of disseminating warning	3
8. Public education about warnings	1
9. Dissemination of lessons learnt	2
10. Performance targets & monitoring	1
11. Organisational culture	3
12. Uncertainty management	2
TOTAL	**25/36**

Table 4: Results of Umbria EWS evaluation

4. Geographical coverage (value:3): All the Umbria area is covered by the EWS; warning thresholds are defined for the whole region, 91 out of 92 municipalities have an emergency plan.

5. Laws relating to warning systems (value:3): Roles and responsibilities, both for warning and emergency management, are well defined by laws and are embedded in emergency plans.

6. Content of warning messages to public (value:2): Although some emergency plans identify warning contents according to the target audience and the way of dissemination, risk knowledge and expected impacts are not usually included in the warning message. This limits EWS effectiveness. As suggested by Kundzewicz (2013) a warning, converting forecast into lay language, should be a communication that a hazard will produce specific damage (i.e. risk) for a specific population. Moreover, people must be told what they can do to reduce they exposure to hazard.

7. Methods of disseminating warning (value:3): Dissemination tools are several and oriented to people needs.

8. Public education about warning (value:1): Public education campaigns are planned by emergency plans; however last events (not only in Umbria but in Italy as a whole) highlighted a weak knowledge of the warning procedure and of the civil protection mechanism by lay people. Coherently, past and ongoing initiatives were/are targeted to improve people knowledge of risk(s), warning and preparedness to react (see Section 5).

9. Dissemination of lessons learnt (value:2): A report is produced after each flood event by the regional Civil Protection in order to disseminate lessons learnt. Moreover collaborations are in place between the regional Civil Protection and the Politecnico di Milano (as well as other resource centres) in order to continuously update and improve civil protection performances. Such collaborations are also an opportunity to share lessons learnt with both

the scientific and the practitioners communities, as this document corroborates. On the other hand, although emergency plans arrange for contents updating according to past events evidences, how and how much this is done in practice is not known as there are not performance measures in this regard (see criterion 10).

10. Performance targets and monitoring (value:2): The regional FC monthly analyses forecasts accuracy in terms of the correspondence between flood/rain forecasts and observations. Future efforts should be made in developing suitable measures which are able to evaluate the performance of the whole system; however, this requires first to develop and implement proper tools to estimate expected impacts (see criterion 1).

11. Organisational culture (value:3): The Umbria EWS is equally balanced with respect to this point. Regional authorities are in charge of warning and forecasting, local authorities are responsible for emergency management, thus highlighting a balanced involvement of all levels of government.

12. Uncertainty management (value:2): Uncertainty is not considered explicitly in warning and emergency management but for the consideration of safety bounds in the definition of warning thresholds.

The implementation of the EUROflood procedure to the Umbria case allowed then to identify the main criticalities of the present EWS on which improvement efforts should focus. In detail, the following directions can be identified as suggestive for future work:

- Enhance methods and tools to develop suitable risk mapping on which emergency plan should be grounded; this implies the establishment of hazard and damage databases supporting the risk modelling phase.

- Increase the current level of communication during emergencies, by improving and targeting warning messages, and of people's education during peace time, by proper educational campaign targeted to increase risk awareness, emergency procedures and the knowledge of the civil protection mechanism;

- enhance performance measures in order to evaluate improvements in EWS effectiveness;

- identify methods for properly including uncertainty assessment and management into warning and emergency procedure.

It is work noting that such a result corroborates the state of art at world level as highlighted for example by Kundezewicz, 2013, Golnaraghi, 2009, UN, 2006, Handmer, 2002.

Ongoing initiatives in the Umbria region in the directions identified above are discussed in the next section. They can be taken as reference as significant attempts toward effective EWS. Future required efforts are analysed in the conclusive section.

5. Initiatives to improve system's level of development

According to results discussed in Section 4 and to lessons learnt from past events, the Umbria regions started several activities which aim at increasing the present level of development of its EWS.

Action 1: Development of depth-damage curves

Depth-damage curves are the standard tool to estimate direct flood damage (FLOODsite 2007, Merz et al. 2010). Such curves allow for the quantification and mapping of flood consequences, at least with respect to direct damages. Depth damage curves are site-specific as to say that they are strictly valid only for the area where they have been derived. With respect to investigated contexts (several curves are available for central Europe, US and Australia: e.g. Thieken et al. 2008, Kok et al. 2005, USACE, 2003, Read Sturgess et al. 2000) Italy differs significantly not only as regards the hazard (i.e. flash floods are the main hazard in Italy unlike investigated context which are mainly affected by riverine floods) but also with respect to buildings typologies and features (i.e. vulnerability). Thus, implementing available curves without calibration and validation may lead to large biases in damage estimates (see e.g. Jongman et. al 2012, Cammerer et al. 2013). Action 1 indented to identify depth damage curves for the Umbria region by validating existing ones or developing new models. The final aim was then to improve the risk information subsystem or, in other words, to increase the performance of the whole EWS by means of more suitable warning and emergency procedures which are designed on the real risk in the region. The activity was based on the survey of past flood damage data and is described in detail in Molinari et al. (2012). The experience suggested that data so far collected after flood events do not permit satisfactory damage functions validation or definition, due to inconsistencies and mismatching methodologies in acquiring relevant data about hazard, vulnerability of exposed items and systems, and damage. For this reason the Umbria region started a new action (Action 2) with the main objective of gathering data in the aftermath of flood events as well as reporting lessons learnt for the future improvement of EWS and for better risk mitigation.

Action 2: A procedure for ex-post damage survey and reporting

In order to gather better data on which risk models can be defined, a new method and procedure for surveying damages to a variety of objects and assets is under definition in the Umbria region. The interest of the regional officers in this activity is also related to the possibility to provide guidance for the recovery and the reconstruction efforts; damage data collected in the aftermath of an event highlight indeed criticalities in the way the whole process (i.e. from emergency management to recovery) has been conducted so as to improve current procedures and organizational protocols. The process of developing a new, improved procedure for post-flood damages survey therefore serves a twofold purpose: (i) to support emergency, recovery and reconstruction decisions and (ii) to provide better data for future risk assessments. A third objective is to support rapid and transparent victim compensation.

The procedure implies also the development of a database for the storage of data. It is worth noting that such an activity is explicitly suggested by the HFA and, for this reason, is strongly encouraged by the EU policy (De Groeve et al. 2013)

So far, Action 2 produced:

- the development of ad hoc survey forms for residential buildings and industries which were applied to survey direct and indirect damages to people and their dwellings after the flood that hit the Umbria region in 2012;

- two event reports, one of these still under development. These reports describe the phenomena (Servizio Protezione Civile – Regione Umbria, 2012) and the most relevant effects (i.e. damages) at both local and the regional, aggregate scale (in progress).

The development of the database (as well as of ICT tools supporting the collection of data) and of the whole procedure for data collection is still under development and is the objective of a research project founded by Politecnico di Milano (i.e. PoliRisposta: stRumentI per la protezione civile a Supporto delle POpolazioni nel poST Alluvione[3]). The research is not merely linked to the "ordinary" work of data collection in the Umbria Region, though it is connected to this experience; the final aim is the development of a procedure which may also serve as a reference in other areas. Specific objectives of PoliRIsposta are:

- Develop an operational procedure for collecting and analyzing all damage data, including: damage to infrastructures and public facilities, damage suffered by citizens and their dwellings and goods, and to economic activities;

- Develop educational material and modules for training the volunteers and officers in the use of the procedure;

- Develop enhanced IT tools (both hardware and software) to support the procedure, easing as much as possible the collection of field data, the creation of databases and the connection between the latter and different regional and municipal databases that already exist for different purposes (from cadastral data, to satellite images, etc.).

Action 3: Harmonisation of warning levels (and corresponding scenarios)

The present activity is conducted by the Umbria region within a wider national effort. So far, every Italian region was allowed to partly modify national standards in order improve its warning capacity; this led to non-uniformity of warning levels among the different regions, and, correspondingly, to non-uniform scenarios in terms of expected impacts. This choice proved to be ineffective in dealing with emergency. For example, during the floods that hit the Liguria region in 2011, the Umbria region in 2012 and, very recently, the Sardinia region in November 2013, misunderstandings of the warning message occurred as well as unsuitable choices in the emergency management by both lay people and civil protection actors. The necessity arose then to adopt common warning levels and corresponding scenarios, at the national level.

The harmonization will be carried out along with a revision of the present procedures for emergency management. In detail, roles, responsibilities, actions and resources to be employed during each warning phase will be revised according to lessons learnt from past events. It is worth noting that also warning messages will be updated. In particular, the

[3] http://home.deib.polimi.it/ardagna/PoliRisposta/index.html (last access: 30 December 2013)

objective is to make warning messages more explicative of the expected scenarios and actions to be taken, as well as clearer in their meaning by the use of colours, symbols, etc.

This action aims to increase the preparedness and dissemination sub-systems, enhancing, this way, the overall performance of regional EWS.

Action 4: increasing risk awareness

From the point of view of dissemination, several activities are in place. The first one is targeted to primary school children. The Umbria region started a teaching program which is called "Alla larga dai pericoli" ("away from dangers"). The objective is manifold: to disseminate a safety culture, to make children aware of risks they are exposed to and strategies to cope with as well as to explain roles and responsibility of civil protection authorities; more in general, the aim is to make every citizens aware of their role in risk(s) reduction. The program includes games, cartoons and meetings tailored to children needs and cognitive ability; a website is also available[4] where children can play with the help of their parents.

Other initiatives are related to the inclusion of the Umbria Region as a living-lab for the following projects:

a) The FLOODMED project[5] ("*Monitoring, forecasting and best practices for FLOOD Mitigation and prevEntion in the CADSES region*", co-financed by ERDF funds under INTERREG III B CADSES;
b) the IMRA project[6] ("*Integrative flood risk governance approach for improvement of risk awareness and increased public participation*"), 2nd ERA-Net CRUE Research Funding Initiative, aiming to integrate, consolidate and disseminate European flood risk management research;
c) the SEE project[7] ("*Safeguarding Educational Environment*"); the latter is a two-years European project, co-funded with the support of the Civil Protection Financial Instrument and involving as partners different organizations operating in the education sector and public bodies from Bulgaria, Greece, Italy, Netherlands, Romania and Spain;
d) the KNOW-4-DRR project[8] ("*Enabling knowledge for disaster risk reduction in integration to climate change adaptation*"), a FP7 project, having the objective to analyze, assess and understand how knowledge about disaster risk reduction and adaptation to climate change is actually produced, managed, and shared and ultimately made use of – or indeed not used – by scientists, practitioners, decisions makers, and by educational and civil society actors.

[4] www.allalargadaipericoli.it (last access: 30 December 2013)

[5] http://www.floodmed.org (last access : 30 December 2013)
[6] www.imra.cnr.it (last access : 30 December 2013)
[7] http://www.seeproject.eu (last access : 30 December 2013)
[8] http://www.know4drr.polimi.it (last access : 30 December 2013)

Action 4 has then the main objective of increasing the response capacity and the involvement of the community in emergency planning activities, leading to more community-based EWS and successful crisis management.

Action 5: Analyses of the performance of monitoring and forecasting system

In order to increase the performance of the whole EWS, the monitoring and forecasting system is continuously verified and improved. In this regard, the activity carried out by the Umbria Region with the support of Politecnico di Milano is particularly significant. The objective was to evaluate the Umbria flood forecasting system not in terms of prediction accuracy but in terms of its capacity of predicting warning outcomes. In detail, by analyzing the joint and conditional distributions of forecasts and observations, the analysis evaluated whether or not forecasts allow to discriminate between flood and no-floods events (and, more in general, among different levels of warning). This information is crucial to update the warning procedure both in terms of thresholds and of activities to be implemented according to the available lead time. The revision of warning thresholds is still under consideration. The analysis brought to the evidence that there is still room for improvement at this perspective.

Conclusion

With respect to the several directions for improvement identified in Section 4, the activities carried out so far in the Umbria region mostly focus on two of them, i.e. increasing the risk information and the communication sub-systems.

It is still too soon to evaluate the effectiveness of such actions. In any case, it is first required to develop properly performance measures according to which the EWS can be evaluated. The methodology implemented in this paper works in this direction. However, a revision is required in order to include other aspects which were identified as important by the recent literature and which were not considered in the above evaluation because of a lack of data for their assessment. For example, Kundzewicz (2013) suggests that useful criteria or indicators of warning quality are the penetration of the warning (i.e. the proportion of those who need information that receive it) and the degree of satisfaction; potential damage reduction as described in Action 5 and in Molinari et al. (2013) is another important criterion. The database that is currently under construction in Action 2, as well as other ongoing actions, should be helpful in overcoming present limitations in data availability. More in general, both the improvement of the EUROflood methodology and the development of a hazards and impacts database represent interesting tools to be exportable to other contexts, supporting EWS evaluation. On the other hand, the main objective of such a database should be the development of proper tools for risk assessment and, specifically, damage assessment (see Action 1).

With respect to the risk information subsystem, another crucial point is its link with the preparedness subsystem. As analysed by Stanganelli (2008), emergency plans in Italy are often unrelated to spatial plans; only recently have some regional planning acts introduced a direct link between them. Some good examples include master plans that have both identified road networks and spaces to be used during emergencies, and defined those actions needed to render them sufficiently resilient to hazards. The implementation of the recent European Floods Directive 2007/60, especially with respect to flood management plans, can be an opportunity to overcome such limits.

Future efforts are required in the Umbria region also with respect to uncertainty management. Increasing hazard forecast accuracy is one aspect; worldwide, many activities are under way in this direction. Two important factors are data assimilation and adaptive forecasting, which makes use of current measurements to reduce forecast errors (Kundzewicz, 2013). Reducing uncertainty in risk estimation is equally important; Action 1 and 2 are just tailored to this point. Finally, uncertainty characterisation and management is crucial; from this point of view, the implementation of probabilistic forecasts and the use of scenarios for the definition of flexible emergency procedures should be investigated.
Collaboration between institutions and research centres proved to be effective both to identify criticalities and ways of improvements, and as a tool to share lessons learnt and best practices. From this point of view, research centres can effectively transfer international research and policy (e.g. HFA) into actions as the experience described in the paper highlights.

References

Berni N., Pandolfo C., Ponziani F., Stelluti M, Viterbo A. 2009. *Umbria Region Forecasting/Decision Support for Hydraulic Risk Mitigation Purposes*. CCWI 2009 Computing and Control in the Water Industry 2009, 1-3 Settembre 2009, Sheffield (UK)

Cammerer, H., Thieken, A. H., Lammel, J. 2013. Adaptability and transferability of flood loss functions in residential areas. *Natural Hazards and Earth System Sciences Discussions*, Vol. 1, Issue 4 : 3485-3527

De Groeve T., Poljansek K., Ehrlich D. 2013. *Recording disaster losses,* JRC scientific and policy reports, Luxembourg

De Marchi B., Funtowicz S., Ravetz J. 1993. *The Management of uncertainty in communication of major hazards*, Joint Research Centre publication: EU 15268 EN

De Marchi B. 1995. Uncertainty in Environmental Emergencies: A Diagnostic Tool. *Journal of Contingencies and Crisis Management*, Vol. 3, Isuue 2

Downton M.W., Morss R.E., Wilhelmi W.V., Gruntfest E. C., Higgins M. L. 2005. Interactions between scientific uncertainty and flood management decisions: Two case studies in Colorado. *Environmental Hazards*. Vol. 6 : 134-146.

Golnaraghi, M. 2009 *Global Assessment Report on disaster reduction: Thematic progress review sub-component on Early Warning Systems*, Geneve

Handmer J. 2002. Flood warning review in North America and Europe: statements and silence. *Australian Journal of Emergency Management*. Vol .17 : 17-24

Jongman, B., Kreibich, H., Apel, H., Barredo, J.I., Bates, P.D., Feyen, L., Gericke, A., Neal, J., Aerts, C.J.H., Ward, P.J. 2012. Comparative flood damage model assessment: towards a European approach, *Nat. Hazards Earth Syst. Sci.*, Vol.12 : 3733–3752

Kok, M., Huizinga, H.J., Vrouwenvelder, A.C.W.M., Barendregt, A. 2005 S*tandard Method 2004: damage and casualties caused by flooding,* Road and Hydraulic Engineering Institute, Netherlands

Kundzewicz, Z.W. 2013. Floods: lessons learnt about early warning systems. In: *Late lessons from early warning*, European Envirinment Agency, Luxembourg

Molinari D., Ballio F., Berni N., Pandolfo C.. 2012. *Implementing the Floods Directive: the case of the Umbria Region*, FLOODRisk 2012, 20-22 November, 2012, Rotterdam (Netherlands)

Molinari D., Ballio F., Menoni S. 2013. *Flood Early Warning Systems: knowledge and tools for their critical assessment*, WIT Press, Southampton, UK

Parker D.J., Fordham M. 1996 An evaluation of flood forecasting, warning and response systems in the European Union. *Water Resource management.* Vol.10 : 279-302

Penning-Rowsell, E.C., Johnson, C., Tunstall, S., Tapsell, S., Morris, J., Chatterton, J., Coker, A., Green, C. 2005. *The benefits of flood and coastal risk management: a manual of assessment techniques*, Middlesex University Press, London

Ponziani F., Berni N., Stelluti M., Zauri R., Brocca L., Moramarco T., Salciarini D., Tamagnini C. 2011. *Landwarn: an operative early warning system for landslides forecasting based on rainfall thresholds and soil moisture*. The Second World Landslide Forum, 3-9 October 2011, Rome (Italy)

Ponziani F., Pandolfo C., Stelluti M., Berni N., Brocca L., Moramarco T. 2012. Soil moisture and rainfall thresholds assessment for hydrogeological risk prevention in a regional operational warning centre. *Landslides*, Vol. 9, Issue 2 : 229-237

Read Sturgess and Associates. 2000. *Rapid Appraisal Method (RAM) for Floodplain Management.* Department of Natural Resources and Environment, Melbourne, Victoria.

Servizio Protezione Civile – Regione Umbria. 2012. *Evento alluvionale 11-14 Novembre 2012: Rapporto di evento.* Available on line at: www.cfumbria.it

Servizio Protezione Civile – Regione Umbria. 2013. *Emergenza idrologio-idraulica 10-12 Novembre 2013. Rapporto preliminare d'evento.* Available on line at: www.cfumbria.it

Stanganelli M. 2008. A new pattern of risk management: the Hyogo Framework for Actions and Italian practise. *Socio-Economic Planning Sciences*. Vol.42 :92-111

UN Global Survey of Early Warning Systems: *An assessment of capacities, gaps and opportunities towards building a comprehensive global early warning system for all natural*

hazards. 2006. Available on line at: http://www.unisdr.org/ppew/info-resources/ewc3/Global-Survey-of-Early-Warning-Systems.pdf

USACE. 2003. *Generic depth-damage relationships for residential structures with basements, economic guidance memorandum (EGM) 04-01*, available at: http://www.usace.army.mil/CECW/PlanningCOP/Documents/egms/egm04-01.pdf/, 2003.

Weick K. 1988, Enacted sensemaking in crisis situations. *Journal of Management studies*. Vol 25, Issue 4