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Lessons learned and best practices from crisis management of selcted natural disasters – elicit to learn crucial post-crisis lessons

Tonje Grunnan and Maren Maal

FFI Forsvarets forskningsinstitutt

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Tonje Grunnan and Maren Maal

Norwegian Defence Research Establishment (FFI)

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Approved by

Monica Endregard	Project Manager
Janet Martha Blatny	Director

Sammendrag

EU-prosjektet ELITE (*Elicit to learn crucial post-crisis lessons*) var et 'Coordination and Support action' prosjekt som ble gjennomført i perioden januar 2013 til juni 2014. Prosjektet fikk støtte fra EUs 7. rammeprogram for forskning, teknologisk utvikling og demonstrasjon etter tilskuddsavtale nr. 312497 og hadde et budsjett på rundt 8 millioner kroner.

Denne rapporten er den siste av i alt fire offentlig tilgjengelige rapporter fra arbeidspakke 4 i ELITE. Målet med arbeidspakken var å studere erfaringer, eller «lessons learned», fra henholdsvis skogbranner, jordskjelv og flom, samt å studere erfaringer fra disse i et helhetlig, «holistic», perspektiv.

Målet med denne rapporten er å oppsummere og strukturere erfaringene fra arbeidet i arbeidspakke 4. Et av hovedresultatene fra arbeidspakken er utviklingen av et rammeverk for å rapportere erfaringer etter krisehåndtering av naturkatastrofer. Rammeverket blir presentert i denne siste rapporten og baserer seg på funnene fra de tre tidligere erfaringslæringsrapportene.[1] Et utkast til rammeverk ble presentert og validert av prosjektets sluttbrukere på en workshop i Weeze, Tyskland, i januar 2014. Ved hjelp av dette rammeverket har ELITE-prosjektet i prosjektperioden samlet, systematisert og analysert utfordringer i ulike krisehåndteringssituasjoner med en «all phases - all hazards» tilnærming.

I tillegg til rammeverket, presenterer rapporten erfaringer og «best practices» fra en rekke ulike casestudier som ble valgt ut av fageksperter i ELITE-konsortiet, basert på den kompetansen de har innen ulike krisehåndteringsfelt. Rapporten inneholder tre kapitler med erfaringer fra land i Europa, Amerika og Asia. Hovedfunnet fra gjennomgangen av skogbrannhendelsene er at de viktigste læringspunktene kan knyttes til temaene samvirke, kunnskap, forebygging, kommunikasjon, risikovurdering, ledelse, opplæring og logistikk. Erfaringene er beskrevet og kategorisert i henhold til disse problemområdene. Utfordringene og erfaringene fra casestudiene om flom er kategorisert etter de viktigste problemområdene som ble identifisert: samvirke, kunnskap, ledelse av frivillige, kommunikasjon, risikovurdering, koordinering, utvinning og logistikk. I forbindelse med håndtering av jordskjelv fant vi at de største utfordringene er knyttet til problemområdene kunnskap, kommunikasjon, logistikk, samvirke, koordinasjon, risikostyring, risikovurdering, forebygging/behandling, trening og restitusjon. Erfaringene fra jordskjelvkatastrofer er kategorisert i henhold til disse områdene. Problemområdene som blir identifisert i denne rapporten, er gjenkjennelige og basert på kategoriseringen i de tre tidligere rapportene. I det siste kapittelet er alle erfaringene oppsummert i tabeller for hver katastrofetype. De utgjør ikke en uttømmende liste, men er eksempler på konkrete erfaringer som utrykningspersonell og andre kriseledere har opplevd i de ulike fasene av en krise: forebygging, skadebegrensning, beredskap, respons og gjenopprettelse. Prosjektets sluttbrukere, det såkalte ELITE Community of Practice (CoP), validert resultatene i alle stadier av prosessen.

[1] Se FFI-rapportene 2014/01969, 2014/01972 og 2014/01973.

English summary

The EU project ELITE (*Elicit to learn crucial post-crisis lessons*) was a Coordination and Support action project, completed during the period from January 2013 to June 2014. The project received funding from the EU's 7th Framework Programme for research, technological development and demonstration from the grant agreement no. 312497 and had a budget of 940, 434 Euros.

This report is the final of the four publicly available deliverables from work package 4 (WP4) in the ELITE project. The aim of the work package was to study lessons learned from crisis management of forest fires, earthquakes and floods, and furthermore, to study these lessons learned in a holistic perspective.

The purpose of this report is to summarize and structure the lessons learned gathered in WP4. One of the main results of the work package is the establishment of a meaningful framework for lessons learned reporting, which is presented in this final report. The development of the framework is based on results from the three previous lessons learned reports.[2] Also, a draft of the framework was presented and validated by the project's end users at a workshop in Weeze, Germany, in January 2014. The ELITE project has gathered, systematized and analyzed challenges in crisis management with an «all phases - all hazards» approach, using the ELITE framework as a basis for this work.

In addition to the framework, this report gathers lessons learned and best practices from cases provided by the ELITE consortium, based on their expertise within various fields of crisis management. The report includes three chapters with lessons learned from the selected natural disasters in European, American and Asian countries. The main finding from the review of the forest fire cases is that the most important learning points can be linked to the themes of interoperability, knowledge, prevention, communication, risk assessment, management, training and logistics, and the lessons learned are categorized according to these. The lessons learned from the cases of flood are categorized and systematized according to the main problem areas identified: interoperability, knowledge, management of volunteers, communication, risk assessment, coordination, recovery and logistics. Regarding earthquakes, we found that the most relevant lessons learned are related to knowledge, communication, logistics, interoperability, coordination, risk management, risk assessment, prevention/preparation, training and recovery, and the lessons learned are categorized in line with these.

The lessons learned described in the report are examples of tangible lessons learned based on problems revealed by first responders and other crisis managers in the different phases of a crisis. They do not constitute an exhaustive list of lessons learned from the three types of natural disasters.

[2] See FFI-reports 2014/01969, 2014/01972 and 2014/01973.

Contents

Preface

The report is written and edited by Tonje Grunnan and Maren Maal from the Norwegian Defence Research Establishment (FFI). However, the work has been carried out with valuable and extensive written contributions from the following consortium partners:

José Mari Sarriegi, Leire Labaka, Ana Laugé, Josune Hernantes and Raquel Gimenez from Tecnun – Faculty of Engineering at the University of Navarra in Spain, and Bénédicte Goujon from Thales Research and Technology (TRT) in France have contributed on the chapter of forest fires.

Pawel Kepka and Szymon Ptak from the Main School of Fire Service (SGSP) in Poland and Gert Lang from the Research Institute of the Red Cross (FRK) in Austria (supported by the Austrian ELITE CoP members Bernhard Kaiser, Karl-Dieter Brückner and Markus Glanzer) have contributed on the chapter of floods.

Maria Rosaria Gallipoli and Sabatino Piscitelli from the Institute of Methodologies for Environmental Research of the National Council of Research (IMAA-CNR) in Italy and Claudia Coccetti and Roberto Raspa from the National Association of Italian Municipalities (ANCI – Umbria) in Italy have contributed on the chapter of earthquakes.

The partners from Tecnun, FRK, TRT and IMAA have revised drafts of the report.

We would like to thank the ELITE CoP members participating in the 4th and final ELITE workshop in Weeze, Germany, 28-29 January 2014, for the validation of the framework and for their hard effort working on a compilation of lessons learned from the Japan 2011 earthquake and tsunami.

1 Introduction to the ELITE project

The EU project ELITE (*Elicit to learn crucial post-crisis lessons*) was a Coordination and Support action project, completed in the period of January 2013 to June 2014. The project received funding from the EU's Seventh Framework Programme for research, technological development and demonstration from the grant agreement no. 312497 and had a budget of 940, 434 Euros.

ELITE was coordinated by Tecnun – Faculty of Engineering at the University of Navarra in Spain, by Dr. José Mari Sarriegi. The Norwegian Defense Research Establishment (FFI), represented by Tonje Grunnan, was the scientific lead of the ELITE project. The other consortium partners included: Gjøvik University College (Norway), International Search and Rescue Germany (ISAR) (Germany), Research Institute of the Red Cross (Austria), Main School of Fire Service (Poland), Thales Research and Technology (France) , Institute of Methodologies for Environmental Research of the National Council of Research (IMAA-CNR) (Italy) and the National Association of Italian Municipalities (ANCI) - Umbria (Italy). Tonje Grunnan and Maren Maal from the BAS7-project (Protection of society 7) conducted the work on behalf of the FFI. Grunnan was the work package leader for WP4. FFI also participated actively in three other work packages.

The ELITE project has developed a prototype of a web-solution (wiki) - *a living document* - which contains information about experiences and lessons learned from natural disasters, primarily in Europe. Much of our knowledge of learning from disasters is fragmented, and the goal of the ELITE project was to collect, categorize and analyze common problem areas in all phases of a crisis, so-called *lessons learned*. The web solution is assumed to help the various actors in crisis management by creating a platform to transfer and share relevant knowledge among users, best practices and guidelines. Due to restricted time, the project focused on natural disasters such as *forest fires, earthquakes and floods*. For this reason the wiki contains mostly reports and documents related to these types of natural disasters, but it is possible to share lessons learned from other types of natural disasters.

ELITE had six work packages (WPs). *WP1* was the coordination and management of the project. *WP2* had the responsibility for arranging the workshops for the ELITE CoP. *WP3* developed the web based platform (the ELITE living document). *WP4* gathered, categorized and analyzed common problem areas and lessons learned in four reports and developed a framework for lessons learned reporting in crisis management. *WP5* mapped the learning process and developed a scientific model of learning. *WP6* disseminated the results from the ELITE project and created a handbook with lessons learned and best practices.

2 The ELITE Community of Practice (CoP)

The project was linked to an extensive group of end users from a total of 16 nations that together formed a Community of Practice (CoP). The end users consisted of a number of actors, such as operational firefighters, police and health professionals, civil protection, emergency and contingency planners at local, regional and national levels, and representatives from NGOs. The aim was to involve stakeholders who were interested in mutual learning and exchanging information, and to help establishing, validating and maintaining the living document.

The ELITE CoP will be continued through the establishment of the Society of Crisis Management Community of Practice (SeCriMaCoP). The aim is to keep the living document alive by getting more crisis managers to share their experiences through this platform. The consortium partners will play a leading role in gathering more end-users and donations for the continuation of the Society. Initially, TECNUN will have the presidency in the SeCriMaCoP, while FFI will have the role as vice president. FFI will work to gather more active end users in Norway.

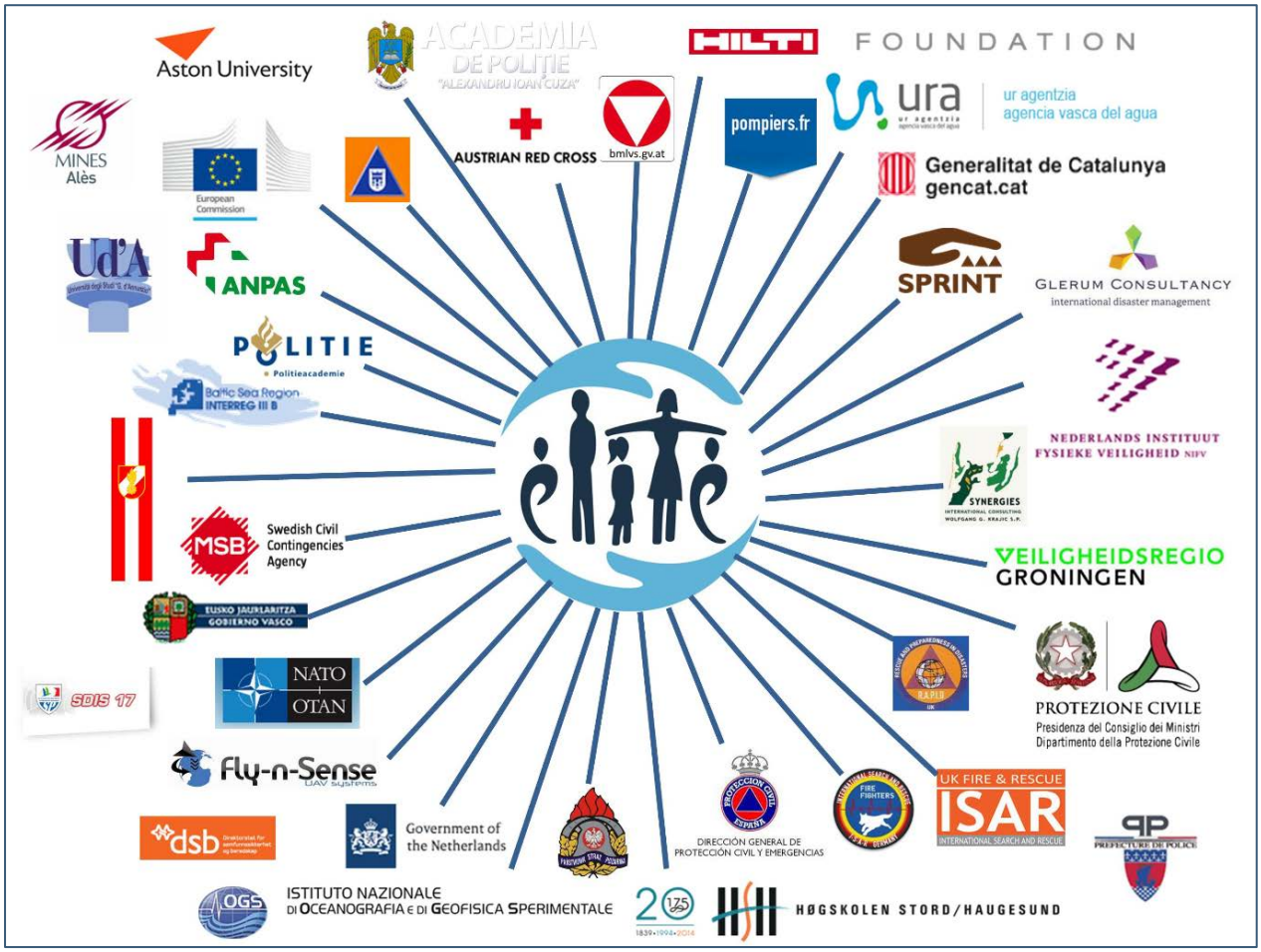

Figure 2.1 The ELITE Community of Practice (CoP).

3 Knowledge gathering, categorization and analysis of lessons learned

The aim of work package 4 was to gather knowledge, categorize and analyze experiences of each of the three natural disasters; forest fires, earthquakes and floods. A comprehensive literature review was conducted with the purpose of identifying the most relevant experiences and lessons learned within each disaster type. Most of the empirical data, however, was collected in four two-day workshops and one table-top/reporting exercise that the project organized for the end users. Findings from these workshops were continued and validated through questionnaires and semi-structured interviews with selected participants.

Five deliverables were produced in the work package. The first report[3] was prepared by Thales Research and Technology (TRT) and was a methodological report describing the development of categories in the ELITE web solution. The report is exempt from public dissemination. Three lessons learned reports were produced from each of the following disaster types; forest fires[4], earthquakes[5] and floods[6]. The goal of these reports was to identify common problem areas and challenges (*lessons learned*) in each type of emergency and describe possible solutions to the problems identified (*best practices*). Furthermore, these findings were used to create a framework or guidelines, to identify the key learning points in the aftermath of large, severe crises. This framework is presented in the fifth report[7]. The final report has a holistic perspective and attempts to transfer findings across the different disaster types and draw knowledge from the previous deliverables.

As responsible for work package 4, FFI decided to publish the four publicly available deliverables as separate reports. This is done in order to disseminate the results and have a wider distribution, nationally and internationally. This report presents the fourth and final lessons learned report; *Holistic analysis of lessons learned report,* see Appendix A.

[3] Goujon, B. (2013). *Methodological report on categorisation*. Deliverable 4.1 ELITE project. FP7-SEC. Contract no. 312497. Restricted.

[4] Maal, M. and Grunnan, T. (2014a). *Forest fires lessons learned report*. Deliverable D4.2. ELITE project. FP7-SEC. Contract no. 312497.

Maal, M. and Grunnan, T. (2014b). *Floods Lessons Learned Report.* Deliverable 4.4. EU FP7 ELITE (Elicit to learn crucial post-crisis lessons). Contract No: 312497.

[5] Maal, M., Grunnan, T., Gallipoli, M.R., Piscitelli, S., Masi, A. and Mucciarelli, M. (2014). *Earthquake lessons learned report*. Deliverable D4.3 in the ELITE project FP7 SEC Contract No. 312497.

[6] Maal, M. and Grunnan, T. (2014b). *Floods Lessons Learned Report.* Deliverable 4.4. EU FP7 ELITE (Elicit to learn crucial post-crisis lessons). Contract No: 312497.

[7] Grunnan, T. and Maal, M. (2014). *Holistic analysis of lessons learned*. Deliverable 4.5. EU FP7 ELITE (Elicit to learn crucial post-crisis lessons). Contract No: 312497.

Appendix A Holistic analysis of lessons learned report

ELITE

Elicit to Learn Crucial Post-Crisis Lessons

DELIVERABLE **D.4.5**

Holistic Analysis of lessons learned

Contract number :	*312497*
Project acronym :	ELITE
Project title :	Elicit to Learn Crucial Post-Crisis Lessons

Deliverable number :	**D4.5**
Nature :	Report
Dissemination level :	PU (Public)
Report date :	12 May 2014

Author(s):	Tonje Grunnan and Maren Maal (both FFI)
Partners contributed :	FFI, TECNUN, IMAA, ANCI Umbria, SGSP, FRK, TRT
Contact :	Norwegian Defence Research Establishment (FFI) Instituttveien 20, Postboks 25 2027 Kjeller, Norway +47 63807717 (tel), tonje.grunnan@ffi.no

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Coordinator: TECNUN

VERSION CONTROL

Version	Date	Contributors	Sections Affected
1	10.04.14	Tecnun	Chapters 3-5
2	23.04.14	Tecnun	Chapters 1-4
3	02.05.14	FRK, TRT, Tecnun, IMAA	All chapters

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EXECUTIVE SUMMARY

The aim of Deliverable 4.5 is to *summarize and structure the lessons learned in work package 4.* Throughout work package 4 a meaningful framework for lessons learned reporting has been developed. The framework is introduced in chapter two of this report and is based on results from deliverables 4.2-4.4. The ELITE project has gathered, systematized and analyzed challenges in crisis management with an *all phases - all hazards* approach, using the ELITE framework as a basis for this work.

This report gathers lessons learned and best practises from cases provided by the ELITE consortium based on their expertise within various fields of crisis management. The report includes three chapters with lessons learned from countries in Europe, America and Asia. The lessons learned from forest fires (chapter three) are gathered from cases in Italy (2002), Portugal (2001 and 2003), Spain (2005), Greece (2007) and France (1997). The main problem areas identified in the forest fires cases are interoperability, knowledge, prevention, communication, risk assessment, management, training and logistics, and the lessons learned are categorized according to these. Chapter four includes lessons learned from the recent floods in Europe (2013), Poland (2001 and 2010) and a major flood in Panama (2012). The lessons learned are categorized according to the main problem areas identified in the cases of floods; interoperability, knowledge, management of volunteers, communication, risk assessment, coordination, recovery and logistics. Chapter five includes lessons learned from earthquakes in Turkey (1999), Italy (2009), Haiti (2010), China (2008) and Japan (2012). The main problem areas identified in the earthquake cases are related to knowledge, communication, logistics, interoperability, coordination, risk management, risk assessment, prevention/preparation, training and recovery, and the lessons learned are categorized in line with these.

The lessons learned described in the report do not constitute an exhaustive list of lessons learned from the three types of natural disasters. They are examples of tangible lessons learned based on problems revealed by first responders and other crisis managers in the different phases of a crisis; prevention, mitigation, preparedness, response and recovery. All lessons learned are summarized in tables for each disaster type in the final chapter.

The lessons learned and the sources of information are available in the ELITE living document. End-users have been involved to validate the results in all stages.

Acknowledgment

The report is written and edited by *Tonje Grunnan* and *Maren Maal* from the Norwegian Defence Research Establishment (FFI). The work has been carried out with valuable and extensive written contributions from the following consortium partners:

José Mari Sarriegi, Leire Labaka, Ana Laugé, Josune Hernantes and *Raquel Gimenez* from Tecnun and *Bénédicte Goujon* from TRT have contributed on the chapter of forest fires.

Pawel Kepka and *Szymon Ptak* from SGSP and *Gert Lang* from FRK (supported by the Austrian CoP members Bernhard Kaiser, Karl-Dieter Brückner and Markus Glanzer) have contributed on the chapter of floods.

Maria Rosaria Gallipoli and *Sabatino Piscitelli* from IMAA and *Claudia Coccetti* and *Roberto Raspa* from ANCI Umbria have contributed on the chapter of earthquakes.

The partners from Tecnun, FRK, TRT and IMAA have revised drafts of the deliverable.

We would like to thank the ELITE CoP members participating in the 4th ELITE workshop 28-29 January 2014 for their hard effort working on a compilation of lessons learned from the Japan 2011 earthquake and tsunami.

1. INTRODUCTION

1.1 The ELITE project

The objective of work package 4 (WP4) in the ELITE project is knowledge gathering, categorization and analysis of lessons learned in each of the disaster areas; forest fires, floods and earthquakes. A comprehensive literature review has been conducted with the purpose of identifying the most relevant problem areas and lessons learned within each scenario. In addition, information has been gathered from four two-day workshops and a table-top/reporting exercise with the ELITE Community of Practice (CoP), questionnaires and semi-structured interviews with crisis managers.

The data gathered have been systematized and presented in three lessons learned reports, one for each disaster type (D.4.2-D.4.4[1]). The aim of these reports was to identify common problems similar in each type of crisis and describe possible solutions or lessons learned. Furthermore, these findings were used to create a framework, or guidelines, for identifying best practices and lessons learned.

The main objective of the ELITE project is to provide a living document which is a web solution that comprises a repository of best practices and guidelines as well as social media features. One report describing the use of the Myriad methodology to identify the criteria that will be useful to characterize the documents in the ELITE living document has also been produced within the work package (D4.1)

This report, which is the fifth and final deliverable in WP4, focuses on presenting tangible lessons learned using a holistic perspective transferring lessons learned across disaster types, and draws upon the findings from all the previous deliverables of the work package.

Due to the space restrictions of this report, only certain cases within each disaster type were selected. High-scale cases, i.e. dramatic disasters with comprehensive consequences were chosen. Many of the cases in this report were discussed during the ELITE workshops in 2013 and 2014 by the ELITE CoP. Also, the ELITE consortium has selected cases within their field of expertise that could bring some additional lessons learned to the set of lessons learned gathered in the project. For example, the Italian consortium partners provided cases from their background in earthquake research, while the Polish consortium partners selected cases within floods that they were familiar and have experience with etc.

1.2 EU funded research on natural disasters

EU countries are exposed to climate change, but some regions are more at risk than others (European Commission 2014:5). The Mediterranean basin, mountain areas, densely populated floodplains, coastal zones, outermost regions and the Arctic are particularly vulnerable. As the climate changes, extreme weather events like heat waves, droughts, heavy rain and snow, storms and floods are becoming more frequent or more intense. Southern and central Europe has seen more frequent heat waves, forest fires and droughts over the last years. Preventing dangerous climate change is a strategic priority for the European Union, and the European Commission, and some member states have developed adaptation strategies to help strengthen Europe's resilience to the inevitable impacts of climate change.

[1] See Maal, M. & Grunnan, T. (2013a), Maal, M. & Grunnan, T. (2013b), and Maal, M. et al. (2013).

The EU has funded several relevant projects on the topic of natural disasters, such as FUME, NEDIES, BRIDGE, EU-FIRESMART, REAKT, ACRIMAS etc. This conveys the importance of this topic especially in light of climate change. FUME is an EU project that is documenting and evaluating which changes in the land or in other factors that has an effect on forest fires in Europe and other fire-affected areas of the world (FUME 2014). EU-FIRESMART is another EU project that "aims to identify and gather information on forest fire prevention practices applied in different European countries" (CEPF No date). REAKT is an ongoing EU project aiming at defining strategies and tools for real time earthquake risk reduction (REAKT 2014). Another relevant EU funded project on earthquakes is SHARE, whose main objective is to provide a community-based seismic hazard model for the Euro-Mediterranean region with update mechanisms, and the project aims to establish new standards in Probabilistic Seismic Hazard Assessment (PSHA) (SHARE 2014). While NEDIES is a project that gathered lessons learned from several natural disasters to support the EU commission and EU members (NEDIES 2014), BRIDGE is an EU demonstration project that focuses more on developing "technical and organizational solutions that significantly improve crisis and emergency management in the EU Member States" (BRIDGE 2014). Finally, ACRIMAS (Aftermath Crisis Management System) is an EU project which developed a roadmap for a demonstration project (in Phase II) within crisis management (ACRIMAS 2011; Pastuszka 2012).

The ELITE project is placed among these examples of projects dedicated to similar research within the EU with the overarching objective of improving European emergency preparedness, response and recovery from disasters, starting with studying lessons learned from natural disasters such as forest fires, floods and earthquakes. Hence, developing a framework (guidelines) for best practices and lessons learned reporting. The natural disasters that are examined are of the most devastating ones. Natural disasters differ with respect to how the crisis evolves and their consequences. However, the emergency preparedness planning process, response efforts and recovery phase, are phases with many of the same challenges.

Results from the ACRIMAS project have served as an inspiration and source of information for designing the workshops in the ELITE project, i.e. development of scenarios as a basis for discussions in the CoP. Notably, results from the NEDIES projects have proved very relevant when gathering and systematizing information on lessons learned from natural disasters and are used as a source in some of the cases in this report. ELITE has established contact with partners in the BRIDGE consortium through attending seminars and conferences, thus, disseminating findings and results.

1.3 Aim of the report

The aim of this report is to present lessons learned from natural disasters such as forest fires, floods and earthquakes. The previous deliverables in WP4 have focused to a large extent on methods; a method for establishing a framework for gathering best practices and lessons learned, and a method for the categorization of documents in the living document. Therefore, this report will focus on the tangible lessons learned from crises.

Based on the findings from the ELITE workshops we presented a possible framework for lessons learned to the CoP and tested it in a reporting exercise. We selected the problem areas that recurred in the three workshops; across disaster types and phases, and created a list/framework of the areas where most lessons learned are found for a crisis of any kind. This holistic framework form the basis for the structure of the tangible lessons learned gathered in this report.

1.4 Structure of the report

Chapter 1 describes the aim of the report and puts it in context with the previous deliverables in WP4 and EU research on related topics, as well as explains the codification of the lessons learned.

Chapter 2 gives a brief description of the framework for lessons learned created throughout the ELITE project; i.e. development, testing and validation, and evaluation.

Chapter 3 presents a comprehensive description of tangible lessons learned from forest fires gathered from cases in Italy, Portugal, Spain, Greece and France. The main problem areas identified in the forest fires cases are interoperability, knowledge, prevention, communication, risk assessment, management, training and logistics, and the lessons learned are categorized according to these.

Chapter 4 includes lessons learned from floods in Poland, recent floods in Europe (2013), and a major flood in Panama. The lessons learned are categorized according to the main problem areas identified in the cases of floods; interoperability, knowledge, management of volunteers, communication, risk assessment, coordination, recovery and logistics.

Chapter 5 includes lessons learned from earthquakes in Turkey, Italy, Haiti, China and Japan. The main problem areas identified in the earthquake cases are related to knowledge, communication, logistics, interoperability, coordination, risk management, risk assessment, preparation/prevention, training/education and recovery, and the lessons learned are categorized in line with these.

Chapter 6 provides a summary of the lessons learned, compiled in tables of lessons learned; one for each disaster type. Based on the process of gathering and categorizing tangible lessons learned, there is a discussion on the use of the ELITE framework for lessons learned reporting, leading to recommendations for an amendment of the framework.

1.5 Codification of lessons learned

The lessons learned presented in chapters 3-5 are numbered and categorized according to the main problem areas identified in each of the natural disaster type; forest fires, floods and earthquakes, respectively. The categorization is related to the ELITE framework for lessons learned, see chapter 2 for more details.

The categories are ranging from knowledge, communication, logistics, to risk assessment, recovery etc. There is one set of categories for each disaster type.

Every category is assigned a number and every lesson learned related to this category is assigned a number. For instance, if *Knowledge* is category 1, the lessons learned related to *Knowledge* are numbered 1.1., 1.2, 1.3 etc.

All lessons learned from all cases are summarized in three tables in chapter 6.

2. CREATING A FRAMEWORK FOR LESSONS LEARNED

2.1 Workshops

The ELITE project has organized three scenario based workshops within the realms of earthquakes, floods and forest fires. A fourth workshop was organized which integrated these. This was done to engage the main stakeholders in the ELITE CoP and to acquire relevant knowledge and experience. The participants in the workshops consist of the end-users and other main stakeholders in crisis management. In order to extract lessons learned an interactive method called the post-it methodology was used.

A framework was created based on findings and validation through the workshops. The CoP can through this framework identify and categorize lessons learned and best practices among experts at different levels in the crisis management sector. However, the framework without tangible lessons learned is not of direct relevance. Therefore, this report will use the framework and fill it with tangible lessons learned gathered from the ELITE CoP as well as lessons learned from other sources.

2.2 Problem structuring method

The creation of the framework for lessons learned reporting is regarded as one of the outputs of the ELITE project. The framework is holistic and incorporates all-phases and is relevant for all hazards. The framework was also important for the development and structuring of best practices and lessons learned in the living document prototype. This is essential for the efficiency and effectiveness of the ELITE living document as a support tool in crisis management planning, operation and recovery.

The framework was developed through a post-it exercise in two steps where the experts in the ELITE CoP had to share experiences. Sharing can be argued to be a type of learning in itself and can be a powerful tool to convey the wisdom and experience gained from living through an incident.

Through the post-it exercise the experts would first write down lessons learned (also referred to as “problems” in the exercise) that they had experienced in their work on different post-its. Challenges like “inter-agency communication”, “lack of knowledge in the population”, “no debriefs” and “few evaluations” were mentioned by the experts. The experts presented their post-its and stuck it onto the whiteboard. This would trigger interesting discussions as the experts from different countries would often provide an example where they experienced this problem and then the other experts would also share similar experiences. This created an interactive context and became a good environment for learning. Post-it notes with similar lessons learned were grouped under larger problem areas and it was also noted in which of the phases of a crisis this problem would occur (pre-crisis, during the crisis, post-crisis). Some examples of problem areas/areas for lessons learned are “communication”, “logistics”, “training experience” and “knowledge”.

The second step of the process consists of a session where the same groups had to identify possible lessons learned to the problems. The problems were plotted into a word-table and projected on a screen. All the problems were analyzed and each time a lesson learned or solution was proposed by the experts. Through the workshop exercises and the following discussions it was possible to disseminate and collect procedures and best practices, establish a common understanding of the possibilities for interoperability, and thus, establish a framework for identifying lessons learned in crisis management and recommendations on how to learn and report from a crisis in a learning environment.

2.3 Testing and validation of framework

In previous workshop the CoP has taken part in defining categories in the framework in order to develop an interesting and useful output, while in the fourth and final workshop they were able to test the living document and scientific framework. During the fourth workshop in January 2014 the framework was both tested and validated. The workshop participants the CoP members were divided into three groups. Their assignment was to write a lessons learned report using both the framework developed in the previous workshops and the prototype of the living document. A concrete, real scenario was presented (the 2011 Japan earthquake followed by a tsunami as a cascading effect). The CoP was supposed to (i) use this scenario as a starting point for the reporting exercise, (ii) access the living document and use sources/documents from the Wiki solution when writing the lessons learned report. The ELITE living document is meant to be a platform for different users within the field of crisis management, where they can find relevant and good information and extract documents for best practices and lessons learned purposes.

In the fourth workshop the participants were given a framework where the major areas for lessons learned were merged together (figure 1). The experts were asked to classify their lessons learned according to these categories. As the categories are rather broad, some questions were provided in order to give them some ideas of what should be included.

Communication (all phases)

- Inter-agency communication
- Crisis communication to the population
- What was the role of media and social media?

Interoperability (during and in the aftermath crisis)

- How was the interoperability between the different actors?
- Is this different when one is facing a crisis with cascading effect?

Coordination and decision-making

- How was the coordination and decision-making in terms of roles and responsibilities of different actors?

Risk assessment

- How to be prepared for a crisis with cascading effects?
- How did the natural disaster affect critical infrastructure
- Were risk assessments conducted during the crisis?

Logistics

- Were there any challenges related to logistics?

Recovery

- What was done in the recovery phase and by whom?

Figure 1: Framework for lesson learned

2.4 Evaluation of the framework by the CoP

After the fourth workshop in January 2014 a questionnaire was distributed among the members of the CoP in order to evaluate the scientific framework. The ELITE consortium received feedback from 16 respondents. One CoP expert wrote: *"the topics in the scientific framework are a good tool to lead you through the most interesting problems regarding lessons identified and lessons learned".* Another CoP expert argued *"It is a good framework because it allowed easy analysis in all crisis- situations and in all phases and it makes it easier to write lessons learned reports".* Other types of feedback included:

***Adding additional topics in the framework*:** Many of the ELITE CoP wanted to have additional topics such as (a) Information, (b) Transition/recovery (passing over the system to the locals), (c) Water and sanitation and (d) Safety and security, (e) Soft factors such as cultural specifics and individual behavior, (f) A specific topic on communication and information that takes into account different situations and contexts (multiculturalism etc.).

Breaking down complex topics: Interoperability is a multi-faceted topic; an expert wondered whether it was convenient to have sub points. Another ELITE CoP member argued that "response" is a more useful term than "coordination and decision making". Some argued that there is a difference regarding planning between crisis planning and emergency planning.

A general tendency was that most of the CoP respondents wanted to add more topics to the framework, but none of the respondents wanted to remove any topics. This will always be a challenge with complex issues such as a crisis situation. Scientific frameworks or models cannot and should not attempt to cover all aspects of the reality. The framework must be practical so that it can be easily used by the CoP.

A way to solve this challenge and use the feedback from the ELITE CoP is that several topics can be mentioned as sub topics under one of the main topics. One example is therefore to write "*Risk assessment; Prevention*". Therefore practitioners can add additional topics in the framework, as well as break down complex topics. This approach will be used in this report.

2.5 Use of framework in this report

The lessons learned of each case within each disaster type are structured in accordance with the framework for lessons learned developed in the project (see figure 1), as far as possible. Through the ELITE workshops, the CoP has defined some of the most relevant and important problem areas or challenges related to the prevention, management and learning from major crises. These are being used as a basis for structuring the tangible lessons learned in this report.

3. LESSONS LEARNED FROM FOREST FIRES

The authors of the IPCC report (2013:5) argue with high confidence that climate change will result in increased wildfire risk in Southern Europe. The IPCC (2014) has observed that the pattern of rainfall in Europe is changing (European Commission 2014). Climate change has different effects on Northern Europe, which is becoming wetter and winter floods could become common (ibid). While "the Mediterranean area is becoming drier, making it even more vulnerable to drought and wildfires" (European Commission 2014). The IPCC findings correspond to the findings of FUME (2014) that analyzed the Mediterranean countries in Europe and California. FUMEs calculations show that climate change and fires have been "positively correlated for the last decades, and that this relationship can be ascertained independently of changes in other drivers that occurred in the areas analyzed during this time" (FUME 2014:21). This corresponds to the findings in EU-FIRESMART (Lopez et al 2011:2).

Preparation for climate change is vital and sharing lessons learned and best practices is a way to reduce the vulnerabilities induced from climate change.

In the previous lesson learned report in ELITE it was focused on forest fires in northern countries like Norway, Russia and Poland (Maal and Grunnan 2013a). This is one of the reasons why this report will focus on forest fires in the southern Europe. This chapter will include cases from Italy, Portugal, Spain, Greece and France. Many of the cases from Italy and Spain were discussed during the ELITE forest fire workshop (2013) by the ELITE CoP. Also, the ELITE consortium has selected cases within their field of expertise that could bring some additional lessons learned to the set of lessons learned gathered in the project. Even though forest fires are different in Southern and the Northern Europe due to different type of terrain, climate and tree species, the management of forest fires still shares similarities.

This chapter includes a comprehensive description of tangible lessons learned gathered from various sources; Regional lessons learned reports, lessons learned reports from international NGO's, EU-project reports, European Parliament papers and the ELITE CoP (ELITE forest fire workshop 2013).

The lessons learned in the following sections are numbered and categorized according to these main problem areas identified related to the forest fires cases:

1. Knowledge
2. Interoperability
3. Prevention
4. Communication
5. Risk assessment
6. Management
7. Training
8. Logistics

These categories will be used in text describing the lessons learned, and every lesson learned within each of the categories gets a number, i.e. all the lessons learned related to Knowledge are numbered 1.1, 1.2, 1.3 etc., and all lessons learned related to Interoperability are numbered 2.1, 2.2, 2.3 and so on.

An overview of the lessons learned in each case is presented in a table in the beginning of each case, to facilitate the learning experience. All forest fire lessons learned from all cases are summarized in one table in chapter 6.

3.1 Forest fires in Cosenza, Italy (2002)

Problem areas		Lessons learned from forest fires
1 Knowledge	1.1	Awareness of prolonged fire seasons
2 Interoperability	2.1	Using the volunteers more actively and incorporate into the regional plans
	2.2	In collaboration with police forces surveillance must be intensified to discourage arsonists to set fires
	2.3	One must improve coordination between the operative structures of the various municipalities involved. Municipalities that are not affected, must assist bordering municipalities
3 Prevention	3.1	Cultivation activities must be a part of the prevention efforts, even when it is outside the 'normal fire seasons', like in this case
	3.2	Training and education of teams of volunteers on municipal level as part of the prevention efforts
4 Communication	4.1	Informing the public of regulations regarding agricultural, forestry, and grazing activities to prevent the principal causes of fire

Table 1: Summary of lessons learned from forest fires in Cosenza, Italy (2002)

On the 5th of March 2002 the province of Cosenza in Italy experienced a major forest fire. The weather conditions at the beginning of March were exceptionally warm and it was observed that there were strong warm winds from the south- east. The warm temperature was followed by a prolonged period that was free of precipitation. Through data collected over time in the province of Cosenza one has seen that most fires occurs and spread in the summertime, while the rest of the year sees a small number of small fires (Nedies 2003:3). Therefore annual "summer campaigns" regarding fire-fighting measures are put into place in this period because it is normally more active than the rest of the year. However, on the 5th of March 2002, from 11.00 o'clock in the morning to the late evening, there were 22 fire outbreaks. These fire outbreaks were located in 15 municipalities in the area that goes between the Thyrrhenian Sea and the Salerno-Reggio Calabria highway north of the city of Paola (Nedies 2003:3). Approximately 1,000 hectares of forest were destroyed by both small and big fires. One of the lessons learned from the fire outbreaks (1.1) was that forest fires are not tied to the rigid concepts of seasonality (summer/winter), but can actually occur at serious levels before the "fire season" has begun. Especially under specific weather conditions related to prolonged periods of drought followed by an increase in temperature and African winds (ibid).

A problem that became apparent during the forest fires in the Region of Calabria was that the region did not make use of the teams of volunteers. A lesson learned (2.1) is that regional plans should foresee that a minimum number of teams of volunteers should support the institutional entities responsible for fire-fighting efforts (Nedies 2003:4).

Through the evaluation of the forest fires the State Forestry Corps found that 80% of the fires were purposely set (ibid). It may appear that arsonists wanted to overload fire-fighting systems, purposely creating considerable damage. A lessons learned (2.2) is that surveillance must be intensified and one must discourage the damaging efforts of arsonists, in collaboration with police forces (Nedies 2003:4).

During the outbreaks of forest fires there were some municipalities that received little help from the State Forestry Corps and the Fire Brigades because the resources, like helicopters, were used elsewhere. In Lago municipality, forestry personnel of the Forestry Command Station were deployed for the fire which hit 75 hectares of forest in another area (Aria Lupi). However, there were no ground team efforts for the other three fires which occurred at the same time (Nedies 2003:6). A lesson learned (2.3) is that coordination must be improved between the "operative structures of the various municipalities involved" (Nedies 2003:6). Municipalities that border the affected areas should assist with their resources and teams (Nedies 2003:6).

A. Scipioni, D. Pontoni and C. Allochis from the Department of Civil Protection in Rome noted that the forest fires were able to spread rapidly because of the amount of shrub layer, grass layer, litter at the surface level and live and dead material in the canopy of the trees (forest fuels). A lesson learned (3.1) is that cultivation activities must be a part of prevention efforts, even when it not 'normally fire seasons' like in this case. The purpose of the cultivation activities is to improve the vegetation conditions of natural and forest environments to lessen the effects of fire passage, and spreading of the fire itself. This can be done through "(a) eliminating dry and easily flammable vegetation from road embankments, (b) clearing grass, bushes and plant residue from the sides of road- and railways, (c) eliminating highly flammable vegetation that covers uncultivated terrains on private properties located near urban areas, (d) creating parking areas for fire-fighting vehicles in forests, (e) creating water supply areas, (f) creating fire barriers, and (g) carrying out maintenance and cleaning operations" (Nedies 2003:5).

Another lesson learned (3.2) is that education of teams of volunteers on the municipal level is necessary.

The local population was informed of the arrival African winds and increase in temperature through weather forecasts, but there was no warning of the possible risk of forest fires. A lesson learned (4.1) is therefore to "increase prevention against the principal causes of fire by better informing the public of regulations regarding agricultural, forestry, and grazing activities" (Nedies 2003:6). This also relates to "hunting associations in defining strategies to prevent fires related to hunting activities" (ibid).

3.2 Forest fires in Guarda, Castelo Branco and Coimbra, Portugal (2001)

Problem areas		Lessons learned from forest fires
1 Knowledge	1.2	If a fire occurs in the Bacalo area in days with a risk index higher than 3 (high) the fire cannot be extinguished in its initial phase. This will become the origin of a major forest fire
	1.3	Fuel breaks are needed therefore one must not carry out monoculture practices

Table 2: Summary of lessons learned from forest fires in Guarda, Castelo Branco and Coimbra, Portugal (2001)

Portugal experienced in September 2001 many forest fires (Nedies 2003:7). José Pedro Lopes (Serviço Nacional de Protecção Civil, Carnaxide) noted that after a week with more than 350 forest fires being fought every day a small village called Balocas, District of Guarda experienced a major forest fire. The forest fire occurred in a place where it was difficult for the fire fighters to intervene. It took nearly 45 minutes for the fire fighters to get to Balocas. The helicopter that was allocated to the area was busy fighting another fire in another area.

On the 9th of September 2001 the meteorological risk index for the District of Guarda was at "4: Very High". A lessons learned (1.2) (based on many years of experience) is that if a fire occurs in this area in days with a risk index higher than 3 (high) the fire cannot be extinguished in its initial phase. This will become the origin of a major forest fire that will spread to other areas.

The fire had a "fast and inconstant progression" due to local changeable winds. This made it difficult to confine and control. It was noted that "the lack of fuel breaks, control lines, penetration paths for the fire-fighters vehicles and the pronounced relief made it possible for the fire to develop in 3 fronts, namely in the Districts of Guarda, Coimbra and Castelo Branco" (Nedies 2003:7).

One of the lessons learned (1.3) is that one must not make the "serious mistake of carrying out monoculture practices". This is because fuel breaks must be maintained in order to be able to contain/ confine the fire from rapidly spreading. Also the "forest planning has to protect the heterogeneity of existing species, avoiding the continuity of the forest of the same species, particularly of resinous three types along many hectares" (Nedies 2003:9).

3.3 Forest fires in Portugal (2003)

Problem areas		Lessons learned from forest fires
1 Knowledge	**1.4**	Public awareness campaigns, monitoring and early warning systems are crucial when informing the public.
2 Interoperability	**2.4**	Decisions on planning and prevention are always required.
	2.5	Collaboration between countries, within and between regions (e.g. on fire suppression, training and information exchange).
	2.6	Establish an approach of military-command or standard Incident Command System at the country level
5 Risk assessment	**5.1**	Incentives to extensive animal farming and small agriculture
	5.2	Promote discontinuity with less fire-susceptible species including the protection of these species on the forest fire prevention programs
6 Management	**6.1**	Political commitment is essential, especially with regard to the provision of adequate budget to fire related activities
	6.2	The adoption of proactive rather than reactive responses, the amendment of conflicting policies and legislations and the definition of clear responsibilities for fire management
7 Training	**7.2**	Specific forest fire training for firefighters
8 Logistics	**8.1**	Investments in fire prevention can be more effective than investment in fire fighters

Table 3: Summary of lessons learned from forest fires in Portugal (2003)

Portugal has experienced a series of forest fires the last years. During the period 1997-2006 Portugal experienced on average more than 162,000 hectares burned yearly due to forest fires (EU 2008:18). According to an EU study the phenomenon "has gotten worse in recent years,

and the average burnt area increased to 200,000 hectares per year during the period 2002-2006" (ibid).

In 2003 a global heat wave caused massive forest fires in Portugal; "the forests fires of 2003 were the worst in the past 27 years in terms of total area burnt, and led to the destruction of about 425,000 hectares" (EU 2008:18). The forest fires in 2003 resulted in 21 deaths and "more than one thousand people were reported to be in need of medical assistance due to smoke intoxication, burns, wounds and other fire related problems" (EU 2008:18).

The forest fires also highlighted the problem of poor education, limited public awareness campaigns on the increased risk of forest fires. The lesson learned (1.4) was therefore to increase public awareness through campaigns. Monitoring and early warning systems are also crucial.

There were several lesson learned on interoperability issues; (i) Decisions on planning and prevention are always required (lesson learned 2.4), (ii) one must have collaboration between countries, within and between regions (e.g. on fire suppression, training and information exchange) (lesson learned 2.5), (iii) establish an approach of military-command or standard Incident Command System at the country level (lesson learned 2.6).

After the forest fires several problem areas were noted. There has been a dramatic decrease of rural population in Portugal. Cultivation has been abandoned and one has witnessed that eucalyptus and pines have been grown. These types of species are highly inflammable. A lesson learned (5.1) is that one must give incentives to people to conduct extensive animal farming and small agriculture. Another lesson learned (5.2) is that one must promote to grow species that are less fire-susceptible and one must include the protection of the less fire-susceptible species in the forest fire prevention programs.

Another lesson learned (6.1) is that political commitment is essential, especially with regard to the provision of adequate budget and decisions on planning and prevention. During the forest fires there was lack of coordination between institutional structures responsible for forest fires which led to ineffective forest management. The operations were overseen by a local command disconnected from the national level. The lesson learned (6.2) is the adoption of proactive rather than reactive responses, the amendment of conflicting policies and legislations and the definition of clear responsibilities for fire management.

Another problem was the lack of specific training of firefighting corps. Forest fires combating in Portugal has been executed by a corps of volunteer fire brigades devoid of special training for forest fires. Lack of professional training of volunteer fire fighters in the local fire departments (legally responsible for extinguishing forest fires) has been seen as a significant hindrance to the country's capacity to respond to forest fires. One lesson learned (7.2) is to have specific forest fire training for firefighters. Also, a lesson learned (8.1) is that investments in fire prevention can be more effective than investment in firefighters.

3.4 Forest fires in Guadalajara, Spain (2005)

Problem areas		Lessons learned from forest fires
1 Knowledge	1.5	Authorities must know the regulation to manage the forest fire
	1.6	Public education in the regulation for use of fire in forests
2 Interoperability	2.7	Identification of an unified command when there is more than one agency with incident jurisdiction
	2.8	Knowledge about the procedures and regulations to call in the army to help when a forest fire occurs
	2.9	Demarcation of the authority of responsible officers at both national and grassroots levels for maximum control and efficiency in firefighting operations
5 Risk assessment	5.3	Harden the forest fire offence and penalty regulations
6 Management	6.3	Update the Civil Protection legislation
	6.4	Regional authorities' surveillance over municipal authorities, and national authorities' surveillance over regional authorities
7 Training	7.1	Training staff from operational level in Incident Command System

Table 4: Summary of lessons learned from forest fires in Guadalajara, Spain (2005)

The 16th of July 2005 a group of excursionists were visiting an area near the village of Riba de Saelices in Spain. It was a hot and windy day, yet the group decided to prepare a barbecue. The fire "produced enough embers that ignited a nearby field of stubble […] Driven by the strong wind, the fire spread very quickly in the extremely dry vegetation rendering fruitless the efforts of the group to extinguish it by the time they realized there was a fire catching up" (EU JRC 2009:10). The fire spread to an area of "complex topography covered by a large extension of old Pinus pinaster plantations and shrubs that were very dry due to an extended drought that was felt in the region and in the Iberian peninsula during 2005" (ibid). Within sixty minutes the fire became virtually uncontrollable.

The fire caused eleven fatal victims and a badly injured survivor, all of them firefighters (EU JRC 2009:10). Firefighters succeeded in creating a fire-break backed up by water-bombing aircraft. The fire lasted for four days. Four villages were affected and an area of more than 12,000 ha was burned. Over 600 people were evacuated.

A lesson learned (1.5) is that the authorities must know the regulation to manage the forest fire. Another lesson learned (1.6) is to have public education concerning the regulation for use of fire in forests. According to Lopéz et al[1]. (2011:2) wildfires in Europe result nowadays mainly from changes in life habit due to socio-economic development; i.e. increased mobility, tourism and recreational activities.

It is important to identify a unified command when there is more than one agency with incident jurisdiction (lesson learned 2.7). Also, a lesson learned (2.8) is to have knowledge about the

[1] Lopéz et al. are disseminating results from the EU-FIRESMART project (2011).

procedures and regulations to call in the army to help when a forest fire occurs. In addition, "demarcation of the authority of responsible officers at both national and grassroots levels for maximum control and efficiency in firefighting operations" (lesson learned 2.9). This was mentioned as a lesson learned from previous forest fires already in 2004 by Mosoti and Mekouar (2004).

One important lesson learned (5.3) was to "harden the forest fire offence and penalty regulations" (EU JRC 2009:10).

There were many lessons learned after the massive fire regarding coordination and interoperability. One lesson learned (6.3) is that one must update the Civil Protection legislation. Another lesson learned (6.4) is that regional authorities must have surveillance over municipal authorities, and national authorities must have surveillance over regional authorities (ibid).

A lesson learned (7.1) is to train the crisis and preparedness staff from the operational level in the Incident Command System.

3.5 Forest fires in Greece (2007)

Problem areas/ Lessons learned		Lessons learned from forest fires
1 Knowledge	**1.7**	Development of fire-unprotected interface zones between forest and urban areas
2 Interoperability	**2.10**	Harmonization of terminology and definitions, and the development of a common format for regional databases on fire across countries
	2.11	Greece must further pursue increased collaboration between countries, within and between regions with regards to fire suppression training and information exchange
5 Risk assessment;	**5.4**	Policy-makers and citizens should not just take decisions when severe fire events occur. Decisions on planning and prevention are always required
	5.5	Public awareness campaigns, monitoring and early warning systems are crucial to increase risk awareness in the population
8 Logistics	**8.2**	Political commitment is vital especially the (i) provision of adequate budget, (ii) the adoption of proactive rather than reactive responses, (iii) the amendment of conflicting policies and legislations and (iv) the definition of clear responsibilities for fire management

Table 5: Summary of lessons learned from forest fires in Greece (2007)

Greece experienced a challenging fire season in 2007. During the winter there was little snowfall. The summer season was very dry, especially in the south of the country (EU JRC 2009:66). Greece was hit by two heat waves during the summer of 2007 that resulted in serious forest fire problems. According to the EU JRC "more than 270,000 hectares of vegetation burned and more than 110 villages were affected directly by the fire fronts" (EU JRC 2009:65). More importantly a total of 78 people, mostly civilians, lost their lives in a series of fire related accidents (ibid).

In Greece there is a division between fire suppression activities executed by the Greek Fire Service and forest fire prevention executed by the Forest Service. However, forest fire prevention has weakened in its competence, structure and is poorly funded (EU 2007:ii). Since 1998 the costs for forest fire management have "greatly increased, with the highest part of funding being absorbed in the acquisition of modern fire suppression equipment". However, the burned forest areas have increased (ibid).

A major problem during the forest fire of 2007 was the lack of substantial fire prevention measures and policies which lead to the eruption of many destructive fires.

A lesson learned (1.7) regarding planning and knowledge is the "development of fire-unprotected interface zones between forest and urban areas". This is a large problem for fire-fighting forces and can have critical impact on damages to homes and infrastructure.

Regarding interoperability there is still a need for "harmonization of terminology and definitions, and the development of a common format for regional databases on fire across countries" (lesson learned 2.10). Another lesson learned (2.11) is that Greece needs to further pursue collaboration between countries, within and between regions (e.g. on fire suppression, training and information exchange). This corresponds to the findings of ACRIMAS stating that there is an "increasing need of working together in crisis management in Europe" due to the "increasing complexity and interconnectedness of European societies, increasing frequency & magnitude of disasters, the need for "doing better with less" in the future" (ACRIMAS 2011:7)

A lesson learned (5.4) regarding prevention is that "policy-makers and citizens should not just take decisions when severe fire events occur […] Decisions on planning and prevention are always required" (EU 2007:ii). Political commitment is essential especially when it comes to the "provision of adequate budget, the adoption of proactive rather than reactive responses, the amendment of conflicting policies and legislations and the definition of clear responsibilities for fire management" (ibid).

Another lesson learned (5.5) is the need for "public awareness campaigns, monitoring and early warning systems" to increase the risk awareness in the public.

A lesson learned (8.2) is that political commitment is vital especially the (i) provision of adequate budget, (ii) the adoption of proactive rather than reactive responses, (iii) the amendment of conflicting policies and legislations and (iv) the definition of clear responsibilities for fire management

3.6 Forest fires in Septèmes-les-Vallons, France (1997)

Problem areas		Lessons learned from forest fires
1 Knowledge	1.8	Necessity to have a coherent network of infrastructures in the forestland to protect the forest against fire
	1.9	Need to have a clean forest without bushes
2 Interoperability	2.12	Need to have an established coherence between the different institutions that may have to cooperate during a forest fire

Table 6: Summary of lessons learned from forest fires in Septèmes-les-Vallons, France (1997)

From the 25th-28th of July 1997 an exceptional forest fire took place near the city of Marseille in France. The fire of Septèmes-les-Vallons was exceptional because of the "large area it affected, its intensity and the potential threat it emanated to the city of Marseille" (NEDIES 2003:39). Almost 3,500 hectares was burnt. A large scale intervention to protect the population living in the outer perimeter of the city was carried out (NEDIES 2003).

The large forestland of Septèmes-les-Vallons was equipped with infrastructure to protect the forest against fires. "There were 160 km of paths, 13 water sources, and the landfill from which the fire started, was protected by a large strip of land that had been initially deprived of bushes" (NEDIES 2003:39).However, not all the paths were linked to each other. Therefore there was no coherent network between the paths. A lesson learned (1.8) is to have a coherent network of infrastructures in the forestland to protect the forest against fire. Also, the area between the paths which was supposed to be cleared of bushes was "covered by blanket vegetation that accelerated the spread of the fire" (ibid). A lesson learned (1.9) is that there is a need to have clean forest paths without bushes.

The fire started in the sector the Batallion of the Marine Fire Fighters of Marseille is responsible for. This is a unit under the supervision of the mayor of Marseille. "The Battalion is basically a parallel structure of the departmental fire service, whilst the Bouches du Rhône takes care of the rest of the territory of Bouches du Rhône" (ibid). During the forest fire the two institutional structures had limited contact. This became apparent during the processes of preparing the monitoring plan, disseminating of the alarm, the rate of response of the terrestrial units and the speed at which the request for reinforcement at national level was carried out. A lesson learned (2.12) is to establish coherence between the different institutions that may have to manage in coordination a forest fire.

3.7 Conclusions

The main problem areas identified in the six forest fires cases were interoperability (12 lessons learned), knowledge (9 lessons learned), prevention (2 lessons learned), communication (1 lesson learned), risk assessment (5 lessons learned), management (4 lessons learned), training (2 lesson learned) and logistics (2 lessons learned).

It seems clear that interoperability is the major problem area when it comes to forest fires. This finding also corresponds with the findings in the ELITE CoP workshop on forest fires. One CoP expert, a fire chief from Austria, argued that an interoperability challenge was that "it is difficult to cooperate with mass media, which does not follow our procedures taking pictures or filming forbidden images". A lesson learned is therefore that stricter regulations regarding journalists in crisis areas are needed. A Polish firefighter argued that one could draw the most lessons learned from training; "the more practical exercises we have the more skills we gain, which can be used during real actions". A lesson learned is therefore to have regular exercises of the firefighters. Some Italian firefighters argued that creating a summary of the incident with the other colleagues who had participated in a forest fire mission "helps us in understanding problems, difficulties and to eliminate them during next rescue operations". A lesson learned regarding knowledge is to summarize the incident with colleagues and identify strengths and weaknesses with the operation.

During the forest fire workshop in 2013 the lessons learned were categorized in phases (before, during and post-crisis). Many of the same categories found in this chapter correspond to the categories that were mentioned in the ELITE forest fire workshop in 2013. However, in the workshop "learning" was the focus and became a topic on its own. During the validation process of the framework, in the holistic workshop in 2014, learning became incorporated into the broader topic "knowledge". Knowledge includes learning in all phases.

4. LESSONS LEARNED FROM FLOODS

The last year we have seen an increased amount of major floods in Europe. This corresponds to the findings and prognosis fronted by the authors of the IPCC report (2014:4). The IPCC authors argue with 'high confidence' that the impact of climate change will result in "Sea level rise and increases in extreme rainfall" (2014:4). These changes "are projected to further increase coastal and river flood risk in Europe and, without adaptive measures, will substantially increase flood damages (people affected and economic losses)" (2014:4). With an increased risk for floods in Europe it is highly important to share lessons learned and best practices regarding cooperation and interoperability challenges in flood scenarios.

This chapter includes tangible lessons learned from the recent floods in Europe, floods in Poland and a major flood in Panama. Many of the cases from Poland (2001 and 2010) and the recent floods in Europe were discussed during the ELITE flood workshop in 2013 by the ELITE CoP. Information on the cases and the lessons learned are gathered from regional lessons learned reports, lessons learned reports from international NGO's, EU-project reports, European Parliament papers and the ELITE CoP (ELITE floods workshop 2013). The ELITE consortium has selected cases within their field of expertise that could bring some additional lessons learned to the set of lessons learned gathered in the project.

The lessons learned in the following sections are numbered and categorized according to these main problem areas identified related to the forest fires cases:

1. Knowledge
2. Communication
3. Logistics and distribution
4. Interoperability
5. Coordination
6. Management of volunteers
7. Risk assessment
8. Recovery

These categories will be used in text describing the lessons learned, and every lesson learned within each of the categories gets a number, i.e. all the lessons learned related to Knowledge are numbered 1.1, 1.2, 1.3 etc., and all lessons learned related to Communication are numbered 2.1, 2.2, 2.3 and so on.

An overview of the lessons learned in each case is presented in a table in the beginning of each case, to facilitate the learning experience. All floods lessons learned from all cases are summarized in one table in chapter 6.

4.1 Floods in Poland (2001)

Problem areas/ Lessons learned		Lessons learned from floods
1 Knowledge	1.1	An assessment within the first days of the disaster pinpointing the need for food, clothing, blankets, hygiene products, clean drinking water and first aid kits
	1.2	The disaster preparedness department in Poland must be responsible for implementation of the operation through regular monitoring, reports and lesson learning
	1.3	Further intensification of protective action like the development of non-structural measures (land use planning, monitoring and warning systems, risk communication)
	1.4	Personal contact is the prevailing means of communication in smaller settlements, while mass media are preferred by those living in larger towns
	1.5	It is necessary to develop a mathematical model based on the numerical map area covering the whole area of Gdańsk, from all watercourses in order to predict in real time the effects of rainfall
	1.6	Since we cannot guard against floods, we must learn to live with them
	1.7	Flooding should be treated as a normal phenomenon, occurring at intervals of several years
2 Communication	2.1	Adaptation of new functionalities to the existent tools
	2.8	Cooperation with mass media is crucial to providing information to public
	2.9	When an event occurs, the funds provided by insurance companies might be an important element in the economic resources available
	2.10	Increasing the number of automatic measurement points and measurement of precipitation water levels on watercourses within the city which is sent to the crisis centre
3 Logistics	3.7	Using the Local Polish Red Cross (PRC) to distribute relief items, such as food, water, clothing, shoes, blankets and hygiene products
	3.8	The first phase of the emergency operation - collection and distribution of relief items, organization of transport to the regions affected by floods, organization of search-and-rescue dog teams in Gdansk - was successful and its budget was fully covered
	3.9	Develop new technological tools
4 Interoperability	4.5	Social capacity is the ensemble of resources available at various levels (e.g. individuals, organizations, communities) that can be used to anticipate, respond to, cope with, recover from and adapt to external stressors
7 Risk assessment	7.1	The flood revealed weaknesses in natural risks management in Poland, due to (i) poor structural measures, (ii) inefficient forecasting, monitoring

		and warning systems, (iii) pre-flood risk communication was very weak to non-existent
	7.2	Precise determination of the frequency, magnitude and risk is not possible
	7.3	The fact of the wave referred to as the "Hundred Years" or even "millennial" cannot put down the services responsible for flood protection and the public. History proves that the disaster of the same or even larger size may occur in the next year
8 Recovery	**8.1**	Number of reservoirs in Gdansk increased by 20 units. Most of them were built in the Upper Terrace. In total there are now 44 in Gdansk reservoirs. In total they can accommodate 457 790 m3 of rainwater
	8.2	From 4 to 11 increased the number of pumping stations for storm water drainage also built a drainage pumping station (in total there are 10)
	8.4	Assess and select the most vulnerable people of the fields (districts) most affected
	8.5	Analyze the factors and processes involved in social capacity building in selected localities, which suffered during the catastrophic floods in Poland in 1997 and 2001

Table 7: Summary of lessons learned from floods in Poland (2001)

Poland and the rest of Eastern Europe experienced in July 2001 floods that submerged many areas. Hurricanes, long-rains and storms caused the floods. Five provinces, Gdansk and Lodz were damaged. The area of these regions is 25% of the entire Poland (Poland area: 322.577 km square, the area of these provinces: 82.029 km sq.)

Communication was interrupted on the national road No. 1 and the railway line relationship Gdańsk - Tczew was seriously threatened. This is the main railway route linking Port and the Tri-City agglomeration to the rest of the country. In total, as a result of the flood losses in the infrastructure of the city was estimated at around 200 million PLN, not counting the losses incurred by the population.

Many villages and towns were flooded. Many farms were submerged and roads and railway lines were partially destroyed. Many bridges and railway viaducts were damaged. Rivers caused massive damages as it in some places exceeded its alarm level by 3 meters.

A lesson learned (1.1) is that the disaster preparedness department must have an assessment within the first days of the disaster and pinpoint the need for food, clothing, blankets, hygiene products, clean drinking water and first aid kits. The disaster preparedness department is responsible for implementation of the operation through regular monitoring, reports and lesson learned reviews (lesson learned 1.2).

During the floods in 2001 the rainwater from the mainstream of local creeks flowed into the Canal Radunia. The Canal have the maximum bandwidth to 25m^3/sec. As a result of the downpour, the channel overflowed as the flow channel was about five times larger than normal-125m^3/sec. Excess water overflowed the surrounding areas. The development of non-structural measures (land use planning, monitoring and warning systems, risk communication) is still relatively slow in Poland (Zielaziński, 2010). The predicted increase in flood frequency (Parry et al., 2007) calls for further intensification of this type of protective action (lesson learned 1.3).

A lesson learned (1.4) was that personal contact is the prevailing means of communication in smaller settlements, while mass media are preferred by those living in larger towns. Another lesson learned regarding knowledge (lesson learned 1.5) is that it is necessary to develop a mathematical model covering the whole area of Gdańsk, from all watercourses. This model must be based on the numerical map area, taking into account the state of development of the area. With this model you can predict in real time the effects of rainfall in different parts of the city. At the same time, this model would allow the simulation of various scenarios of rainfall and hydrological external source (water levels in the sea, water levels in the main riverbed of the Vistula). It is important to remember that since we cannot guard against floods, we must learn to live with them (lesson learned 1.6) and flooding should be treated as a normal phenomenon, occurring at intervals of several years (lesson learned 1.7).

Another lesson learned is to adapt new functionalities to the existent tools (lessons learned 2.1) Regarding interoperability, cooperation with mass media is crucial to providing information to public (lesson learned 2.8). Also when an event occurs, the funds provided by insurance companies might be an important element in the economic resources available (lesson learned 2.9).

A lesson learned (2.10) is to increase the number of measurement points and measurement of precipitation water levels on watercourses within the city. They have to be points of automatic measurement and transmission of information to the crisis center.

The flood affected 300 families and about 5 thousand people received "flooding card" entitling them to receive social assistance. A lesson learned (3.7) is the importance of volunteers. The local Polish Red Cross (PRC) chapters mobilized more than 200 volunteers in affected areas and distributed relief items, such as food, water, clothing, shoes, blankets and hygiene products. Another lesson learned (3.8) is that the first phase of the emergency operation - collection and distribution of relief items, organization of transport to the regions affected by floods, organization of search-and-rescue dog teams in Gdansk - was successful and its budget was fully covered. Another lesson learned was the importance of developing new technological tools that can be helpful during floods (lesson learned 3.9).

A lesson learned (4.5) is that social capacity is the ensemble of resources available at various levels (e.g. individuals, organizations, communities) that can be used to anticipate, respond to, cope with, recover from and adapt to external stressors.

Vistula River and its tributaries in the upper reaches caused many giant flood waves that moved north and destroyed villages and towns located nearby. One of the big cities in the northern Poland, which suffered from flooding, was Gdansk. On July 9th, 2001, in the afternoon Gdansk experienced a powerful cloudburst. As a result of rain poured streams and some districts of the city were under water. During the eight hours heavy rain, from 12.00 to 20.00, 127.7 mm of water rained per square meter. That's twice the monthly average for Gdansk rainfall in the month of July (68 mm/m^2). After the flood 20 reservoirs in Gdansk were built, most of them were built in the Upper Terrace. In total there are now 44 reservoirs in Gdansk. In total they can accommodate 457 790 m^3 of rainwater (lesson learned 8.1). A lesson learned (8.2) was to get more pumping stations (it went from 4 to 11) and storm water drainage pumping station (now there is a total of 10 drainage pumping stations).

The extraordinary scale of this event highlighted many weaknesses in natural risks (including flood risk) management in Poland. This is not only due to poor structural measures and inefficient forecasting, monitoring and warning systems, but also making it equally evident that pre-flood risk communication was very weak to non-existent (lesson learned 7.1).

Precise determination of the frequency, magnitude and risk is not possible (lesson learned 7.2). However, that one refers to "Hundred Years" or even "millennial" floods does not mean that services responsible for flood protection are not needed (lesson learned 7.3).

One should also assess and select the most vulnerable people in the districts most affected (lesson learned 8.4). A lesson learned (8.5) was to analyze the factors and processes involved in social capacity building in selected local villages, which suffered during the catastrophic floods in Poland in 1997 and 2001.

4.2 Floods in Panama (2012)

Problem areas		Lessons learned from floods
2 Communication	**2.2**	The communication system should be strengthened with wider coverage within the country
	2.3	Improve the communication flow between the local committees and headquarters
	2.4	Identify a focal point for the communication between local committees and headquarters
	2.5	Training should be provided to people in charge of managing the information during an emergency
	2.6	Dissemination of the action plan among the supporting staff and volunteers
3 Logistics	**3.1**	Establish a pre-agreement with other institutions and private companies in order to get resources, equipment, trucks during the emergency
	3.2	Classify properly foods and cleaning items when packing them
	3.3	Maintain an updated control of the inventory to avoid deterioration
	3.4	Establish an emergency fund of first aid assets
	3.5	Pre-positioning of equipment and material in the committees by the headquarters
	3.6	Provide training in logistics and distribution to the practitioners and volunteers
5 Coordination	**5.1**	The coordination should be improved among the temporary shelters
	5.2	Strengthen coordination mechanisms among different responders
	5.3	Maintain regular meetings to improve the coordination with civil protection
	5.4	Improve the coordination channels between the governmental institutions and response system
	5.5	Define the roles and responsibilities of each responder and disseminate the action plan within administrative entities and volunteers
	5.6	Maintain an active participation of private companies within the decision

		making and coordination meetings
6 Management of volunteers	**6.1**	Establish a record of entry of volunteers and the abilities required for the entry
	6.2	Delegate functions to the volunteers in order to manage the operation
	6.3	Establish monitoring mechanisms to assess the improvement level of the volunteers' training and enhance the response capacity of volunteers' leaders
	6.4	Establish and disseminate encouraging programs for volunteers to take part in response activities and promote and provide training capacities to improve their response abilities
	6.5	Provide psychological support to the volunteers
	6.6	Improve the communication between volunteers and managers
	6.7	Establish volunteers' health prevention measures

Table 8: Summary of lessons learned from floods in Panama (2012)

In November 2012 Panama experienced heavy precipitation which resulted in "floods, landslides and damage to livelihoods and communications in the western provinces of Colón and Panama" (Red Cross Panama 2013). The government in Panama declared a state of emergency. The floods caused five deaths and over 6,500 families were affected. It was registered that 2,570 houses were damaged. Critical infrastructures like hospitals, roads and aqueducts affected by the flood. "21 aqueducts were damaged […] and over 8 hospitals were affected by the floods" (ibid).

During the floods communication was a major challenge. In several places of the country the radio-communication coverage was limited and the messages would often not arrive. A lesson learned (2.2) is to strengthen the communication system and expand the coverage within the country. The EU-project BRIDGE (Hellwagner 2014) also highlighted the need to develop robust and resilient communication because "When a disaster strikes, communication and networking facilities will be at least partially affected and become non-operational". BRIDGE is working on providing "a wireless mesh network that establishes ad-hoc networking services on an incident site, as far as physically possible" (Hellwagner 2014).

The communication flow between the local committees and Red Cross headquarters was limited. The flow of communication should be improved between the local committees and headquarters (lesson learned 2.3). Another lesson learned (2.4) regarding strengthening the communication is to identify a focal point for the communication between local committees and headquarters.

There were few people who had the knowledge and capacity to manage the received information. A lesson learned (2.5) is to provide training to the people in charge of managing the information during an emergency. Another challenge was that the local committee did not know the content of the Red Cross action plan. A lesson learned (2.6) is to disseminate the action plan among the supporting staff and volunteers during the preparation. The action plan lacked clearly defined roles and responsibilities for the responders.

During the state of emergency there were several challenges with logistics and distribution. Panama lacked means of transport to distribute the required equipment. It is vital to strengthen the means and capacities for transportation and distribution of the required equipment. This

could be done by establishing a “pre-agreement with other institutions and private companies in order to get resources, equipment, trucks during the emergency” (lesson learned 3.1).

Another problem was the coordination and management of food and cleaning items. A lesson learned (3.2) was to properly classify food and cleaning items when packing them. One also experienced that food expired before one managed to distribute it to the flood victims due to the lack of proper management. A lesson learned (3.3) was to maintain an updated control of the inventory to avoid deterioration (ibid).

The headquarters were delayed when sending the required help. A lesson learned (3.4) is to establish an emergency fund of first aid assets and equipment. One must also pre-position equipment and material in the committees by the headquarters (lesson learned 3.5). Another lesson learned (3.6) is that practitioners and volunteers who work with these topics must receive training in logistics and distribution (ibid).

Several lessons learned were drawn regarding coordination. For example there is deficient coordination of the authorities in the management of temporary shelters for people who are hurt. The coordination should be improved among the temporary shelters (lesson learned 5.1).

Within the teams there was little coordination among the responders. The lesson learned (5.2) is to strengthen coordination mechanisms among different responders. There was also lack of regional coordination meetings. A lesson learned (5.3) was to maintain regular meetings to improve the coordination with civil protection. Also there was little coordination between the response agents and governmental entities. A lesson learned (5.4) is to improve the coordination channels between the governmental institutions and response systems.

The lesson learned (5.5) is to define the roles and responsibilities of each responder and disseminate the action plan within administrative entities and volunteers.

Private companies did not participate in the coordination meetings. A lesson learned (5.6) is to maintain an active participation of private companies within the decision making and coordination meetings.

Management of volunteers also proved to be a challenge. This corresponds to findings from ACRIMAS (2011:5) that highlighted that management of volunteers is one of the main areas for development.

There were deficiencies in the management of shifts of volunteers. A lesson learned (6.1) was to establish a record of entry of volunteers and the abilities required for the entry. Also the volunteers were not assigned to any specific function. A lesson learned (6.2) was to delegate functions to the volunteers so they could carry out actions based on the action plan already developed. Here one also needs a leader who will coordinate the response agents and the volunteers.

Few opportunities for volunteers to improve their response capacity and few monitored the improvement of the response capacity among the volunteers. A lesson learned (6.3) is to establish monitoring mechanisms to assess the improvement level of the volunteers’ training and enhance the response capacity of volunteers’ leaders. One should also improve the coordination between the regional and national responders through strategic alliances.

A lesson learned (6.4) is to establish and disseminate encouraging programs for volunteers to take part in response activities and promote and provide training capacities to improve their response abilities. Other lessons learned regarding taking care of volunteers is to (i) provide

psychological support to the volunteers (lesson learned 6.5), (ii) provide training and preparation to the volunteers, (iii) improve the communication between volunteers and managers (lesson learned 6.6), (iv) establish volunteers' health prevention measures (lesson learned 6.7) and (v) increase the level of awareness in the society through training exercises and talks (Red Cross Panama 2013).

4.3 The recent Floods in Europe (2013)

Problem areas/ Lessons learned		Lessons learned from floods
1 Knowledge	**1.8**	Strengthening the risk awareness and availability of information about flood risks and damage
	1.9	Flood maps should be disseminated widely and be more accessible for the public to enhance the awareness and improve flood preparedness
3 Logistics	**3.10**	Making use of additional means of protection, such as flood water retention areas along rivers
	3.13	Applying improved flood resilience structures which better withstand floods and mitigate risks when rebuilding
4 Interoperability	**4.4**	Strengthening multi-stakeholder alliances in order to build long-term resilience
6 Management of volunteers	**6.8**	Finding innovative ways of engaging people civil protection and strengthening cooperativeness
8 Recovery	**8.3**	Making the inhabitants of affected flood areas an offer for resettlement

Table 9: Summary of lessons learned from the recent floods in Europe (2013)

The recent floods in central Europe, which took place from end of May to the beginning of June 2013, was caused by heavy rainfalls for days, especially across the northern Alps areas. After the floods in the years 2002 and 2005 it was categorized as a century extreme event because of the intensity of rainfalls and – as a consequence – the floods, in particular along the River Danube and Elbe. Several European countries were affected by the crisis, mainly Germany, Austria, Switzerland, Czech Republic, Poland, Slovakia and Hungary. Because of the flood crisis thousands of persons were affected, houses were devastated, and villages had to be kept out of the water masses. It was difficult to measure the damages, but it was estimated that the flood in 2013 cost more than 15 billion Euros (note: even more than the flood in 2002 which cost about 15 billion Euros). In the end, the floods resulted in 20 deaths and thousands of people were forced to seek temporary shelter.

The key lesson learned (1.8) is strengthening the risk awareness and availability of information about flood risks and damage. Most of the losses were registered in high hazard areas with high probability of floods. It was recognised that there is a high need to make data for disaster risk reduction accessible and open for the public. For instance, existing flood hazard maps are a reliable measure and indicator. Hence, a lesson learned (1.9) is that flood maps should be disseminated widely and more accessible for the public. This is done to enhance the awareness and understanding of the situation (potential flood risks) in the population and to improve the preparedness in what to do when the flood takes place. Moreover, these maps should be adopted consequently in the planning process for construction and risk mitigation policies on a

mandatory basis. For the latter, an improved understanding of the needs of the affected communities is needed (i.e. A 'needs analysis') (Gremli et al. 2013). A best practice related to the civil awareness of floods was provided by the Austrian Red Cross. They developed an online application (app-name: Worst Case Hero) where interested audiences can check with a funny game what they know about flooding (Austrian Red Cross 2014).

Another lesson learned (3.10) is making use of additional means of protection, such as flood water retention areas along rivers. Technical protection measures – whether physical or permanent such as levees or flood walls – provides an important option against flood disasters but does not deliver complete safety. In addition, new flood water retention areas need to be created which allow storing significant volumes of water, lowering flood peaks and reducing the water downstream. These measures are often more reliable and less prone to fail. This can be put into practice by widening areas where rivers flow and creating designated flood plains but are – without any doubt – difficult to realise. If this is not possible, to build temporary structures and mobile barriers still offers as a reasonable alternative. Nevertheless, these measures require good scientific knowledge, careful land use/emergency planning and pre-installation (technical monitoring), warning services (people-centred dissemination, and sufficient and early information), deployment and training in order to be set up in time (Gremli et al. 2013; IFRC). For instance, the Provincial Governments of Upper and Lower Austria decided to extend the protective measures and start to accelerate special programs to build flood resilience structures (Ecker, 2013).

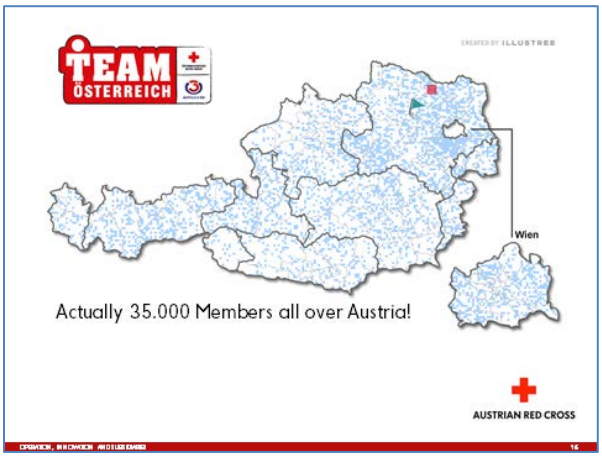
Another lesson learned (3.13) is applying improved flood resilience structures which better withstand floods and mitigate risks when rebuilding. After heavy floods vulnerable installations, important parts of public infrastructure and private buildings need to be repaired. This is necessary again and again after each flood disaster. Therefore, buildings that are likely to be affected (again) need to have improved flood resilience. An increased awareness about how to make structures and buildings more resilient to floods is needed because this is often associated to costs. Additionally, it is necessary to provide incentives in order to inform and advice owners or to reward them for installing improved flood resilience standards, e.g. through state relief payments (Gremli et al. 2013).

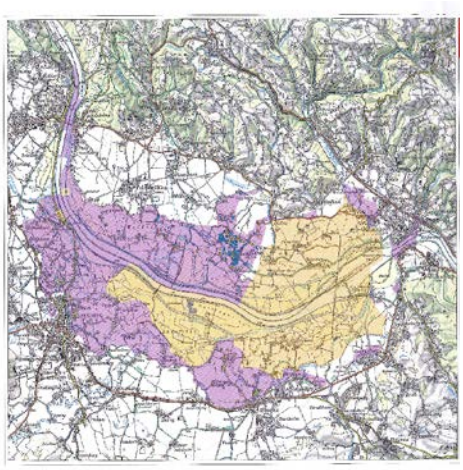
Regarding interoperability, a lesson learned (4.4) is to strengthen multi-stakeholder alliances in order to build long-term resilience. There is an urgent need to improve the coordination, participation of various stakeholders engaged in pre-event mitigation and measures to enhance flood resilience. For risk reduction a collaboration between public and private sectors seem to be beneficial, e.g. between government authorities, NGO/NPO, insurance companies and so on (Gremli et al. 2013). For a better preparedness technological means should be used more efficiently, for mapping resources (e.g. databases and mobilisation systems), for sharing best practices (e.g. knowledge networks and practice communities), and for training responders and communities (e.g. effective use of technology) (IFRC 2014).

A lesson learned (6.8) was to find innovative ways of engaging people in civil protection and strengthening cooperativeness. If flood disasters hit heavily populated areas, their effect is not devastating and rapidly disposable. First responders are usually not able to provide long-term assistance and especially not recovery activities, i.e. cleaning-up. For instance in Austria a lesson learned after several extensive disasters and emergencies was that many people want to assist as spontaneous volunteers. A best practice was the disaster management initiative TEAM Österreich ("Team Austria"). Team Austria was launched in 2007 with the aim to channel existing spontaneous helpfulness of people before a disaster and so to make use of these resources directly after a disastrous event has happened. Volunteers are asked to sign-up on a platform of the Austrian Red Cross and Ö3 (biggest Austrian radio broadcaster) for their availability to help during an emergency for disaster relief operations. Currently there are 35.000

volunteers registered as a “Team Austria” member. Wherever necessary, crisis teams, authorities, etc. may request for their assistance, selected according to their qualifications and their distance to the scene. They are trained in disaster management and supervised for a potentially upcoming crisis. In a case of emergency they may cover a broad range of activities, ranging from simple manual activities like sorting, packing of relief goods, shovel snow, fill sand bags, distribute relief goods, take care of children, help with administration etc. (Austrian Red Cross 2014; Team Österreich 2014a)

Figure 2: Team Austria map of cooperativeness (Team Österreich 2014b) (left) and Figure 3: Absiedelungsgebiete - areas of resettlement (right)





A lesson learned (8.3) regarding the recovery phase is that the government should make the inhabitants of affected flood areas an offer for resettlement. The central European floods in 2013 were a centenarian flood, but also showed that they do not occur only once every 100 years and certain areas might be affected again. Because no comprehensive protection is possible resettlements might be an option. For instance, the Provincial Government of Upper Austria decided to make the inhabitants an offer for resettlement, i.e. to the inhabitants of an affected area of 25 km² in the Eferdinger Becken. The criteria for resettlement are: To those who are living in the most affected areas an offer was made for a voluntary resettlement choice. Based on an appraisal report the state of construction before the flood will be estimated of which 50 % is covered by the Federal State, 30 % of the Province, and 20 % by the owner. In addition, it is not allowed any more to build estate in these areas (building and construction ban). Nevertheless, first experiences have shown that this is a sensitive issue for the population. This is because many families live there for several generations and for some it is the economic basis for living (OÖN 2014).

4.4 Floods in Wroclaw, Poland (2010)

Problem areas/ Lessons learned		Lessons learned from floods
2 Communication	**2.7**	Platform for the exchange of information between authorities responsible for crisis management and agencies should be created
	2.8	Cooperation with mass media is crucial to providing information to public
3 Logistics	**3.11**	Legislation that allows monitoring of municipal flood storage equipment from the provincial level must be created. This is because stocks in those warehouses were inadequate to scale of event
	3.12	Number of vessels, lighting equipment and other specific equipment should be increased in flood warehouses and emergency services
	3.14	Implementation of remote monitoring devices to provide water level information for responsible authorities
	3.15	Hydrological monitoring and crisis management should cover all water bodies
	3.16	Digital maps of potential flood risk areas should be prepared
	3.17	Efforts should be made to cause provincial and district crisis management centers were fully modern and functional structures
4 Interoperability	**4.1**	Relevant agencies should create unified maps with a detailed evaluation of threats and vulnerabilities list of hydro technique facilities
	4.2	Better coordination of military forces by civilian specialists during flood protection is needed
	4.3	It should be clarified regulations regarding crisis management competences and responsibilities such as district governor in relation to the municipality
	4.6	One should strengthen (i) supervision, (ii) spatial planning procedures for floodplains, (iii) having a closer link with the spatial planning law, water law and construction law in this aspect. (iv) changes in legislation to facilitate the process of expropriation of land for the construction of levees
5 Coordination	**5.7**	The law should be changed to allow accurate determination of responsibility for particular section of embankments, dams and other hydraulic engineering is needed

Table 10: Summary of lessons learned from floods in Wroclaw, Poland (2010)

In May-June 2010 Poland experienced major floods. The direct cause of flooding in Lower Silesia in the second half of May 2010 was intense and continuous rainfall in the eastern part of the Odra river basin. They lasted from 16th May to 19th of May. The Provincial Crisis Management Team during the floods gathered and had 48 meetings. The frequency of meetings was adapted to the scale of rising threats. All meetings were attended by 15 members, supported by others according to their needs.

The effects of the floods in May-June 2010 caused major losses in infrastructure. It was estimated to be over 4,2 billion euros. This included losses in municipalities and counties infrastructure (roads, schools, etc.) and the Regional Water Management Authority, Provincial Administration of Melioration and Water Installation etc. Wroclaw experienced also major losses in agriculture; over 1,881 farms were affected, as well as private households.

In a crisis situation there should be a rapid exchange of data between crisis management authorities. It should be established a platform for the exchange of information between authorities responsible for crisis management and agencies that help in removing the effects of floods (lesson learned 2.7). The tasks of the municipalities should include the creation of networks of local leaders who know the phenomena of floods. In an emergency situation a skilled person with training would be able to objectively assess where strengthening of embankments are necessary.

An important role of the mass media is to inform the public about the flood situation, or other hazards. Information should be given on a regular basis, by spokespersons in organized press conferences, but also by the employees of crisis management centers (lesson learned 2.8).

During the floods stocks were gathered from the flood protection warehouses. The resources gathered in flood protection warehouses at the local administrative level (municipalities and counties) were inadequate to the scale of the threat. It is therefore necessary to introduce such legislation, which would allow for the monitoring of flood storage equipment in municipalities and counties from the provincial level (lesson learned 3.11). Another lesson learned (3.12) is that one should also increase the number of vessels (especially boats with outboard motors), lighting equipment and other equipment which may be used during floods. High-efficiency pumps and refill sandbags kits should be bought. One should also purchase additional portable measuring patches of centimeter scales, which will allow the correct measures of water levels in sensitive measuring points.
Another lesson learned (3.14) is to implement remote monitoring devices for flood protection, from which data would be sent to the Regional Water Management Authority decision-making centers, and could be made available on a regular basis for example on the website.

The hydrological monitoring and crisis management should cover all water bodies (including those industrial or energy) (lesson learned 3.15). The digital maps of land areas of potential flood risk for extreme flows should be prepared (lesson learned 3.16).

Efforts should be made to get the provincial and district crisis management centers fully modern and functional structures (lesson learned 3.17). It should be built to a certain standard and employ professionals and educated employees (including meteorologists, hydrologists, specialists in the field of hydraulic engineering). In addition, crisis management centers should be equipped with the GIS maps and decision support systems.

After the flood in 2010 the Governor's Office of Lower Silesian Wroclaw wrote a flood report with lesson learned about improving the national flood protection and reduces flood losses. There is a need to implement short-and long-term programs to improve the technical condition of embankments and flood protection devices. At the same time attention should be paid to the improvement of melioration facilities. According to preliminary estimates, in Lower Silesia 70 percent of embankments is in poor condition.

A unified information platform containing hydrological data in the region should be established (lesson learned 4.1). Provincial Administration of Melioration and Water Installation and Regional Water Management Authority should create unified maps with a detailed evaluation of threats and vulnerabilities and a list of hydro technique facilities. Information about the state of

the levees, obtained during the inspection must be forwarded to the District Crisis Management Centers. One should create a system to control flood water flow covering the entire area of the province. And one must pay attention to the preservation of the corresponding flood retention for tanks.

During the floods in May and June 2010 Poland used all forces and means possible to work with preventive and rescue efforts for central and local government. These played an important role during the flood; the State Fire Service and the Voluntary Fire Brigade, Units of the Armed Forces, Police and inmates of penal institutions dislocated in the province. A lesson learned (4.2) is to have better coordination of military forces by civilian specialists during flood protection.

Lessons learned relating to competence is that regulations regarding crisis management competence and responsibility should be clarified; for example a district governor's role in relation to the municipality so that the competences do not overlap (lesson learned 4.3). It is crucial to spell out the responsibilities each department have when participating in the flood operation, in particular the relationship: county crisis management center - administrator of levees etc.

There were several lessons learned (4.6) regarding legislation. One should strengthen supervision and spatial planning procedures for floodplains. One should consider having a closer link with the spatial planning law, water law and construction law in this aspect. One should have changes in legislation to facilitate the process of expropriation of land for the construction of levees. Flood protection should be a priority compared to "ecological practice".

Another lessons learned (5.7) is that the law should be changed to allow accurate determination of responsibility for particular section of embankments, dams and other hydraulic engineering.

4.5 Conclusions

The main problem areas identified in the four cases of floods are interoperability (6 lessons learned), knowledge (9 lessons learned), management of volunteers (8 lessons learned), communication (10 lesson learned), risk assessment (3 lessons learned), coordination (7), recovery (6) and logistics (17 lessons learned).

Studying the flood cases, logistics stands out as the most dominant area for crisis managers. In the ELITE workshop on floods the ELITE CoP members argued that there are often shortages of sandbags and other equipment used during floods. The lesson learned proposed by several ELITE CoP members was to expand the rescue resources in countries where there is scarcity of high efficiency pumps, high power generators, sand bags, big bags and other useful equipment.

One ELITE CoP member argued during the workshop that "a great amount of resources is needed for a very short time during crisis, and reserves will get smaller and smaller every hour […] However, there may be reluctance to prepare for low possibility events and have large stocks of resources that may be unused for a long period of time" (Maal and Grunnan 2013b:23). A lesson learned proposed in the floods workshop is to have updated "national databases of equipment in the country and abroad" (Maal and Grunnan 2013b:28). This is important in order to know what type of resources that a country or region can use in a crisis. The ELITE CoP members argued that "if one were able to integrate all the rescue resources into a single system this would have solved many problems relating to equipment" (ibid).

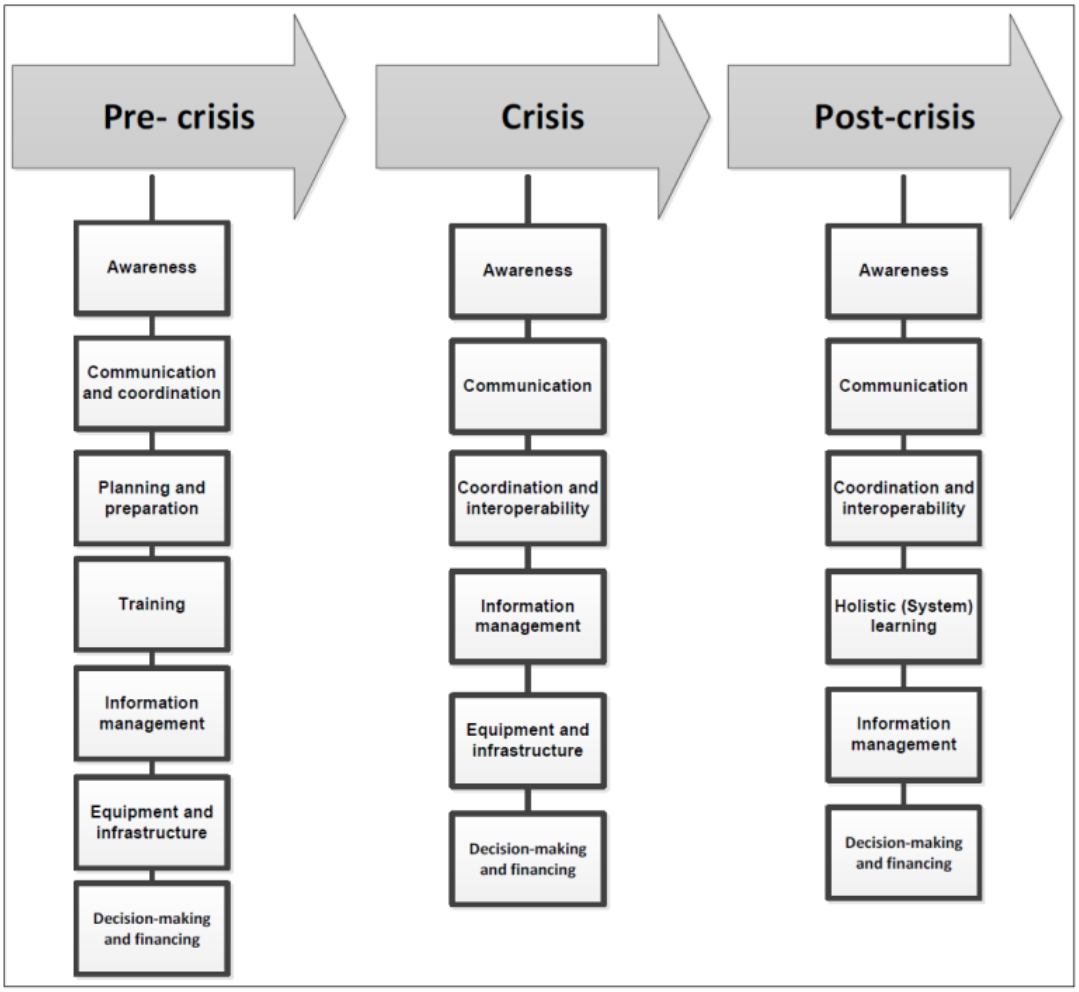


Figure 4: Lessons learned from the ELITE Floods workshop 2013

Above is a figure of the problem areas identified in the ELITE floods workshop in 2013. Many of the problem areas in figure 4 are the same in the different phases (pre-crisis, during and post-crisis). The problem areas of *awareness* and *holistic system learning* mentioned by the ELITE CoP have been incorporated into the broader topic of *knowledge* in this report. *Management of volunteers* was mentioned in the floods workshop as well as the holistic workshop. However, in the Floods workshop this was mentioned as a sub-topic under *interoperability*. In the amended framework presented in chapter 6 *interoperability* will be the main topic while *management of volunteers* as a sub-topic.

5. LESSONS LEARNED FROM EARTHQUAKES

According to the chief of the inter-governmental panel on climate change (IPCC) disasters such as floods, earthquakes and tsunamis will occur more frequently (The Times of India 2011). He explains that human actions are increasingly interfering and affecting the delicate balance of nature. Europe is also exposed to this threat and has a long history of devastating earthquakes. The EU funded research project SHARE has produced a map displaying that the Balkans and Mediterranean countries as well as Turkey are among the most exposed regions and are all at higher risk of earthquakes than other parts of the continent (Du Brulle 2014).

This chapter includes a representative selection of tangible lessons learned from major earthquakes that have happened in different parts of the world, including Europe, Asia and America, over the last ten years. The earthquake lessons learned are structured around categories defined in the lessons learned framework (see chapter 2). However, there are also some additional categories that have proved to be especially relevant for earthquakes, like *risk management* and *response*.

Several of the cases were discussed and used as examples during the ELITE earthquakes workshop in 2013 by the ELITE CoP, especially the earthquake in L'Aquila in Italy and the earthquake in Haiti. This is one of the reasons these cases were selected for this study. However, the ELITE lessons learned report on earthquakes focused on recent examples from Italy; the L'Aquila and Emilia earthquakes (Maal et al 2013), and this chapter will therefore have more information about other earthquakes, for example the earthquake in China in 2008, than the Italian case.

In addition, the consortium partners with expertise in the field of earthquakes have chosen the other cases as they are good examples of earthquakes that might confirm findings already established, as well as bringing additional lessons learned. In the fourth and final workshop in January 2014 a reporting exercise was held to validate the prototype of the ELITE living document, to test and validate the scientific framework established for lessons learned reporting, and to discuss lessons learned from a major disaster with cascading effects with the CoP members. The 2010 Japan earthquake and tsunami was chosen for this purpose (see chapter 2 for more information). In this workshop, the CoP got the task of writing a lessons learned report on the Japanese disaster based on information found and gathered in the ELITE living document. The lessons learned gathered from this exercise are the sources for the Japan case (see 5.5).

This chapter includes a comprehensive description of tangible lessons learned gathered from various sources; Regional lessons learned reports, lessons learned reports from international NGO's, consulting companies, academic papers and from the ELITE CoP (i.e. from the ELITE earthquake workshop in 2013 and the holistic workshop in 2014).

The lessons learned in the following sections are numbered and categorized according to these main problem areas identified related to the earthquake cases:

1. Knowledge
2. Communication
3. Logistics
4. Interoperability
5. Coordination
6. Risk management
7. Risk assessment

8. Prevention/Preparation

9. Training

10. Recovery

These categories will be used in text describing the lessons learned, and every lesson learned within each of the categories gets a number, i.e. all the lessons learned related to *Knowledge* are numbered 1.1, 1.2, 1.3 etc., and all lessons learned related to *Communication* are numbered 2.1, 2.2, 2.3 and so on.

An overview of the lessons learned in each case is presented in a table in the beginning of each case, to facilitate the learning experience. All earthquake lessons learned from all cases are summarized in *one* table in chapter 6.

5.1 Earthquake in Kocaeli-Golcuk & Duzce-Bolu,Turkey (1999)

Problem areas/ Lessons learned		Lessons learned from earthquakes
1 Knowledge	**1.1**	Improve safe construction practices and control the quality of construction.
	1.2	Learn from the earthquake-resistance retrofitting program in Athens.
	1.3	Turkey's lessons could have internationally importance: there are some sprawling developing cities worldwide facing similar challenges where rapid and uncontrolled urban development has eclipsed housing safety standards
	1.4	Handing inspection should be publicly regulated
	1.5	Turkey needs to take more quality control measures to assure that buildings are designed and built according to code.
2 Communication	**2.1**	Create a “top down-bottom up” crisis action centre with backup communications
6 Risk management	**6.1**	Create and practice a national quick response program for search and rescue
	6.2	Create and practice preparation for massive casualties.
	6.3	Clarify the role of the gendarmeries in national disasters
	6.4	The Public Works Law should be upgraded and adapted to new technology.
	6.5	Improved international relations with European Union and with Greece (quake diplomacy).
	6.6	Improve all provincial centres with high-tech, dog-supported emergency search teams.

Table 11: Summary of lessons learned from Earthquake in Turkey (1999)

On August 17, 1999, a magnitude 7.4 earthquake rocked western Turkey at 3:02 a.m. for 45 seconds near the city of Izmit in the Kocaeli province (Bellamy 2010). The earthquake occurred along the North Anatolian fault, a strike-slip fault. The result was a large number of casualties and damage to buildings and infrastructure in the region. There were approximately 20,000 people killed and 50,000 injured along with over $30 billion in damage (Anderson 2001). At least 20,000 buildings sustained heavy damage or collapsed (EQE 1999). Many buildings collapsed due to liquefaction of soil near the Izmit Bay, but a large percentage also were either not properly designed or constructed. This earthquake was considered by many to be the most destructive in Turkey's strong seismic history due to the timing and location near a highly populated region with poorly constructed buildings.

Several problems were revealed related to communication. The President and Prime Minister were unable to communicate with Ankara from Istanbul for up to four hours after the earthquake stroke and there was no operational communications back-up. A lesson learned is that is important to create a “top down-bottom up” crisis action centre with backup communications (2.1). The press, television, and radio coverage was continuous and around the clock for about a week by most of Turkey’s private and government stations. The government radio and television stations (TRT) continued with frequent earthquake specials and updates well into September. The media were very sympathetic toward the foreign assistance and aid; however, they were exceptionally critical of the Turkish government and those who had condoned shoddy construction, particularly those who had become wealthy in the building industry. The laws of preventing criticism of the government leaders and its institutions were overtly ignored by much of the press.

The earthquake demonstrated the improper building constructions that had flourished during the ‘80s and ‘90s. The remains of destroyed buildings along the coast had seashells and beach sand mixed in with the concrete, a cost-cutting shortcut that proved fatal. A key lesson learned is improving safe construction practices and control the quality of construction (1.1), and it will be useful to learn from the earthquake-resistance retrofitting program in Athens (1.2).

Negligence in building construction was used as ways to cut costs. There was no structural engineer to verify that earthquake-resistant buildings were being built as designed, buildings were built with poor or inappropriate building materials along with poor workmanship, buildings were knowingly built in regions with soils highly prone to liquefaction, and in some causes buildings were built based on previous designs rather than being engineered specifically. Some buildings were not even designed or detailed properly by engineers to handle the predicted seismic loads. Turkey's lessons could have internationally importance: there are some sprawling developing cities worldwide that facing similar challenges, Lima, Tehran and Karachi, where rapid and uncontrolled urban development has eclipsed housing safety standards (1.3).

Handing inspection of building standards over to private companies is a mistake and handing inspection should be publicly regulated; otherwise the relationship between contractors and regulatory firms is open to misuse (1.4).

According to the World Bank, only 15% of the residences in the Istanbul urban area are insured for earthquake, in other areas of the country the estimates are as low as 2%. Domestic insurers have insufficient capital. A lesson learned is that Turkey needs to take more quality control measures to assure that buildings are designed and built according to code (1.5).

The disaster response had a slow start. Coordination and command at all levels were very limited especially for the first day. There was duplication of tasks and uncovered responsibilities. The sheer size of the disaster (covering a very large, heavily populated urban and industrial area) combined with the initially limited national and local institutional and organizational response, detracted from a more efficient timely start for the emergency phase and rescue management. The most important lesson learned is therefore to create and practice a national quick response program for search and rescue (6.1), and furthermore, to create and practice

preparation for massive casualties (6.2). The government of Turkey has implemented disaster response plans during past earthquake disasters but in this case, the prime minister's crisis action centre was reportedly activated within hours of the event, but no on-scene response from the national or provincial public agencies occurred for an excessive period. The earthquake calls for a clarification roles in national disasters, e.g. of the gendarmerie (6.3).

The military was directly affected by the devastation of its naval headquarters at Gölcük; the fault ran through the naval base. There were many casualties, including many flag officers killed. There was also a significant fire at the Tüpras Refinery, and main roads and railway were closed. These effects highlight the importance of avoiding building dangerous or peculiar structures in areas with seismic risk.

Law enforcement, particularly crowd and traffic control, was reportedly lacking during the first day or two. Evacuation of victims was conducted by whatever means available: private automobile, tractor, taxi, truck, ambulance, ferryboat, hydrofoil, private boat, and helicopter. As a result of the poor coordination and cooperation among the organizations, the Public Works Law should be upgraded and adapted to new technology (6.4).

The initial search and rescue was unorganized and mostly performed by the earthquake survivors themselves. These volunteers were not trained emergency personnel, and their efforts were limited. Several survivors said that they waited all day before receiving even minimal assistance; others waited up to four days. Distribution of water and food was slowed by lack of organized planning, resulting in large amounts of perishable food (bread) being dumped on the ground uneaten.

A national volunteer's search and rescue team (AKUT) began working in Istanbul within 24 hours of the event. In search and rescue attempts by international teams, there was friction between those who were trying to hear sounds from possible survivors buried under the concrete and debris and the heavy equipment operators, who wanted to bulldoze, load, and remove the damaged buildings. The government did request international assistance for emergency aid, fire fighting, and eventually recovery, including restoration and reconstruction.

The Turkish Red Cross was harshly criticized for its slow response and for the quality of its canvas tents, which had no floors and were not waterproof. It was also criticized for selling burial shrouds for the deceased.

The most important relevant lessons learned related to the relief response were improved international relations with European Union and with Greece (quake diplomacy) (6.5) and to improve all provincial centres with high-tech, dog-supported emergency search teams (6.6).

5.2 Earthquake in L'Aquila, Italy (2009)

Problem areas/ Lessons learned		Lessons learned from earthquakes
1 Knowledge	1.6	Seismic code and categorization
8 Prevention	8.1	Protect the historical and cultural heritage
	8.2	Protect the strategic and essential facilities
	8.3	Anchorage and bracing of hazardous equipment and content is recommended
9 Training	9.1	Emergency response: a formal post-earthquake engineering inspection program

Table 12: Summary of lessons learned from earthquake in L'Aquila, Italy (2009)

On April 6th, 2009, a 6.3 magnitude earthquake occurred approximately 85 km northeast of Rome in central Italy. The university town of L'Aquila (which means "the eagle" in Italian) has one of the oldest educational institutions in Europe and a population of close to 70,000. L'Aquila and nearby villages were especially hard-hit by the earthquake.

This earthquake resulted in 305 fatalities and thousands of injuries, displaced more than 25,000 people, and caused significant damage to more than 10,000 buildings in the L'Aquila area. The event was felt throughout central Italy, including Rome. Most of the deaths occurred when people were buried under collapsed buildings. After the earthquake, the Italian government set up shelters for people who were displaced. The total cost of this earthquake, including financial losses and reconstruction efforts, is expected to exceed US$16 billion. Earthquake damage was not limited to buildings, however; roadways and bridges were also affected. In addition, industrial and commercial structures sustained damage, leading to business interruption and other financial losses.

Many types of damages from this event have also been observed in past earthquakes. For example, damage to unreinforced masonry structures was widespread. However, buildings constructed in recent years—and supposedly according to more advanced seismic codes—including hospitals, industrial plants, and college campus buildings, also experienced damage. A particular feature of this earthquake was the significant damage to historic and vintage buildings, including churches. Many of these structures were built centuries ago, and therefore such damage is a great loss.

The 2006 earthquake code used in Italy divides the country into five seismic regions: Zones 1, 2, 3a, 3b, and 4. Zone 1 has the highest intensity. This system is similar to that used by earlier editions of the building codes in the United States. A close-up of the seismic zonation for L'Aquila, as identified in the 2006 earthquake code, shows the L'Aquila area to be in Zone 2, which indicates moderate seismicity. However, past earthquakes and fault maps indicate that the area really should be rated as Zone 1 or high seismic hazard. The April 2009 earthquake was a moderate event that resulted in localized but spectacular damage. A large earthquake in this area, which is probable, would result in thousands of casualties and much greater 5 and widespread damage.

Starting from 1 July 2009, according to the law of 2008, there is a specific categorization for the territory that considers the risk of area (square with 5 km per each side). So it's very

important know how the territories respond to the seismic waves in order to set up the right methodologies to build the buildings. A Zone 1 designation is recommended for the L'Aquila City.

For example, Onna is a small village in a valley near a river about 6 km east of L'Aquila. Many buildings either collapsed or were near collapse. Soft soils in this river meadow area may have contributed to the higher ground acceleration and destruction. Earthquake motions tend to increase in soft-soil areas. Residential buildings in Onna were made of unreinforced brick and concrete floors, one of the most dangerous building types. More than 40 people were killed in this village of 300. One residential three-story building was leveled. Such a collapse is typically sudden (brittle) and does not provide any warning to the occupants to escape.

The key lesson learned deriving from this experience is that correct categorization and use seismic code is of great importance (1.6). Furthermore, the L'Aquila earthquake demonstrated the importance of protecting the historical and cultural heritage in a proper manner (8.1). The heritage of the L'Aquila region's medieval past and treasured architecture is represented by churches and monuments. The city itself dates back to the 1240s. L'Aquila and the surrounding area experienced sporadic but significant damage to historic buildings, some of which date back to Roman times, the Middle Ages, or the Renaissance. Given the heritage of this area, it is important to protect these unique and invaluable structures. These buildings are typically of unreinforced masonry (URM) or stone construction. Fortunately, this was a moderate earthquake. The damage would have been much more substantial if this had been a larger seismic event. Also, a lesson learned is to protect the strategic and essential facilities (8.2). Essential structures such as schools, hospitals, and emergency response facilities should be designed to protect life safety and remain functional during and after earthquakes. Therefore, a more stringent seismic design is needed for these structures. The L'Aquila earthquake caused significant damage to essential facilities. Also troubling is the damage to recent-vintage buildings that should have been constructed to comply with more modern codes. More severe damage or collapse would have occurred if this had been a larger earthquake. Seismic retrofit is simpler and more cost-effective than post-earthquake reconstruction.

Damage to industrial buildings in the affected region directly correlated to the construction type and the distance to the earthquake epicenter. For example, industrial buildings in the L'Aquila area were significantly affected. Many of these buildings are of newer vintage, and given the low amplitude of the earthquake, the level of damage was a surprise. Most of the damaged structures had precast- concrete framing systems. Several industrial facilities, approximately 50 to 70 km from the epicenter, were surveyed after the earthquake. Such a distance is generally too long to cause damage to modern buildings. However, for precast-concrete-frame structures, minor cracking was observed, highlighting the low seismic resistance of this building type. The equipment at industrial plants in both the L'Aquila area and Pescara area was generally unanchored or inadequately braced for earthquakes. As seen during other earthquakes, like Sichuan, China, unanchored equipment will move and/or collapse, causing major business interruption. A lesson learned is that anchorage and bracing of hazardous equipment and content is recommended (8.3). It is very cost-effective to retrofit this equipment using simple anchors.

Another key lesson learned from this earthquake is introducing a formal post-earthquake engineering inspection program (9.1). Such inspections would have evaluated the condition of the buildings, tagged them for safety (green, yellow, or red), and informed people whether they could safely reoccupy their homes and businesses. Not performing these inspections increases the number of displaced people, delays recovery, and increases the

post-earthquake response and recovery costs. In Japan and California, post-earthquake building inspection programs are well established and include thousands of pre-trained volunteer engineers who will inspect buildings after major earthquakes.

5.3 Earthquake in Haiti (2010)

Problem areas/ Lessons learned		Lessons learned from earthquakes
1 Knowledge	**1.7**	Monitor and study the earthquake and other natural events
6 Risk management	**6.7**	Even the most devastated communities and governments retain capacities
	6.8	Private and institutional donors should be encouraged to give cash rather than assistance in kind
9 Training	**9.2**	Building Haitian capacity to analyze, address problems and manage the emergencies will need systematic training
10 Recovery	**10.1**	Avoid rebuilding vulnerability

Table 13: Summary of lessons learned from earthquake in Haiti (2010)

An earthquake registering 7.0 on the Richter scale struck Haiti at 16:53 local time on Tuesday 12 January, 2010, at a shallow depth of 13 km. The epicentre was near Léoĝane, 25 km from the capital Port au Prince. Approximately 220,000 people died. Three hundred thousand were injured. Two million people were suddenly made homeless. One million three hundred thousand of these were relocated to spontaneous settlements. These depressing figures were in part due to the earthquake occurring in a highly urban area, but also due to underlying vulnerabilities.

The actors who would normally be expected to lead and manage the response were themselves victims of the earthquake. Many national and municipal government buildings were destroyed and many civil servants died, were injured or were absent caring for their own families. Specifically the National Disaster Risk Management System, Emergency Operations Centre and the Direction de la Protection Civile, Port au Prince's main fire station and innumerable government vehicles were badly damaged or destroyed.

Over 1.5 million people (approximately 15% of the national population) have been directly affected by the earthquake. The Haitian government estimates over 300,000 people lost their lives and more than 330,000 were injured in the earthquake. It is estimated that over 105,000 homes were completely destroyed and more than 208,000 damaged. Approximately 1,300 educational institutions and over 50 medical centers and hospitals collapsed or were damaged; 13 out of 15 key government buildings were severely damaged. The Haitian government estimates that the damage caused by the earthquake totals approximately $7.8 billion, which is more than 120% of Haiti's 2009 gross domestic product. The earthquake affected all segments of Haitian society. Approximately 150,000 Haitians left the country. At least 600,000 people abandoned damaged urban areas to find shelter in the more rural areas of the country.

In comparison with many other parts of the world, the characteristics of earthquake and tsunami hazards in Hispaniola are poorly understood. Estimates of hazard in Haiti are limited by the unknown timing and location of pre-colonial earthquakes, their recurrence intervals, and the geometry and segmentation of subsurface faults. Local surface deformation data and seismic

data were sparse prior to the earthquake. The expansion and densification of networks to monitor ongoing seismicity (using an advanced seismic network) and post seismic deformation (using GPS and InSAR methods) is essential. High-resolution topography and bathymetry have the potential to supplement an improved understanding of the structural geology of Haiti. A very important lesson learned is therefore related to knowledge about earthquakes; to monitor and study the earthquake and other natural events (1.7).

There are many lessons learned regarding the management and the response phase of the Haitian earthquakes. On lesson learned is that even the most devastated communities and governments retain capacities (6.7). Although the physical/material infrastructure is destroyed, the communities still have strong relationships, personal skills, organizational abilities, important norms and values, effective leaders and the ability to make decisions. Slow down to allow meaningful engagement of community and civic leaders in the assessments who will add significantly to the quality and timeliness of results. While the humanitarian agencies who responded initially were almost all supported by Haitian civil society counterparts and government-nominated cluster co-leads, the absence of sound capacity assessments and weak situational analysis led many within the humanitarian community to wrongly assume there was no or very weak residual local capacity. As a result, insensitive to concerns and nascent capacities of local civil society and of the Haitian government, the humanitarian community made “strategic misjudgments and errors”. At best this manifested itself as highly unclear roles and responsibilities between stakeholders and at worst in a response designed to replace, not support, local actors. This served to further disempower Haitian society already severely weakened by the earthquake. In addition to handicapping strategic planning and intervention design, the limited inclusion of Haitians in needs assessments and analyzes missed an opportunity to build relationships with Haitian partners. Inclusiveness is not necessarily a barrier to speed.

Furthermore, private and institutional donors should be encouraged to give cash rather than assistance in kind (6.8). Assistance in kind can be inappropriate, wasteful and take resources to dispose of. If used, inappropriate assistance can damage and detract from the humanitarian effort. While the vast majority of donations to the Haiti earthquake response were cash donations in response to the UN Flash and other appeals, many private and institutional donors, motivated both by well-meaning compassion and by political considerations sent some aid to Haiti that was inappropriate and had to be disposed of unused.

An important lesson learned related to both the recovery and prevention phases, is that building Haitian capacity to analyze, address problems and manage the emergencies will need systematic training (9.2). Support and empower affected government and civil society however incremental, to play a central role in the humanitarian response. Better capacity assessments of Haitian political and civil leadership should be undertaken. Understand and build on Haitian resilience and coping strategies to better inform recovery strategies and preparedness process. Empower cluster leads and ensure they are fully aware of and able to meet their responsibilities. Put in place back-up mechanisms for scenarios where persons in key leadership positions in country are killed, injured or otherwise unable to perform their functions. Strengthen capacities and mechanisms for dealing with large numbers of often inexperienced humanitarian NGOs. Embed clusters with relevant line ministries whenever possible and draw heavily upon existing Haitian capacity. Strengthen coordination and engagement with Haitian civil society. Humanitarian coordination should accommodate non-humanitarian actors, most notably military, private sector, host government and local community and civil society. Emergency preparation should be undertaken jointly with all relevant stakeholders and should put in place agreements that outline how stakeholders should collaborate in the event of emergencies. In a country with significant underlying vulnerabilities, including chronically weak governance, insecurity and violence, systemic and desperate poverty, and frequent tropical storms, disaster risk reduction

featured low on Haiti's development agenda. It focused, in any case, on mitigating the effects of its most common natural disaster: hurricanes. In a desperately poor country unaffected by earthquakes in almost 200 years, seismic monitoring and related earthquake response was a low priority for disaster risk reduction. There was no civil guidance on what to do in the event of an earthquake and no modern building codes to minimize damage and a weak enforcement capability in any case.

The most important lesson learned in the recovery phase is to avoid rebuilding vulnerability (10.1). It is necessary to examine and militate against plausible risks. Vulnerable infrastructure degraded natural environment and fragmented social and institutional infrastructure. The harrowing loss of life during the 2010 earthquake is directly attributable to the exceptional vulnerability of the Haitian building inventory. Large well-engineered structures were largely immune to damage as were single story shacks using indigenous materials. Worse hit were multifamily dwellings formed from concrete. Such vulnerabilities are not unique to Haiti, or even to Hispaniola, but are common in many developing nations.

5.4 Earthquake in Sichuan/Wenchuan, China (2008)

Problem areas		Lessons learned from earthquakes
1 Knowledge	**1.8**	Implement timely image-acquiring systems based on high resolution satellite-to-earth observation and aerial photographs and to improve data acquisition, processing and image quality of satellite monitoring systems
2 Communication	**2.2**	Need for a high-quality emergency radio communication system that can adapt to multiple circumstances
	2.3	Small size, light weight, and highly integrated base stations are well suited for emergency communication systems and can significantly enhance the robustness of the application communication system
	2.4	Build an emergency radio system that operates when the entire conventional communication network is down
	2.5	Marine satellite phone became the sole means of communication in a hilly area laced with rivers, blocked by debris, and deprived of water and power
	2.6	There must be adequate radio equipment stored around a country to establish an emergency communication network as soon as possible after a disaster
3 Logistics	**3.1**	Robustness of the lifelines relies on the built-in redundancy
	3.2	Regular review and upgrade of lifeline facilities is necessary in normal time as well as prompt repair of failed components after an earthquake
	3.3	The internet can be used by the earthquake investigators for conducting earthquake intensity survey, and to coordinate international investigation efforts through dedicated websites, links, individual blogs and social media
	3.4	Modern information technology equipment contributes to the efficiency of an individual investigator

5 Coordination	**5.1**	Twinning of communities in need and those who helped accomplished dual goals: sharing of enormous financial hardship; and cultivating camaraderie among population
	5.2	Mutual-aid plans among adjacent jurisdictions, both locally and internationally, should be pre-arranged prior to the occurrence of earthquake
	5.3	Greater efforts could have been made to enlist the support of specialized international agencies in specific areas, including emergency shelter, livelihoods and health
	5.4	Very little attention was paid to psychosocial and mental health programs, especially among elderly people, who may well have benefited from specialized support from the humanitarian community
	5.5	Lack of transparency in terms of specific data and details of the response have concealed many of the successes of the response, as well as obscuring areas for improvement
6 Risk management	**6.9**	Importance of designing and building buildings with full consideration of earthquake resistance and seismic loadings
	6.10	School buildings and hospital structures should be conform to building design standards that are higher than design codes for standard residential and office buildings
	6.11	Schools and emergency-response facilities, especially those located on weak sub soils prone to liquefaction, tsunami vulnerable zone, or site subject to geologic hazard, should be relocated or retrofitted to meet the requirement of maintaining their function after an earthquake
	6.12	Increase in specialists in internal medicine, obstetrics and gynecology, pediatrics, and infectious diseases could effectively reduce the complications and mortality associated with late rescue work
	6.13	Supportive medical forces should be distributed to meet the specific demands within the disaster area to improve prognosis and reduce death and disability
7 Risk assessment	**7.1**	Microzonation for identifying areas susceptible to strong earthquakes and determination of appropriate *land use*
	7.2	Consider potential impacts on secondary damages in order to devise realistic response strategy, and to plan for orderly implementation of long-term upgrade of existing facilities
	7.3	The impact of potential fault displacement on the performance of the sub- and super-structures crossing active faults is a serious challenge to designers
	7.4	Installation and maintenance of modern instrumentations for recording strong ground motion is important
	7.5	Update of seismicity hazard and upgrade of seismic design should be carried out on a regular basis
	7.6	Periodical review and update of the building code is necessary

8 Preparation	**8.4**	Establishment of a national disaster medical response system is crucial to reduce mortality and morbidity and promote overall effectiveness of rescue efforts after a major earthquake
9 Training	**9.3**	Drills of emergency response need to be practiced regularly to enhance the capability of response agencies and personnel
	9.4	Society has to change from a response culture to a prevention culture to cope better with natural disasters
	9.5	Preservation of certain damaged or failed structures in the earthquake-stricken areas remind and educate the public about the importance of adequate seismic design and earthquake preparedness

Table 14: Summary of lessons learned from earthquake in Sichuan/Wenchuan, China (2008)

The Sichuan/Wenchuan Earthquake took place at 14:28 (Beijing Time) on 12 May 2008. The earthquake had a magnitude of 8.0 Ms and 7.9 Mw, lasting for around 2 minutes. The epicenter was in Wenchuan County, 80 km west/northwest of the provincial capital of Chengdu. In the quake almost 80% of buildings were destroyed (Fig. 5).

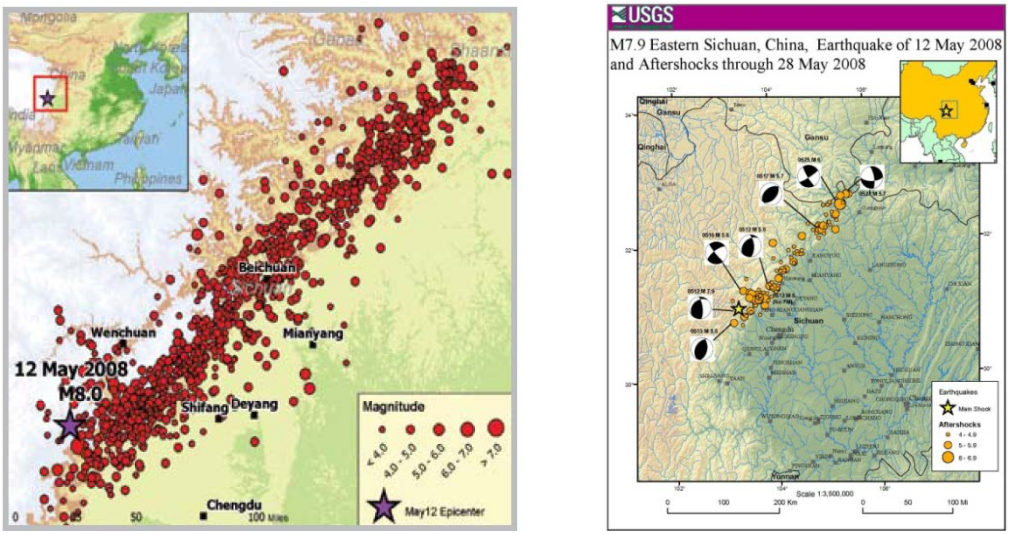


Figure 5: Location of the May 12, 2008 Wenchuan Earthquake epicenter and associated aftershocks

According to a study by the China Earthquake Administration (CEA), the earthquake occurred along the Longmenshan fault, a thrust structure along the border of the Indo-Australian Plate and Eurasian Plate. In a United States Geological Survey (USGS) study, preliminary rupture models of the earthquake indicated displacement of up to 9 meters along a fault approximately 240 km long by 20 km deep. The earthquake generated deformations of the surface greater than 3 meters. At least 69,195 people killed, 374,177 injured and 18,392 missing and presumed dead in the Chengdu-Lixian-Guangyuan area. More than 45.5 million people in 10 provinces and regions were affected. At least 15 million people were evacuated from their homes and more than 5 million were left homeless. The total economic loss was estimated at 86 billion US dollars. Beichuan, Dujiangyan, Wuolong and Yingxiu were almost completely destroyed. Landslides and rockfalls damaged or destroyed several mountain roads and railways and buried buildings in the Beichuan-Wenchuan area, cutting off access to the region for several days

There were many lessons learned after this devastating earthquake within a number of areas. The true extent of the Sichuan earthquake was not immediately recognized, since no satellite and remote sensing images were available for the rest of the earthquake areas. Air-photography of the disaster areas did not start until 3 days later, on the afternoon of May 15, 2008 *(Huang, 2011)*. A key lesson learned is that it is essential to implement timely image-acquiring systems based on high resolution satellite-to-earth observation and aerial photographs and to improve data acquisition, processing and image quality of satellite monitoring systems (1.8).

Due to the steep and rugged topography in the affected mountainous region, wide spread landslides have been major destructing factors, besides strong earthquake shaking. About 20,000 fatalities were caused by 15,000 geohazards in the form of landslides, debris flows and rockfalls. Regarding the risk assessment of the earthquake; several lessons learned are found. First, *microzonation* is to be prepared for identifying areas susceptible to strong earthquake shaking, ground failures such as landslides, fault displacements, slope failures and liquefaction, etc. Determination of appropriate *land use* should then be guided by the identified hazards to mitigate potential loss (7.1). Second, potential impacts on secondary damages by earthquakes such as fires, landslides, debris flows, dam breaches, disruptions of lifelines and release of hazardous material are to be considered in order to devise realistic *response strategy*, and to plan for orderly implementation of long-term upgrade of existing facilities (7.2). Third, the impact of potential fault displacement on the performance of the sub- and super-structures crossing active faults remains to be a serious challenge to the designers (7.3).

The strong shaking with peak ground acceleration up to 0.98 g, ground failures and fault displacements up to 2 to 4 m caused wide spread destruction of communities and infrastructures (Lo and Wang, 2012). Other lessons learned related to the risk assessment includes *instrumentation for strong ground motion, seismic design and building code*. Installation and maintenance of modern instrumentations for recording strong ground motion are important to characterize earthquake motion. Further instrumentation to measure the response of critical structures would improve the understanding and analysis of seismic behavior of the instrumented structures (7.4). Update of seismicity hazard and upgrade of seismic design are to be carried out on a regular basis (7.5). Up-to-date seismic design measures should be implemented in new structures. Whenever possible, retrofit of existing structures should be facilitated by legal requirements and/or financial incentives. The *building code* is a living document, which requires periodical review and update to reflect current understanding of the regional and local site seismicity, structural earthquake performance and latest design and technology. Any important new findings, such as the recognition of new or higher seismic hazard than that envisaged by the current code, should be carefully reviewed and implemented in the revised code as soon as practical (7.6).

Lifelines are those systems required for the survival and function of societies, and include: water and wastewater, electric power, communications, transportations, natural gas and liquid fuels, etc. Problems revealed and lessons learned related to these facilities have been categorized as *logistics*. Various geotechnical issues affect the seismic performance of lifelines facilities, such as rupture of water and waste water pipelines, disruption of power and communication lines, and damage to bridges, power transmission and communication towers, etc. due to foundation failures, liquefaction and lateral spreading. Lessons applicable to lifelines facilities include the following (Lo and Wang, 2012): *Redundancy, review and update, internet, and information technology*. Robustness of the lifelines relies on the built-in redundancy. As a certain line or node of a given lifeline is down, the availability of alternate lines or nodes is critical for maintaining the lifeline function during the critical period of emergency response and restoration (3.1). The reliable service of a lifeline depends on proper functioning of all its important components at all times. It requires regular review and upgrade of these facilities in normal time

as well as prompt repair of failed components after an earthquake (3.2). The internet can be used by the earthquake investigators for conducting earthquake intensity survey, and to coordinate international investigation efforts through dedicated websites, links, individual blogs and social media (3.3). Modern equipment such as digital camera, GPS, laptop and satellite communication, etc. all contributes to the efficiency of an individual investigator (3.4).

Communication disruption was immediate and lasted long after the earthquake. In metropolitan Chengdu, the biggest city in the area, major mobile communications were disrupted immediately, and there was extreme communication congestion and hardship for at least 24 hours after the quake. After the quake, nearly all operators' networks were seriously damaged, and some of the affected towns lost contact with the outside world for days. Although emergency crews tried every possible means to repair the damaged network, their efforts were hindered by complex geography and continuous aftershocks (Xian et al., 2009). This illustrated the shortcomings of modern fixed network and mobile network communication systems and emphasized the need for a high-quality emergency radio communication system that can adapt to multiple circumstances (2.2). The small size, light weight, and highly integrated base stations are well suited for emergency communication systems. They have stronger capabilities to survive natural disasters compared to traditional cellular base stations, and can significantly enhance the robustness of the application communication system (2.3).

After the Sichuan earthquake, people found that optical cables could be used in certain areas where the mobile signals were blocked, and mobile phones could receive signals in other areas where the fixed network was totally cut off (Xian et al., 2009). This showed that diversified emergency communication networks can serve as mutual standby, and that extra attention should be paid to building an emergency radio system that operates when the entire conventional communication network is down (2.4).

In Beichuan, a county seriously damaged by the earthquake, people were isolated for 28 hours before local government used marine satellite phone, by which they directed delivery of relief materials and received weather reports and geographic details (Xian et al., 2009*)*. *Marine satellite phone* became the sole means of communication in a hilly area laced with rivers, blocked by debris, and deprived of water and power (2.5). It provided both rescue workers and the government with information needed to understand the disaster and deploy appropriate help.

Reportedly, after the earthquake, the Chinese government dispatched rescue teams to the disaster-hit areas, but they did not bring radio communication equipment with them and therefore could not contact the Command Center (Xian et al., 2009). There must be adequate *radio equipment* stored around a country to establish an emergency communication network as soon as possible after a disaster (2.6).Temporary dispatching is not reliable; instead, storage, dispatch, and distribution systems of the emergency radio communication equipment must be built in advance, supplemented and updated in a timely manner, and the supervision and management these materials strengthened.

In the aftermath of the earthquake, it became evident that the buildings properly designed for earthquake resistance performed better than those that did not adhere to the building codes This sends a strong message in support for seismic design: even under large shaking, buildings that have been designed and built with full consideration of seismic loadings will inherently be safer buildings than those where little consideration is given (6.9).

Because the earthquake took place on a weekday afternoon, casualties were concentrated in densely populated areas because most people were at work. Schools were heavily hit and about 10 243 (80%) medical institutions in Sichuan were damaged (Zhang et al., 2012*)*. In

terms of school casualties, thousands of school children died due to shoddy construction. At least 7,000 school buildings throughout the province collapsed (Paterson et al., 2008). School buildings and hospital structures are expected to conform to building design standards that are higher than design codes for standard residential and office buildings, and thus the collapse of such a large number of these buildings has been a major factor in pushing the Chinese government to move quickly to assess the earthquake resistance of existing schools and hospitals in other seismically active parts of the country (6.10). Another lesson learned is that schools and emergency-response facilities, including fire and police stations, and hospitals, especially those located on weak subsoils prone to liquefaction, tsunami vulnerable zone, or site subject to geologic hazard such as landslides, rock falls, etc., should be relocated or retrofitted to meet the requirement of maintaining their function after an earthquake (6.11).

Supportive medical forces during the Wenchuan earthquake consisted of rescue teams from the non-disaster area, inside or outside Sichuan province. These forces accounted for more than 80% of the total medical rescue workers in Sichuan after the earthquake. Specialists in obstetrics, pediatrics, dermatology, and other disciplines were in short supply because a large number of those injured were children and elderly people.

An increase in specialists in internal medicine, obstetrics and gynecology, pediatrics, and infectious diseases could effectively reduce the complications and mortality associated with late rescue work (6.12). Supportive medical forces should be distributed to meet the specific demands within the disaster area to improve prognosis and reduce death and disability (6.13).

Initially, accesses to remote areas were handicapped by the disruptions of highways and railways. The prompt and orderly nation-wide rescue and restoration programs were responsible for mitigating the suffering of affected population and the recovery of the region to normalcy (Lo and Wang, 2012).

The unique Chinese mechanism for emergency response, recovery and reconstruction involved communities and jurisdictions located far away from the damaged areas. A lesson learned is that this twinning of communities in need and those to help accomplished dual goals: sharing of enormous financial hardship; and cultivating camaraderie among population (5.1). Another lesson learned on coordination and cooperation is that mutual-aid plans among adjacent jurisdictions, both locally and internationally, should be pre-arranged prior to the occurrence of earthquake (5.2). This way the precious time required for effective rescue operations in the initial golden period of 72-hours will not be wasted.

The response to the earthquake was dominated by the Chinese government. Although the government invited international humanitarian assistance, few international NGOs engaged directly in emergency response, for a number of reasons (e.g. Sichuan was probably not a priority for organizations already involved in responding to concurrent disasters including Cyclone Nargis, which made landfall in neighboring Myanmar just ten days before the earthquake). The direct provision of aid by the Chinese military was a key element in the emergency response phase. Officials reported that, within 14 minutes of the earthquake, the central government had dispatched the People's Liberation Army (PLA) to the affected areas, and within days 113,000 soldiers and armed police had been mobilized (Hoyer, 2009).

The overall success of the government's response was made possible by its authoritarian position, its experience of managing large population movements and natural disasters and the rapid deployment of the military (Hoyer, 2009*).* At the same time, however, greater efforts could have been made to enlist the support of specialized international agencies in specific areas, including emergency shelter, livelihoods and health (5.3). In the health sector, for instance, very little attention was paid to *psychosocial and mental health programs*, especially among elderly

people, who may well have benefited from specialized support from the humanitarian community (5.4). Finally, although the state deserves praise for its handling of the response, a *lack of transparency* in terms of specific data and details of the response have concealed many of these successes, as well as obscuring areas for improvement (5.5).

After the earthquake, the army sent 215 medical, epidemic prevention, psychological assistance, and field medical equipment maintenance teams; and 7000 servicemen. Because of their mobility, the military medical teams moved into the hardest-hit area to start medical rescue efforts immediately, despite poor weather and road conditions. Establishment of a national disaster medical response system, an active and effective commanding system, successful coordination between rescue forces and government agencies, effective treatment, a moderate, timely and correct public health response, and long-term psychological support are all crucial to reduce mortality and morbidity and promote overall effectiveness of rescue efforts after a major earthquake (8.4).

Earthquake emergency preparation was inadequate when the 2008 earthquake struck. No disaster relief plans had been made, which resulted in the chaos of early self-rescue attempts (Zhang et al., 2012).

A key lesson learned regarding emergency response and public education is that drills of emergency response need to be practiced regularly to enhance the capability of response agencies and personnel, and public awareness (9.3). Society has to change from a response culture to a prevention culture to cope better with natural disasters, and to reinforce the key role of pre-disaster preparation in the reduction of casualties (9.4). Preservation of certain damaged or failed structures in the earthquake-stricken areas as memorial sites would go a long way to remind and educate the public about the importance of adequate seismic design and earthquake preparedness (9.5).

5.5 Earthquake-Tsunami in Japan (2011)

Problem areas		Lessons learned from earthquakes
2 Communication	**2.7**	Need tsunami warning system
	2.8	Need of good communication and help from LEMA to set up radio links and integrate with other agencies
	2.9	Cell phones should be allocated to roles not people, and stay in the EOC (Emergency Operation Center)
	2.10	Wireless networking is essential in an emergency situation.
	2.11	Strengthen aspects of nuclear safety culture
3 Logistics	**3.5**	Regularly reassess and adjust the logistics disaster plan to take into account any changing circumstances
	3.6	Suitably designed depots with cargo-handling equipment are needed
	3.7	Prior quantitative estimates of urgently needed goods should be carried out based on regional demographic statistics
	3.8	Emergency delivery systems should be closed down as soon as feasible to allow normal commercial distribution systems to take over
	3.9	There should be prior identification and training of local government staff that will be tasked with responding to large-scale disasters
	3.10	There should be prior formulation of a list of goods and a standard format for shipments and orders for smooth and seamless activation of the disaster response

4 Interoperability	**4.1**	Training and periodic drills must be sufficiently challenging and realistic to prepare operating crews and emergency response personnel to cope with and respond to a multi-unit accident
	4.2	It is strongly recommended not to send any relief goods without coordination with the government or the local authorities
5 Coordination	**5.6**	Nuclear operators must establish the necessary infrastructure to respond effectively to severe accident conditions, mitigate core damage, and stabilize the units if core damage does occur
	5.7	Establish strategies for staffing operating crews, other key plant positions, and site and corporate emergency response organizations
	5.8	Ensure that primary and alternative methods for monitoring critical plant parameters and emergency response functions are available
	5.9	Clearly define and communicate the roles and responsibilities of emergency response personnel to help ensure effective post-accident communications and decision-making
	5.10	Establish systems to deal with long-term public health effects, including stress-related illness
	5.11	Establish a detailed and transparent program of decontamination and relocation
7 Risk assessment	**7.7**	always be prepared for unexpected and unprecedented phenomenon and crisis
	7.8	Plant design features and operating procedures alone cannot completely mitigate the risk posed by a beyond-design-basis event. Additional preparations must be made to respond if such an event were to occur.
	7.9	Maintain the regulations up to date and build them up according to the scientists' simulations.
	7.10	Keep the population informed using the images of effects of the previous disaster, rather than numbers and statistics.
	7.11	Develop a culture of disaster preparedness to the population situated in the vulnerable areas (depending on the type of risk)
	7.12	Make the simulations as close as possible to the reality, taking into account all data and measurements obtained from real sensors or network stations
	7.13	Decrease the damage by fixing furniture and other security measures.
10 Recovery	**10.2**	Set up a "Reconstruction Agency" after disaster
	10.3	Government assistance and support for disaster survivors and local government, reconstruction of infrastructure, disposal of tsunami debris, industrial revitalization, and promotion of employment
	10.4	Establishment of new tsunami warning system
	10.5	Establishment of a national recovery plan including the issues foreseeing large-scale societal changes concerning tsunami preparedness

Table 15: Summary of lessons learned from earthquake in Japan (2011)

The 2011 earthquake off the Pacific coast of Tōhoku in Japan was a magnitude 9.0 (Mw) undersea megathrust earthquake. It occurred at 14:46 JST (05:46 UTC) on Friday 11 March 2011, with the epicenter approximately 70 kilometers east of the Oshika Peninsula of Tōhoku and the hypocenter at an underwater depth of approximately 30 km) (USGS 2011). It was the most powerful earthquake ever recorded to have hit Japan, and the fifth most powerful earthquake in the world since modern record-keeping began in 1900 (CBS News 2011). The earthquake triggered powerful tsunami waves that reached heights of up to 40.5 meters and in

some areas travelled up to 10 km inland (Buerk 2011). The earthquake moved Honshu (the main island of Japan) 2.4 m east (Deutsche Welle 2011). 15,885 deaths were reported, 6,148 injured and 2,623 people missing. The earthquake and tsunami also caused extensive and severe structural damage in north-eastern Japan, including heavy damage to roads and railways as well as fires in many areas, and a dam collapse (Buerk 2011; Syed 2011). The tsunami caused nuclear accidents, primarily the level 7 meltdowns at three reactors in the Fukushima Daiichi Nuclear Power Plant complex, and the associated evacuation zones affecting hundreds of thousands of residents (CNN 2011). Many electrical generators were taken down, and at least three nuclear reactors suffered explosions due to hydrogen gas that had built up within their outer containment buildings after cooling system failure. Early estimates placed insured losses from the earthquake alone at US$14.5 to $34.6 billion (Hennessy-Fiske 2011).

In this context, communication is about inter-agency communication as well as crisis communication to the media. Information and communication technologies have a great potential to improve the resilience of organizations during the management of emergencies, by providing the right information in due time to anticipate evolution and take appropriate decisions, by providing reliable communication channels between stakeholders in the field and in control rooms, by providing tools and systems to simulate phenomena, to monitor situations, to track resources and vehicles, etc. The key lessons learned from the Japan earthquake related to communication are the need of a tsunami warning system (lesson learned 2.7) and the need of good communication and help from LEMA to set up radio links and integrate with other agencies (lesson learned 2.8). Tsunami warning systems did alert some of the population as sirens and speaker system are in place in most areas in Japan, but it did also hamper the search by faulty alarms. Work could not be performed during night time because the tsunami warning system did not function after the incident. Medical data were lost or could not be accessed because of lack of power and no internet connections which made medical treatment worse. Telephone services remained variable with disaster messaging services in operation through mobile phone providers the first week post event. It is essential to have backup for telecommunications. One of the key learning points associated with Information and Communications Technology (ICT) is that cell phones should be allocated to roles not people, and stay in the Emergency Operations Center (EOC) (lesson learned 2.9). This ensures that any contact list is valid 24 hours/day and minimizes individuals receiving calls ‘out-of-hours’. ICT equipment needs to have asset-labeling for the role/function it belongs to. This is especially important for laptops that have specialized software installed to perform a role. The laptop needs to remain with the role/function and not leave the EOC, but be handed over to the incoming incumbent at shift changeover. Mobile equipment also needs to be recorded as to its whereabouts. Tracking of valuable hardware is vital in an emergency. Wireless networking is essential in an emergency situation. Any future EOC site should be equipped with wireless technology, along with necessary technology, fiber distribution, and additional networking so the IT team is ready from day one of the emergency operation (lesson learned 2.10).

A lesson learned related to the Fukushima Daiichi nuclear facility is that behaviours prior to and during the event revealed the need to strengthen several aspects of nuclear safety culture (lesson learned 2.11). It would be beneficial for all nuclear operating organizations to examine their own practices and behaviours in light of this event and use case studies or other approaches to heighten awareness of safety culture principles and attributes.

Quick inspection of building damage and needs assessment must be done in the first stage of actions after an earthquake disaster. In Japan delivery of relief goods and services is the responsibility of the prefectural governor, who responds to requests from the municipalities. According to the post disaster plan, delivery of relief goods was to be executed using depots at two levels: prefectural and municipal. Especially in the first two weeks, fuel shortages made

downstream deliveries from prefectural depots very difficult. Also, manpower shortages and the inconvenient building specifications of depots were the main causes of unnecessary stockpiling in depots. Telecommunications disruptions furthered mismatches between real needs and supplies. But the professional support of logistics specialists was effective in relieving the bottlenecks in depots. It is evident from reports of the disaster that the logistics part of the plan did not cover all the possible affects resulting from this major event. In fact it is clear that the magnitude of the event totally overwhelmed the available resources and capabilities of all those concerned, requiring a considerably longer period to source action the various stages of the plan.

Therefore it would be prudent to regularly reassess and adjust the disaster plan to take account of any changing circumstances and current risk assessment opportunities and in short “plan for the unexpected” (lesson learned 3.5). Many believed that transportation problems were the critical factors, but several other factors were at play. The workload spiked at the same time that many staff were being lost to the disaster. Moreover, while the disaster countermeasure manuals state that the economic or industrial support branch of the local government is responsible for the delivery system, workers in that section did not have enough knowledge or experience with logistics and supply chain management. They simply stored the goods in public buildings, with no logistics management plan, so the space was quickly filled.

The building specifications and design of the depots was also a contributing factor. The depots require large storage and handling capacity as well as easy access to expressways, especially prefectural depots. Privately owned warehouses would have been ideal if they had not been damaged. The lessons learned related to logistics were many. Suitably designed depots with cargo-handling equipment such as forklifts are needed, along with the support of logistics professionals (lesson learned 3.6). Also, information on arrival times at each depot is crucial for planning storage and location management. A key lesson learned is that prior quantitative estimates of urgently needed goods should be carried out based on regional demographic statistics (lesson learned 3.7). This helps arrange “push delivery”, supply-driven deliveries, in the first few days after the disaster. One very important lesson learned is that emergency delivery systems should be closed down as soon as feasible to allow normal commercial distribution systems to take over (lesson learned 3.8). They are capable of serving a variety of consumers, and are more flexible and demand driven. At the intermediate stage, logistics management is best delegated to designated municipal authorities in unaffected areas.

The speed and manner of the transition from public to private supply logistics should be determined by how dependent the affected population is on relief supplies, and on the robustness and speed with which the private sector networks can restore commercial operations. In this case, delivery of relief goods lasted for 40 to 50 days after the disaster. Commercial businesses reappeared in about a month. Public facilities, such as gymnasia and community halls, can be used as logistics depots as they are well designed with strong-enough floors, wide-enough entrances and exits, and good accessibility for cargo handling. Prior agreements can be put in place between the government and logistics companies specifying the terms and conditions and payment methods for hiring logistics professionals, machinery, and depot facilities. Some of the lessons learned related to the post-crisis phase are: There should be prior identification and training of local government staff that will be tasked with responding to large-scale disasters (lesson learned 3.9), and there should be prior formulation of a list of goods and a standard format for shipments and orders for smooth and seamless activation of the disaster response (lesson learned 3.10).

In order to achieve good interoperability between first responders and between first responders and other crisis management organizations, training is essential. Training and periodic drills must be sufficiently challenging and realistic to prepare operating crews and emergency

response personnel to cope with and respond to situations that may occur during a multi-unit accident, including a nuclear accident resulting from a natural disaster (lesson learned 4.1). Plant design features and operating procedures alone cannot completely mitigate the risk and additional preparations must be made to respond if such an event were to occur. Plans must address the immediate emergency response needs for human resources, equipment, and facilities in the first few hours of an event, as well as the need for a long-duration response capability. In addition, plans should address how to engage the domestic and international nuclear industry to obtain needed support and assistance during an event.

Immediately after the earthquake, the World Health Organization (WHO) joined the United Nations Disaster Assessment and Coordination (UNDAC) team on stand-by. WHO also undertook three missions to Japan for fact-finding, information collection and public health risk assessment.

The Government of Japan's Emergency Management agencies was leading the response through the Emergency Response Team, headed by Prime Minister. A network of NGO/ volunteer organizations "Japan Civil Network for Disaster Relief in East Japan" was established in order to coordinate the assistance and to facilitate the communication and exchange of information among the organizations working in Tohoku area to support the survivors. NGOs and volunteers were focusing on assistance to those living outside the evacuation centres and outside of the distribution network. With regard to relief items, the government of Japan received offers for relief goods/material from many countries, and international organizations (UN OCHA 2011). The Government is identified the needs and tried to match the offers with the identified needs for efficient and effective delivery. An important lesson learned is that when the transportation and storage capacity are rather limited (as it often is in the beginning of such a disaster), it is strongly recommended not to send any relief goods without coordination with the government or the local authorities (lesson learned 4.2). Although the Japanese Red Cross Society (JRCS) did not issue an international appeal for aid, the disaster brought generous donations from all over the world (Japanese Red Cross Society 2013).

It was the tsunami that followed the earthquake that got most attention in this case, especially since it caused severe damage to nuclear plants. In order to prevent future disasters, fundamental reforms must take place. These reforms must cover both the structure of the electric power industry and the structure of the related government and regulatory agencies as well as the operation processes. They must cover both normal and emergency situations. One key lesson learned is that nuclear operators must establish the necessary infrastructure to respond effectively to severe accident conditions, mitigate core damage, and stabilize the units if core damage does occur (lesson learned 5.6). This infrastructure includes necessary personnel, equipment, training, and supporting procedures to respond to events that may affect multiple units, last for extended periods, and be initiated by beyond-design-basis events. Provisions should also be made to allow an effective corporate and industry response in support of the affected nuclear operating organization. Another lesson learned is to establish strategies for staffing operating crews, other key plant positions, and site and corporate emergency response organizations quickly in the initial stages of a multi-unit event and over the long duration of the event response (lesson learned 5.7). Furthermore, it is important to ensure that primary and alternative methods for monitoring critical plant parameters and emergency response functions are available (lesson learned 5.8). Use drills and exercises to ensure that emergency response personnel are able to use the available monitoring tools and methods.

Early in the response to a nuclear plant event, clear strategies for core cooling and recovery actions should be developed and communicated to control room and ERC personnel. In addition, leaders should establish clear priorities and provide direction and oversight to enable

the strategy to be implemented effectively. A lesson learned is that it is essential to clearly define and communicate the roles and responsibilities of emergency response personnel to help ensure effective post-accident communications and decision-making (lesson learned 5.9). The government has responsibility for public health and welfare. Social welfare support and assistance must be given to those affected by the nuclear power plant accident. Some important lessons learned are to establish systems to deal with long-term public health effects, including stress-related illness (lesson learned 5.10), and to establish a detailed and transparent program of decontamination and relocation, as well as provide information so that all residents will be knowledgeable about their compensation options (lesson learned 5.11).

The magnitude of the earthquake, the tsunami, the accident at the Fukushima power plant and so forth was all expressed as unexpected and unprecedented events. A lesson learned (lesson learned 7.7) is to always be prepared for unexpected and unprecedented phenomenon and crisis (Japan disaster prevention forum 2012:10).

After the Great Hanshin Earthquake in 1995, measures were made with nuclear power plants and the resistance to earthquakes was given priority while measurements regarding tsunamis were postponed. The plants were in good condition, with well-maintained equipment and well-organized work spaces, even under outage conditions. A lesson learned (lesson learned 7.8) is that the Plant design features and operating procedures alone cannot completely mitigate the risk posed by a beyond-design-basis event. Additional preparations must be made to respond if such an event were to occur (ibid).

Over the years, nuclear plant operators around the world have focused on continuously improving plant safety by ensuring (i) compliance with regulations, (ii) operating plants within their design bases, (iii) making safety improvements based on worldwide operating experience and best practices. A lesson learned (7.9) is to maintain the regulations up to date and build them up according to the scientists' simulations. The earthquake resistant criteria were reinforced, in Japan, after 1982, because of the Great Hanshin Earthquake on the studies developed by Kozo Keikaku Engineering. Therefore, 480.000 people were saved in March 2011 (Japan disaster prevention forum 2012:10-11).

Organizations have also worked to improve plant programs, processes, and personnel performance. However, is important to not forget the population. A lesson learned is (7.10) Keep the population informed using the images of effects of the previous disaster, rather than dry information, as results of calculations obtained in labs or the surface of the flooded areas on a map. Another lesson learned (7.11) is to develop a culture of disaster preparedness to the population situated in the vulnerable areas (depending on the type of risk) (Japan disaster prevention forum 2012:10-11).

Japan National Institute for Earth Science and Disaster Prevention specialists have been able to simulate precisely the engineering with the wave motion and an earthquake, the propagation of tsunamis and the shaking of a building – Japan's technology is progressing. A lesson learnt is to (7.12) make the simulations as close as possible to the reality, taking into account all data and measurements obtained from real sensors or network stations (Japan disaster prevention forum 2012:10-11).

The seismic movement of the skyscrapers influenced not only the building, but also the furniture installed and how it shakes. Printers and copy machines became "killing machines". A lesson learned (7.13) decrease the damage by fixing furniture and implement other security measures (ibid).

The recovery phase is very crucial, it is necessary to focus on it even at the beginning of the operation. There is no gap between relief and recovery and recovery is the biggest challenge during natural disasters. Recovery phase can last 3 or 5 years after disaster and is performed by government, aid agencies, NGOs and other local and international organizations. After the earthquake in Japan (Fukushima) in 2011, the recovery phase included several activities. According to an UN OCHA report (2011), individuals and private sector companies, along with countries and aid organizations have contributed in total USD951 million bilaterally to the Government of Japan, Red Cross Societies, NGOs and other partners to support relief efforts.

In July 2011 the Japanese government formulated a Basic Policy on Reconstruction, estimating the budget for the next 10 years, USD 231 billion (Japanese Red Cross Society 2013) and set up a "Reconstruction Agency" after disaster (lesson learned 10.2). In 2 years after disaster, government assistance included support for disaster survivors and local government, reconstruction of infrastructure, disposal of tsunami debris, industrial revitalization, and promotion of employment (lesson learned 10.3). People residing in evacuation centres were offered temporary housing. There was also announced a new strategy for evacuees of the nuclear disaster that focuses on decontamination, education, health and psychological care for children, support for parental care and improvement of living conditions.

Japan Meteorological Agency introduced a new tsunami warning system on March 7, 2013 (lesson learned 10.4). A national recovery plan was published on June 25, 2011, and this measure should be adhered to also in other countries that experience such disasters (lesson learned 10.5). It included the issues foreseeing large-scale societal changes concerning tsunami preparedness; overall makeup of the city (relocating them to safer area); improvement of coordination among systems of medical care, public health and welfare; better communication with community leaders. It can be concluded that the recovery phase is still going on in Japan, since the activities and steps taken by authorities and organizations have got their long-term objectives and results will be observed in future.

5.6 Conclusions

The main problem areas identified in the earthquake cases were knowledge (8 lessons learned), communication (11 lessons learned), logistics (10 lessons learned), interoperability (1 lessons learned), coordination (8 lessons learned), risk management (13 lessons learned), risk assessment (13 lessons learned), preparation/prevention (4 lessons learned), training (5 lessons learned) and recovery (5 lesson learned).

A summary table with all lessons learned from all the earthquake cases described in this chapter is found in section 6.1.3.

Based on these examples, risk assessment and management stands out as the most challenging problem areas when it comes to earthquakes. Major earthquakes are usually very devastating. Compared to other natural disasters, which also have devastating effects, earthquakes are normally not warned. In addition, earthquakes are over in a few minutes, it is not a crisis that develops gradually and escalates into devastating results (like floods). Therefore, the challenges related to response and risk management are very demanding for the rescue workers, national governments and others involved in the emergency work. Typically, logistics challenges are also dominant in earthquake scenarios and the recovery phase is often long and complicated.

The lessons learned that are prominent in this review corresponds with the findings in the ELITE CoP workshop on earthquakes. In the June 2013 workshop all aspects of crisis management of earthquakes; preparation, prevention, mitigation, response and recovery, were discussed with the attending experts. The lessons learned were discussed related to the three different phases

of a crisis, see figure 6 below, however, this report has an all hazard approach and the lessons learned are therefore grouped according to problem areas without considering phases. Reading the descriptions of the earthquake cases in this report and comparing with the approached used in the workshop, there are some problems that are dominant in the different phases. For example, logistics is particularly challenging during the crisis as all kinds of infrastructure is very much affected. In the ELITE workshop on earthquakes the challenges to communication, both between first responders and inter-agency, as well as crisis communication to the people, were highlighted. Several of the CoP members had been involved in search and rescue in devastating earthquakes, such as Haiti and Bam (Iran), and stressed the communication problems. Likewise, they talked about their lessons learned related to logistics, especially how to transport equipment and personnel to the affected areas as well as goods to the affected people. One important lesson learned from the workshop that was not emphasized in the earthquake cases in this report was the importance of debriefing. Often recovery is related to the reconstruction of buildings, infrastructure and landscape, but debriefing of the first responders and other personnel is vital.

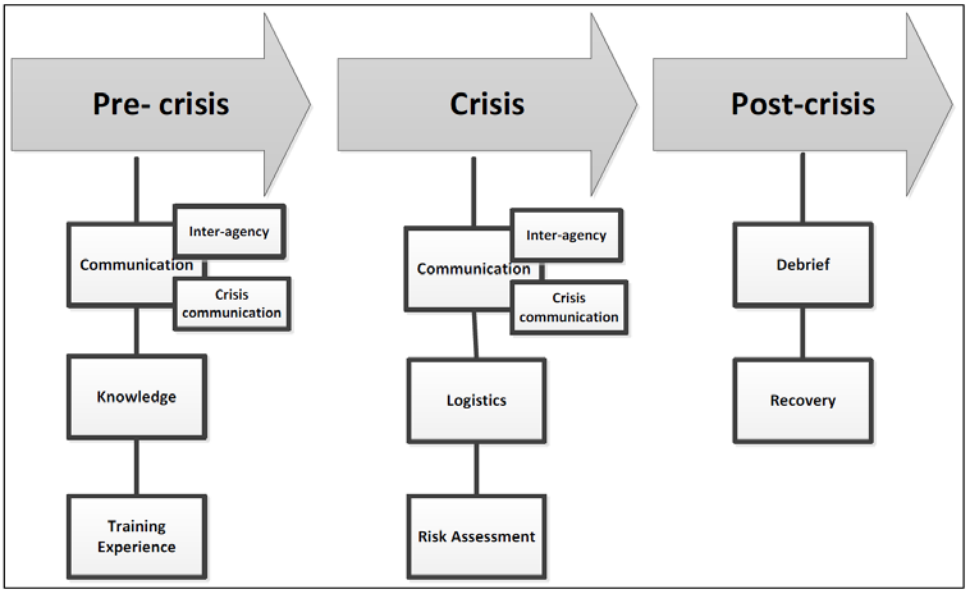


Figure 6: Lessons learned from ELITE Earthquake workshop 2013

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary of lessons learned

The selection of cases is not representative nor an exhaustive list of incidents. Thus, it is not possible to draw any wide reaching conclusions based on our findings from the different cases. Yet, the lessons learned in this report provide insights into problem areas where disaster managers can learn from each other. The examples of tangible lessons learned based on problems revealed by first responders and other crisis managers in the different phases of a crisis; prevention, mitigation, preparedness, response and recovery. In this chapter all lessons learned are summarized in three tables, one for each disaster type. In the tables the sources are indicated and they are also available in the ELITE living document. End-users have been involved to validate the results in all stages.

Interoperability, communication and knowledge seem to be problem areas that are crosscutting topics for all the hazards mentioned. However, there are some problems that are more relevant in certain types of crises. Logistics is a major challenge especially in floods and earthquakes, this corresponds well with results from the workshops.

Tangible lessons learned have been provided from cases mainly from Europe, but also from Asia and America. The ELITE framework for lessons learned reporting has been used to put the lessons learned into a system.

Through work package 4 a lesson learned process has been tailored and shaped by disaster managers and the stakeholders involved. This has resulted in a framework which has been validated by the ELITE CoP. In WP4 social media networks, such as Facebook, Twitter and LinkedIn, has been used to keep in touch with the CoP and create a platform for exchanging information. The living document has been promoted to other EU projects, like BRIDGE, and through a wider network of stakeholders. In this sense one has attempted to advance the state of the art.

6.1.1. Table of lessons learned on forest fires

	Lessons learned from forest fires	Problem area	Source
1	**1.1** Awareness of prolonged fire seasons *(Province of Cosenza in Italy 2002)*	1 Knowledge	NEDIES (2003a)
	1.2 If a fire occurs in the Bacalo area in days with a risk index higher than 3 (high) the fire cannot be extinguished in its initial phase. This will become the origin of a major forest fire *(districts of Guarda, Castelo Branco and Coimbra in Portugal 2001)*	1 Knowledge; local and experiential based knowledge	NEDIES (2003a)
	1.3 fuel breaks are needed therefore one must not carry out monoculture practices *(districts of Guarda, Castelo Branco and Coimbra in Portugal 2001)*	1 Knowledge; prevention	NEDIES (2003a)
	1.4 Public awareness campaigns, monitoring and early warning systems are also crucial *(Portugal forest fire 2003)*	1 Knowledge	EU (2008)
	1.5 Authorities must know the regulation to manage the forest fire *(Forest fires in Guadalajara, Spain 2005)*	1 Knowledge	Belt iberica (2005)
	1.6 Public education in the regulation for use of	Knowledge	Belt iberica

	fire in forests *(Forest fires in Guadalajara, Spain 2005)*		(2005)
	1.7 development of fire-unprotected interface zones between forest and urban areas *(Forest fires in Greece 2007)*	1 Knowledge	EU (2008)
	1.8 Necessity to have a coherent network of infrastructures in the forestland to protect the forest against fire *(The Septèmes-les-Vallons Forest Fires in France 1997)*	1 Knowledge	NEDIES (2003a)
	1.9 Need to have a clean forest without bushes *(The Septèmes-les-Vallons Forest Fires in France 1997)*	1 Knowledge	NEDIES (2003a)
2	**2.1** Using the volunteers more actively and incorporate into the regional plans *(Province of Cosenza in Italy 2002)*	2 Interoperability	NEDIES (2003a)
	2.2 *In collaboration with police forces surveillance must be intensified to discourage arsonists to set fires (Province of Cosenza in Italy 2002)*	2 Interoperability	NEDIES (2003a)
	2.3 One must improve coordination between the operative structures of the various municipalities involved. Municipalities that are not affected, must assist bordering municipalities *(Province of Cosenza in Italy 2002)*	2 Interoperability	NEDIES (2003a)
	2.4 Decisions on planning and prevention are always required *(Portugal forest fire 2003)*	2 Interoperability; Coordination; training	EU (2008)
	2.5 Collaboration between countries, within and between regions (e.g. on fire suppression, training and information exchange) *(Portugal forest fire 2003)*	2 Interoperability; Coordination; training	EU (2008)
	2.6 Establish an approach of military-command or standard Incident Command System at the country level *(Portugal forest fire 2003)*	2 Interoperability; Coordination	EU (2008)
	2.7 Identification of an unified command when there is more than one agency with incident jurisdiction *(Forest fires in Guadalajara, Spain 2005)*	Coordination, Interoperability,	Belt iberica (2005)
	2.8 Knowledge about the procedures and regulations to call in the army to help when a forest fire occurs *(Forest fires in Guadalajara, Spain 2005)*	2 Interoperability; Coordination	Belt iberica (2005)
	2.9 Demarcation of the authority of responsible officers at both national and grassroots levels for maximum control and efficiency in firefighting operations *(Forest fires in Guadalajara, Spain 2005)*	2 Interoperability; Coordination	Belt iberica (2005)
	2.10 Harmonization of terminology and definitions, and the development of a common format for regional databases on fire across countries *(Forest fires in Greece 2007)*	2 Interoperability; knowledge	EU (2008)
	2.11 Greece must further pursue increased collaboration between countries, within and between regions with regards to fire suppression training and information exchange *(Forest fires in Greece 2007)*	2 Interoperability; Coordination; collaboration	EU (2008)

	2.12 Need to have an established coherence between the different institutions that may have to manage in coordination a forest fire *(The Septèmes-les-Vallons Forest Fires in France 1997)*	2 Interoperability; Coordination; collaboration	NEDIES (2003a)
3	**3.1** *cultivation activities must be a part of prevention efforts, even when it not 'normally fire seasons' like in this case (Province of Cosenza in Italy 2002)*	3 Prevention	NEDIES (2003a)
	3.2 Training and education of teams of volunteers on municipal level as part of the prevention efforts *(Province of Cosenza in Italy 2002)*	3 Prevention	NEDIES (2003a)
4	**4.1** informing the public of regulations regarding agricultural, forestry, and grazing activities to prevent the principal causes of fire *(Province of Cosenza in Italy 2002)*	4 Communication	NEDIES (2003a)
5	**5.1** Incentives to extensive animal farming and small agriculture *(Portugal forest fire 2003)*	5 Risk assessment	International Forest Fires News (2006)
	5.2 Promote discontinuity with less fire-susceptible species including the protection of these species on the forest fire prevention programmes *(Portugal forest fire 2003)*	5 Risk assessment	International Forest Fires News (2006)
	5.3 Harden the forest fire offence and penalty regulations *(Forest fires in Guadalajara, Spain 2005)*	5 Risk assessment	Belt iberica (2005)
	5.4 Policy-makers and citizens should not just take decisions when severe fire events occur. Decisions on planning and prevention are always required *(Forest fires in Greece 2007)*	5 Risk assessment; Prevention	EU (2008)
	5.5 Public awareness campaigns, monitoring and early warning systems are crucial to increase risk awareness in the population *(Forest fires in Greece 2007)*	5 Risk assessment; Awareness	EU (2008)
6	**6.1** Political commitment is essential, especially with regard to the provision of adequate budget, *(Portugal forest fire 2003)*	6 Management	EU (2008)
	6.2 The adoption of proactive rather than reactive responses, the amendment of conflicting policies and legislations and the definition of clear responsibilities for fire management *(Portugal forest fire 2003)*	6 Management	EU (2008)
	6.3 Update the Civil Protection legislation *(Forest fires in Guadalajara, Spain 2005)*	6 Management	Belt iberica (2005)
	6.4 Regional authorities' surveillance over municipal authorities, and national authorities' surveillance over regional authorities. *(Forest fires in Guadalajara, Spain 2005)*	6 Management	Belt iberica (2005)
7	**7.1** Training staff from operational level in Incident Command System *(Forest fires in Guadalajara, Spain 2005)*	7 Training	Belt iberica (2005)
	***7.2** Specific forest fire training for firefighters (Portugal forest fire 2003)*	7 Training	EU (2008)
8	**8.1** Investments in fire prevention can be more effective than investment in fire fighters *(Portugal forest fire 2003)*	8 Logistics	EU (2008)
	8.2 Political commitment is essential,	8 Logistics; Risk	EU (2008)

	especially with regard to the provision of adequate budget, the adoption of proactive rather than reactive responses, the amendment of conflicting policies and legislations and the definition of clear responsibilities for fire management *(Forest fires in Greece 2007)*	assessment	

Table 16: Summary of lessons learned from forest fires

6.1.2. Table of lessons learned on floods

	Lessons learned from Floods	Problem area	Source
1	**1.1** An assessment within the first days of the disaster pinpointed a need for food, clothing, blankets, hygiene products, clean drinking water and first aid kits *(floods in Poland 2001)*	1 Knowledge	IFRC (2013b)
	1.2 The disaster preparedness department is responsible for implementation of the operation through regular monitoring, reports and lesson learning *(floods in Poland 2001)*	1 Knowledge	IFRC (2013b)
	1.3 The development of non-structural measures (land use planning, monitoring and warning systems, risk communication) is still relatively slow in Poland (Zielaziński, 2010) and the predicted increase in flood frequency (Parry et al., 2007) calls for further intensification of this type of protective action *(floods in Poland 2001)*	1 Knowledge	Parry, M. L., Canziani, O. F., Palutikof, J. P., and Co-authors (2007)
	1.4 Personal contact is the prevailing means of communication in smaller settlements, while mass media are preferred by those living in larger towns *(floods in Poland 2001)*	1 Knowledge	Żeleziński, J.(2011)
	1.5 It is necessary to develop a mathematical model covering the whole area of Gdańsk, from all watercourses. This model must be based on the numerical map area, taking into account the state of development of the area. With this model you can predict in real time the effects of rainfall in different parts of the city. At the same time, this model would allow the simulation of various scenarios of rainfall and hydrological external (water levels in the sea, water levels in the main riverbed of the Vistula) *(floods in Poland 2001)*	1 Knowledge	Institute of Meteorology and Water Management, Warszawa (No Date)
	1.6 Since we cannot guard against floods, we must learn to live with it *(floods in Poland 2001)*	1 Knowledge	Institute of Meteorology and Water Management, Warszawa (No Date)
	1.7 Flooding should be treated as a normal phenomenon, occurring at intervals of several years	1 Knowledge	Institute of Meteorology and

	(floods in Poland 2001)		Water Management, Warszawa (No Date)
	1.8 Strengthening the risk awareness and availability of information about flood risks and damage *(floods in Europe 2013)*	1 Knowledge; Awareness; information policy	Austrian Red Cross (2014); Gremli et al. (2013)
	1.9 flood maps should be disseminated widely and more accessible for the public to enhance the awareness and understanding of the situation (potential flood risks) and to improve the preparedness in what to do when the flood takes place *(floods in Europe 2013)*	1 Knowledge; Awareness; information policy	Austrian Red Cross (2014); Gremli et al. (2013)
2	**2.1** Adaptation of new functionalities to the existent tools *(floods in Poland 2001)*	2 Communication	Herranz et al. (2012).
	2.2 the communication system should be strengthened with wider coverage within the country *(Floods in Panama 2012)*	2 Communication	Cruz Roja Panameña (2013)
	2.3 Improve the communication flow between the local committees and headquarters *(Floods in Panama 2012)*	2 Communication	Cruz Roja Panameña (2013)
	2.4 Identify a focal point for the communication between local committees and headquarters *(Floods in Panama 2012)*	2 Communication	Cruz Roja Panameña (2013)
	2.5 Training should be provided to people in charge of managing the information during an emergency *(Floods in Panama 2012)*	2 Communication	Cruz Roja Panameña (2013)
	2.6 Dissemination of the action plan among the supporting staff and volunteers *(Floods in Panama 2012)*	2 Communication	Cruz Roja Panameña (2013)
	2.7 Platform for the exchange of information between authorities responsible for crisis management and agencies should be created (Poland, Lower Silesia, 2010)	2 Communication	Governor's Office of Lower Silesian Wroclaw (2010)
	2.8 Cooperation with mass media is crucial to providing information to public (Poland, Lower Silesia, 2010)	2 Communication	Governor's Office of Lower Silesian Wroclaw (2010)
	2.9 When an event occurs, the funds provided by insurance companies might be an important element in the economic resources available *(floods in Poland 2001)*	2 Communication	Institute of Meteorology and Water Management, Warszawa (No Date).
	2.10 Increasing the number of measurement points and measurement of precipitation water levels on watercourses within the city. They have to be points of automatic measurement and transmission of information to the crisis centre *(floods in Poland 2001)*	2 Communication	Institute of Meteorology and Water Management, Warszawa (No Date).
3	**3.1** Establish a pre-agreement with other institutions and private companies in order to get resources, equipment, trucks during the emergency *(Floods in Panama 2012)*	3 Logistics; distribution	Cruz Roja Panameña (2013)
	3.2 Classify properly foods and cleaning items when packing them *(Floods in Panama 2012)*	3 Logistics; distribution	Cruz Roja Panameña (2013)
	3.3 Maintain an updated control of the inventory to avoid deterioration *(Floods in Panama 2012)*	3 Logistics; distribution	Cruz Roja Panameña (2013)

	3.4 Establish an emergency fund of first aid assets *(Floods in Panama 2012)*	3 Logistics; distribution	Cruz Roja Panameña (2013)
	3.5 Pre-positioning of equipment and material in the committees by the headquarters *(Floods in Panama 2012)*	3 Logistics; distribution	Cruz Roja Panameña (2013)
	3.6 Provide training in logistics and distribution to the practitioners and volunteers *(Floods in Panama 2012)*	3 Logistics; distribution	Cruz Roja Panameña (2013)
	3.7 Local Polish Red Cross (PRC) chapters mobilised more than 200 volunteers in affected areas and distributed relief items, such as food, water, clothing, shoes, blankets and hygiene products *(floods in Poland 2001)*	3 Logistics	IFRC (2013b)
	3.8 The first phase of the emergency operation - collection and distribution of relief items, organization of transport to the regions affected by floods, organization of search-and-rescue dog teams in Gdansk - was successful and its budget was fully covered *(floods in Poland 2001)*	3 Logistics	IFRC (2013b)
	3.9 Development of new technological tools *(floods in Poland 2001)*	3 Logistics; Resources	Herranz et al. (2012)
	3.10 Making use of additional means of protection, such as flood water retention areas along rivers *(floods in Europe 2013)*	3 Logistics; Resources; Technology (technical protection measures)	Ecker (2013); Gremli et al. (2013); IFRC (2013b)
	3.11 It is necessary to create legislation that will allow for the monitoring of municipal flood storage equipment from the provincial level because stocks in those warehouses were inadequate to scale of event (Poland, Lower Silesia, 2010)	3 Logistics	Governor's Office of Lower Silesian Wroclaw (2010)
	3.12 Number of vessels, lighting equipment and other specific equipment should be increased in flood warehouses and emergency services (Poland, Lower Silesia, 2010)	3 Logistics	Governor's Office of Lower Silesian Wroclaw (2010)
	3.13 Applying improved flood resilience structures which better withstand floods and mitigate risks when rebuilding *(floods in Europe 2013)*	3 Logistic; Resilience	Gremli et al. (2013)
	3.14 Implementation of remote monitoring devices to provide water level information for responsible authorities (*Poland, Lower Silesia, 2010*)	3 Logistics; Organizational matters	Governor's Office of Lower Silesian Wroclaw (2010)
	3.15 Hydrological monitoring and crisis management should cover all water bodies (*Poland, Lower Silesia, 2010*)	3 Logistics; Organizational matters	Governor's Office of Lower Silesian Wroclaw (2010)
	3.16 Digital maps of potential flood risk areas should be prepared (Poland, Lower Silesia, 2010)	3 Logistics; Organizational matters	Governor's Office of Lower Silesian Wroclaw (2010)
	3.17 Efforts should be made to cause provincial and district crisis management centers were fully modern and functional structures (Poland, Lower Silesia, 2010)	3 Logistics; Organizational matters	Governor's Office of Lower Silesian Wroclaw (2010)
4	**4.1** Relevant agencies should create unified maps with a detailed evaluation of threats and vulnerabilities list of	4 Interoperability	Governor's Office of Lower Silesian

	hydro technique facilities (Poland, Lower Silesia, 2010)		Wroclaw (2010)
	4.2 Better coordination of military forces by civilian specialists during flood protection is needed (Poland, Lower Silesia, 2010)	4 Interoperability	Governor's Office of Lower Silesian Wroclaw (2010)
	4.3 It should be clarified regulations regarding crisis management competences and responsibilities such as district governor in relation to the municipality (Poland, Lower Silesia, 2010)	4 Interoperability	Governor's Office of Lower Silesian Wroclaw (2010)
	4.4 Strengthening multi-stakeholder alliances in order to build long-term resilience *(floods in Europe 2013)*	4 Interoperability; Stakeholder involvement	Gremli et al. (2013); IFRC (2013b)
	4.5 Social capacity is the ensemble of resources available at various levels (e.g. individuals, organizations, communities) that can be used to anticipate, respond to, cope with, recover from and adapt to external stressors *(floods in Poland 2001)*	4 Interoperability	Governor's Office of Lower Silesian Wroclaw (2010); Town Hall Documents
	4.6 One should strengthen supervision and spatial planning procedures for floodplains. One should consider having a closer link with the spatial planning law, water law and construction law in this aspect. One should have changes in legislation to facilitate the process of expropriation of land for the construction of levees (Poland, Lower Silesia, 2010)	4 Interoperability	Governor's Office of Lower Silesian Wroclaw (2010)
5	**5.1** The coordination should be improved among the temporary shelters *(Floods in Panama 2012)*	5 Coordination	Cruz Roja Panameña (2013)
	5.2 Strengthen coordination mechanisms among different responders *(Floods in Panama 2012)*	5 Coordination	Cruz Roja Panameña (2013)
	5.3 Maintain regular meetings to improve the coordination with civil protection *(Floods in Panama 2012)*	5 Coordination	Cruz Roja Panameña (2013)
	5.4 Improve the coordination channels between the governmental institutions and response system *(Floods in Panama 2012)*	5 Coordination	Cruz Roja Panameña (2013)
	5.5 Define the roles and responsibilities of each responder and disseminate the action plan within administrative entities and volunteers *(Floods in Panama 2012)*	5 Coordination	Cruz Roja Panameña (2013)
	5.6 Maintain an active participation of private companies within the decision making and coordination meetings *(Floods in Panama 2012)*	5 Coordination	Cruz Roja Panameña (2013)
	5.7 The law should be changed to allow accurate determination of responsibility for particular section of embankments, dams and other hydraulic engineering is needed (Poland, Lower Silesia, 2010)	5 Coordination	Governor's Office of Lower Silesian Wroclaw (2010)
6	**6.1** Establish a record of entry of volunteers and the abilities required for the entry *(Floods in Panama 2012)*	6 Management of volunteers	Cruz Roja Panameña (2013)
	6.2 Delegate functions to the volunteers in order to manage the operation *(Floods in Panama 2012)*	6 Management of volunteers	Cruz Roja Panameña (2013)
	6.3 Establish monitoring mechanisms to assess the improvement level of the volunteers' training and enhance the response capacity of volunteers' leaders *(Floods in Panama 2012)*	6 Management of volunteers	Cruz Roja Panameña (2013)
	6.4 Establish and disseminate encouraging programs for volunteers to take part in response activities and promote and provide training capacities to improve their	6 Management of volunteers	Cruz Roja Panameña (2013)

	response abilities *(Floods in Panama 2012)*		
	6.5 Provide psychological support to the volunteers *(Floods in Panama 2012)*	6 Management of volunteers	Cruz Roja Panameña (2013)
	6.6 Improve the communication between volunteers and managers *(Floods in Panama 2012)*	6 Management of volunteers	Cruz Roja Panameña (2013)
	6.7 Establish volunteers' health prevention measures *(Floods in Panama 2012).*	6 Management of volunteers	Cruz Roja Panameña (2013)
	6.8 Finding innovative ways of engaging people civil protection and strengthening cooperativeness (floods in Europe 2013)	6 Management of volunteers	Austrian Red Cross (2014); Team Österreich (2014a)
7	**7.1** The extraordinary scale of this event highlighted many weaknesses in natural risks (including flood risk) management in Poland, not only due to poor structural measures and inefficient forecasting, monitoring and warning systems, but also making it equally evident that pre-flood risk communication was very weak to non-existent *(floods in Poland 2001)*	7 Risk assessment	Konieczny, R., Madej, P., and Siudak, M.(2001)
	7.2 Precise determination of the frequency, magnitude and risk is not possible *(floods in Poland 2001)*	7 Risk assessment	Institute of Meteorology and Water Management, Warszawa (No Date)
	7.3 The fact of the wave referred to as the "Hundred Years" or even "millennial" cannot put down the services responsible for flood protection and the public. History proves that the disaster of the same or even larger size may occur in the next year *(floods in Poland 2001)*	7 Risk assessment	Institute of Meteorology and Water Management, Warszawa (No Date)
8	**8.1** Number of reservoirs in Gdansk increased by 20 units. Most of them were built in the Upper Terrace. In total there are now 44 in Gdansk reservoirs. In total they can accommodate 457 790 m3 of rainwater *(floods in Poland 2001)*	8 Recovery	Town Hall Documents from Poland
	8.2 From 4 to 11 increased the number of pumping stations for storm water drainage also built a drainage pumping station (in total there are 10) *(floods in Poland 2001)*	8 Recovery	Town Hall Documents from Poland
	8.3 Making the inhabitants of affected flood areas an offer for resettlement *(floods in Europe 2013)*	8 Recovery; Resettlement	OÖN (2014)
	8.4 Assess and select the most vulnerable people of the fields (districts) most affected *(floods in Poland 2001)*	8 Recovery; learning; experience	IFRC (2013b)
	8.5 Analyze the factors and processes involved in social capacity building in selected localities, which suffered during the catastrophic floods in Poland in 1997 and 2001 *(floods in Poland 2001)*	8 Recovery; learning; experience	Żeleziński, J.(2011)

Table 17: Summary of lessons learned from floods

6.1.3. Table of lessons learned on earthquakes

	Lessons learned from Earthquakes	Problem area	Source
1	**1.1** Improve safe construction practices and control the quality of construction (*Earthquake in Turkey 1999*)	1 Knowledge	Mitchell, W. A. (2000)
	1.2 Learn from the earthquake-resistance retrofitting program in Athens (*Earthquake in Turkey 1999*)	1 Knowledge	Mitchell, W. A. (2000)
	1.3 Turkey's lessons could have internationally importance: there are some sprawling developing cities worldwide that facing similar challenges, Lima, Tehran and Karachi, where rapid and uncontrolled urban development has eclipsed housing safety standards (*Earthquake in Turkey 1999*)	1 Knowledge	Kocael et al. (1999)
	1.4 Handing inspection should be publicly regulated; otherwise the relationship between contractors and regulatory firms is open to misuse (*Earthquake in Turkey 1999*)	1 Knowledge	Turgut, P. (2012)
	1.5 Turkey needs to take more quality control measures to assure that buildings are designed and built according to code (*Earthquake in Turkey 1999*)	1 Knowledge	EQE International, Inc. (1999)
	1.6 Seismic code and categorization (*Earthquake in Italy 2009*)	1 Knowledge	Global Risk Miyamoto (2009)
	1.7 Monitor and study the earthquake and other natural events (*Earthquake in Haiti 2010*)	1 Knowledge	Earthquake Engineering Research Institute (2010)
	1.8 Implement timely image-acquiring systems based on high resolution satellite-to-earth observation and aerial photographs and to improve data acquisition, processing and image quality of satellite monitoring systems *(Earthquake in China 2008)*	1 Knowledge	Lo and Wang (2012)
2	**2.1** Create a “top down-bottom up” crisis action center with backup communications (*Earthquake in Turkey 1999*)	2 Communication; inter-agency	Mitchell, W. A. (2000)
	2.2 Need for a high-quality emergency radio communication system that can adapt to multiple circumstances *(Earthquake in China 2008)*	2 Communication	Xian et al. (2009)
	2.3 Small size, light weight, and highly integrated base stations are well suited for emergency communication systems and can significantly enhance the robustness of the application communication system *(Earthquake in China 2008)*	2 Communication	Xian et al. (2009)
	2.4 Build an emergency radio system that operates when the entire conventional communication network is down *(Earthquake in China 2008)*	2 Communication	Xian et al. (2009)
	2.5 Marine satellite phone became the sole means of communication in a hilly area laced with rivers, blocked by debris, and deprived of water and power *(Earthquake in China 2008)*	2 Communication	Xian et al. (2009)
	2.6 There must be adequate radio equipment stored around a country to establish an emergency	2 Communication	Xian et al. (2009)

	communication network as soon as possible after a disaster *(Earthquake in China 2008)*		
	2.7 Need tsunami warning system *(Earthquake- Tsunami in Japan 2011)*	2 Communication	Japanese Red Cross Society (2013)
	2.8 Need good communication and help from LEMA to set up radio links and integrate with other agencies *(Earthquake- Tsunami in Japan 2011)*	2 Communication	Japanese Red Cross Society (2013); INPO (2012); Wright (2011)
	2.9 Cell phones should be allocated to roles not people, and stay in the EOC *(Earthquake- Tsunami in Japan 2011)*	2 Communication	Japanese Red Cross Society (2013); INPO (2012); Wright (2011)
	2.10 Wireless networking is essential in an emergency situation. Any future EOC site should be equipped with wireless technology, along with necessary technology, fiber distribution, and additional networking so the IT team is ready from day one of the emergency operation *(Earthquake- Tsunami in Japan 2011)*	2 Communication	Japanese Red Cross Society (2013)
	2.11 Need to strengthen several aspects of nuclear safety *(Earthquake- Tsunami in Japan 2011)*	2 Communication	Institute of Nuclear Power Operations (2012)
3	**3.1** Robustness of the lifelines relies on the built-in redundancy *(Earthquake in China 2008)*	3 Logistics; lifeline facilities	Lo and Wang (2012)
	3.2 Regular review and upgrade of lifeline facilities is necessary in normal time as well as prompt repair of failed components after an earthquake *(Earthquake in China 2008)*	3 Logistics	Lo and Wang (2012)
	3.3 The internet can be used by the earthquake investigators for conducting earthquake intensity survey, and to coordinate international investigation efforts through dedicated websites, links, individual blogs and social media *(Earthquake in China 2008)*	3 Logistics	Lo and Wang (2012)
	3.4 Modern information technology equipment contributes to the efficiency of an individual investigator *(Earthquake in China 2008)*	3 Logistics	Lo and Wang (2012)
	3.5 Regularly reassess and adjust the logistics disaster plan to take into account any changing circumstances *(Earthquake- Tsunami in Japan 2011)*	3 Logistics	Okumura (No date)
	3.6 Suitably designed depots with cargo-handling equipment such as forklifts are needed, along with the support of logistics professionals *(Earthquake- Tsunami in Japan 2011)*	3 Logistics	Okumura (No date)
	3.7 Prior quantitative estimates of urgently needed goods should be carried out based on regional demographic statistics *(Earthquake- Tsunami in Japan 2011)*	3 Logistics	Osa et al. (No date)
	3.8 Emergency delivery systems should be closed down as soon as feasible to allow normal commercial distribution systems to take over *(Earthquake- Tsunami in Japan 2011)*	3 Logistics	Osa et al. (No date)
	3.9 There should be prior identification and training of local government staff that will be tasked with responding to large-scale disasters *(Earthquake- Tsunami in Japan 2011)*	3 Logistics	Osa et al. (No date)
	3.10 There should be prior formulation of a list of goods and a standard format for shipments and orders for smooth and seamless activation of the disaster response *(Earthquake- Tsunami in Japan 2011)*	3 Logistics	Osa et al. (No date)

4	**4.1**Training and periodic drills must be sufficiently challenging and realistic to prepare operating crews and emergency response personnel to cope with and respond to situations that may occur during a multi-unit accident, including a nuclear accident resulting from a natural disaster *(Earthquake- Tsunami in Japan 2011)*	4 Interoperability	INPO (2012)
	4.2 It is strongly recommended not to send any relief goods without coordination with the government or the local authorities *(Earthquake- Tsunami in Japan 2011)*	4 Interoperability	INPO (2012)
5	**5.1** Twinning of communities in need and those who helped accomplished dual goals: sharing of enormous financial hardship; and cultivating camaraderie among population *(Earthquake in China 2008)*	5 Coordination	Lo and Wang (2012)
	5.2 Mutual-aid plans among adjacent jurisdictions, both locally and internationally, should be pre-arranged prior to the occurrence of earthquake *(Earthquake in China 2008)*	5 Coordination	Hoyer, B. (2009)
	5.3 Greater efforts could have been made to enlist the support of specialized international agencies in specific areas, including emergency shelter, livelihoods and health *(Earthquake in China 2008)*	5 Coordination	Hoyer, B. (2009)
	5.4 Very little attention was paid to psychosocial and mental health programs, especially among elderly people, who may well have benefited from specialized support from the humanitarian community *(Earthquake in China 2008)*	5 Coordination	Hoyer, B. (2009)
	5.5 Lack of transparency in terms of specific data and details of the response have concealed many of the successes of the response, as well as obscuring areas for improvement *(Earthquake in China 2008)*	5 Coordination	Hoyer, B. (2009)
	5.6 Nuclear operators must establish the necessary infrastructure to respond effectively to severe accident conditions, mitigate core damage, and stabilize the units if core damage does occur *(Earthquake-Tsunami in Japan 2011)*	5 Coordination; decision making	Japanese Red Cross Society (2013): INPO (2012)
	5.7 Establish strategies for staffing operating crews, other key plant positions, and site and corporate emergency response organizations quickly in the initial stages of a multi-unit event and over the long duration of the event response *(Earthquake- Tsunami in Japan 2011)*	5 Coordination; decision making	Japanese Red Cross Society (2013); INPO (2012)
	5.8 Ensure that primary and alternative methods for monitoring critical plant parameters and emergency response functions are available *(Earthquake-Tsunami in Japan 2011)*	5 Coordination; decision making	Japanese Red Cross Society (2013); INPO (2012)
	5.9 Clearly define and communicate the roles and responsibilities of emergency response personnel to help ensure effective post-accident communications and decision-making *(Earthquake- Tsunami in Japan 2011)*	5 Coordination; decision making	Japanese Red Cross Society (2013); INPO (2012)
	5.10 Establish systems to deal with long-term public health effects, including stress-related illness *(Earthquake- Tsunami in Japan 2011)*	5 Coordination	Japanese Red Cross Society (2013); INPO (2012)
	5.11 Establish a detailed and transparent program of	5 Coordination	Japanese Red Cross

	decontamination and relocation, as well as provide information so that all residents will be knowledgeable about their compensation options *(Earthquake-Tsunami in Japan 2011)*		Society (2013); INPO (2012)
6	**6.1** Create and practice a national quick response program for search and rescue (*Earthquake in Turkey 1999*)	6 Risk management; disaster response	Mitchell, W. A. (2000)
	6.2 Create and practice preparation for massive casualties (*Earthquake in Turkey 1999*)	6 Risk management; disaster response	Mitchell, W. A. (2000)
	6.3 The role of the gendarmeries in national disasters needs to be clarified (*Earthquake in Turkey 1999*)	6 Risk management; rescue management	Mitchell, W. A. (2000)
	6.4 The Public Works Law should be upgraded and adapted to new technology (*Earthquake in Turkey 1999*)	6 Risk management; rescue management	Mitchell, W. A. (2000)
	6.5 Improved international relations with European Union and with Greece (quake diplomacy) (*Earthquake in Turkey 1999*)	6 Risk management; Response	Mitchell, W. A. (2000)
	6.6 Improve all provincial centres with high-tech, dog-supported emergency search teams. (*Earthquake in Turkey 1999*)	6 Risk management; Response	Mitchell, W. A. (2000)
	6.7 Even the most devastated communities and governments retain capacities (*Earthquake in Haiti 2010*)	6 Risk management; Response	Patrick, J. (2011)
	6.8 Private and institutional donors should be encouraged to give cash rather than assistance in kind (*Earthquake in Haiti 2010*)	6 Risk management; Response	Patrick, J. (2011)
	6.9 Importance of designing and building buildings with full consideration of earthquake resistance and seismic loadings *(Earthquake in China 2008)*	6 Risk management	Xian et al. (2009)
	6.10 School buildings and hospital structures should be conform to building design standards that are higher than design codes for standard residential and office buildings *(Earthquake in China 2008)*	6 Risk management	Zhang et al. (2012); Paterson et al. (2008)
	6.11 Schools and emergency-response facilities, especially those located on weak sub soils prone to liquefaction, tsunami vulnerable zone, or site subject to geologic hazard, should be relocated or retrofitted to meet the requirement of maintaining their function after an earthquake *(Earthquake in China 2008)*	6 Risk management	Zhang et al. (2012); Paterson et al. (2008)
	6.12 An increase in specialists in internal medicine, obstetrics and gynecology, pediatrics, and infectious diseases could effectively reduce the complications and mortality associated with late rescue work *(Earthquake in China 2008)*	6 Risk management	Zhang et al. (2012)
	6.13 Supportive medical forces should be distributed to meet the specific demands within the disaster area to improve prognosis and reduce death and disability *(Earthquake in China 2008)*	6 Risk management	Zhang et al. (2012)
7	**7.1** Microzonation for identifying areas susceptible to strong earthquakes and determination of appropriate *land use*, guided by the identified hazards to mitigate	7 Risk assessment	Lo and Wang (2012)

	potential loss *(Earthquake in China 2008)*		
	7.2 Consider potential impacts on secondary damages in order to devise realistic response strategy, and to plan for orderly implementation of long-term upgrade of existing facilities *(Earthquake in China 2008)*	7 Risk assessment	Lo and Wang (2012)
	7.3 The impact of potential fault displacement on the performance of the sub- and super-structures crossing active faults is a a serious challenge to designers *(Earthquake in China 2008)*	7 Risk assessment	Lo and Wang (2012)
	7.4 Installation and maintenance of modern instrumentations for recording strong ground motion is important *(Earthquake in China 2008)*	7 Risk assessment	Lo and Wang (2012)
	7.5 Update of seismicity hazard and upgrade of seismic design should be carried out on a regular basis *(Earthquake in China 2008)*	7 Risk assessment	Lo and Wang (2012)
	7.6 Periodical review and update of the building code is necessary *(Earthquake in China 2008)*	7 Risk assessment	Lo and Wang (2012)
	7.7 always be prepared for unexpected and unprecedented phenomenon and crisis *(Earthquake- Tsunami in Japan 2011)*	7 Risk assessment	Japan disaster prevention forum (2012)
	7.8 Plant design features and operating procedures alone cannot completely mitigate the risk posed by a beyond-design-basis event. Additional preparations must be made to respond if such an event were to occur *(Earthquake- Tsunami in Japan 2011)*	7 Risk assessment	Japan disaster prevention forum (2012)
	7.9 Maintain the regulations up to date and build them up according to the scientists' simulations *(Earthquake- Tsunami in Japan 2011)*	7 Risk assessment	Japan disaster prevention forum (2012)
	7.10 Keep the population informed using the images of effects of the previous disaster, rather than numbers and statistics *(Earthquake- Tsunami in Japan 2011)*	7 Risk assessment	Japan disaster prevention forum (2012)
	7.11 Develop a culture of disaster preparedness to the population situated in the vulnerable areas (depending on the type of risk) *(Earthquake- Tsunami in Japan 2011)*	7 Risk assessment	Japan disaster prevention forum (2012)
	7.12 Make the simulations as close as possible to the reality, taking into account all data and measurements obtained from real sensors or network stations *(Earthquake- Tsunami in Japan 2011)*	7 Risk assessment	Japan disaster prevention forum (2012)
	7.13 Decrease the damage by fixing furniture and other security measures *(Earthquake- Tsunami in Japan 2011)*	7 Risk assessment	Japan disaster prevention forum (2012)
8	**8.1** Protection of historical and cultural heritage (*Earthquake in Italy 2009*)	8 Prevention/ Preparation	Global Risk Miyamoto (2009)
	8.2 Protection of strategic and essential facilities (*Earthquake in Italy 2009*)	8 Prevention/ Preparation	Global Risk Miyamoto (2009)
	8.3 Anchorage and bracing of hazardous equipment is recommended (*Earthquake in Italy 2009*)	8 Prevention/ Preparation	Global Risk Miyamoto (2009)

	8.4 Establishment of a national disaster medical response system, an active and effective commanding system, successful coordination between rescue forces and government agencies, effective treatment, a moderate, timely and correct public health response, and long-term psychological support are all crucial to reduce mortality and morbidity and promote overall effectiveness of rescue efforts after a major earthquake (*Earthquake in China*)	8 Prevention/ Preparation	Zhang et al. (2012)
9	**9.1** Emergency response: introducing a formal post-earthquake engineering inspection program (*Earthquake in Italy 2009*)	9 Training; education	Global Risk Miyamoto (2009)
	9.2 Building Haitian capacity to analyze, address problems and manage the emergencies will need systematic training *(Earthquake in Haiti)*	9 Training	Patrick, J. (2011)
	9.3 Drills of emergency response need to be practiced regularly to enhance the capability of response agencies and personnel, and public awareness (*Earthquake in China*)	9 Training	Zhang et al. (2012)
	9.4 Society has to change from a response culture to a prevention culture to cope better with natural disasters, and to reinforce the key role of pre-disaster preparation in the reduction of casualties (*Earthquake in China*)	9 Training	Zhang et al. (2012)
	9.5 Preservation of certain damaged or failed structures in the earthquake-stricken areas as memorial sites will remind and educate the public about the importance of adequate seismic design and earthquake preparedness (*Earthquake in China*)	9 Training	Zhang et al. (2012)
10	**10.1** Avoid rebuilding vulnerability. It is necessary to examine and militate against plausible risks (*Earthquake in Haiti*)	10 Recovery	Earthquake Engineering Research Institute (2010)
	10.2 Set up a "Reconstruction Agency" after disaster *(Earthquake- Tsunami in Japan 2011)*	10 Recovery	
	10.3 Establish government assistance which includes support for disaster survivors and local government, reconstruction of infrastructure, disposal of tsunami debris, industrial revitalization, and promotion of employment *(Earthquake- Tsunami in Japan 2011)*	10 Recovery	Japanese Red Cross Society (2013)
	10.4 Establishment of new tsunami warning system *(Earthquake- Tsunami in Japan 2011)*	10 Recovery	Japan Meteorological Agency (2013)
	10.5 Establishment of a national recovery plan including the issues foreseeing large-scale societal changes concerning tsunami preparedness *(Earthquake- Tsunami in Japan 2011)*	10 Recovery	Japanese Red Cross Society (2013)

Table 18: Summary of lessons learned from earthquakes

6.2 Holistic framework for lessons learned reporting

Based on the process of gathering and categorizing tangible lessons learned it has become clear that the framework presented in chapter 2, must be modified. It has been an iterative process and it is important that the insights and comments from the ELITE CoP through the validation process are incorporated in the framework. The modified table is titled "a holistic framework for lessons learned" (figure 7). This takes into account all phases, all hazards and topics that are specific for certain phases. Eight topics have been proposed as the main categories.

Some categories have been added; *knowledge* and *prevention*. *Knowledge* includes *awareness* and *learning*. *Prevention* merges the topics of *preparation*, *training* and *education.* Crosscutting categories has been identified; *communication, knowledge, coordination and decision-making* and *logistics*. *Coordination and decision-making* incorporates the topic of *management*.

The categories of *prevention, interoperability* and *recovery* can be regarded as problems that are specific to a certain phase. This ensures that no phases are "forgotten". During the ELITE CoP workshop several experts argued that the topic of *recovery* in the post-crisis phase is forgotten.

Communication (all phases)

- Inter-agency communication
- Crisis communication to the population
- What was the role of media and social media?

Knowledge (all phases)

- Knowledge or awareness in the population
- Knowledge/awareness/learning among the operationals

Coordination and decision-making (all phases)

- How was the coordination and decision-making in terms of roles and responsibilities of different actors?
- Management

Risk assessment (all phases)

- How to be prepared for a crisis with cascading effects?
- How did the natural disaster affect critical infrastructure
- Were risk assessments conducted during the crisis?

Logistics (all phases)

- Were there any challenges related to logistics?

Prevention (pre-crisis)

- Specific training of operationals?
- Education of operationals/the public?

Interoperability (during)

- How was the interoperability between the different actors?
- Management of volunteers

Recovery (post-crisis)

- What was done in the recovery phase and by whom?
- Debrief

Figure 7: A holistic framework for lessons learned

Within each category examples of questions are provided. Since the categories are very broad, these questions can help in the lesson learned reporting process.

We recommend that the holistic framework developed in the ELITE project is used as guidelines for lessons learned. It is especially relevant to use in order to connect the learning process, i.e. going from lessons identified in the post-crisis phase to lessons learned and implemented in the pre-crisis phase. The relevance of these guidelines was stated by several CoP members in the final workshop, as one expert claimed: "*This framework is suitable for all types of crises, and is a very helpful tool for us to sort out all areas and topics that we must consider when writing lessons learned reports*."

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