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Review report of key challenges and lessons learned from historical extreme hydro-meteorological events

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Editors	Enrico Duo (CFR) Paolo Ciavola (CFR)
Authors	PART I: Enrico Duo (CFR), Paolo Ciavola (CFR), Clara Armaroli (CFR), Laura Rossello (CIMA), Nicola Rebora (CIMA), Guntram Seiß (BAW), Lisa Segnestam (SEI), Xavier Bertin (LIENSs-CNRS), Gael Arnaud (LIENSs-CNRS), Anna McIvor (UCAM), Tom Spencer (UCAM), T.A. Plomaritis (UAlg), Susana Costas (UAlg), Oscar Ferreira (UAlg), Jose A. Jimenez (UPC), Nikolay Valchev (IO-BAS), Steven Smets (IMDC), M.M. Uddin (CFR), S.H.M. Fakhruddin (WMO). PART II: Paolo Ciavola (CFR), Emmanuel Garnier (UCaen), Anna McIvor (UCAM), Tom Spencer (UCAM), T.A. Plomaritis (UAlg), Susana Costas (UAlg), Oscar Ferreira (UAlg), Nicola Rebora (CIMA), Laura Rossello (CIMA), Clara Armaroli (CFR), Enrico Duo (CFR), Xavier Bertin (LIENSs-CNRS), Gael Arnaud (LIENSs-CNRS), S.H.M. Fakhruddin (WMO), Grit Martinez (Ecologic)
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List of Main Acronyms

CC	Climate Change
CCAS	Climate Change Adaptation Strategy
EC	European Commission
EU	European Union
FD	Floods Directive
HFA	Hyogo Framework for Action
ICZM	Integrated Coastal Zone Management
MS	Member State (MSs for plural)
MSP	Maritime Spatial Planning
PFA	Priority for Action
UN	United Nations
UNISDR	United Nations International Strategy for Disaster Reduction
WFD	Water Framework Directive

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Publishable Summary

The objective of this report was to establish a starting position for potential advances in DRR strategies through review, data collection and historical analysis. In particular, the report reviewed (supra-)national DRR management plans for all CSs and analysed large-scale historical events to derive lessons-learned at RISC-KIT European CSs in the United Kingdom, Portugal, Italy, and France. Large-scale events like tropical cyclones and hurricanes were also analysed for Bangladesh and the USA. An interdisciplinary approach drawing on the physical, economic, social and historical sciences was used to ensure that all aspects relevant to the project were considered.

Although intergovernmental, supra-national and national DRR polices exist and are publicly available, it resulted quite difficult to obtain a complete overview of their structure and mutual relations. The perception was that there is a huge documentation on the topic but no sources can be considered exhaustive. Moreover, especially at the supra-national level, the number of Strategies, Directives, Guidelines and Tools related to Disaster Management and DRR turned to be uncountable. A significant effort is spent by the European Commission to try to coordinate policies at EU level but it is still difficult to identify a clear roadmap for citizens and policy-makers.

On the other hand, at the national level, even when there is a clear intent to solve and face the issue in a comprehensive and integrated way, administrative and political obstacles identified in the analyses make a common approach difficult between member states. Comparisons and standardization processes of the approaches used for example for the application of the EU flood directive seem to be far away from the target.

Several shortcomings in policies, in terms of clearness, consistency and coordination were evidenced. Complex systems of emergency response and management at national level were highlighted. Moreover, a general discordance from official national adaptations claims and what is the technical perception that practitioners have of coastal risk management, was evidenced for UN HFA and EU FD.

An analysis was undertaken on the record of historical large-scale events on the case study sites of the Norfolk Coast (UK), the Charente-Vendée coast (France), the Cinque Terre-Liguria (Italy), the Emilia-Romagna coast (Italy) and the Ria Formosa coast (Portugal). In addition to these European cases, the review was extended to non-European examples from areas exposed to tropical storms: tropical cyclones in Bangladesh(1991, 1997, 2011), New Orleans and the Louisiana coast (2005, 2008), New York City and New Jersey (2012).

The analyses of a database developed ad-hoc from the European case study sites managed to date large-scale disasters to the middle ages. It also evidenced the re-occurrence of events with comparable magnitudes overtime, showing that the "exceptionality" of recent disasters is only a matter of perception, generally due either to an increase in coastal occupation or to a loss of historical memory. As the database became more quantitative regarding the forcing factors (e.g. from the XX century

onwards), it was clear that in some occasions (e.g. the re-occurrence of a comparable storm along the coast of Eastern England) large spatial variations in flood level might occur. Notably an analysis of high magnitude tropical storms (hurricanes) in the USA found that a large change in DRR policies only took place after the largest coastal disasters in American history (e.g. Katrina, Sandy).

Executive Summary

According to the DoW, the task of analysis and report writing was divided into two phases: the first one was marked by the production of Milestone 5 (Part I of this report), while the second one led to the completion of the deliverable D1.1 (Part II of this report).

In the first phase, this activity started with a review of the current-practice coastal DRR management plans at the EU level, at the national level for member states with case study sites and at the supra-national level by reviewing UN policy such as the HFA, and the UNESCO-IOC Group on Coastal Hazards. The review identified similarities and disparities between countries, and limitations and gaps concerning marine-driven events and rain-driven flash floods.

As first step, the report collected information on policies identifying links to publicly available documents, which are often difficult to find as they are in the form of grey literature or unpublished reports. Moreover, the review gathered several links to web tools, mainly informative tools that were published by the European Commission, by the United Nations and by National Authorities but limited dissemination makes them unknown to the majority of the population and policy-makers.

The analyses of the DRR polices at different level showed that even when there is a will to solve and face the issue in a comprehensive and integrated way at national level, it often encounters administrative and political obstacles, impeding the use of a standard approach difficult to apply. Comparisons and standardization processes of the approaches used for the application of the EU flood directive seem to be far away from the target. Several shortcomings in intergovernmental and supra-national policies, in terms of clearness, consistency and coordination add confusion in the complex systems of emergency response and management that were identified at national level.

Several analyses on the implementation of supra-national initiatives (EU and UN) at national level in the countries belonging to the project's consortium were undertaken. The implemented analyses on national adaptation to intergovernmental (e.g. the UN Hyogo Framework for Action-HFA) and supra-national (e.g. EU Floods Directive) policies were made to understand whether States are following the requirements or not. However, they were necessarily limited in time and space and we may have omitted some important documents. RISC-KIT consortium members to overcome for example language barriers did the collection of sources. RISC-KIT consortium members were also requested to evaluate the level of application of the policies to their own country. It was asked to adopt a point of view as objective as possible, focusing on national level assessment and trying to be free from official outcomes and local perspective.

First, the adaptation of Member States to the EU Floods Directive was analysed following three steps: (i) a review of some examples of risk assessment; (ii) an analysis based on RISC-KIT Case Study Owners' experience; (iii) a web-based overview on the available and published documents from the ROD EIONET web database.

Then, national adaptation to the UN Hyogo Framework for Action was investigated through an analysis of available official reports and through an internal perception-based questionnaire compiled by RISC-KIT CSOs.

At EU level, the analyses evidenced that, although best practices for the implementation of the Floods Directive can be found over Europe (e.g. Italy and UK) and the Member States are in line with the requirements, criticisms were evidenced in the practical terms, especially at local level, evidencing consistent differences in the application of the directive that should be instead standardised. Moreover, while riverine applications of the FD are clear and implemented, the coastal aspect is often secondary and unclear or incomplete. Despite being a requirement of the directive the "basin scale approach" is often missed.

Officially, regarding UN directives, all States included in the analysis showed a medium-high achievement of HFA Priorities, with some exceptions. On the other hand, looking at the RISC-KIT self-check assessment by the Case Study Partners, only Bangladesh, United Kingdom, Germany and Sweden were confirmed in their status. For Italy, France, Portugal and Bulgaria the RISC-KIT CSOs were in disagreement from governmental official reports. In Spain and Belgium, for which only the RISC-KIT assessment is available at the moment, the achievement of HFA Priorities was far away from the good status.

Focusing on Europe, a geographical pattern in successful implementation was found. Northern European States, with the exception of Belgium, are firmly implementing HFA Priorities and their governments are reporting on time. On the other hand, southern ones are not. In particular, the governments of southern European States reported positive outcomes about the application of the HFA, whereas our RISC-KIT CSOs reported otherwise.

The historical analysis undertaken for the second phase of the task considered a time span for the frequency of storms which at some sites extended over 300 years backwards. The event inventory was based on the database of historical storms developed within WP1 for Task 1.3. The historical researches were undertaken at five case studies (Ria Formosa, Porto Garibaldi, Bocca di Magra, North Norfolk and Faute-sur-Mer) through a visit to local archives, libraries etc. Additionally, a study of the occurrence of tropical storms was undertaken for Eastern Coast of the United States and for the Bangladesh coastline using either public databases or literature sources.

For the east coast of the UK records backdate to the 11thCentury but for the specific case study site the first available record is from 1655 up to the present day, with the disaster of 31 January 1953 standing out as having the greatest impact.

For the Ria Formosa site in Algarve (Portugal) the historical research was complex, as the area remained uninhabited till the beginning of the 20th century. The available historical material provided a list of 13 storms from the beginning of the 19th century. To notice the occurrence of the 1941 "cyclone" that hit the entire Iberian Peninsula, becoming the largest natural disasters of the last 200 years. The most important recent event in the Ria Formosa was the group of storms occurred between the 22nd of February until the 4th of March 2010.

Historical research on the RISC-KIT case study site of Bocca di Magra (Liguria, Italy) was a real challenge because the valley became populated only at the beginning of the 20th century. We have collected 23 relevant events in the last 400 years. The first historical storm dates back to the 11th November 1613 while the last one happened on 19th March 2013.

Despite its foundation at the beginning of the 20th century, the coastal city of Porto Garibaldi (Emilia-Romagna, Italy) paradoxically offered abundant historical documentation. The site recorded the best-documented storm in 1927, the year of the disastrous "*mareggiata*" of Porto Garibaldi, which damaged most of the village. The storm of 4th November 1966 also was particularly critical for the Emilia-Romagna coastline and caused extensive erosion and flooding due to marine water ingression and river overflow generated by the persistent heavy rainfall. The 1966 storm had significant consequences on both the population and the territory and damages were widespread all over the regional coastline.

The historical approach to the study of past extreme event on the site of La Faute-sur-Mer (France) was extremely difficult because this coastal city did not exist at administrative level before the second half of the 20th century. However, a large amount of historical data was collected, opening many new perspectives, particularly for the area of La Faute-sur-Mer where many storm-induced flooding occurred over the last century. To notice that immediately after Xynthia, French authorities and local representatives claimed that the event was "exceptional" and thus unpredictable. This dramatically illustrates that there was a loss of historical memory because we found that the site had already undergone 4 floods between 1900 and 2010.

In the case of cyclone impacts in Bangladesh, data were collected and analysed using both existing information and consultation with National Agencies of the Government of Bangladesh. The review considered the following events: the severe Cyclonic Storm of 24-30 November, 1988; the severe Cyclonic Storm of 24-30 April 1991; the severe Cyclonic Storm of 15-20 May 1997; the severe Cyclonic Storm SIDR of 11-16 November 2007; the severe Cyclonic Storm AILA, 22-26 May 2009. An analysis of DRR showed that Bangladesh has gone through a process of significant reforms in recent years. Following the devastating floods of 1988 and the cyclone of 1991, which created massive economic destruction in the economy, the focus shifted towards a holistic approach that embraces processes of hazard identification and mitigation, community preparedness, and integrated response efforts.

The NOAA Historic Hurricane and Storm Database was the main source of information on US hurricane and storms. It was used to derive the description of hurricanes Katrina and Ike (and their impacts). For hurricane Sandy the investigation was mainly based on reports by the National Hurricane Centre and NOAA. Hurricanes Katrina, Ike and Sandy mark records in the history of the U.S. in terms of their deadly impacts and property damages. Although only in the case of hurricane Katrina major deficits in the quality of the flood-control system account for a high proportion of the disaster, in all three extreme events a major break-down of public risk communication and early warning before, during and after the event signals the need for wide improvements in early warning and risk awareness communication in the U.S.

The current report provides an important guideline on how to exploit historical datasets of storm records merging them with recent and high quality observations. Our review strongly builds on arguably the most complete dataset on marine storm impacts available for the European Union and Bangladesh, with its current strength (as of May 2015) of 217 extra-tropical storm events for Europe and 38 tropical storms for Bangladesh.

1 Introduction

Recent and historic low-frequency, high-impact events such as Xynthia (impacting France in 2010), the 2011 Liguria (Italy) Flash Floods and the 1953 North Sea storm surge which inundated parts of the Netherlands, Belgium and the UK have demonstrated the flood risks faced by exposed coastal areas in Europe. Typhoons in Asia (such as Typhoon Haiyan in the Philippines in November 2013), hurricanes in the Caribbean and Gulf of Mexico, and Superstorm Sandy, impacting the northeastern U.S.A. in October 2012, have demonstrated how even larger flooding events pose a significant risk and can devastate and immobilize large cities and countries.

These coastal zone risks are likely to increase in the future (IPPC, AR5) which requires a re-evaluation of coastal disaster risk reduction (DRR) strategies and a new mix of prevention (e.g. dike protection), mitigation (e.g. limiting construction in flood-prone areas; eco-system based solutions) and preparedness (e.g. Early Warning Systems, EWS) (PMP) measures. Even without a change in risk due to climate or socio-economic changes, a re-evaluation is necessary in the light of a growing appreciation of ecological and natural values that drive ecosystem-based or Nature-based flood defense approaches. In addition, as free space is becoming sparse, coastal DRR plans need to be spatially efficient, allowing for multi-functionality.

1.1 Project objectives

In response to these challenges, the RISC-KIT project aims to deliver a set of open-source and open-access methods, tools and management approaches to reduce risk and increase resilience to low-frequency, high-impact hydro-meteorological events in the coastal zone. These products will enhance forecasting, prediction and early warning capabilities, improve the assessment of long-term coastal risk and optimise the mix of PMP-measures. Specific objectives are:

1. Review and analysis of current-practice coastal risk management plans and lessons-learned of historical large-scale events;
2. Collection of local socio-cultural-economic and physical data at case study sites through end-user and stakeholder consultation to be stored in an impact-oriented coastal risk database;
3. Development of a regional-scale coastal risk assessment framework (CRAF) to assess present and future risk due to multi-hazards (Figure 1.1, top panel);
4. Development of an impact-oriented Early Warning and Decision Support System (EWS/DSS) for hot spot areas consisting of: i) a free-ware system to predict hazard intensities using coupled hydro-meteo and morphological models and ii) a Bayesian-based Decision Support System which integrates hazards and socio-economic, cultural and environmental consequences (Figure 1.1, centre panel);
5. Development of potential DRR measures and the design of ecosystem-based and cost-effective, (non-)technological DRR plans in close cooperation with end-users for a diverse set of case study sites on all European regional seas and on one tropical coast (Figure 1.1, bottom panel);

6. Application of CRAF and EWS/DSS tools at the case study sites to test the DRR plans for a combination of scenarios of climate-related hazard and socio-economic vulnerability change and demonstration of the operational mode;
7. Development of a web-based management guide for developing integrated DRR plans along Europe's coasts and beyond and provide a synthesis of lessons learned in RISC-KIT in the form of policy guidance and recommendations at the national and EU level.

The tools are to be demonstrated on case study sites on a range of EU coasts in the North- and Baltic Sea Region, Atlantic Ocean, Black Sea and Mediterranean Sea see Figure 1.2. Moreover, an International case study site was chosen in Bangladesh (Sandwip Island, see Figure 1.3). These sites constitute diverse geomorphic settings, land use, forcing, hazard types and socio-economic, cultural and environmental characteristics. All selected regions are frequently affected by storm surges and coastal erosion. A management guide of PMP measures and management approaches will be developed. The toolkit will benefit forecasting and civil protection agencies, coastal managers, local government, community members, NGOs, the general public and scientists.

1.2 Project structure

The project is structured into seven Work Packages (WP) starting with WP1 on 'Data collection, review and historical analysis'; WP2–4 will create the components of the RISC-toolKIT containing an 'Improved method for regional scale vulnerability and risk assessment' (WP2), 'Enhanced early warning and scenario evaluation capabilities for hot spots' (WP3) as well as 'New management and policy approaches to increase coastal resilience' (WP4). The toolkit will be tested through 'Application at case study sites' (WP5). WP6 will be responsible for 'Dissemination, knowledge transfer and exploitation' and 'Coordination and Management' are handled in WP7.

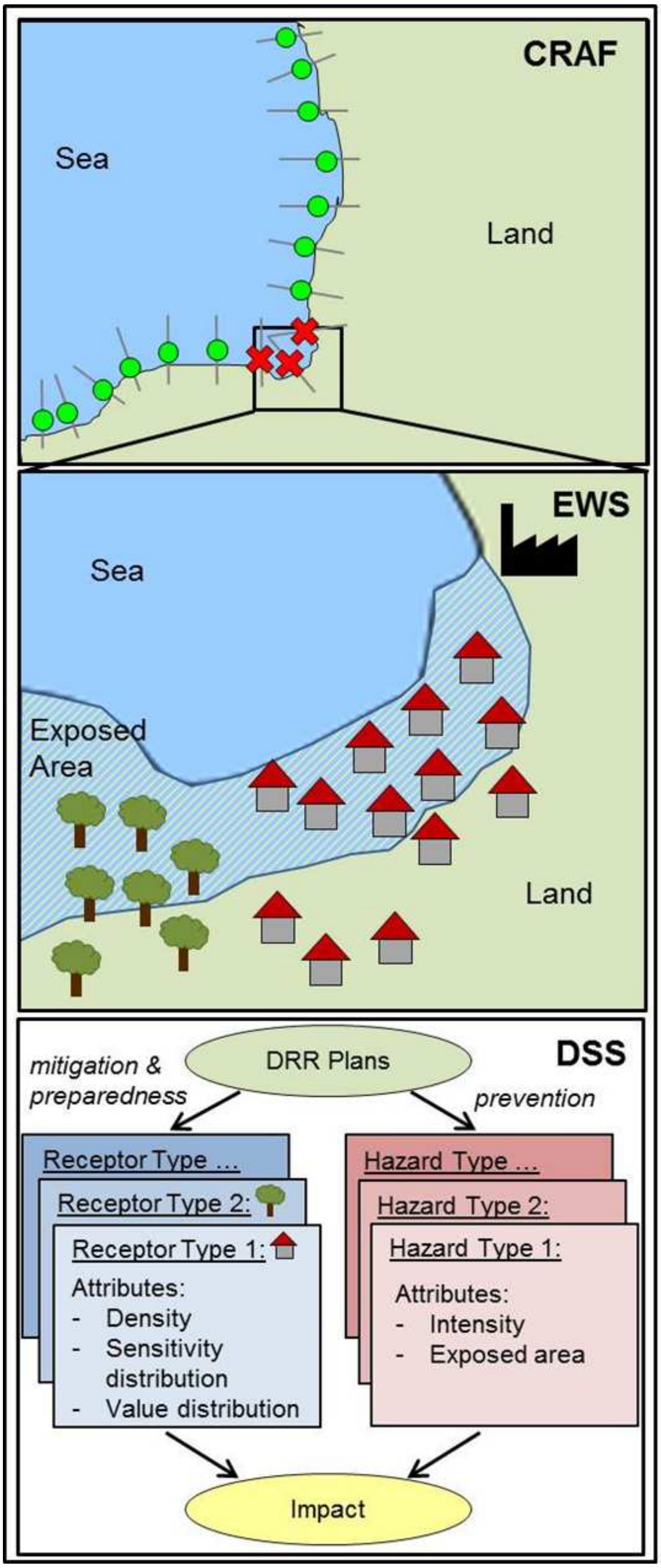

Figure 1.1 Conceptual drawing of the CRAF (top panel), the EWS (middle panel) and the DSS (bottom panel).

Figure 1.2 EU Case study sites (stars), RISC-KIT case study site partners (blue solid dots) and non-case study site partners (red open circles).

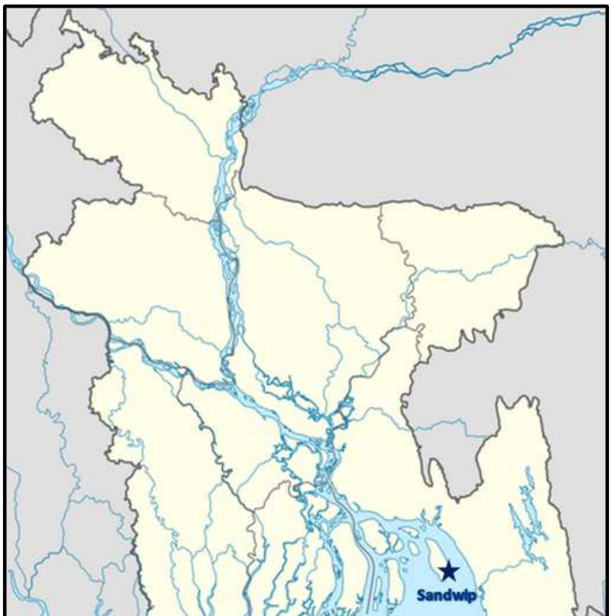

Figure 1.3 International Case study site (star).

1.3 Report context and objective

The present report is the Delivery D.1.1 and belongs to WP1. The objective of this WP are described in the DOW as follow:

"The objective of WP1 is to establish a starting position for potential advances in DRR strategies through review, data collection and historical analysis. In particular, WP1 will:

- *Review intergovernmental, supra-national and national DRR management plans and analysis of large-scale historical events to derive lessons-learned (Task 1.1);*
- *Review current-practice coastal risk management plans at the case study sites (Task 1.2);*
- *Collect socio-economic, cultural and physical data through end-users and stakeholders consultations at the case study sites (Task 1.2);*
- *Develop a WEB-GIS impact-oriented database for the case study sites (Task 1.3).*

An interdisciplinary approach drawing on the physical, economic, social and historical sciences will be used to ensure that all aspects relevant to the project are considered. The WP deliverables will be used in WP4 and WP5."

The DOW describes the Deliverable D.1.1 as follows: *"Review report of key challenges and lessons learned from historical extreme hydro-meteorological events: this deliverable will report on the current-practice coastal DRR management plans at the EU level, national level (for member states with case-study sites) and supra-national level. The report will identify similarities and disparities between countries, and limitations and gaps concerning marine-driven events and rain-driven flash floods. These findings will be discussed in the context of an analysis of historical large-scale events in the EU and world-wide."*

This report includes: (i) a first part (PART I - Milestone Project 5) on WP1 Phase 1 to be used by Task 4.1 on the development of potential prevention, mitigation and preparedness measures, and (ii) a second part (PART II) related to the historical analyses and derived lessons learned.

The main objective of PART I is to review and report on the intergovernmental, supra-national and national polices on the basis of the WP1 objective for Phase 1, hereby described in the DoW as follows: *"In the first phase, this activity will review the current-practice coastal DRR management plans at the EU level, at the national level for member states with case study sites and at the supra-national level by reviewing UN policy such as the HFA, and the UNESCO-IOC Group on Coastal Hazards. RISC-KIT will identify similarities and disparities between countries, and limitations and gaps concerning marine-driven events and rain-driven flash floods"*.

The second part (PART II) refers to the description of the second phase of Task 1.1. In particular the DOW: *"In the second phase of this task, we will analyse historical large-scale events on the case study sites of the Norfolk Coast (UK), the Charente-Vendée coast (France), the Cinque Terre-Liguria, the Emilia-Romagna coast and the Ria Formosa coast (Portugal). In addition to these European cases, knowledge derived from recurrent high magnitude events like hurricanes and typhoons will provide an important* *understanding of the interaction between DRR elements such as prevention, mitigation and preparedness, and resilience. Thus, the review will be extended to non-European examples from areas exposed to tropical storms: tropical cyclones in Bangladesh (1991, 1997, 2011), New Orleans and the Louisiana coast (2005, 2008), New York City and New Jersey (2012), amongst others."*. Thus, the PART II of D.1.1 reviews the historical analysis on the listed areas including several lessons learned on emergency measures and DRR.

1.4 Approach

The first phase was characterized by a review of the current-practice coastal DRR management plans at supra-national (EU), inter-governmental (UN) and national level for Case Study countries. Legislative Frameworks, agreements and policies were analyzed and compared. The adaptation and implementation was investigated at national level through official reports, technical questionnaire and target desk researches.

The second phase, related to the analysis of large-scale events, was implemented through historical investigations for Norfolk Coast (UK), the Charente-Vendée coast (France), the Cinque Terre-Liguria, the Emilia-Romagna coast and the Ria Formosa coast (Portugal). For Bangladesh and USA, analyses of recent documents, papers and databases were carried out. Lessons learned were derived analyzing the evolution of DRR and emergency responses along with the occurrence of the large-scale events. Publications were used to support the information.

1.5 Outline of the report

The report will firstly introduce a brief description of the RISC-KIT Case Study sites (Chap. 2). Then, an overview of the adopted methodology is shown for both PART I and II (Chap. 3).

PART I. The supra-national policies will be analyzed in Chap.4, while national ones are examined in Chap. 5. In Chap. 6 a description of the implemented analysis (and relative outcomes) on the national adaptation to the supra-national policies will be presented.

PART II. In Chap. 7, the outcomes from the historical analyses and an overview of the lessons learned from historical extreme events are shown for the Risck-KIT regional Case Study areas: North Norfolk (UK), Ria Formosa (PT), Liguria (IT), Emilia-Romagna (IT) and Charente-Vendee (FR). Moreover, an overview of extremely intensive events (cyclones) for Bangladesh (RISC-KIT Case Study country) and USA are shown.

In Chap. 8, the overall conclusions can be found.

2 RISC-KIT Case Study sites: locations and brief descriptions

In this section, a brief description for each Case Study site is shown, as well as a short motivation of the reason why they were selected for the RISC-KIT Project. A complete description of the sites can be found at the RISC-KIT website (www.risckit.eu).

2.1 Bocca di Magra, Italy

Figure 2.1 Bocca di Magra, panoramic view (Source: risckit.eu).

Case Study Owner: CIMA Foundation

The Bocca di Magra Case Study site is located at the mouth of the Magra River in Italy, Liguria Region, Province of La Spezia, municipality of Ameglia and Sarzana. The territory of the Magra River Basin is classified as mainly mountain and hill area, with absence of lowland territories, even at the mouth of the river. The basin, in its more elevated and steep slopes, presents widespread wooded vegetation interspersed with herbaceous vegetation and bushes used as pastures and meadows. In areas with a milder slope and lowland agricultural and industrial activities are located. The landscape of the Magra River basin is under the determining human influence, not only in what concerns the development of residential and other, but also in what concerns vegetation and agriculture (e.g. expansion of the chestnut grove at the expense of other tree species, creating terraced agricultural areas, etc.). The coastal zone is a very narrow strip of land that descends almost immediately to considerable marine depths, where alternate environments and varied landscapes occur and where most of the human activities are concentrated.

Bocca di Magra was selected in order to test the interaction between the marine flood and the Magra river flood. The particular interest lies in the influence of the marine conditions on the river discharge. Severe weather conditions may generate a high risk state in the coastal areas due to the interaction between marine and river flooding.

2.2 Porto Garibaldi – Bellocchio, Italy

Figure 2.2 Large overwash into the Bellocchio marsh, in the south area of the Case Study site (Source: Regione Emilia-Romagna).

Case Study Owner: Consorzio Futuro in Ricerca

The Case Study site of Porto Garibaldi-Bellocchio is a 9km stretch of coast, located in the Ferrara and Ravenna provinces, in the region of Emilia-Romagna, northern Italy, facing the Northern Adriatic Sea. It is located in the Po plain, to the south of the Po River Delta, the largest natural reserve in Emilia-Romagna and an UNESCO World Heritage site. Porto Garibaldi-Bellocchio and its hinterland is characterised by the presence of wide lagoons, wetlands and canals. Most of the territory is extremely low-lying, with coastal elevations reaching a maximum of just 2m above MSL, and a large part of the hinterland being below sea level. The area can be divided into a northern and southern section of almost equal lengths. The northern section is mostly urbanised and the beach is characterised by the presence of bathing establishments that provide numerous services to beach users during the summer months. Two towns, Lido degli Estensi and Lido di Spina, with a total of 2,750 inhabitants, were built in this section in the 1970s and are divided by an artificial canal. The northern section also includes a short stretch of natural dunes. The southern section of the study area meanwhile is natural and characterised by the presence of the Bellocchio marsh that is divided into two parts by an artificially-created channel that connects the wetland systems with the sea. This connection is important in order to maintain water quality within the wetlands and to prevent adverse effects to aquaculture and fisheries as well as to birds and biodiversity.

The coastal area is composed of low sandy beaches of widths ranging from 30 to 300m, south-to-north. The micro tidal regime of this area has a neap tide range of 0.3 to 0.4m and a spring tide range of 0.8 to 0.9m. The wave regime is generally of low energy, with almost 65% of wave heights being less than 1m. Energetic storms come from the east-northeast (Bora wind) and southeast (Scirocco wind). The 1-in-1 year return period wave height is 3.3m with a wave period of 7.7s.

Porto Garibaldi-Bellocchio is a low-lying area, highly exposed to extreme events, in which multiple human activities co-exist. Of high importance for the goal of the project, is the co-existence of a complex and exposed ecosystem with high socio-economic stakes.

2.3 Kiel Fjord, Germany

Figure 2.3 Wooden bridge with berths typical in Kiel Fjord region (Source: GuntramSeiß).

Case Study Owner: Bundesanstalt für Wasserbau

Kiel Fjord site is a fjord at the Western Baltic Sea, about 20km long and at the mouth up to 7km wide The inner part is up to 2.5km wide. It is open to the Baltic Sea in north-northeast direction. The outer fjord is characterized by sandy beaches and on the western border by sandy cliffs. Small villages have developed along the coast in the outer fjord. The local population was traditionally occupied in small-scale fisheries but after industrialization the touristic business developed and displaced almost the whole traditional fishery. Today the villages are characterized by beach tourism and water sports activity including the business around it. The inner fjord is dominated by

the City of Kiel, the capital of the German Federal State Schleswig-Holstein, with about 250,000 permanent residents. The center of the city is directly located at the waterfront and occupied with different ports and shipyards.
The typical wind climate is dominated by winds directed from south to north-northwest. Strong westerly winds lead to lower water levels, which can hinder the navigation. The wave climate during westerly winds is moderate and no threat to the eastern border of the fjord. North to south-easterly wind occurs during the development of winter high pressure. In summertime strong northeast winds are seldomly observed. Northeaster to north-northeaster winds can cause higher sea levels if they reach heavy storm to hurricane strength. Waves up to 3.5m have been measured and considered as typical during hurricane winds from north to northeast for the fjord mouth. Near the coast the waves measured are averagely around 1.5m in height. Inside the inner fjord the waves extreme events can reach approximately 1.0m of height (estimated).

The Kiel Fjord region was affected by heavy marine surges several times and, even if there are high standards of coastal protection in Germany, it still has vulnerabilities due to the fact that high values are exposed to the water during summer season. Storm surges in the Western Baltic fulfil the criterion of floods with small probability but heavy impact to the prosperity of the region. In August 1989 a small pressure system caused a storm surge, which had heavy impact to marinas in Wendtorf and Kiel as well to beaches and their infrastructure, camping sites, and cliff coasts.

2.4 Kristianstad and Åhus, Sweden

Figure 2.4 Aerial picture showing the landscape of the Kristianstad CS site (Source: PatrikOlofsson).

Case Study Owner: Stockholm Environment Institute

The Kristianstad Case Study site is located within the Kristianstad Municipality in the northeast Scania County (SkåneLän), Sweden's southernmost province. The overall physical environmental setting of the site includes the lower part of the Helge Rivera catchment area and the coastal regions of Hanö Bay. The main river in the site is the Helge River a, which runs through the central town of Kristianstad (the seat of Kristianstad Municipality) and drains an area of 4775km^2. The lower part of the catchment contains mainly the Plain of Kristianstad, through which the Helge River eventually drains into the Baltic Sea. The lower Helge River catchment contains Sweden's lowest point at 2.41m below Mean Sea Level, as well as two shallow lakes with a total area of 22km^2, making the site Sweden's largest flooded meadows landscape. Climatically, the site belongs to the so-called "temperate and sub-polar broadleaf forests or woodlands", with a warm temperate climate. There are substantial variations within the site in both temperature and precipitation with, in general, colder and wetter areas on high ground in the southwest and north, and milder, dryer areas along the coast. In the coastal area a narrow stretch of dunes is surrounded by water providing a form of natural protection.

The distinctive morphology and geology of the area, the interface between lakes and running water and the brackish water of the Baltic Sea, and the variations in local climates have created unique conditions for a diversity of land cover types that support a large number of ecosystems and species in the site area.

The extent to which the area has been affected by human intervention varies considerably. The densest concentration of population is in the town of Kristianstad, which is centrally situated in the area, whereas on the coast it is the urban area of Åhus. There are a number of small communities and villages on the Plain of Kristianstad, while the forested areas remain somewhat sparsely populated. During the summer there is a significant increase in the number of temporary residents with some 1700 vacation homes along sections of the coast.

Kristianstad Municipality offers an especially complex case with a combination of various ecosystems, economic sectors, the lowest lying areas of Sweden, and multiple hazards related to both marine and river floods affecting the municipal capital and surroundings. It is furthermore involved in a number of processes and activities of interest for the management of risks related to climate change and flooding, including a Maritime Spatial Planning and Vattenriket–a wetland area designated as a Biosphere Reserve by UNESCO.

2.5 La Faute sur Mer, France

Figure 2.5 View of the devastating impact of storm Xynthia in La Faute sur Mer village, on February 2010 (Source: lemoniteur.fr[1]).

Case StudyOwner: LIENSs CNRS/Université de La Rochelle

The La Faute-sur-Mer Case Study site is located on the Atlantic Coast, in the Bay of Biscay, roughly half way between Spain and Brittany, in the department of Vendée, 20 km north from La Rochelle. Two big islands separated by several embayments, which correspond to drawn river valley segments, characterize this stretch of coastline. The local tidal regime is semi-diurnal and ranges from less than 2m during neaps, to more than 6m during springs. The wave regime is energetic at the entrance of the estuaries, where winter storms cam yield wave height larger than 8 m, but wave energy is rapidly dissipated by refraction and bottom friction in the inner part of the estuaries where the study area is located.

La Faute-sur-Mer is a small touristic village of roughly a 1,000 inhabitants during the winter season. Very popular, the village may attract more than 20,000 tourists per day during the summer season. Built on a sandy spit between the ocean and the Lay River, 75% of the village's surrounding territory is characterized as natural protected area and has been preserved from big constructions along the seaside.

The devastating impacts of the storm surge associated with storm Xynthia, combined with the high spring tide, brought in light the great risk in which the area is under as well as the significant resources that are necessary in order to deal adequately with similar incidents. As most of the residential area of the village is still considered hazardous, the implementation of RISC-KIT methodology can provide important

[1]Available at: http://www.lemoniteur.fr/media/IMAGE/2010/03/02/IMAGE_2010_03_02_1111199.jpg

benefits for the local community offering at the same time a Case Study with very strong socio-economic impact component for the project.

2.6 North Norfolk, United Kingdom

Figure 2.6 Scolt Head Island 09.12.2013 (Photo by Mike Page[2]).

Case Study Owner: University of Cambridge

The North Norfolk Case Study site comprises a 45km long, north-facing coastline, between Old Hunstanton and Kelling Hard, characterised by both gravel and sand barriers, with an extensive (>2,000ha) saltmarsh area behind barrier islands, spits and areas of low-angle sands on open coasts. The barriers support various categories of sand dunes, from embryonic, mobile dunes to fixed dunes (in places with plantation forest), as well as saline lagoons. Landward margins are characterised by brackish reedbeds and freshwater grazing marshes in areas of reclaimed saltmarshes (>800ha).

This mosaic of habitats is recognised internationally through the North Norfolk Coast Special Area of Conservation(SAC) and as a Special Protection Area (SPA) under the Ramsar Convention. There are important bird reserves at Titchwell and Cley, which attract significant numbers of visitors. Four small river valleys make outfall at the coast. The hinterland is predominantly agricultural with small towns and villages developed around fishing settlements and medieval ports.

This site was chosen as an example of an area where the natural environment is both a major source of revenue for the local economy via its contribution to tourism and

[2]Mike Page website: http://mike-page.co.uk/

recreational uses, and where the natural environment also plays a role in flood risk reduction from storm surges. This Case Study site differs from other Case Study sites due to its relative lack of development and low population density. Nevertheless it provides a good example of how long term shoreline management planning is taking place alongside emergency response planning. The recent storm surge (5-6 December 2013) also provides an opportunity to look at the efficacy of current measures in reducing risk from such extreme events and the resilience of the communities and local economy to such events.

2.7 Ria Formosa, Portugal

Figure 2.7 Impact of extreme storm on March 1990, Praia de Faro - Ria Formosa (Author: J. Alveirinho Dias).

Case Study Owner: University of Algarve

The Ria Formosa coastal lagoon Case Study site is located on the southern coast of Portugal. It consists of a lagoon protected by five barrier islands and two peninsulas, spatially distributed to produce a cuspate shoreline that extends over 55km. The barrier islands are highly dynamic systems in a constant process of recycling, mostly driven by inlet breaching and migration. At present, two out of the six tidal inlets are artificially constructed, three have been relocated and only one preserves its natural origin. The back-barrier area consists mainly of tidal flats, salt marshes, small sandy islands, and tidal channels.

Tides are semi-diurnal, with mean spring tidal range of 2.8 m and mean neap tidal range of 1.3 m. The input of freshwater to the system is very low as a result of the low fluvial and rain input. This explains the semi-arid character of this region with low precipitation and surface runoff. Consequently, water levels and tidal prism within the Ria Formosa are modulated by the tidal range, storm surge and the actual lagoon topography. The wind-field is dominated by westerly and easterly winds. Two main wave directions, W-SW and E-SE, dominate the regional wave climate. The geographical, geomorphological and climatic conditions of the Ria Formosa made the lagoon a breeding and transit area for fishes and birds. The area is internationally recognized and protected within the Wetlands of International Importance Convention (Ramsar) and the Birds and Habitats Directive (Natura 2000 Network). At a national level, Ria Formosa was integrated within the Natural Park network of Portugal since 1987.

The combined factors of a low lying barrier island system with high ecological value and the existence of multiple anthropogenic activities, classify Ria Formosa as a very complex system with potential for the occurrence of significant impacts due to climate change and low-frequency, extreme storm events.

2.8 Tordera Delta, Spain

Figure 2.8 S'Abanell beach during the impact of an extreme storm in December 2008 (Source: PubliBlanes.net).

Case Study Owner: Universitat Politècnica de Catalunya

The Case Study site of the Tordera Delta area is located at the Tordera river's mouth (Punta de la Tordera), covering an area of approximately 1.4km^2. It is a low-lying, coastal plain and as so, a large part of the delta plain, mainly south of the mouth, has a low relative height, with respect to the Mean Sea Level (1–1.5m). This configuration is creating increased vulnerability to flooding of coastal and river origin, during storm events.

The delta affects two contiguous municipalities, separated by the river, a natural border between them: Malgrat de Mar, southward of the river, covering an area of 8.8km^2 (Maresme county) and Blanes, northward of the river, covering an area of 17.7km^2 (La Selva county). The total population of the area has increased from 10,942 in the 1940's to 58,089 in 2013. According to municipal data, there is approximately

18% increase of the population during the summer due to the tourism importance of the region.

The Tordera Delta Case Study site is a profound example of an area where the adequate protective mechanisms of the local ecosystem were significantly weaked due to poorly designed human interventions, thus resulting in increased vulnerability and risk from extreme events. Erosion and inundation are the main hazards that this area faces are due to storm impacts.

2.9 Varna, Bulgaria

Figure 2.9 Flooding of Varna Central beach (north), undermining of Sea Baths foundation, damages to the buildings and beach erosion (Source: dariknews.bg).

Case Study Owner: IO-BAS Institute of Oceanology

The case study area runs from cape St. George in the north, to cape Galata in the south, while at regional level it stretches from cape Ekrene to cape Cherni nos. The most western part of the bay is a sandy spit – a low-lying area with range of width varying between 2,000 and 2,700m. Two navigable canals running through the sandy spit connect Varna bay to Varna Lake, as the latter is linked also to Lake Beloslav to the west. The length of both lakes and the canals is about 30km. Within this area is located the largest transport and port agglomeration in Bulgaria –the Varna-Beloslav-Devnya industrial complex, covering an area of 150km^2. Given that more than 50% of the coast is directly affected by wave induced erosion, Varna coast can be defined as erosive.

The impact of northeastern and eastern winds is critical for the study area. Following the wind wave patterns propagate most frequently from the east and the northeast but important events can be expected from the southeast as well. The eastern waves are predominant within the entire shelf zone, ranging between a 30 and 40% probability of occurrence. The most frequent significant wave height is smaller than 1.5m. On rare occasions, it is larger than 4m, while waves around 7m have a return period of 100 years. The storm surge level with corresponding return period is about 85cm. Tidal fluctuations are very small and considered irrelevant. Largest waves are observed during the storm season (October-March), which can reach a 7m significant wave height. The current sea-level rise trend (excluding subsidence) was estimated to be 1.2mm per year.

Varna case study site represents a unique combination of low-laying beaches and an artificial island, occupied primarily with touristic and industrial activities, and residential, touristic and park areas located on a cliff prone to land sliding. The ecosystems and their role as a natural buffer in storm impact mitigation were significantly compromised due to ineffective managerial decisions and illegal construction. Poorly designed and maintained protection structures, which have failed to sustain the natural beach resources in a balanced manner, additionally contribute to the risk vulnerability.

2.10 Zeebrugge, Belgium

Figure 2.10 View of Westerhoofd, in Zeebrugge, Belgium (Source: risckit.eu).

Case Study Owner: International Marine and Dredging Consultants (IMDC)

The coastal environment in the general area of the Case Study site is macro-tidal with sandy beaches. The coastal zone comprises three main units: (i) a very gently sloping and fine sandy beach, (ii) a dune ridge and (iii) a coastal plain. The area presents a bi-diurnal tide with a small asymmetry and an average tidal range of 4m. The tidal wave moves along the coast from west to east. The tidal range decreases in the same direction by ±0.5m. Spring tides occur twice a month when the tidal variation has reached its maximum (±5m), while for neap tides the tidal range reaches its minimum, i.e. ±3m. Long-lasting intense winds may influence the water level, resulting in extremely low or high water levels. This important tidal range is linked to quite significant tidal currents, which exceeds generally 1.5knots in the near shore areas. Because of the shallow seas and the short fetch, waves are typically short crested. The wave climate is mainly determined by meteorological circumstances, predominantly southwesterly winds, and by the shallow depth of the North Sea. Under normal circumstances the waves are lower than 1m. During heavy storms wave heights of over 5m can occur. The wave period is 3 to 4 seconds under calm weather conditions, but during storms it can reach 10 to 15 seconds.

The harbour of Zeebrugge consists of 3 parts: (i) the outer port, (ii) the inner port and (iii) the seaport of Bruges. The outer port has been constructed on land reclaimed the sea and is protected by two breakwaters. The direct access to the sea and the available water depth makes this part of the port appropriate for roll-on/roll-off and container traffic. Also Liquefied Natural Gas (LNG) vessels moor in the outer port. Via the Pierre Vandamme lock and the Visart lock vessels sails towards the inner port. Around the docks of the inner port logistic centres are located for the handling, storage and distribution of mobile vehicles, break-bulk cargoes or food products. The connection with the seaport of Bruges is made through the Baudouin canal. The activities in this part of the port mainly consist of bulk and conventional cargoes. The residential area of Zeebrugge is located in between the harbour docks.

The case study of Zeebrugge, with its industrial port, is important for RISC-KIT because it will focus on diverse aspects of coastal risk management, including economical aspects of an industrial port. The outer port of Zeebrugge is a weak link regarding the area's coastal protection, as it is not integrated in the masterplan for coastal safety. The protection level of the outer harbour is not known as no flood risk studies of the outer harbour have been performed before.

2.11 Sandwip Island, Bangladesh

Figure 2.11 Damaged home and the affected homeowner, after the occurrence of an extreme event in Sandwip Island (Source: risckit.eu).

Case Study Owner: World Meteorological Organization, Consorzio Futuro in Ricerca

The international RISC-KIT Case Study site of Sandwip Island is located in the northeastern side of The Bay of Bengal, nearby the main port city of Chittagong. It is one of the most ancient islands of Bangladesh. As of the 2001 Bangladesh census, Sandwip has a population of 292,773. The entire island is 25-35 km long and 10-15km wide. This spatial variability is due to the large rates of erosion and deposit. It has been formed by silt deposits from the estuary of the Meghna River, thus resulting in fertile lands.

The island is located in a position of frequent passage of tropical cyclones and therefore extremely prone to storm induced floods and other associated natural hazards. Every year people in the island face risks from cyclones and following storm surges threatening lives and households of the entire community. Coastal erosion is rapidly changing the living space for the community. It is also exposed to a macro-tidal regime, with tidal variation in the range of 3 to 6m from neap to spring tides. A prominent, counter- clockwise, residual circulation, which is very turbulent in nature, is present around it. The highest tidal current velocities, of up to 4m/s, are observed in the Case Study site and upper reach of the estuary during the spring tides and the rainy seasons respectively. Located in an active delta, the morphological evolution around the Island is also very active due to the significant degree of hydrodynamic and sediment transport processes. The Meghna estuary is mostly meso-tidal, with the exception of a small locality near Sandwip which is macro-tidal. It is predominantly semidiurnal in nature, with the tidal range varying between the spring and the neap tide. During monsoon season (high discharge period), the tidal influence diminishes significantly and it can even be completely flushed out of the estuary. During the periods from May through September, southwesterly monsoon winds predominate, with an occasional intensity of gale force (11.5–28.0m/s). Wave observations at the Sandwip Channel, off the Karnofully River mouth, showed only a moderate wave climate with a maximum wave height of 2.4m.

The geographical position, the frequent occurrence of extreme climatological events and the socio-economic regime in Bangladesh, transforms effective Disaster Risk Reduction (DRR) measures into an extremely challenging task. Regardless of the immeasurable difficulties, continuous effort for early warnings and for a community-based response framework has significantly reduced the loss of lives in the past decades. One of the biggest challenges in the region is to provide reliable and easy-to-understand warnings on coastal flooding in the district and sub-district level and thus, the work done during this project will provide the base and demonstrate the future directions towards these actions.

3 Methodology overview

Author: Enrico Duo.

3.1 PART I: Emergency response and DRR measures at national and supra-national levels

The adopted methodology that produced the first part of this report is mainly based on desk research. In particular, it was implemented at intergovernmental and supra-national level (Chap.4) on Disaster Management, Floods, DRR measures, Coastal policies and related topics, focusing mainly on available documents and databases on official web sites, which links are included in the text. At the same time, the RISC-KIT Case Study Owners helped to investigate the national policies (Chap. 5) following the same methodology.

Concerning the analyses on the implementation of the supra-national polices at national level, the adaptation to the EU Floods Directive (Par. 6.1) was investigated through an analysis of several papers and documents, and a target research based on simple research questions on the topic, which CSOs were requested to answer, giving their individual technical perspective. Then, the national adaptation to Climate Change impacts based on the review of the European Environment Agency Report 4/2014 is given (Par. 6.2). The official monitoring national reports were analysed for country adaptation to UN Hyogo Framework for Action (Par. 6.3). Moreover, CSOs were requested to give their technical opinion and perceptions on the topic through a questionnaire. To note that the desk research and the analyses described in PART I were performed in October 2014, based on the available documentation.

3.2 PART II: Historical extreme hydro-meteorological events

A desk research was implemented at general and local level. In particular, historical municipal archives, libraries and other minor archives were visited to get information on meteorological events that had a significant or limited impact on the target areas. Ancient maps, local newspapers, pictures were really useful in the investigations.

For each of the areas described in Chap. 7, a paragraph on "Materials and methods" is presented. Based on the available documents, "historical overview" at regional and local scales are shown for each area. "Lessons learned" were derived comparing the occurrence of the events and the evolution of DRR and emergency measures in relation with the evolution of the presence of people, infrastructures and activities in the areas. To note that in the sections "Lessons learned" there are several information that were integrated from Chap. 5, investigating the regional and local levels.

PART I: Emergency response and DRR measures at national and supra-national levels

4 Intergovernmental and supra-national policies

Authors: Enrico Duo and Paolo Ciavola.

In this section, a desk-based overview of intergovernmental and supra-national policies on Disaster Risk Reduction measures is given with particular regard to the United Nations and European Community policies.

4.1 UN framework

The main extra-EU international policies on Disaster Risk Reduction and related topics are produced by the United Nations. In particular, the main guide is the Hyogo Framework for Action (UNISDR, 2005), which elaborates upon the "Yokohama Strategy for a Safer World: Guidelines for Natural Disaster Prevention, Preparedness and Mitigation and its Plan of Action", adopted in 1994.The UNESCO-IOC (International Oceanographic Commission) is working on producing simplified guidelines through the work of the UNESCO-IOC Technical Group on Coastal Hazards.

4.1.1 Hyogo Framework for Action 2005-2015

During the World Conference on Disaster Reduction (Kobe, Hyogo, Japan, 18th – 22nd January 2005), a strategic and systematic approach to reduce vulnerability and risk hazard was adopted by the international community. This approach is summarized in the Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters (UNISDR), also known as Hyogo Framework for Action (HFA).

Taking into account the challenges posed by disasters in general and referring to the Yokohama Strategy's outcomes and identified gaps in risk management, the Hyogo's World Conference on Disaster Reduction was convened producing 5 specific objectives related to the need to increase the resilience of world population to disasters:

- To conclude and report on the review of the Yokohama Strategy and its Plan of Action, with a view to updating the guiding framework on disaster reduction for the twenty-first century;
- To identify specific activities aimed at ensuring the implementation of relevant provisions of the Johannesburg Plan of Implementation of the World Summit on Sustainable Development on vulnerability, risk assessment and disaster management;

- To share good practices and lessons learned to further disaster reduction within the context of attaining sustainable development, and to identify gaps and challenges;
- To increase awareness of the importance of disaster reduction policies, thereby facilitating and promoting the implementation of those policies;
- To increase the reliability and availability of appropriate disaster-related information to the public and disaster management agencies in all regions, as set out in relevant provisions of the Johannesburg Plan of Implementation.

Consequently, the HFA expected outcome for the decade 2005-2015 is "the substantial reduction of disaster losses, in lives and in the social, economic and environmental assets of communities and countries". This target should be achieved through the involvement of all actors, from national governments, to the civil society, including international organizations and more.

The Conference defined the following strategic goals to achieve the strategic outcome:

- The more effective integration of disaster risk considerations into sustainable development policies, planning and programming at all levels, with a special emphasis on disaster prevention, mitigation, preparedness and vulnerability reduction;
- The development and strengthening of institutions, mechanisms and capacities at all levels, in particular at the community level, that can systematically contribute to building resilience to hazards;
- The systematic incorporation of risk reduction approaches into the design and implementation of emergency preparedness, response and recovery programmes in the reconstruction of affected communities.

The Framework for Action also defines *5 Priorities for Action*, with a strong practical meaning:

1. *Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation.*
2. *Identify, assess and monitor disaster risks and enhance early warning.*
3. *Use knowledge, innovation and education to build a culture of safety and resilience at all levels.*
4. *Reduce the underlying risk factors.*
5. *Strengthen disaster preparedness for effective response at all levels.*

Each of them is specified in the document and explained through several key activities that lead to the practical implementation of the priorities.

The HFA concentrates on a multi-sectoral approach to adoption, sustainability, knowledge- and data-sharing and society involvement, calling nations, regional and international organizations and institutions to their duties. It also defines a road for States for the implementation and review of achievement of the objectives/priorities.

A requirement of the HFA is the monitoring and reporting on the local, national and regional implementation of the measures. National authorities and officials have responsibilities in the implementation of DRR and have to report to UNISDR.

In 2008 the UNISDR published the guide "Indicators of Progress: Guidance on Measuring the Reduction of Disaster Risks and the Implementation of the Hyogo Framework for Action" where it defines a semi-quantitative standard method to monitor and report to the Secretariat about HFA implementation.

The method is based on a five-level assessment (marks from 1 to 5) of several quantifiable Indicators of Progress for HFA's Strategic Outcome, Strategic Goals and Priorities for Action. In Figure 4.1 the five-level assessment scale is shown while in Figure 4.2 and Figure 4.3,the proposed Indicator of Progress are shown for Expected Outcome and Strategic Goals, while the Indicators of Progress for the five Priorities for Action are hereby reported:

- Priority for Action 1:
  i. National institutional and legal frameworks for disaster risk reduction exist with decentralized responsibilities and capacities at all levels;
  ii. Dedicated and adequate resources are available to implement disaster risk reduction plans at all administrative levels;
  iii. Community participation and decentralization is ensured through the delegation of authority and resources to local levels;
  iv. A national multi-sectoral platform for disaster risk reduction is functioning.
- Priority for Action 2:
  i. National and local risk assessments based on hazard data and vulnerability information are available and include risk assessments for key sectors;
  ii. Systems are in place to monitor, archive and disseminate data on key hazards and vulnerabilities;
  iii. Early warning systems are in place for all major hazards, with outreach to communities;
  iv. National and local risk assessments take account of regional/ trans-boundary risks, with a view to regional cooperation on risk reduction.
- Priority for Action 3:
  i. Relevant information on disasters is available and accessible at all levels, to all stakeholders (through networks, development of information sharing system;
  ii. School curricula, education material and relevant trainings include risk reduction and recovery concepts and practices;
  iii. Research methods and tools for multi risk assessments and cost benefit analysis are developed and strengthened;

iv. Country wide public awareness strategy exists to stimulate a culture of disaster resilience, with outreach to urban and rural communities.

- Priority for Action 4:
  i. Disaster risk reduction is an integral objective of environment-related policies and plans, including for land use, natural resource management and climate change adaptation;
  ii. Social development policies and plans are being implemented to reduce the vulnerability of populations most at risk;
  iii. Economic and productive sectoral policies and plans have been implemented to reduce the vulnerability of economic activities;
  iv. Planning and management of human settlements incorporate disaster risk reduction elements, including enforcement of building codes;
  v. Disaster risk reduction measures are integrated into post-disaster recovery and rehabilitation processes;
  vi. Procedures are in place to assess disaster risk impacts of all major development projects, especially infrastructure.
- Priority for Action 5:
  i. Strong policy, technical and institutional capacities and mechanisms for disaster management, with a disaster risk reduction perspective are in place;
  ii. Disaster preparedness plans and contingency plans are in place at all administrative levels, and regular training drills and rehearsals are held to test and develop disaster response programmes;
  iii. Financial reserves and contingency mechanisms are in place to enable effective response and recovery when required;
  iv. Procedures are in place to exchange relevant information during disasters and to undertake post-event reviews.

The monitoring and reporting review has to be implemented every two years. States already reported for the two-years periods 2007-09, 2009-11 and 2011-13.

Through the website page http://www.unisdr.org/we/coordinate/hfa it is possible to download and get detailed information about the Hyogo Framework for Action. Moreover, it is possible to access the webpage http://www.preventionweb.net/english/hyogo/progress/ where users can easily get information about the progresses in the HFA implementation at regional, national and local level: reports are available and downloadable, where they exist.

Level	Generic description of achievement	Examples of an assessment of the indicator "A strategy for data provision for disaster risk reduction is in place"
5	Comprehensive achievement has been attained, with the commitment and capacities to sustain efforts at all levels.	"Systematic, properly resourced processes for data collection and dissemination are in place, with evaluation, analysis and improvements being routinely undertaken. Plans and commitments are publicised and the work is well integrated into other programmes."
4	Substantial achievement has been attained, but with some recognised deficiencies in commitment, financial resources or operational capacities.	*"Processes for data collection and dissemination are in place for all hazards and most vulnerability factors, but there are shortcomings in dissemination and analysis that are being addressed."*
3	There is some commitment and capacities to achieving DRR but progress is not substantial.	*"There is a systematic commitment to collecting and archiving hazard data, but little awareness of data needs for determining vulnerability factors, and a lack of systematic planning and operational skills".*
2	Achievements have been made but are relatively small or incomplete, and while improvements are planned, the commitment and capacities are limited.	*"Some data collection and analysis has been done in the past, but in an ad hoc way. There are plans to improve data activities, but resources and capacities are very limited."*
1	Achievements are minor and there are few signs of planning or forward action to improve the situation.	*"There is little awareness of the need to systematically collect and analyse data related to disaster events and climatic risks."*

Figure 4.1 HFA five-level assessment scale (HFA Indicators of Progress, 2008).

Expected Outcome	Recommended Indicators
The substantial reduction of disaster losses, in lives and in the social, economic and environmental assets of communities and states	i. Number of deaths arising from natural hazard events ii. Total economic losses attributed to natural hazard events iii. Number of people affected by natural hazard events

Figure 4.2 Expected Outcome and Recommended Indicators (HFA Indicators of Progress, 2008).

Strategic Goal	Recommended Indicators
1: The integration of disaster risk reduction into sustainable development policies and practices.	i. National development plans include elements which address disaster risk reduction. ii. All international plans and programmes such as; a. poverty reduction strategies, b. common programming tools of the UN and international agencies, c. climate change adaptation plans and strategies, d. and donor supported country development assistance programmes include elements which address disaster risk reduction.
2: Development and strengthening of institutions, mechanisms and capacities to build resilience to hazards	i. A national policy framework for disaster risk reduction exists, that includes policies, plans and activities for national to local administrative levels ii. A national multi-sectoral platform for disaster risk reduction is functioning iii. Dedicated and sufficient resources are available for planned activities to reduce disaster risks.
3: The systematic incorporation of risk reduction approaches into the implementation of emergency preparedness, response and recovery programmes.	i. The national policy framework incorporates disaster risk reduction into the design and implementation of emergency, response, recovery and rehabilitation processes. ii. Post-disaster reviews are routinely undertaken to learn lessons on risk reduction and these lessons are incorporated into plans and preparedness for response.

Figure 4.3 Strategic Goals and Recommended Indicators (HFA Indicators of Progress, 2008).

4.1.2 A look forward Hyogo: the 3rd World Conference on Disaster Risk Reduction – Sendai 2015

The 3rd World Conference on Disaster Risk Reduction (WCDRR) was held in Sendai (Japan) from the 14th to the 18th of March 2015. The main aim of the conference was to review the implementation of the Hyogo Framework for Action and adopt a post-2015 framework for Disaster Risk Reduction.

In 2011 the UN General Assembly decided to prepare to the post-Hyogo requesting UNISDR to facilitate the process and in 2012 decided to convene the World Conference. In 2013 the Government of Japan proposed to host it. The preparatory process officially started in July 2014 with the first session of the Preparatory Committee. During the process, stakeholders and volunteers were also involved.

The World Conference ended up with two main documents that will be the main guidelines for UN for the period 2015-2030. The *Sendai Framework for Disaster Risk Reduction 2015-2030*, explaining the expected outcomes and goals, guiding principles and priorities for the coming years is available at http://www.wcdrr.org/uploads/Sendai_Framework_for_Disaster_Risk_Reduction_2015-2030.pdf. The Sendai Declaration on the "Adoption of the final outcomes of the Conference" can be found at: http://www.wcdrr.org/uploads/Political_Declaration_WCDRR.pdf. To note that, before, during and after the Conference, a strong effort in the stakeholders involvement was put. More information about WCDRR can be found at http://www.wcdrr.org/.

4.1.3 UNESCO-IOC Technical Group on Coastal Hazards

The International Oceanographic Commission of UNESCO has devoted much effort in producing simple-to use guidelines for the use of coastal communities worldwide. Following the disastrous December 2004 tsunami that affected coastal states around the Indian Ocean, IOC was given a mandate by its members to facilitate the expansion of global coverage of tsunami warning systems. While the main impetus for these developments has come from tsunamis, these warning systems are intended to be an integral component of a comprehensive multi-hazard and multi-purpose warning system, including the prevention of impacts generated by meteorological phenomena like tropical storms (hurricanes, cyclones and typhoons) and extreme storms. These include systems coordinated by IOC and the World Meteorological Organization (WMO), through the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology(JCOMM).

The implementation plan for Working Group 4 (WG4 – Advisory, Mitigation and Public Awareness) of the Intergovernmental Coordination Group for Tsunami Early Warning and Mitigation System in the North-eastern Atlantic[3](NEAMTWS) specifically included an action to prepare guidelines, such as the "Hazard Awareness and Risk Mitigation in Integrated Coastal Management (ICAM)" (UNESCO, 2009). The Guide is directed to communities exposed to coastal storms, extreme waves, coastal erosion, storm surges and tsunamis. This Guide will help communities understand and take practical steps to

[3]Information available at: http://neamtic.ioc-unesco.org/neamtws

reduce coastal risks – the probable consequences of a coastal hazard event impacting a coastal community.

The Guidelines aim to promote ways within the framework of ICAM in which national and local authorities can prepare for, and respond to, these hazards with a planned and coordinated approach among the many agencies and other organizations involved. They aim to assist IOC MS in minimizing the risk to their coastal communities, infrastructure and service-providing ecosystems through consultation, coordination and cooperation among all stakeholders with coastal hazard mandates. The guidelines are written with the goal to raise level of awareness of the coastal hazards and their associated risks amongst stakeholders and the "mainstreaming" of these hazards and risks in emergency and strategic planning in order to enhance hazards resiliency and create more hazard-resilient communities. In accordance with the Hyogo Framework (UN/ISDR, 2007), these guidelines aim to promote among people, their leaders and decision makers an acceptance of the value of managing these hazards to reduce the risks of future losses. The implementation of the Guidelines within members is expected to lead to an increased resilience to hazard events. In particular, it should promote the institutional capacity for emergency preparedness and response.

In this context, UNESCO's Intergovernmental Oceanographic Commission established in 2011 a new Technical Expert Group composed of natural and social scientists, coastal engineers, coastal zone managers, to start working on the preparation of a set of international guidelines on best practices related to the formulation of climate change. The Group is co-sponsored by the Government of Korea and the World Meteorological Organization (WMO). It will build on the work of the IOC Programme on Integrated Coastal Area Management (ICAM), and the guidebook published in 2009 on Hazard Awareness and Risk Mitigation through the Integrated Coastal Area Management (IOC Manual and Guide No 50), which have been prepared for use by national and local governments. The aim of the group is to publish a new set of guidelines which are currently in final draft form undergoing review by external experts (P. Ciavola, personal communication).

4.2 EU policy

There are multiple EU strategies and directives which address coastal hazards, namely coastal flooding. European legislation on reducing risks associated to coastal hazards remains quite diversified and complex, despite efforts in the last few years to coordinate directives and strategies and make them clear to the public.

The main focus of the current report is on the Floods Directive (and the related Water Framework Directive) and its implementation and timeline. Then, an overview of several policies on coastal and marine areas is presented, as well as a description of the EU Strategy on Climate Change Adaptation. Furthermore, an introduction on the structure and aims of the ECHO European Civil Protection can be found.

4.2.1 Floods Directive

The Directive 2007/60/EC, also known as Floods Directive (FD), aims to establish a common framework to reduce flood risk within the European Union. It covers all types of floods with particular regard to riverine and coastal floods.

The Floods Directive (FD), along with the Water Framework Directive (WFD, 2000/60/EC), leads to an integrated approach for River Basin Management. In particular, while WFD focuses mainly on the water quality, ecological, social and environmental aspects of the basins, the FD focuses on flood risk management. Thus, FD's terminology and structure are based on WFD and it refers to the same philosophy and principles (emphasis on subsidiarity and solidarity - see Bakker et al, 2013), with particular focus on socio-economics and environment. Moreover, both of them emphasise on the opportunity to involve stakeholders and make all implemented measures and related reports available to the public. In general the Commission and the Member States aim to synchronize the implementation of the FD with the WFD one in order to improve efficiency and coordination with their timeline. Outcomes from the FD monitoring reports should be consistent with those from WFD ones. In Table 4.1, an overview of the WFD and FD timelines is shown. To better address the common implementation of the WFD and the FD, a Common Implementation Strategy (CIS) was developed. Detailed information and documents can be found at http://ec.europa.eu/environment/water/water-framework/objectives/implementation_en.htm. A guide document is the informal Work Programme "Strengthening the implementation of EU water policy through the second river basin management plans - Work Programme 2013-2015"[4], which goes into details on the implementation of the directives.

The FD Prevention and Management measures are based on *River Basin Districts* that can cover more than one river basin and can be managed by one or more Member States. *River Basin Districts* are defined in the WFD.

Main measures consist of *Preliminary Flood Risk Assessment*, *Hazard and Risk Maps* and *Flood Risk Management Plan*. The FD defines purposes, methods and implementation schedule for each measure. Each Member State has to fulfil the targets and report to the Commission about the implementation of the measures.

The Floods Directive entered into force in 2007. It established that Member States by May 2010 had to adapt to the Directive with particular focus on River Basin Districts definition and related authorities. Furthermore it forces states to implement and report about:

- The Preliminary Flood Risk Assessment, by the end of 2011: it consists of an already-available-data-based assessment on flood risk of each basin district that shall include: (i) topographic and land use maps, indicating basin and sub-basins borders and coastal areas where existing; (ii) description of significant historical flood events, describing extension, damages and effects on social, economical and environmental systems; (iii) past events that are expected to

[4]Available at: http://ec.europa.eu/environment/water/water-framework/objectives/pdf/Work%20Programme%202013-2015.pdf

be repeated in the future; (iv) an assessment of potential consequences of future events on socio-economics and environmental issues, in relation to topography and hydro-geomorphology of the basins, water-management structures and natural environment, human activities, long-term human development and climate change affection.

- The Flood Hazard and Risk Maps for each district, by the end of 2013: these maps have to cover each basin district and have to be developed (i) basing on low, medium and high probability of event occurrence, (ii) describing potential flood areas, water levels and velocities, and (iii) including information about affected population and activities, potential pollution and other necessary information; to note that for coastal areas the Directive prescribes only low probability (high magnitude) scenario maps;
- The Flood Risk Management Plan, by the end of 2015: for each basin district Member States shall develop floods risk management plans, (i)establishing objectives for the risk management, focusing on the reduction of potential adverse consequences on social, economics and environmental systems;(ii) measures have to be defined to achieve the objectives, taking into account aspects such as costs and benefits, floods extensions and infrastructures affection, potential human and natural water retainers, the environmental objectives defined by the Water Directive (2000/60/EC), soil and water management, spatial planning, land use, ecosystems conservation and sustainability, river and maritime navigation and port infrastructures; (iii) the plans have to take into account all risk management related aspects: prevention, protection and preparedness, including forecasting and early warning systems based on the river basin features and promoting sustainable activities and resources use; (iv) Member States shall take into account the principle of solidarity and adopt measures that do not significantly increase flood risk upstream and downstream.

The Flood Directive also prescribes the review of Preliminary Flood Risk Assessment by the end of 2018, of Hazard and Risk Maps by 2019 and of Flood Risk Management Plan by 2021. In these reviews the impact of climate change shall be taken into account. To note that, being this report written at the end of 2014, all Member States may have implemented and reported about Flood Hazard and Risk Maps measures.

Detailed official information about the FD and its implementation, can be found at http://ec.europa.eu/environment/water/flood_risk/.

Member States reports and deliverables can be found through the Reporting Obligation Database (ROD) maintained by the European Environment Information and Observation Network (Eionet) as a partnership between the European Environmental Agency (EEA) and the Members States. In particular the direct link to the Floods Directive is: http://rod.eionet.europa.eu/instruments/630. From that page the users can select which obligation they would like to check and then search for the specific national report/delivery. However, parts of those reports/files were kept confidential at the request of MSs. Delivered information is double-checked at the European level. For this reason, each Member State can decide to leave it as confidential, as reported information needs to be confirmed. However, it is not clear how long information can remain confidential, as per our knowledge there are still several confidential documents from the Unit of Management and PFRA reporting, that should have already been reviewed.

From the WISE - Water Information System for Europe- webpage (http://water.europa.eu/) it is possible to access at several water-related databases. As example, from the page people can access at the Water Data Centre (http://www.eea.europa.eu/themes/water/dc) where products of the implementation of the WFD and the FD can be found.

As an example, the Floods Directive Viewer, which at the state-of-the-art of the tool only displays a Units of Management layer, can be found at http://www.eea.europa.eu/themes/water/interactive/floods-directive-viewer. Moreover, the PFRA mapped information can be found at http://www.eea.europa.eu/themes/water/interactive/floods-directive-pfra-apsfr.

Table 4.1 Water Framework and Floods Directives' timetables overview.

Year	2000	2003	2004	2006	2007	2008	2009	2010	2011	2012	2013	2015	2018	2019	2021	2027
Water Framework Directive 2000/60/EC	**Entry into force**	Transposition to national level	Characterization of river basins	Monitoring network		Draft on River Basin Management Plans	**Finalization of River Basin Management Plans**	Introduction of pricing policies		Operational programmes of measures		Meet environmental objectives			**End of II cycle and start of III cycle**	**End of III cycle and deadline for meeting objectives**
		River basin authorities		Start public consultations								**End of I cycle and start of II cycle**				
Floods Directive 2007/60/EC					**Entry into force**		Transposition	Cut-off transitional measures	**Preliminary Flood Risk Assessment**	Start public participation	**Flood Hazard and Risk Maps**	**First Flood Risk Management Plans**	**Second Preliminary Flood Risk Assessment**	**Second Flood Hazard and Risk Maps**	**End of I cycle**	
							Reporting format on Preliminary Flood Risk Assessment	Administrative arrangements to be in place and notification					Commission report		**Second Flood Risk Management Plans**	

4.2.2 Coastal and Marine Policies

Coastal and marine waters and ecosystems include complex interactions between humans and nature, resulting in multi-sectoral issues. Due to this complexity, the European Community adopted instruments to manage these areas, including specific legislative tools such as the Common Fisheries Policy or the Water Framework Directive. However, these instruments, despite inclusion of modern integrated approaches, are implemented related to their sectors. Because of this reason and the spatial applicative limits of the tools, the European Commission proposed Integrated Coastal Zone Management, through the EU Recommendation on ICZM (2002/413/EC), and the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC). These instruments represent a comprehensive and integrated approach for the protection of coastal and marine areas and waters. Related polices include the Integrated Maritime Policy and in particular the Maritime Spatial Planning Directive 2014/89/EU.

Marine Strategy Framework Directive

In order to more effectively protect the European marine environment and waters, the European Union adopted on 17th June 2008 the Marine Strategy Framework Directive (Directive 2008/56/EC), requiring Member States (MS) to translate the Directive into national legislation by 15th July 2010.

The Directive establishes a 6-year cyclic roadmap for implementation, aiming to achieve Good Environmental Status (GES) for EU marine waters by 2020. It applies concepts such as sustainability, balance within human activities and environmental protection. Furthermore, a focal point of the MSFD is the involvement of stakeholders through public consultation.

Moreover, the Directive prescribes an adaptive management approach to update Strategy every 6 years, to account for climate change and the evolution of human activities. Notably, in 2010 the Commission created a set of methods to help MS implement the Directive and monitor and report on its implementation.

Another common point with the other relevant Directives is the definition of management areas. On the basis of geographical and environmental criteria, the Directive defines management regions and sub-regions. The four EU regions are: the Baltic Sea, the North-East Atlantic Ocean, the Mediterranean Sea and the Black Sea, based on the Regional Sea Convention (http://ec.europa.eu/environment/marine/international-cooperation/regional-sea-conventions/index_en.htm). Member States are requested to cooperate also with extra-EU neighbour countries, in order to implement the Strategy.

The Strategy includes: (i) a first assessment of the environmental status of marine waters and the consequent definition of objectives and targets to reach during the cycle (first cycle deadline: 2012); (ii) the definition of monitoring plans for the assessment and objectives and targets achievements (first cycle deadline: 2014); (iii) the definition of programmes of measures (first cycle deadline: 2015) and (iv) its implementation (first cycle deadline: 2016); (iv)the review of the Strategy and preparation of the new cycle (first cycle period: 2018-21).

An interesting point is that the Commission defined a Common Implementation Strategy (CIS) to help and coordinate MSs in the implementation of the Strategy. The

CIS defines a structure of working groups linking the main political authority with technical working groups.

The current state of the implementation, based on the official outcomes, is that all MSs fulfilled their duties transposing in national law the Directive (report due on 2010) and the definition of the competent authorities (report due on 2011). By 2012 MSs were requested to report on the first assessment of the current environmental assessment of marine waters, the definition of GES to achieve for marine waters and the definition of appropriate targets and indicators. All MSs reported on transposition, competent authorities, status definition, related targets and indicators, except for Portugal, Croatia (partial/incomplete report on status, targets and indicators) and Poland (not submitted report on status, targets and indicators). The monitoring programmes report (due on October 2014) was delivered only by 12 Member States.

The Directive directly interacts with several EU policies such as the Habitats and Birds Directives and the Common Fisheries Policy. The strongest link, however, is with the Water Framework Directive. Indeed, the two directives share the same aim of achieving GES for waters and similar management structure, while focusing on different spatial areas.

This Directive is considered as the environmental pillar of the Integrated Maritime Policy (http://ec.europa.eu/maritimeaffairs/policy/index_en.htm), a set of strategies, directives and tools that aims at coordinating, and not replacing, several policies on maritime affairs and issues, such as the Maritime Spatial Planning Directive.

More detailed information on the Marine Strategy Framework Directive is available at:http://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm.

Integrated Coastal Zone Management and Maritime Spatial Planning

Coastal areas are a junction between inland and sea areas where intensive human activities are related to the environment. More than 200 million people live near coastlines placing high pressure on coastal areas and their ecosystems. Moreover, these are the first areas that are vulnerable to climate change and natural hazards.

The complexity and vulnerability of coastal areas lead to the adoption of an integrated system of management and development. The European Community began to introduce coastal protection measures since the 1970s (Resolution (73) 29 on the protection of coastal areas). However, it started to officially introduce the features of an “Integrated Approach” on coastal management only in the 1980s with the Resolution on the European Charter (1982), which supported the principles introduced by the Conference of Peripheral Maritime Regions in Europe in the European Coastal Charter (1981). Both highlighted the need of integrated planning of coastal areas.

Subsequently, the UN Programme of Action, an outcome of the Earth Summit of Rio de Janeiro in 1992, also known as Agenda 21, introduced the concept of Integrated Coastal Zone Management. The European Council adopted the resolutions 92/C 59/01 and 94/C 135/02, in 1992 and 1994 respectively, about ICZM. Then it adopted a Demonstration Programme (1996-1999), involving administrators, technicians and stakeholders in order to lead the Community towards a general consensus about the integrated measures.

Finally, in 2002, the Parliament and the Council adopted the Recommendation 2002/413/EC on Integrated Coastal Zone Management in response to the Commission's Communications COM/2000/547 e COM/2000/545 on the ICZM strategy and implementation. The ICZM was also a focal point for the 6th Environment Action Programme of the European Community (2002-2012), as well as for the environment (including climate change) theme within the FP7.

On the 12th March 2012 the Commission adopted a proposal[5] for a specific directive to join Maritime Spatial Planning (MSP) and Integrated Coastal Zone Management(ICZM) issues. The integrated proposal was not approved by the European Parliament and the Council with the exception of MSP issues, as a specific Directive on MSP (2014/89/EU) was adopted.

The proposal, focused on ICZM and would requested that the MSs adopt integrated strategies on coastal areas, by first assessing the current state of coastal management plans and the need for implementation of integrated strategies. Following this assessment, measures would have to be adopted in consultation with diverse stakeholders, including coastal sector actors (authorities and stakeholders mainly), using available datasets where possible and coordinating with the Directive 2001/42/EC on Strategic Environmental Assessment.

The proposal stressed the mutual interaction between coastal and marine sectors according to a coherent approach. Indeed, the optimal distribution of maritime space among various uses (MSP's main objective) and coordinated management of coastal zones across sectors would have enabled concurrent activities to achieve their full potential. A single approach for ICZM, predominantly a participatory process, and MSP, which is more focused on spatial/temporal management with some participatory elements, would ensure increased certainty for investors in coastal and marine dependent economic activities and a reduction of administrative burden. Moreover, the integrated approach would support the preservation of ecosystems in balance with human activities, merging socio-economics, natural resources management, environmental sustainability, health, risk and natural hazards assessment and climate change impacts.

The ICZM/MSP proposal aimed to interact with several EU directives and policies, as a tool to support their implementation, such as the Marine Strategy Framework Directive, the Water Framework Directive, the Natura and Habitats Directives, the Biodiversity Strategy, the Integrated Maritime Policy, the Strategy on Climate Change Adaptation, the Renewable Energy Directive, the Motorways of the Sea Initiative and the Common Fishery Policy.

Elements of this proposal were incorporated into the Maritime Spatial Planning Directive (2014/89/EC),approved by the European Parliament and European Council on 2014The MSP Directive was adopted to avoid potential conflicts and create

[5] The Proposal on ICZM and MSP is available at:
http://ec.europa.eu/environment/iczm/pdf/Proposal_en.pdf

synergies between different activities. The need for a common framework for an efficient management approach was highlighted by increasing competition for maritime space for renewable energy equipment, aquaculture and other growth areas.

The MSP Directive aims to integrate maritime spatial uses with the concepts of sustainability and environmental protection. It directly refers to the Integrated Maritime Policy.

More detailed information on EU Integrated Coastal Zone Management can be found at: http://ec.europa.eu/environment/iczm/home.htm. More detailed information and documents on MSP can be found at: http://ec.europa.eu/maritimeaffairs/policy/maritime_spatial_planning/index_en.htm.

A tool for EU ICZM. An ICZM related tool is the OURCOAST Database. This interactive website aims to collect and share all knowledge and lessons learned on coastal management with focus on sustainability, adaptation to risk and climate change, information and dissemination, management coordination and planning and management instruments in general. The Database is a product of the three years project OURCOAST. More information is available at http://ec.europa.eu/environment/iczm/ourcoast.htm and at http://ec.europa.eu/ourcoast/.

Floods Directive vs Coastal and Marine Policies. It is clear that the above-cited policies interact with the Flood Directive in terms of sustainability, environmental protection and related concepts. They apply more or less the same integrated management approach. Moreover, they all stress the involvement of stakeholders and public awareness, to foster interaction between the public and administrations for a common purpose.

4.2.3 Climate Change Adaptation Strategy

The European Commission is well aware of climate change impacts globally and within MSs (IPCC 2014). Quantitative assessments of impacts are inconsistent, yet international reports confirm the increasing trend insubstantial effects(IPCC 2013, IPCC 2014, AR5 Report).

High temperatures, water scarcity, severe floods and droughts and sea level rise are among the significant issues the international community will face. These phenomena interact with several sectors such as infrastructure, agriculture and forestry, energy, tourism, as well as health, insurance systems and businesses. Anticipated societal impacts include an increase in health problems (affecting human, animals and plants), population vulnerability (in terms of natural hazards and socio-economics mainly), and social tensions due to employment scarcity and less productivity. Education systems will also be affected as they relate to community welfare.

Climate change will affect communities in different ways relative to geographical position. European regions will face diverse issues across national and local scales.

To face a variety of issues, the European Commission adopted, in 2013, the Climate Change Adaptation Strategy (CCAS), a framework of guidelines and actions that aim to make Member States more climate-resilient. In particular, the EC will encourage Member States to adopt their own CCAS. At present 16 MSs have an adaptation strategy and the EC provides funds at national and local levels to improve and adopt CCAS. Moreover, the EC will put more effort in the adaptation of key-vulnerable sectors, such as agriculture and fisheries, supporting MS towards the adoption of insurances against natural and man-made hazards. A key objective is to make decision-makers more informed through involving of the research community to fill knowledge gaps about climate change and create an information-sharing platform (Climate-ADAPT[6]).

Adaptation actions will consist of: mitigation and adaptation policies implemented with available EU funds to address socio-economic and environmental issues, such as infrastructure, agriculture, forestry and fisheries, health, water management and more; addressing knowledge gaps through research funding frameworks, such as FP7 (http://ec.europa.eu/research/fp7/index_en.cfm) or the new Horizon 2020 programme (http://ec.europa.eu/programmes/horizon2020/), and through the Climate-ADAPT platform (http://climate-adapt.eea.europa.eu/) that informs policy-makers, researchers and stakeholders on climate change related issues; community, regional, national and local administrator and stakeholder involvement and guidance in the adoption and use of the strategy.

The strategy also includes adapting the EU funding system through the Europe 2020 and the Multiannual Financial Framework 2014-2020. Other funds will be included in the strategy from structural programmes (e.g. European Social Funds, ESF), as well as sectoral fund sources, such as the European Agricultural Fund for Rural Development (EAFRD) or the European Maritime and Fisheries Fund (EMFF) or the already cited Horizon 2020 for research development.

At an international level, the EU CCAS aims to interface with the United Nations Framework Convention on Climate Change (UNFCCC) with particular regard to developing countries through the Global Climate Change Alliance (GCCA) and the Global Approach to Migration and Mobility (GAMM) that integrates climate change adaptation in its policies.

More information about EU CCAS can be found at: http://ec.europa.eu/clima/policies/adaptation/index_en.htm. From this page, the documentation about CCAS and its sub-topic can be found in the *Documentation* sections. Moreover, all cited programmes and strategies web pages can be reached through this page.

Floods Directive vs Climate Change Adaptation Strategy. The Floods Directive is related to the CCAS, and viceversa. Indeed, the Directive fits with the majority of sectoral targets of the strategy (e.g. environment and socio-economics) and calls for the involvement of policy and decision makers, researchers and stakeholders to include climate change impacts in the review of all integrated assessments and measures described in the FD. Moreover, the CCAS emphasizes DRR, as an essentially integrated approach to reduce risk and increase resilience against natural and man–made hazards that will increase due to climate change. In particular, direct reference to the

[6]The Climate-ADAPT Platform link ishttp://climate-adapt.eea.europa.eu/

EU DRR Strategy7, as well as to the Hyogo Framework for Action and UNISDR are included to emphasize the worldwide role of DRR.

National adaptation policy processes in European countries – 2014: the European Environment Agency Report 4/2014

In October 2014, the European Environment Agency (EEA) published the Report 4/2014 "National adaptation policy processes in European countries – 2014". It reports on the outcomes of a self-assessment survey that the EEA sent to MS (2013) on the national adaptation policy processes related to the Climate Change impacts.

The Agency received answers from 30 countries, which provided answers on the basis of the involvement of several actors (policy makers, scientists and stakeholders). The dataset represent a comprehensive overview of the national adaptation policy process for Climate Change.

The report is structured in 8 key topics:

1. Public and policy awareness of the need for adaptation
2. Knowledge generation and use
3. Planning adaptation
4. Coordination of adaptation
5. Stakeholder involvement
6. Implementation of adaptation
7. Transnational cooperation
8. Monitoring, reporting and evaluation

For each key topic, a section is provided giving the related key message (summary of findings), the description of the topic, the findings from the questionnaire and some national examples of good practice, followed by a discussion f results.

Direct information on the report and its framework can be found at: http://www.eea.europa.eu/highlights/extreme-weather-driving-countries-to?portal_status_message=Changes%20saved. The report can be downloaded at: http://www.eea.europa.eu/publications/national-adaptation-policy-processes.

4.2.4 Emergency Response: the ECHO European Civil Protection

The European Commission's Humanitarian Aid and Civil Protection department (ECHO) were created to save and preserve, protect and educate the populations exposed to natural and man-made disasters. It also coordinates the European Civil Protection, providing aid at European and international level, with particular attention to developing countries.

[7]Follow this link: http://ec.europa.eu/clima/policies/international/summit_2014/resilience/index_en.htm

ECHO also provides a thematic policy document on DRR related to humanitarian action: DG ECHO Thematic Policy Document n. 5 "Disaster Risk Reduction: Increasing resilience by reducing disaster risk in humanitarian action"[8].

The ECHO web portal can be found at http://ec.europa.eu/echo/en and the section on Civil Protection at http://ec.europa.eu/echo/en/what/civil-protection.

The European Civil Protection provides a web tool to get information about MS national Civil Protection. It is called Vademecum for Civil Protection and can be directly found at http://ec.europa.eu/echo/files/civil_protection/vademecum/.

[8]Available at: http://ec.europa.eu/echo/files/policies/prevention_preparedness/DRR_thematic_policy_doc.pdf

5 Emergency response and DRR measures at national level: RISC-KIT Case Study Countries overview

Author: Enrico Duo.

In the following section a desk-research-based overview on the national emergency response and DRR policies is given for each RISC-KIT's Case Study Country. When necessary or advisable, a look into the sub-national and local level is presented. This is due to the structure of disaster management that consistently varies across the European countries.

Sources were mainly national legislations and reports, official web sites and papers. In particular, the Vademecum for Civil Protection – ECHO European Civil Protection (http://ec.europa.eu/echo/files/civil_protection/vademecum/index.html) was used to understand the emergency response issue, focusing on the national structure and management. To note, that the information in this chapter will be integrated and expanded at the regional and local level for North Norfolk (UK), Ria Formosa (PT), Liguria (IT), Emilia-Romagna (IT), Charente-Vendee (FR) and Bangladesh in Chap. 7, in the sections related to the "lessons learned".

5.1 Italy

Authors: Clara Armaroli, Paolo Ciavola, Laura Rossello and Nicola Rebora.

Italy does not have a clear national DRR strategy. DRR strategies are mostly carried out at the local level (e.g. Regions or Municipalities). At the national level DRR is the competence of the National Civil Protection, which is also sitting on DRR tables at the EU (e.g. DG-ECHO) and in the UN organizations (e.g. HYOGO tables). The operational activities on the ground are instead coordinated by Regional Civil protection agencies.

The responses to major flood and landslide disasters such as the Polesine (1951), Vajont (1963), Firenze (1966), Valtellina (1987), Piedmont (1994), Crotone (1996), Sarno (1998), Soverato (2000), and Piedmont (2000) events have contributed to shaping the country's flood risk governance. In the aftermath of the devastating 1966 flood in northern Italy and Tuscany, an interministerial commission was appointed to design principles of modern flood risk management in Italy, and to develop flood management standards tailor-made for the disaster-afflicted country. It took almost two decades to reach a political consensus and to produce a new flood risk legislation based on the recommendations of the commission. The law 183/89 of 18 May 1989 introduced several key principles of effective water and flood risk management later embraced when applying the EU Water Framework Directive (2000/60/EC) and the EU Floods Directive (2007/60/EC). River basins (RBs) were adopted as planning and management units.

Before 1985, the Civil Protection was mainly intended as search and rescue, and was managed by the Fire Brigade National Corps and their local detachments. Fire Brigades were, and are now, under the responsibility of the administration of the

Ministry of Internal Affairs. Volunteers, locally organized at the time into a number of non-profit associations, helped to alleviate the conditions of damaged population.

In 1985 the Ministry for Civil Protection was established, with the task of coordinating the resources needed for search and rescue but also with the task of designing a national policy for preparedness and prevention. After seven years, in 1992, the National Service of Civil Protection was institutionalized with the promulgation of Law 225/92.

Law 225/92 is, so far, the fundamental law that defines the general framework of the Civil Protection designing and organizing the National System of Civil Protection at National and Local Levels*.* In the following years *Level 1* was locally organized by Regional laws, following the guidelines of the national law.

The National Service of Civil Protection was created with law 100/2012. Law n. 100/2012 amended and supplemented Law no. 225/1992. The Civil Protection activities are traced to the original core of competencies defined by the law 225/1992, intended principally to cope with disasters and increase the effectiveness of interventions in emergency management. It emphasized the role of guidance and coordination of the Department of Civil Protection of the activities carried out by the various components and operational structures of the National Service.

Law 100/2012 modified - among others - some key issues for the whole system: the classification of disasters, the civil protection activities, the declaration of a “state of emergency” and the power of an ordinance. In this sense, the law redefines the first emergency phase, focusing on the "time factor". It is specified that the resources and extraordinary powers to deal with disasters (events of type "c") should be used for limited time and pre-defined interventions. Moreover, the duration of the “state of emergency” cannot exceed 90 days, with the possibility of extension for another 60 days. The “state of emergency” may be declared not only at the occurrence of an event but also before it happens if the forecasted scenario poses threats for the population in an imminent period. The declaration of emergency, as amended by law 100/2012, requires the timely identification of the competent authority that will give prosecution to the activities at the expiration of a state of emergency.

The Italian National Platform for Disaster Risk Reduction was formally created by a Decree of the Prime Minister issued on 18February, 2008, aiming at ensuring the full implementation of the Hyogo Declaration and of the Hyogo Framework for Action in Italy. The risk of significant damage due to tornados, sea surges and tsunamis is considered small on Italian territory and preparedness, alert procedures, mitigation activity and search and rescue organisation in this area are consequently not especially developed.

The "Habitat” Directive (used to classify natural areas and accordingly protect them, Po Delta Park), was transposed in Italy through the D.P.R. n. 357/1997, recently modified and completed in the D.P.R. n. 120/2003.

The Flood Directive was transposed in the Italian legislation through the D.Lgs n° 49/2010, the Marine Directive was transposed in Italy through the D.Lgs. 190/2010.

A look into Coastal Legislation in Italy. Coastal areas show a very highly fragmentation and superimposition in competences. Legal frameworks on the topic that defines responsibilities at national, regional and local level are L. 59/97, the D.Lgs. 112/98 and the D.Lgs. 86/99. The L. 183/89, already introduced above, also introduced several key principles for coastal floods risk planning and management.

The legal framework on competences (the L. 183/89 and then, the D.Lgs. 152/2006) is well defined, even if complex. However, a general lack in the implementation of measures at national level has to be highlighted (ISPRA, 2012).

A look into the Liguria Region. The plan for the protection of water, in accordance with Article 44 of Legislative Decree 152/99, replaced by Article 121 of Legislative Decree 152/06, is an instrument for planning of water resources that defines objectives, the attainment or maintenance of environmental quality objectives and the definition of the necessary measures for the protection of the qualitative and quantitative water resource. The Regional Council by Resolution DGR No. 1705 of 18/12/03 approved the procedural training plan, the contents of the plan as well as the list of significant water bodies of the region, corresponding to the requirements of Annex 1 to Decree 152/99 and subsequent amendments.

A look into the Emilia-Romagna Region. Regional policies and strategies for management of water, coastal zones, natural resources and land use are listed in the regional guidelines named "Gestione Integrata delle Zone Costiere (GIZC)", that were approved by the Regional Council in 2005 following European recommendations issued in 2000 and 2002 regarding Integrated Coastal Zone Management (V European Action Programme).

The most important regional law is the n° 20/2000 named "General Rules on Land Protection and Use".

With regards to hazards and risks, more recently the EU Flood Directive 2007/60/CE and Marine Strategy Framework Directive 2008/56/CE are being used to produce vulnerability and risk maps and to preserve the environment and biodiversity respectively.

The Region also issues planning guidelines at provincial level named Piano Territoriale di Coordinamento Provinciale (PTCP), Piano Territoriale Paesistico Regionale (PTPR) that is part of a wider regional plan named Piano Territoriale Regionale (PTR). These plans are used to classify important elements of the territory (e.g.: protected ecosystems, etc.) and are used as territorial planning guidelines.

It must be noted that along the Emilia-Romagna coastal area there is a very important common practice identified as the "winter dune" construction that is the construction of sand mounds (artificial dunes) to protect establishments from damages and inundation during the winter season (Harley and Ciavola, 2013). The used sand is taken either from outside the beach and/or from the beach itself (from the swash/intertidal area). The practice was regulated through guidelines (not compulsory) issued in 2006 that state that the artificial dune should be $<= 2.5$ m height from its base, with a 1:4 seaward slope and located away from the usual influence of modal storms (i.e. 1-in-1 year return period).

Long term actions partly included into the regional ICZM plan (see above) are: 1) subsidence reduction through a better control of water extraction and a protocol between ENI and the Regione Emilia-Romagna to monitor the effects of gas extraction on subsidence rates); 2) actions on rivers (dam removal, avoid to take sand out of riverbeds, change the land use from abandoned lands and forests to cultivated areas – that produce more sediments); 3) favour the set-back of bathing establishments; 4) reduce or almost obliterate the expansion of coastal urban areas; 5) increase the good practice of reutilisation of dredged sands (from ports and channels) for nourishments; 6) favour the good practice of recovering the sand when beach cleaning is performed.

5.2 Germany

Authors: Guntram Seiß and Enrico Duo.

Germany is a federal republic divided into 16 constituent states, known as Länder. Each Land has its own parliament and governments with a high level of autonomy from the federal government. A Land is generally divided into administrative districts. Each district can be divided into administrative counties and county boroughs. The local governments (municipalities) administrate local transports, roads, electricity, water and gas supplies, sewerage systems and daily life protection.

The legal basis for the emergency response is the Constitution and the Länder's law that defines responsibilities, involvements and activities.

According to the Constitution, the Länder are, in peacetime, responsible for the management of all kind of disaster. To note that in the same document there are no structural differences in the definition of disasters type. In wartime, the federal government is in charge of the emergency response. In that way, Germany shows two different areas of law and administration for the emergency response.

Focusing on peacetime (Figure 5.1), the emergency response authority in charge depends on the Land law. In general, the director of the designed authority – that could be the rural district, the county or the municipal authority – is in charge to manage the local response. Further assistance from other authorities and local services depends on the needs. The director indicates a director of the operations, in charge of the technical and tactical execution of the operations. A staff of representatives from police, NGO's, fire brigade and others will assist him. Nevertheless, the Civil Protection is defined at all administrative level.

In case the disaster affects several districts or it exceeds the response capacity of the local government, the next highest hierarchical authority coordinates the response. To note that, when asked, the federal government supports local and regional authorities and states with its forces such as the Federal Police or the Federal Office for Civil Protection. In conclusion, at national level, the overall objective in the emergency planning is to protect the State and its citizens. Operational response is carried out at Land level. Preparedness is a federal responsibility while prevention and management planning involves all administrative levels.

A look into the Land Schleswig-Holstein. The Disaster Risk Reduction Management (DRRM) in Schleswig-Holstein is organised through a variety of public authorities, who are responsible at different levels (Figure 5.2). In case of a disaster, the Ministry of the Interior of Schleswig-Holstein would be responsible for coordinating a response when more than one district was affected. This is commonly the case during flood events. The lower level DRRM authorities act in their district or city respectively, if the disaster is limited to their sphere of influence. For the Kiel Fjord area, the districts of Rendsburg-Eckernförde and Plön, as well as the City of Kiel, are responsible.

The authorities in the event of a disaster guide the actors in practice. Additionally, they often act of their own accord if immediate help is needed.

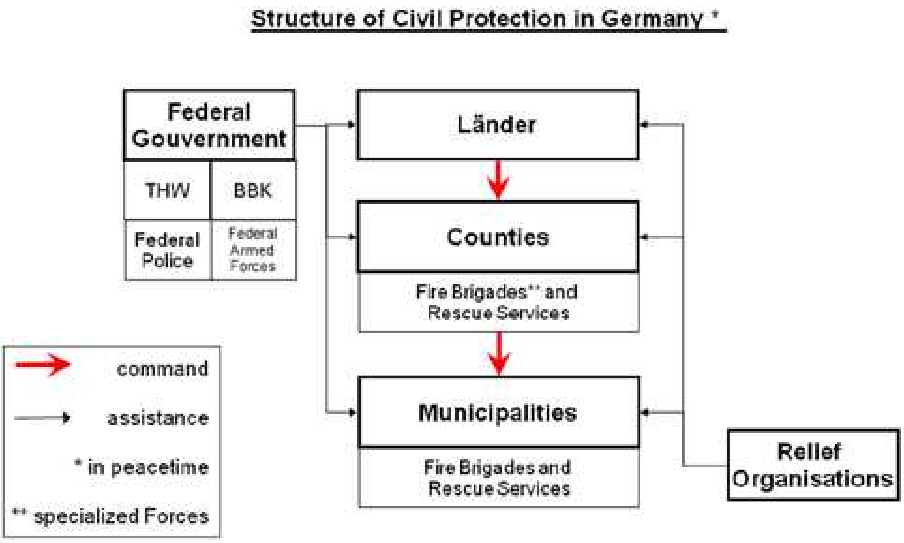

Figure 5.1 Civil Protection structure in Germany (ECHO Vademecum).

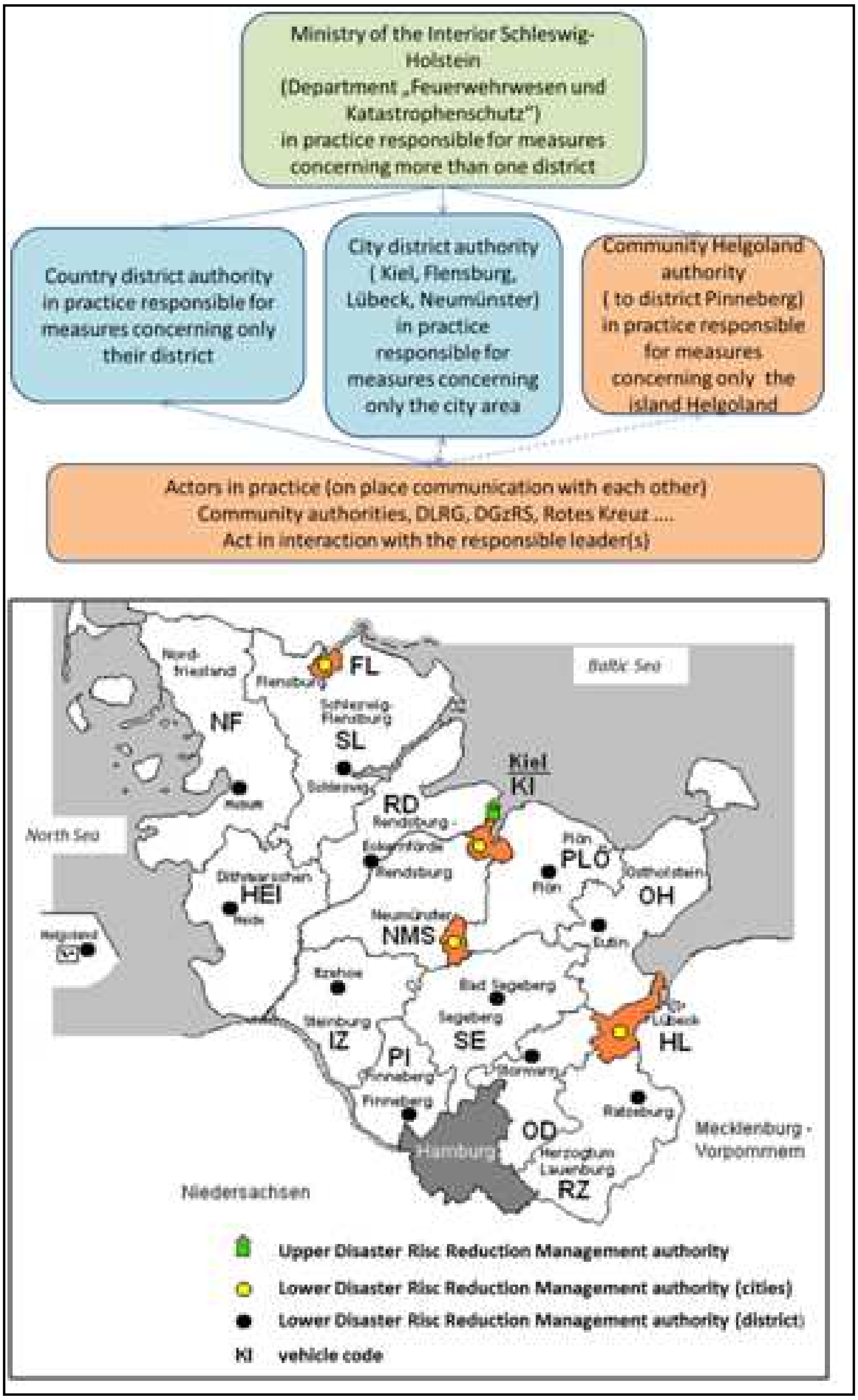

Figure 5.2 Disaster risk reduction management in Schleswig Holstein (Ministry of Interior of Land Shleswig Holstein, website[9]).

[9]MinistryofInteriorof Land Schleswig Holstein: Grafik der Organisation des Katastrophenschutzes. http://www.schleswig-holstein.de/SharedDocs/Bilder/Cover/IM/AFK/organisation__blob=poster.jpg, last visited: 17.04.2014

5.3 Sweden

Authors: Lisa Segnestam and Enrico Duo.

Sweden is divided in to 21 counties (län) and 290 municipalities. The national government appoints regional (county) governors while local administrations are elected.

The civil emergency management system (Figure 5.3)includes three levels (national, regional and local) and is based on three main principles:

- Responsibility: the person who is responsible for an activity under normal conditions should also be responsible for such operations in an emergency;
- Equality: to the extent possible, operations should be organised in the same way during emergencies as under normal conditions;
- Proximity: emergencies should be handled at the lowest possible level in society.

In normal situation the main activities for the risk and emergency management refer to the minimization of risks and effects of disasters, improve the preparedness and enhance the coordination between actors.

The national level is mainly driven by the principle of responsibility and is responsible for management, planning and coordination. Each office is responsible for its specific sector or area but coordination is ensured by a cross-sector approach.

The regional level is responsible for the implementation of training, risk analysis related to land use, dissemination and information sharing.

The municipal level, in accordance with the principle of proximity, is the main actor in the emergency activities, as well as in the local implementation of prevention, preparedness and emergency planning. During a crisis, the Country Administrative Board mainly supports the municipality.

The "Swedish Civil Protection Act" is the legal framework. Other main instruments, that defines the roles at regional and local level are the "Act on Measures to be taken by Municipalities and County Council in Preparedness for and during Extraordinary Incidents during Peacetime and Periods of Heightened Alert" and the "Emergency Preparedness and Heightened Alert Ordinance".

A look into Floods Emergencies. An effect of the storms in Scania has, in later years, been a reopened debate on climate change and climate adaptation and a wish to create a political will and public awareness for dealing with these issues. Numerous studies have also been initiated to better understand the genesis of extreme weather, especially sudden and unpredicted storms. The Swedish Civil Contingencies Agency (MSB) and other agencies involved in preventive measures are also increasing their level of knowledge through various studies. For example the Swedish Defense Research Agency (FOI) initiated the work on Climatools to better provide municipalities with tools to prepare for climate change (see http://www.foi.se/en/Customer--Partners/Projects/Climatools/Climatools/). There is, however, a lack of scientific studies on how households cope with disasters. A lot of the research is oriented towards authorities, organisations, and other professional actors and experts.

Already in the prognosis stage storms trigger collaborative actions among many actors – formal authorities as well as volunteers - at local, municipal, and regional levels. Private actors are also mobilising their capacity, for example power producers. A lot of voluntary organisations and military personnel are also mobilised and organised which shortens the time of recovery and increases the resources needed. The linkages between telecommunications and electricity have been realised and resources mobilised to decrease vulnerability during storms.

As a policy change occurred in Sweden in 1996, responsibilities for risk, preparedness and safety were transferred from the national to the municipal level. Though this has not generally changed municipal flood planning in Sweden (Boverket, 2001), in Kristianstad it has mandated the municipal level to take an active initiative for coastal defence (Johannessen and Hahn, 2013).

A compilation of management documents and strategies shows that Sweden's work on natural disasters is relatively well regulated in the form of laws, and instructions to the authorities. It furthermore has a well-functioning collaboration in natural disaster prevention and emergency work, including the National Platform. However, there are some gaps in terms of integrated flood risk management (Swedish Water House[10], 2013).

Regarding adaptation, the picture is somewhat different, with weaker regulatory structure and weak national coordination. The government's focus and strategy is currently on the sectorial responsibilities and regional coordination throughout the county. An inspection has been announced for 2015 but so far the content is not embodied in an assignment given to the Environmental Protection Agency. (MSB[11], 2012).

A look into Kristianstad Municipality. Following the planning cycle of the national marine spatial planning a marine spatial plan is being prepared in the municipality. Based on a suggestion from the city planning office (Swe: stadsbyggnadskontoret) the housing committee (Swe: Byggnadsnämnden) has requested the municipal executive board (Swe: kommunstyrelsen) to assign the city planning office to be responsible for the process of developing a marine spatial plan as a supplement to the comprehensive plan. The work needs to be done in cooperation with other departments within the municipality, such as the municipal executive office (Swe: kommunledningskontoret), the technical department (C4Teknik), and the environment and health office (Swe: miljö- ochhälsoskyddskontoret) backed by their respective committees and other relevant departments.

[10] Stakeholder dialogue 12 Nov 2013. http://www.swedishwaterhouse.se/en/seminars/previous/seminar.html?id=407&year=2013&type=archive

[11] Strategier och styrandedokumentförklimatanpassning och katastrofriskreducering. https://www.msb.se/RibData/Filer/pdf/26229.pdf

Kristianstad Municipality is lacking comprehensive strategies and guidance for how the coastal zone and sea areas at flood risk should be planned, therefore these aspects have been emphasised as important elements of future work.

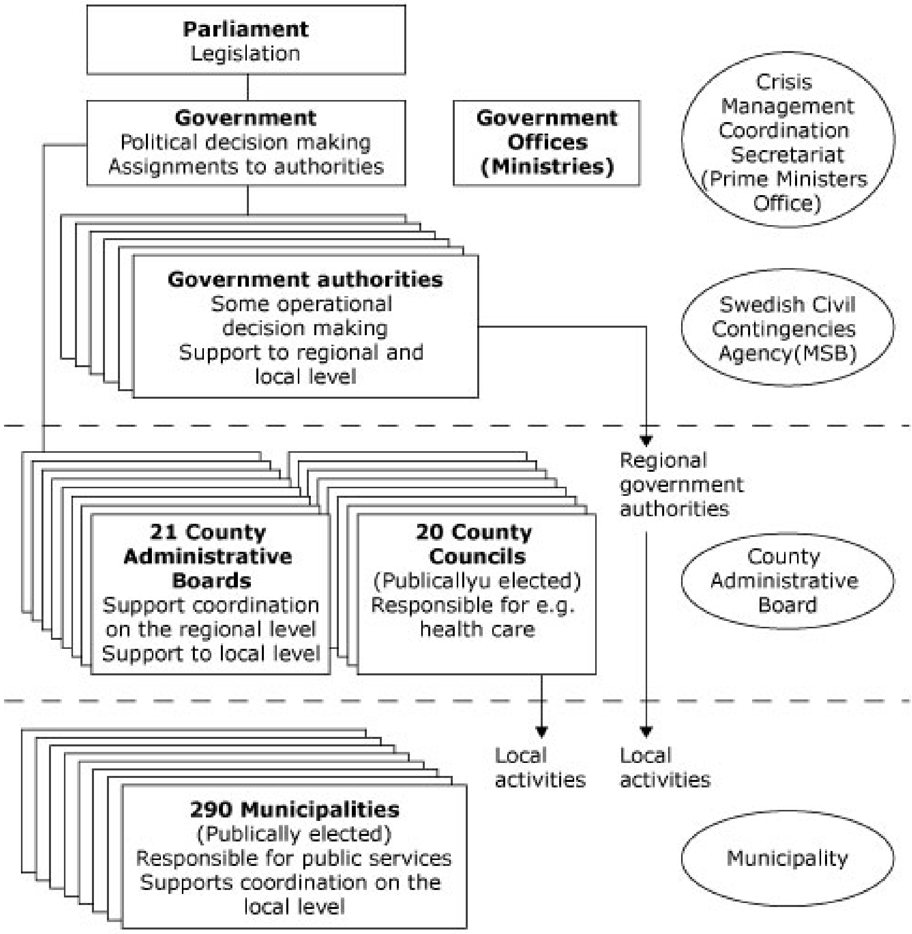

Figure 5.3 Emergency response in Sweden (ECHO Vademecum).

5.4 France

Authors: Xavier Bertin, Gael Arnaul and Enrico Duo.

France consists of 26 regions (22 metropolitan regions and 4 overseas regions) and subdivided into 96 metropolitan departments and 4 overseas departments.

The Civil Protection emergency response (Figure 5.4) is organized at national, zonal and departmental level (higher administrative level than municipalities). At national level, the Minister of the Interior has responsibility for planning, preparing and coordinating. At zonal level, the zone prefect coordinates the operational activities. The department Prefect manages the emergency at the departmental level. In the occurrence of a crisis all three level are activated. To note that the Mayor (belonging to the municipal level, lower than the departmental one) shares responsibilities on public safety within the State.

The reference law framework for Civil Protection is defined by the 1950 Ordinance and the 1965 Decree relating to civil defence, the Law of 22 July 1987 as amended by the Laws of 5 January 1988 and 28 November 1990 with respect to civil security and the Order of 24 August 2000 concerning the organisation and powers of the Directorate of Civil Defence and Security.

A look into DRR planning. Initial DRR, formally PPRI (Plan de Prévention des Risques Inondations in French), which is the Prevention Plan for Flooding Risks, was initiated in 2007 but was never approved until after the storm Xynthia came (2010). After the disaster, things went faster and the plan was finally approved in 2012. The DRR plan is mainly focused on identifying the most vulnerable zones in order to relocate all the constructions off these areas. Different zones have been defined according to the degree of hazard (mainly level of the zone compared to the critical water level defined by the plan).

In June 2012, 525 properties were acquired in the solidarity area presented. These land units have become unsuitable according to their new status. The rest of the land units were subjected to specific negotiations. These negotiations have been hard and many mission and counter expertise have been conducted. A second solidarity map was defined after tough discussions and pressures between owners and the state services.

Regarding the zones outside the solidarity zone, specific requirements were expected according to the level of hazard. These requirements are effective according to the location of the building in the different red or blue zones.

Projects are also subject to specific planning rules mentioned in the PPRI. The red zone can see only special buildings such as:

- Buildings that are not permanently occupied
- Buildings for nautical activity purpose
- Buildings for agricultural or forestry usage

In blue zones B1, rules are less strict but still, buildings for outside accommodation such as campsites are strictly forbidden. Idem strategic buildings are forbidden. In blue zone B2, constructions are still authorised but the floor level must be over the 4,70m level defined as the lowest level admitted. A first step was to consider one to one agreements to acquire houses that were located in the solidarity zone.

For the protection of residential areas, the work planned is mainly based on the maintenance of dikes, thus prevention. The protection plan gives a lot of procedures to keep these dikes efficient. For preparedness, an early warning system is activated as soon as Météo France gives the alert. The COGIC, which is the Operational Inter-Ministry Centre for Crisis Management was operational the civil security was ready before the storm hit the land. All details of the chronologic events are given in a Senat Report[12].

[12] For the Report of the Senat see: http://www.senat.fr/rap/r09-554/r09-5541.pdf

During the storm, the local services of the two towns severely impacted have been quite paralysed. It appears that mayors did not give any directives in the hours preceding the storm. The States services should have been informed straight away as the situation had become critical (Enquete E011000480/44[13]).

Since the storm Xynthia, the Fire Department (SDIS) works on a similar emergency plan as ORSEC (which is the French polyvalent plan for Organising Rescue in case of any important events that need important means of rescue) that would be an alert plan oriented toward 'wave/surge'.

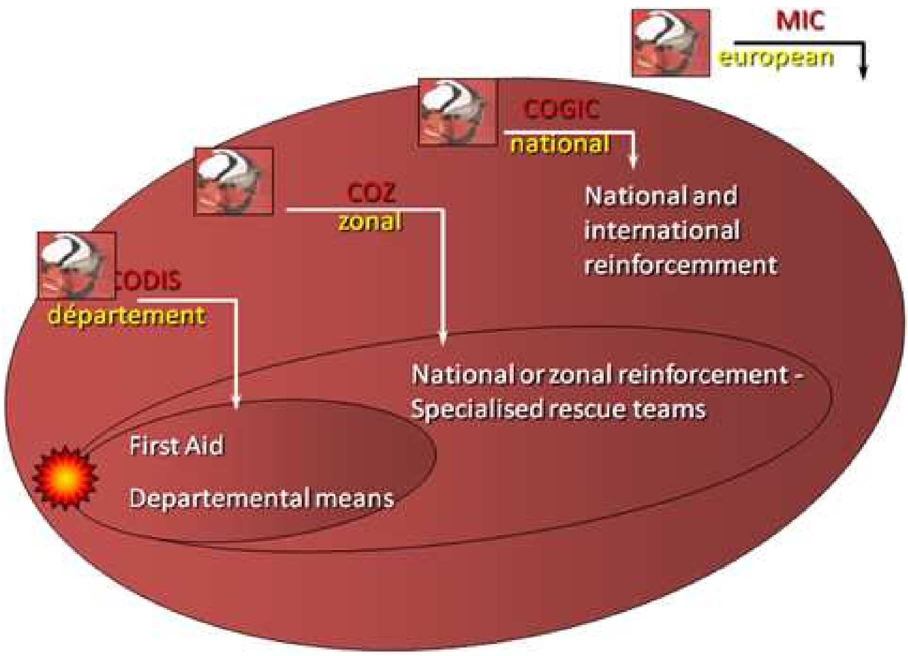

Figure 5.4 Emergency response for France (ECHO Vademecum).

5.5 United Kingdom

Authors: Anna McIvor and Tom Spencer.

The United Kingdom, or United Kingdom of Great Britain and Northern Ireland, includes the countries of England, Scotland, Wales and Northern Ireland. In particular, England consists of 34 two-tier counties, 32 London boroughs and 1 City of London or Greater London, 36 metropolitan counties and 46 unitary authorities. Northern Ireland consists of 26 district council areas and Scotland and Wales has 32 and 22 unitary authorities respectively.

The Civil Contingencies Secretariat (CCS), based in the Cabinet Office at the heart of central government, is responsible for civil emergency planning in England and Wales. This is a devolved responsibility in Scotland and Northern Ireland. The CCS was established in July 2001 and the administration has since then worked in partnership

[13] For the Enquete-Report see: http://www.vendee.gouv.fr/IMG/pdf/conclusions_et_avis_de_la_commission_d_enqute.pdf

with government departments, the devolved administrations and key stakeholders to enhance the UK's ability to prepare for, respond to and recover from emergencies.

The role of central government, devolved administrations and the regional tier is to support and supplement the efforts of local responders through the provision of resources and coordination. The central and regional tiers will only become involved in emergency response and recovery efforts where it is necessary or helpful to do so. This is based on the principle of subsidiarity; if the type or scale of a disaster warrants it, then COBR (Cabinet Office Briefing Rooms) will be activated to enable a central government response. Therefore the institutional basis and responsibility for responding to disaster is flexible and varies according to the nature and scale of the disaster. A guiding principle is that the prime responsibility for handling disasters should remain at the local level where possible. For this reason the overview of the national policy on DRR and Emergency response will often include aspects of the local arrangements.

The British authorities and agencies (the Met Office - Meteorological Office - and Environment Agency) base their system of prevention and coastal defence essentially on the event of 1953. This flood devastated the Netherlands, Belgium and the east of Great Britain. The UK government established an investigation known as the Waverley Committee. This produced the Waverley Report, the guiding document that changed coastal management. For the first time, it recommended the establishment of a warning system for this kind of flooding, which was quickly put in place. As a result of this storm surge an official service for forecasting coastal flooding (Storm Tides Warning Service) was established within the Met Office.

A look into DRR – Emergency Response. The Civil Contingencies Act[14](2004) provides a framework for civil protection in the UK. The act is divided into two parts: local arrangements for civil protection and emergency powers. Part 1 of the Act, alongside the statutory guidance 'Emergency Preparedness', sets out the roles and responsibilities of those involved in emergency preparation and response at the local level. Responders are divided into two categories: Category One responders provide the core emergency response, and include the emergency services, NHS bodies, and local authorities. Category Two responders are 'cooperating bodies', and include the Health and Safety Executive, transport and utility companies. The local response is coordinated via local Resilience Forums, which are based on police areas.

There are several ways that people can be warned about upcoming hazards. The primary source of information for local people is a telephone messaging system, operated by the Environment Agency. A separate system exists for first and second category responders. This system is operated by the Flood Forecasting Centre, which is a partnership between the Environment Agency and the Met Office; this became operational in April 2009, following the Pitt Review of the UK summer floods of 2007. When necessary, the Flood Forecasting Centre sends a message to these responders,

14 https://www.gov.uk/preparation-and-planning-for-emergencies-responsibilities-of-responder-agencies-and-others

who then enact local emergency plans. These plans include aiding the evacuation of vulnerable people, and making sure everyone has evacuated from exposed areas.

A look into an example of Operational Local Best Practice. The storm surge in November 2007 provides an example of how the early warning system and evacuation plans are put into action. The surge was the highest tide since 1953 (since surpassed by the surge in December 2013). Eight severe flood warnings were issued 23 hours in advance of the high tide. This resulted in 27,000 calls being made to local responders and residents, using Floodline Warnings Direct. In Great Yarmouth, 7,500 houses were identified by the Environment Agency as being at risk, while 10,000 houses were identified in Norfolk and Suffolk (including the Case Study area). All these houses were called on by police to alert residents to the dangers. 1,050 people were housed in evacuation centres, and hundreds of others self-evacuated to friends and family. The Floodline number (08459881188) received 5,000 calls per hour, and the website received 457,419 hits on 8 November 2007.

The Environment Agency activated demountable defences to protect a power station supplying 31,000 homes (demountable defences are defences that can be put into action when required; they are already present but are normally not in use, e.g. flood barriers that slide into place when needed). Water rescue teams were mobilised from as far away as Devon and Merseyside.

A look into risk management along coasts. Alongside emergency response, risk reduction measures are also in force around the UK coast. The Department for the Environment, Food and Rural Affairs (Defra) provides funding to risk management authorities to manage flood and coastal erosion risk in England. This includes funding to provide flood warnings, build new and improved flood and coastal defences, maintain existing structures and respond to flood incidents. The majority of this funding is given as a flood defence grant to the Environment Agency. Defra and the Department for Communities and Local Government also provide funding directly to lead local flood authorities (LLFAs) (county or unitary authorities, who have responsibility for managing local flood risk at the local level, under the Flood and Water Management Act 2010). Local authorities also spend money from their revenue budget on ongoing flood and coastal erosion risk management activities.

Key documents outlining the management of coastal risk around the coastlines of England and Wales are the Shoreline Management Plans. These plans identify the most sustainable approach to managing the flood and coastal erosion risks to the coastline over 3 epochs: 2009 – 2025; 2025 – 2055; and 2055 - 2105.

5.6 Portugal

Authors: Susana Costas, T.A. Plomaritis and Enrico Duo.

Portugal is divided into 18 districts and 2 autonomous regions. Administrators at regional levels are appointed by the national governments, while they are elected at local (municipal) level.

The Civil Protection (Figure 5.5) is defined at national (National Authority for Civil Protection), regional (Regional Services for Civil Protection for Azores and Madeira, District Commands for Relief Operations) and municipal level (Municipal Services for

Civil Protection). The legal framework is generally defined through the General Law for Civil Protection (Law 27/2006), the National Civil Protection Authority Law (Law-Decree 75/2007), the Law Decree establishing the Integrated System for Relief and Protection Operations (SIOPS) (Law-Decree 134/2006) and the Law defining the organisation of Civil Protection at local level (Law 65/2007).

The Prime Minister and the Ministry of Interior are responsible for the National Authority for Civil Protection and nominate the directive staff for this institution. The National Authority nominates the head officers at regional (district) level, which is structured into the District Civil Protection Commission (political coordination activities) and the District Coordination Center (operational coordination activities). Moreover, in each district there is a District Command for Relief Operations, directly linked to the Portuguese Civil Protection Authority.

At regional level, the civil governors are responsible for the Civil Protection policy, activation during emergency (also in terms of prevention, aid, assistance and recovery). At local level, these responsibilities are included in part of the mayor duties.

In case the emergency cannot be managed and solved at local or district levels, the National Authority activates the National Coordination Center and a National Command for Relief Operations works 24h a day in order to coordinate the activities.

Inter-ministerial and inter-agency coordination is ensured by the National Civil Protection Commission and the National Coordination Centre, respectively. The latter represents the coordination body of the Integrated System for Relief and Protection Operations, a set of rules and procedures to coordinates the operational level, while decisions are made by the National Coordination Centre.

Other organizations can be involved in the emergency response depending on the disaster type.

A look into DRR measures. Although the Civil Protection appears to be well-defined and structured, there seems to be no general notion of Disaster Risk Reduction (DRR) in Portugal. The Portuguese language does not have a term such as “plano de redução de desastre” and so DRR measures are often a part of coastal management plans or integrated inside them (Ferreira, O., personal communication). Hence, there is not a specific policy devoted to DRR at coastal level. Risk reduction measures are included in the Coastal Zone Spatial Plans (POOCs), and in the POLIS Litoral plan, the Portuguese programme on Integrated Operations towards the Renewal and Enhancement of the Coastal Zone, as well as in conservation plans and other documents.

The political-administrative structure in which DRR policies are embedded is made up of a complex net of organisations. Although DRR activities can be decided at national level, e.g. at the APA (Agência Portuguesa do Ambiente) in Lisbon or at a regional level (APA – Algarve), they are usually implemented at the local level. Moreover, DRR plans are operated on a basis that is highly site dependent. For instance, in conservation areas such as the Ria Formosa Natural Park, the main interventions are brought forward by the Instituto da Conservação da Natureza e das Florestas (ICNF), which is also the responsible for management at a local level of the Natural Park. At specific sites, which are not under the public domain, the municipality is responsible for implementing DRR measures.

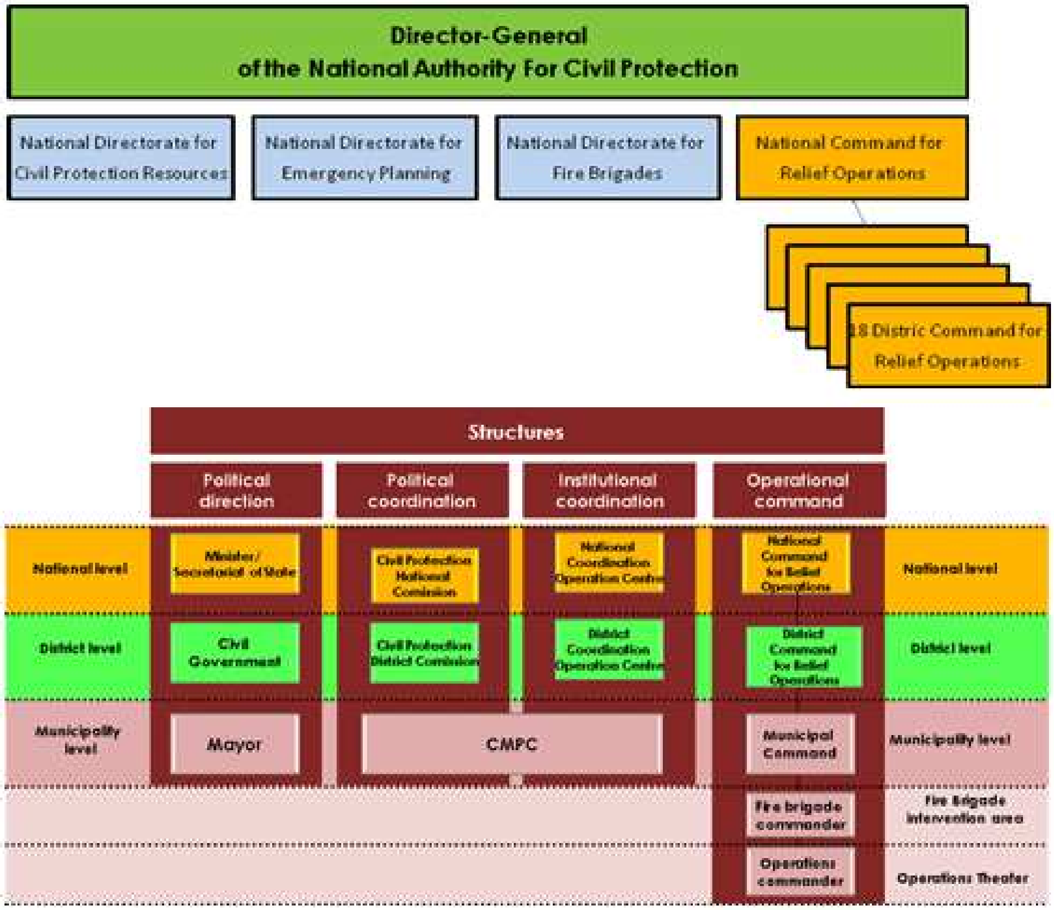

Figure 5.5 Civil Protection structure in Portugal (ECHO Vademecum).

5.7 Spain

Authors: Jose A. Jimenez and Enrico Duo.

Spain is subdivided in 17 autonomous communities and 2 autonomous cities. The heads of the administrations are appointed by the national government.

The Civil Protection is intended to defend people and goods in time of crisis such as a natural disaster. Responsibilities in emergency management are shared between Civil Protection authorities. The organizational structure (Figure 5.6) is outlined by (i) the Delegate Commission of the Government for Crisis Situations, established in 1986 and consisting of the Prime Minister (main decision-maker) and the Deputy Prime Ministers, which the task is to direct and coordinate all actions related to the prevention, control and management of crises; (ii) the National Civil Emergency Planning Committee, subordinated to the Ministry for Governmental Presidency, mainly concerned with tasks related to the provision and implementation of resources in situations of crisis or emergency; (iii) the Directorate General of Civil Protection and Emergencies, under the Minister of the Interior, that leads the Civil Protection structure, and its representative delegation in the sub-national administrative units.

The legal framework on the disaster management structure is defined by the Decree 1125/1976, the Organic Act 1/1980 on National Defence, the Organic Act 4/1981 about warning, exceptions and siege situations, the Act 2/1985 about Civil Protection (and the legal arrangements derived of that act), the Prime Minister's National Defence Guideline 1/1986, the Royal Decree 2639/1986, the Royal Decree 163/1987, the Ministers Council Agreement (15 January 1988) and the Royal Decree 1883/1996.

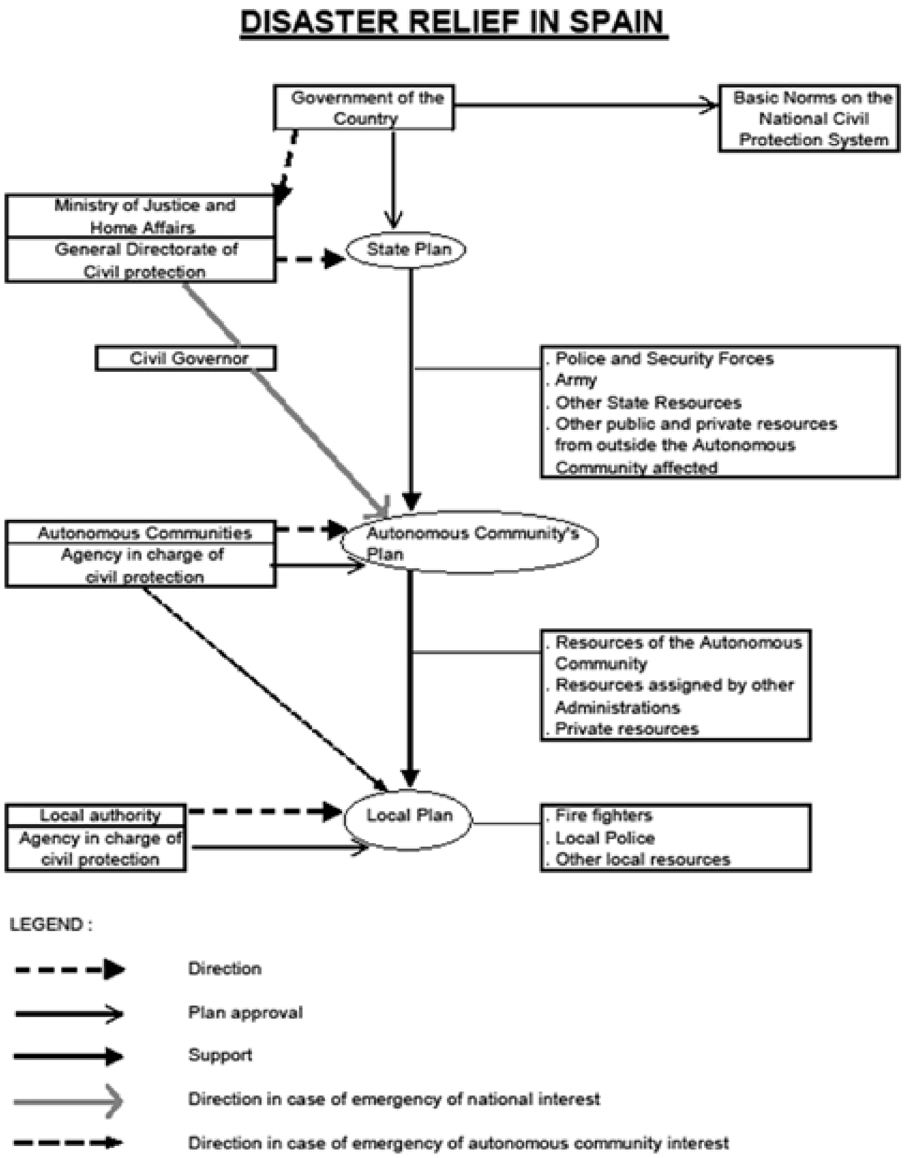

Figure 5.6 Emergency response in Spain (ECHO Vademecum).

A look into Governance in Catalunya. The central government and autonomous regions have exclusive or shared competences for a wide range of issues which affect coastal zone management, ranging from urban and spatial planning to biodiversity, water quality and tourism.

As is visible from Table 5.1, the coastal zone is the responsibility of all three levels of administration. This complex map of competences and responsibilities has led to situations of conflict within the various administrations and has been hampered by the lack of proper administrative coordination (Ministerio de Medio Ambiente, 2006).

In 2007 a Strategy for Coastal Sustainability (SCS), a Spanish initiative for implementing coastal interventions under the principles of Integrated Coastal Zone Management (ICZM) was presented to the public. Exclusive competences on urban development in the coastal zone (landward of the coastal public domain) belong to the Government of Catalonia (Generalitat de Catalunya). Within this framework, the Generalitat de Catalunya developed the Urban-Development Master Plan for the Coastal System, PDUSC(*Plan Director Urbanístico del Sistema Costero*).

The PDUSC does recognize existing problems related to natural processes that could affect existing installations exposed to flooding under the present conditions and, also, considering climate change. A recent modification of the PDUSC (Generalitat de Catalunya, 2013) specifically mentions the need to consider potential changes in the DPMT due to coastal erosion (shoreline retreat) in the regulation for camp site installations located in the "first row", i.e. just landwards of DPMT.

An example of shared competences is the application of the Floods Directive (Directive 2007/60/EC). The delineation of the risk areas corresponding to river floods is on the hand of the Generalitat de Catalunya through the Catalonia Water Agency (ACA), which have already delineated the risk areas associated with events of Tr of 10, 100 and 500 years. On the other hand, the application of the directive regarding the elaboration of risk maps for coastal floods along the Spanish coastal zone (including Catalunya) was done by the Central Government (MAGRAMA, 2013) which is the one with competences on the coastal public domain.

Table 5.1 Coastal areas administration structure.

Sector	National	Regions	Town halls
Coastal zones	Maritime-Terrestrial Public Domain Demarcation, oversight and management Studies, projects and public works of general interest Basic fisheries legislation Basic legislation on protection and recuperation of natural values Defence works Rights of use and passage	MTPD Rights of way Public works of regional interest Regional planning Planning of coastal areas River and sea fishing in inland waters Shell-fishing and Mariculture Health and hygiene Defence installations and use of defence works Tourism planning and promotion	Town planning Use, safety and cleaning of beaches Health Monitoring and safety Reports on applications for use of MTPD
Waters	Infrastructure planning and management and protection of water resources (where a waterway affects more than one region);	Water resources and infrastructures(where waterway affects one region only) Discharges Control and monitoring of water quality (bathing water and living resources) in coordination with the State	Wastewater treatment; Water supply
Biodiversity	Basic legislation Coordination and promotion of protection policies	Management of protected natural areas and additional legal instruments National Parks	
Ports and Navigation	Primary commercial ports Lighting of coasts and maritime signals Shipping control Sea rescue	Regional commercial ports, marinas and fishing ports	

5.8 Bulgaria

Authors: Nikolay Valchev and Enrico Duo.

Bulgaria is divided into 28 administrative districts (*oblast*), administrated by governors appointed by the national government. Each district has its own Fire Safety and Civil Protection Regional Directorate included in the National Civil Protection Service headed by the Directorate General for Fire Safety and Civil Protection, part of the Ministry of Interior (Figure 5.7).

The legal basis of disaster management is the Disaster Protection Law and the Law on the Ministry of the Interior. Several documents define practical issues and national programmes and plans for the disaster protection, rescue and emergency. Moreover, other specific laws define function and authorities.

The DG for Fire Safety and Civil Protection is a specialized structure in charge of implementing natural and man-made disaster prevention, preparedness, management, reaction and recovery tasks. It is structured into three Departments: Operational, Prevention and Administrative Activities.

Responsibilities at national and regional level are shared between Civil Protection - Interagency Level of Command, Control and Coordination. At municipal and regional level the mayor and the regional governor are responsible for Civil Protection coordination and management (including prevention and preparedness activities). Operationally, the coordination is achieved through the Operational Communication and Information Centres. In case of a disaster, at municipal level, the mayor coordinates the rescue and emergency activities through coordination headquarters. The mayor also announces the state of emergency and manages information exchange through the Operational Centers. And can request assistance from the regional government. Both of them are requested to regularly report to the Ministry of Interiors.

A look into Governance and Coastal Floods. Coastal protection, as well as the related financing of adaptation measures, is mainly a national matter. The main institutions involved are the Ministry of Regional Development and Public Works and its former executive agency, Geozashtita, now a state enterprise presently engaged in researching and partially in designing and realising specific stabilising measures in landslide areas and unstable land.

In Table 5.2the role of each organisation in flood risk management (strategic and/or operational), as well its responsibilities (e.g. legislative, executive, services) for protection, spatial planning and disaster management are shown, focusing on national, regional and local levels (Varna example).An example from Varna coastal area institutional management is shown in Figure 5.8.

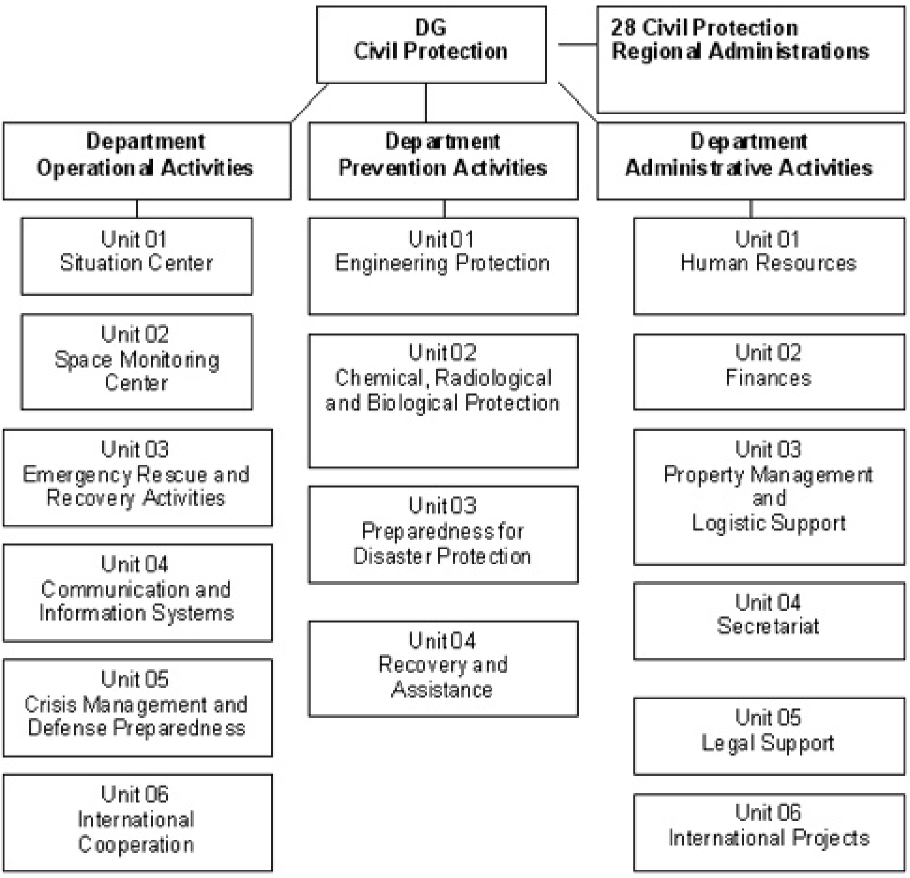

Figure 5.7 Civil Protection structure in Bulgaria (ECHO Vademecum).

Table 5.2 Flood risk management organization, Bulgaria.

Stakeholder	Flood protection	Spatial planning	Disaster management
National **1.** MRDPW – General Directorate for Strategic Planning of Regional Development and Administrative -Territorial Division	Operational Strategic	Strategic, operational and legislative	Strategic and operational, services
2. Ministry of Environment and Water - Executive Environment Agency	Strategic and operational services	Operational legislative	Operational services
3. Ministry of Interior	Strategic and operational executive	-	Strategic and operational executive
4. Executive Agency Marine Administration (Ministry of Transport)	Operational Strategic	Strategic and operational, services	Operational services
Regional 1. Regional Administration – Varna	Operational services	Strategic and operational services	Operational executive
2. Directorate "Marine Administration"	Operational services	Operational services	Operational services
3. Basin Directorate for the Black Sea Region – Varna	Operational strategic	Operational	Operational services
4. Regional Inspectorate for Environment and Waters -Varna	Operational services	-	Operational services
5. Fire Safety and Civil Protection – Varna	Strategic and operational	-	Strategic and operational
6. Geozashtita	Operational	Operational	Services
Local 1. Port EAD - Varna	Operational services	-	Operational executive
2. TP "Port" - Varna	Operational services	-	Operational executive
3. Municipality Varna	Operational services	Operational, strategic Executive	Operational services

4. NIMH (National Institute for Meteorology and Hydrology) – Varna	Operational services	-	-
5. Territory Design Organisation - Varna	-	Operational executive	-

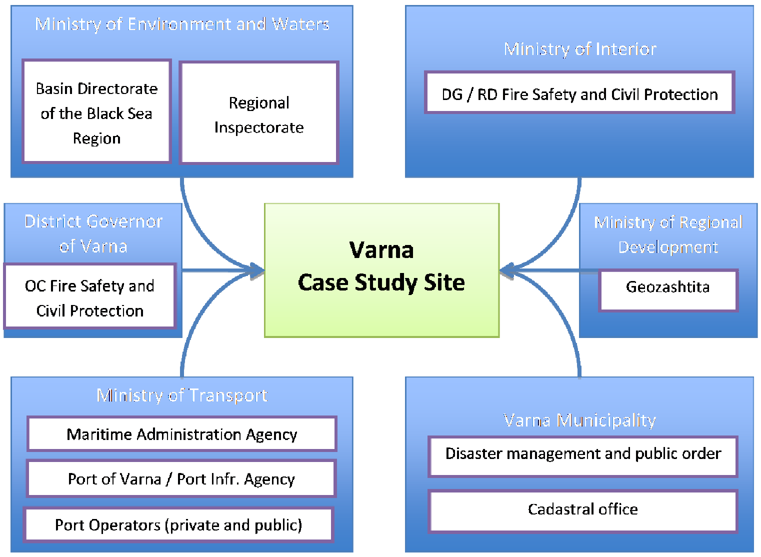

Figure 5.8 Simplified institutional map and interactions.

5.9 Belgium

Authors: Steven Smets and Enrico Duo.

Belgium is divided into three regions: Brussels Capital, Flanders and Wallonia. The last two regions are subdivided into five provinces. After 1993, the state evolved into a federal state. Consequently, the administrative structure has four levels: federal, regional, provincial and municipal.

Responsibilities during a crisis (e.g. natural disaster) are defined depending on the magnitude of the event (Royal Decree of 16 February 2006): a municipal scale event management belongs to the mayor; at provincial level it is the responsibility of the provincial governor, while the Ministry of Home Affairs is responsible for national issues (Figure 5.9).

In general, the emergency response is characterized by the activation of fire brigades at the municipal level, while the Civil Protection service is defined at federal level. In particular, the Civil Protection consists of six operational units, coordinated by the Directorate of Operations. It belongs to the Directorate General for Civil Security that is the competent authority for national coordination. It is responsible for Civil Protection (directly) and fire brigades at municipal level (indirectly). It coordinates activities of prevention, intervention and crisis management, communication, refunding and more. The national level management is regulated by the Royal Decree of 31 January 2003.

When a disaster event of federal magnitude occurs, the three bodies in the federal crisis centre that contribute to the decision process are activated: (i) the assessment cell (expert board); (ii) the management cell (policy and decisions makers) and (iii) the information cell. At operational level, the response is implemented through several tasks related to 5 disciplines (sectors): (i) assistance operations, (ii) medical, sanitary and psychosocial assistance, (iii) local police in to the area of the emergency situation, (iv) logistical support and (v) information.

At the provincial level the activation starts at the onset of an event that over exceeds the capacity of the municipal level. The Ministry of the Home Affairs will not be involved in the management but only informed. At municipal level the mayor activates the response of municipal crisis informing the higher level.

More details on Civil Protection structure, activities and legal framework can be found in English at http://www.securitecivile.be/en.

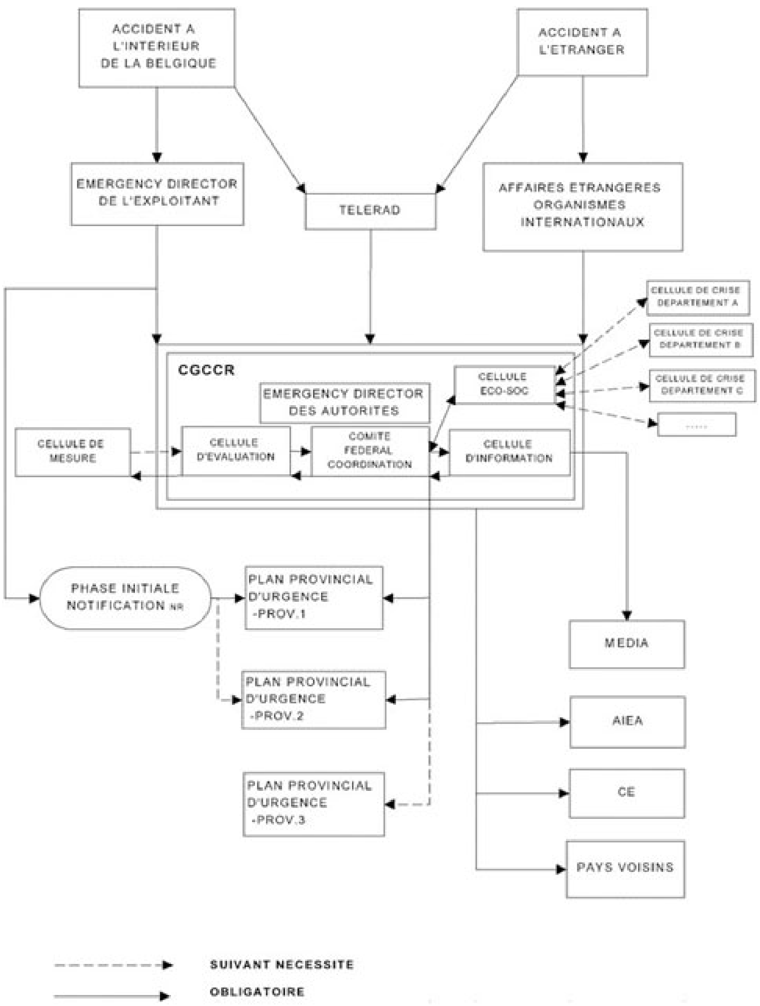

Figure 5.9 Emergency response structure in Belgium (ECHO Vademecum).

A look into Flood Risk Management in Flanders. Flanders implemented the EU Floods Directive in 2010 by modifying the Decree on Integrated Water Policy of 18 July 2003. The modified decree took into account the defence against inundations, as well as the control of flood risks. The Coordination Committee on Integrated Water Policy (CIW) set up an integrated approach by means of a platform to consult the different policy domains and administrative levels that are involved in the water policy, together with the water company (Lescrauwaet et al, 2013).

In 2011, the Coastal Division (part of the Agency for Maritime and Coastal Services – MDK of the Flemish policy domain of Mobility and Public Works - MOW) finalised a flood risk management plan for the coastal area, the Masterplan Coastal Safety, which was approved by the Flemish government on 10 June 2011 (Lescrauwaet et al, 2013). The studies for the Masterplan started in 2007. Between the start of the studies and the implementation of the Masterplan, an emergency scenario was tested. The most urgent problems were addressed in order to protect land inwards parts of the coast against a storm with a return period of 100 years.

There is a specific national contingency plan in Belgium for an emergency concerning flooding. Next to that, each municipality has its own specific contingency plans on issues that relate to that municipality. The provincial authorities of West-Flanders have an overarching plan for their specific role during an emergency.

The Coastal Division is responsible for issuing warnings in case abnormal high water levels are expected, for organising the control of the coastal defence structures, and if necessary taking urgent repair measures (AfdelingKust, 2013).

On the 10th of June 2011 the Flemish government approved the Masterplan for the Coastal Safety (MDK, 2011). The goal of this Masterplan is to protect the coast on a long term basis against inundations. The aim of the Masterplan is to protect the coast against a storm with a return period of 1000 years and to have no breaching for a +8m TAW storm, but, if minimal costs are expected to result in high benefits, protection against larger storms will be implemented. In the Masterplan, climate change scenarios such as the rise of sea-level are also taken into account. The time horizon of the plan is 2050 and protection is guaranteed if beach nourishing continues. Additionally, a durable balance with flexible and nature friendly measures, such as sand nourishment, and the maintenance of the biodiversity along the coast, has also been taken into account.

Figure 5.10shows the flow chart of the Masterplan. The Master Plan defines an optimal safety level, differentiated along the coast (and, if possible, in time). The different solutions are subjected to a social cost - benefit analysis (SCBA) and an environmental impact assessment (EIA). The social cost – benefit analysis compares construction and maintenance costs, with the benefits, i.e. no damage or less damage during storms. However, not only the technical costs and benefits are important, but also the social and ecological impact and the impact on the economy and especially on recreation and tourism. Therefore the time aspects of investments, sea level rise, beach erosion, etc. are also taken into account. Flood risk calculations for the actual situation and the future situation, after executing the coastal protection measures, are being carried out. All legislation is clarified and extended communication with coastal stakeholders was organised to avoid surprises in a later phase.

In order to improve coastal safety, measures for the weakest points of each coastal city are listed in the Masterplan for Coastal Safety. The measures are the so called 'soft' and 'hard' defence structures. First of all, soft measures, in this case sand nourishment on beaches and in dunes, are used to improve the safety. Only if necessary, 'hard' structures, such as dikes, are built or further improved. These measures are the most advisable alternatives based on technical studies, impact analyses and communication with the stakeholders. Each coastal city/municipality gave their agreement in principle with the suggested measures. The realisation of the Masterplan also has budgetary repercussion on the cities/municipalities. If a hard defence structure is needed to improve the safety against 1000-year storm, the municipalities and the Coastal Division cooperated to design and construct architectural defence structures and/or to combine the construction with renovation of existing structures. There was a general as well as a financial cooperation.

The Masterplan for the Coastal Safety is the first step of the project "VlaamseBaaien" (Flemish Bays). The goal of the project "VlaamseBaaien" is to develop an integral long term (2100) vision for the future policy. The implementation of the Masterplan for Coastal Safety is considered to be the precondition of all the other projects developed within the project "VlaamseBaaien".

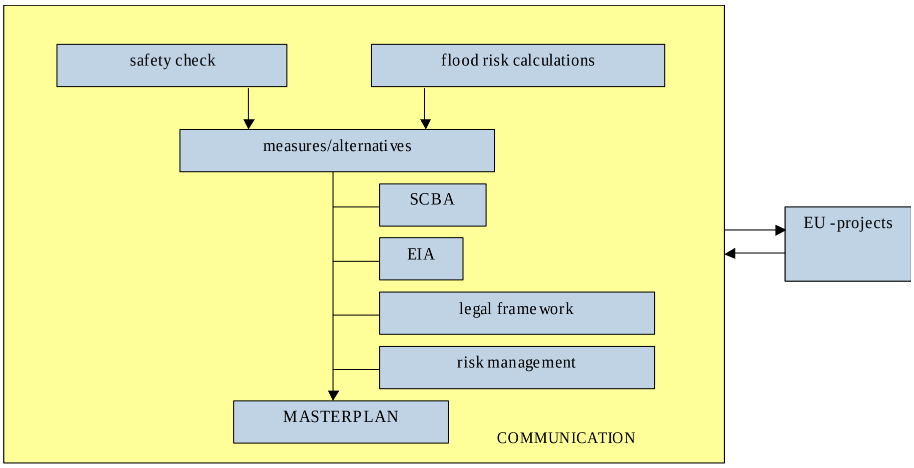

Figure 5.10 Flow chart of the Masterplan for Coatal Safety (Mertens et al.).

5.10 Bangladesh

Authors: M.M. Uddin and S.H.M. Fakhruddin.

The Standing Orders on Disaster (SOD; Government of Bangladesh: 2010) outlines the roles and responsibilities of the ministries, divisions, agencies, organizations, committees and public representatives to cope with any natural disaster occur in Bangladesh (Figure 5.11). Building on this, the WMO produced the CIFDP User Requirement Plan for Bangladesh in 2013 [15].

[15]Available at: http://www.jcomm.info/index.php?option=com_oe&task=viewDocumentRecord&docID=12566

The Bangladesh government's regulatory framework for disaster management provides for a legislative, policy and practice framework under which the activity of Disaster Risk Reduction and Emergency Management in Bangladesh is managed and implemented. The framework includes:

Disaster Management Act. A Disaster Management Act was enacted with a view to create the legislative tool under which disaster risk and emergency management actions are undertaken in Bangladesh, providing the legal basis for which activities and actions are identified, undertaken and managed. It also establishes roles and responsibilities for Ministries, committees and appointments.

National Plan for Disaster Management. The Ministry of Food and Disaster Management prepared the National Plan for Disaster Management. This plan covers a way to foster a culture of prevention, one that should be developed by introducing disaster management in school curriculum, including relevant aspects of disaster management in professional courses, enhancing the capacity of disaster managers by improving training facilities and creating mass awareness at all levels. Additionally, the involvement of people at the grassroots (particularly those who are more vulnerable) in improvements to preparedness and response should encourage community level initiatives for disaster preparedness. Appropriate zonal regulations, design standards, building codes and performance specifications have been developed for safe constructions. All development schemes in vulnerable areas include a disaster mitigation analysis, whereby the feasibility of a project is assessed with respect to the vulnerability of the area. Disaster mitigation components are built into all development projects financed under the Plan, as part of approved project costs.

National Disaster Management Policy. A National Disaster Management Policy has been formulated to define the national perspective on disaster risk reduction and emergency management, and to describe the strategic framework and national principles of disaster management in Bangladesh. It is strategic in nature, and describes the broad national objectives and strategies in disaster management.

In January 1997 the Standing Orders on Disaster (SOD) was issued to guide and monitor disaster management activities throughout the respective ministries, departments and agencies. The SOD was revised and published in 2010. In addition, a series of inter-related institutions, at both national and sub-national levels have been created for planning and coordination of disaster risk reduction and emergency response management. The most important are the District Disaster Management Committee (DDMC), Upazila Disaster Management Committee (UZDMC), Union Disaster Management Committee (UDMC), Pourashava (Municipality) Disaster Management Committee (PDMC) and City Corporation Disaster Management Committee (CCDMC). Chairs comprising representatives of NGO's and civil society at large head the committees. The committees are required to meet bimonthly during normal periods, and as necessary during emergency situations.

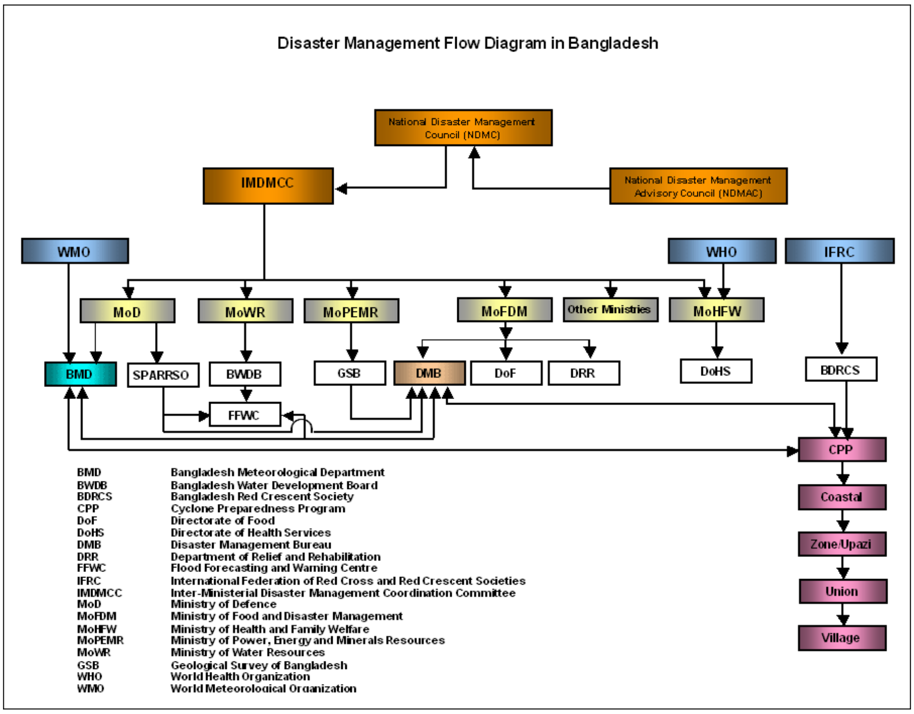

Figure 5.11 Overview of Disaster Management Institutions in Bangladesh.

6 Analysis and outcomes

Author: Enrico Duo.

In the previous chapters, an overview of supra-national and national policies on disaster response and management and DRR measures was presented. It was based on a review of available official and scientific reports on the topic, as well as documents available by governments and international authorities on the web.

In this section, several analyses on the implementation of the supra-national initiatives (EU and UN) at national level were implemented. First, the adaptation of Member States to the EU Floods Directive was analysed following these steps: (i) a review of some examples of risk assessment from Italy and the United Kingdom; (ii) an analysis was based on RISC-KIT Case Study Owners' experience; (iii) a web-based overview on the available and published documents from ROD EIONET web database. Then, national adaptation to the UN Hyogo Framework for Action was investigated through an analysis of available official reports and through an internal perception-based questionnaire compiled by RISC-KIT CSOs.

6.1 National adaptations to EU Floods Directive (2007/60/EC)

6.1.1 Examples of Risk Assessment implementation

Scientific papers on the proper methodologies that are currently and can be adopted by EU countries to fulfil the requirements of the Floods Directive range from the overall analysis of Moel et al. (2009), which gives an overview of adopted methodologies in Europe, to the study on the use of probabilistic methods based on SLR projections (Purvis et al., 2008), which include climate change impacts. Wadey et al. (2012) demonstrated how existing methods, which often exclude climate change assessment impacts, could be integrated within innovative climate-change-impact-based methodologies.

Several methodologies to estimate coastal flooding are available in the scientific community, but often do not meet the needs of governmental bodies and local administrations. Typically governmental stakeholders need to apply the FD within large areas, with limited information and under pressure to produce the maps in a timely manner to comply with the Directive guidelines. In this section, an incomplete but effective overview of some best practices in hazard and risk assessment is shown focusing on examples from Italy and the United Kingdom. At the time of the analyses no examples for other countries were found. In these examples, and their related documentation, a certain degree of merging between knowledge and expertise at scientific and administrative levels can be recognized.

Italy

ISPRA is providing at national level several guidelines for the implementation of the EU Water Framework and Floods Directives' requirements. As examples, it proposes methodologies on monitoring networks and measures to apply for the WFD requirements (GdL "Reti di monitoraggio e Reporting Direttiva 2000/60/CE", 2014) and for Flood Hazard and Risk Maps (Barbano et al., 2012).

The aim of the first document cited above was to propose a nationally uniform set of methods and instruments to monitor the waters status, matching the Water Framework Directive requirements with the national regulations and management structure. The Floods Directive was not considered in this document. The coastal water section in the document focussed on the interpretation of the water body definition and its monitoring methods, standards and classifications. Chemical, physical, biological and hydro-geomorphological aspects were taken into account. Chemical and biological risk is analysed too. Floods risk and management aspect were not considered. Because of the governance structure of Italy, the document is addressed to the Regions, nevertheless while recommending a national approach. No information about the reception of the document at national level is available. To note that the working groups that produced this document included delegates from the Regions, but not from all of them.

The second document cited above, on the other hand, reviews the implemented hazard and risk assessment maps at the national level, suggesting several methodologies for a uniform implementation and updating knowledge on flood hazards. It also includes a section on coastal areas, reviewing the state-of-the-art methods used for map production within Italy. The document demonstrates, a general lack of practice at national level for coastal areas in comparison with riverine hazard and risk mapping. To fill this gap, it proposes some methodologies, specific for coastal areas. In particular, in Annex 3, an overview of some regional methodologies is provided, including the Liguria and Emilia-Romagna ones.

Indeed, the work done in Emilia-Romagna on this topic can be considered an example of *"Best Practice"*. This comes from a long-standing tradition of local government studies on the coastal areas, driven by the fact that coastal activities are very important in socio-economic terms. Public documentation is available through the website www.ambiente.regione.emilia-romagna.it[16]. As an example, the document *"Mappatura della pericolosità nelle aree costiere marine della Regione Emilia-Romagna ricadenti nel distretto padano e dell' Appennino Settentrionale"*[17] (2012) shows an overview of the hazard and risk assessment maps produced using up-to-date data and methodologies implemented on the Emilia-Romagna coast. Moreover, it anticipates several further steps on their validation and systematic implementation. General information on the whole steps of the Floods Directive implementation can be found in the document "La Direttiva Alluvioni 2007/60/CE e le attività in corso nel territorio della Regione Emilia-Romagna"[18] (no date). Two other Regions adopted in an

[16]The coastal section is available at: http://ambiente.regione.emilia-romagna.it/suolo-bacino/argomenti/difesa-della-costa

[17]Available at: http://ambiente.regione.emilia-romagna.it/suolo-bacino/sezioni/piano-di-gestione-del-rischio-alluvioni/piano-gestione-del-rischio-alluvioni/documenti-1/mappatura-della-pericolosita-nelle-aree-costiere-marine-della-regione-emilia-romagna-ricadenti-nel-distretto-padano-e-dell2019appennino-settentrionale-bozza/at_download/file

[18]Available at: https://www.google.it/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&cad=rja&uact=8&ved=0CD

unofficial way the Emilia-Romagna methodology: Friuli Venezia Giulia and Liguria (P. Ciavola, personal communication).

The United Kingdom

The UK 2012 Climate Change Risk Assessment, project of the Department of Environment, Food and Rural Affairs[19] (DEFRA) produced the report Climate Change Risk Assessment for the Floods and Coastal Erosion Sector (Ramsbottom et al, 2012). It belongs to a more comprehensive set of reports on Climate Change[20]. Despite not being undertaken by the UK government in response to the Flood Directive, it is discussed below to highlight the many ways the report anticipates the requests of the European Union. The National Flood Risk Assessment (NaFRA - 2009) also fulfilled many of the requirements. Both focus only on England and Wales (each of the home countries have transposed and adopted the requirements of the Floods Directive slightly differently).

The "Climate Change Risk Assessment for the Floods and Coastal Erosion Sector" provides the results of the analysis on climate change impacts on risk assessment, focusing on floods and coastal erosion. It explains the adopted methodology, highlighting strong and weak points. In particular, the report takes into account the UK Climate Projections 2009[21] (UKCP09), assuming that no measures will be taken to adapt to climate change, and that no changes in socio-economic activity will happen, except for population growth. As a result, several impacts for the 2020s, 2050s and 2080s are shown for several sectors, such as people at risk, infrastructure at risk, agriculture losses and more. The authors note that the results need to be carefully used in way that takes into account local circumstances and implementation, as the methodology was applied at national and regional level. Moreover, they stress the qualitative interpretation of results rather than a more quantitative one.

6.1.2 Official reporting database

The Reporting Obligation Database (ROD), maintained by the European Environment Information and Observation Network (Eionet) as a partnership between the European Environmental Agency (EEA) and the Members States, was chosen as the reporting portal for Member States on Floods Directive implementation. MS were requested to upload documentation on the implementation, such as reports, databases, GIS files and more. They could also, when necessary, secret the documents (make them confidential to the Commission). In this case, maps are simply available as images but not as interrogable GIS layers.

MQFjAC&url=http%3A%2F%2Fambiente.regione.emilia-romagna.it%2Fsuolo-bacino%2Fnotizie%2Fallegati-2013%2Fnote-illustrative-meeting-direttiva-alluvioni%2Fat_download%2Ffile%2FNoteIllustr_DirettivaAlluvioni.pdf&ei=EBRNVPXvKob6ywPakYIg&usg=AFQjCNGzDdrPOQlXB93B7rMVjKR-c0QM6g&bvm=bv.77880786,d.bGQ

[19]Information at: https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs

[20]Available through the link https://www.gov.uk/government/policies/adapting-to-climate-change

[21]Seehttp://www.metoffice.gov.uk/services/climate-services/uk/ukcp

The direct link to the Floods Directive documentation is: http://rod.eionet.europa.eu/instruments/630. Through that page, an overview analysis of available reports and files was implemented for RISC-KIT Member States.

The work we undertook highlighted that all MS reported and uploaded information about the Units of Management, mainly as GIS files, and the Preliminary Flood Risk Assessment, mainly maps, GIS files and guideline reports when necessary. No documents were found for Transitional Measures adopted by RISC-KIT MS, while for Flood Hazard and Risk Maps, documents (mainly GIS) were found for project partners except for Portugal and Bulgaria.

Notably, some MS adopted the confidentiality option: Italy and France for the Units of Management documents; Italy secreted all documents for PFRA, while Germany, France, the United Kingdom and Bulgaria secreted only some documents for the same issue; Italy, Germany and France make some of their documents on FHRM confidential.

Thus, the overview was limited to an analysis of the availability of the documents, not going deep into the contents.

6.1.3 The RISC-KIT Case Study Owners experience

In order to analyse the state of the application of the EU Flood Directive in the Case Study Countries, our partners were requested to develop a target research based on three simple questions on their Member State:

1. Who is applying the Flood Directive at national level?
2. What is the state of the application of the Flood Directive at national level?
3. What is the national roadmap for the application of the Flood Directive?

It was decided to directly involve the project partners for a number of reasons. First, it was not always easy to obtain this information from public sources without knowing the national details of the application of the directive. Second, on several occasions the available national documentation is produced only in the local language. The research was implemented analysing official reports, national legislations and looking at the effectiveness of the implementation at national and local level. On the basis of the answers, a summary was compiled and a description for each European Case Study Country follows hereafter.

Italy. In Italy, ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale) - Ministry of Environment, Land and Sea, is in charge for implementing the EU Flood Directive.

The Italian State has exclusive legislative power, as well as the guiding, coordinating and substituting power for the local authorities. At national level the Ministry of Environment, Land and Sea, the Institute for Environmental Protection and Research (ISPRA) and the National River Basin Authorities (coordinating the River Basin Districts) are the main stakeholders involved. Together, they are responsible for providing a national framework with regard to the application of the directive, which at the local level is done by a variety of actors varying from region to region and across levels, from Regional Authorities to River Basin authorities. On some occasions, the work leading to the required products (e.g. risk maps) is being done in-house by public authorities. On other occasions it is subcontracted to University institutes. Including international river basin cooperation, Italy has eight river basin districts, from which two are international sharing watercourses with France to the west (river Rhone), Switzerland and Austria to the north (Rhine, Danube and Po rivers) and Slovenia to the east (river Vipacco). The internationally shared watercourses in Italy are quite negligible because they include just a small part of the river basins.

Italy is in line with the requirements of the EU Flood Directive and the Italian Law (D. Lgs 49/2010) adapted from the FD to the Italian physical and institutional situation. As previous deadlines were respected (at least at the ''official'' level), the next target is the definition of the Management Plans by December 2015.

Notably, however, that there is a general lack of implementation and interest in coastal areas, while implementation progress is clear and evident for river basins.

Germany. In Germany, the flood protection issue, is delegated to the 16 constituent states through the Ministry of Interior. In practice, the FD is implemented by the states.

The requirements for most recent delivery (Flood Hazard and Risk Maps) were respected and information was provided to the population. Germany expects fulfilling the requirement for next reporting about Flood Risk Management Plans without any delay.

Through the following links, information about the implementation and maps can be found at:

- For Schleswig-Holstein: http://www.schleswig-holstein.de/UmweltLandwirtschaft/DE/WasserMeer/14_HWRL/02_Formulare/ein_node.html;
- For Niedersachsen: http://www.umwelt.niedersachsen.de/hochwasser_kuestenschutz/risikomanagement/eu-hochwasserrisikomanagement-richtlinie-9012.html;
- For Mecklenburg-Vorpommern: http://www.regierung-mv.de/cms2/Regierungsportal_prod/Regierungsportal/de/lm/Themen/Wasser/Hochwasserschutz/Hochwasserrisikomanagement-Richtlinie/index.jsp;
- For Hamburg: http://lsbg.hamburg.de/downloads-berichte/.

Sweden. The Swedish Civil Contingencies Agency (MSB), under the Ministry of Defence, is responsible for coordinating the ongoing implementation of the FD in close cooperation with the county administrations in three steps during 2009-2015. At the regional level, 21 County Administrative Boards are responsible for carrying out part of the work to implement both FD and WFD directives at the regional level. The five county administrations, who are also responsible hosts of the five water authorities, will be central actors in the implementation.

However, the national level does not take any responsibility for the practical application at local level. Sweden is a highly decentralised country. The municipalities are solely responsible for protecting its citizens against flooding through planning the use of land and water within a legal framework. Periodically, every five years, comprehensive plans are developed for the municipality for current and long term aims. The plan is not binding, but contains guidelines for the future development, approved in a participatory process. The more detailed physical development plan covers parts of the municipality and is binding (MEFNA 2004).

Sweden is in line with requirements. The Preliminary Flood Risk Assessment has been finalized – where 18 areas have been identified as being at high risk, with Kristianstad (RISC-KIT Case Study) at the top in terms of number of people at risk – as well as Flood Hazard and Risk Maps for these areas (MSB 2011 and 2013). In particular:

- Hazard maps were made for 50 and 100 years return period events and for the highest-intensity-event ever. These are based on earlier flood mapping done in Sweden that was updated with new recorded events and more advanced methodology, showing the water distribution and the depth (and sometimes velocity) of the floods. There were also maps produced for cities at risk because of their position, close to lakes;
- Risk maps have been finalized, and made available on the web in pdf format. The aim is to identify areas, objects or activities that can be damaged and those sources which can pollute the water during a flood. These maps are meant for the municipality to help in the risk management of the identified areas. For every area there are maps describing the 50 year, 100 year and highest-intensity-event scenario. There are also maps for the associated lakes. The maps will form the basis for the future flood risk management plans.

A concern is that it seems that the approach focused mainly on downstream issues and did not integrate an upstream analysis, consequently missing the river basin perspective. Moreover, several assumptions during the development of the maps can be considered inconsistent. For example, embankments were considered as the physical limitation for flood risk, without taking into consideration a failure scenario.

In general, the implementation is officially on track according to the EU schedule, but informally the implementation has received some criticism for not being as inclusive and consultative as it should be. MSB seems very satisfied with what they are achieving in this area, but there has also been published criticism that general adaptation measures in Sweden are left to the municipality: consequently, they are often too local and only focusing on a few technical structural measures. An example of identified gaps in the application of the directive at local level can be found in Johannessen and

Granit (2014). In a recent consultation with the municipalities of the Scania county administration on the future regional adaptation strategy it seems however that there is a general understanding in the municipalities that flood protection and response should be planned at regional level. In Sweden there are established river basin authorities under the water framework directive, which according to EU guidelines, should align with the FD in the future.

Sweden will be required to produce catchment-based Flood Risk Management Plans focusing on prevention, protection and preparedness by December 2015, setting out a prioritized set of measures for achieving those objectives, and harmonizing with the WFD River Basin Management Plans (EU 2012). Sweden is interpreting this as the production of plans for the areas of flood risk, but according to the guidance given for these plans (MSB 2014) both an increase and reduction of the mapped area can come into question. The responsible agency for this is the county administration for the area where the flood risk has been identified. The roadmap can be found in Figure 6.1.

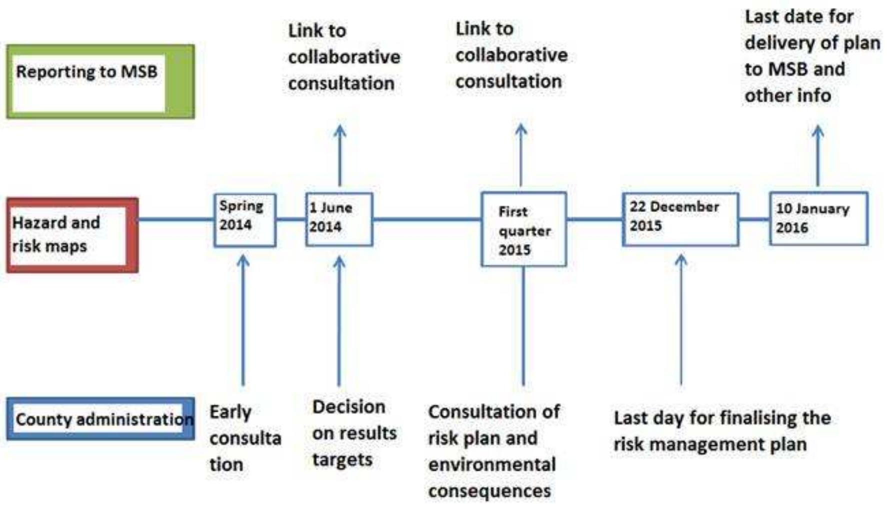

Figure 6.1 Floods Directive roadmap for Sweden (translated from Swedish, MSB 2014).

The FD stipulates that the plans have to contain "appropriate objectives" for the management of flood risks, but these do not seem to be binding and the FD does not set any priorities (Mostert and Junier, 2009). This puts emphasis on the importance of an informed Swedish strategy for measures which create synergies between these two policies. Considering the gaps above and that the future guidance for the roadmap does not clearly talk about addressing such gaps, there is a slight concern that the approach will continue to be in the area of traditional flood control. The future implementation of the FD and the strategy Sweden chooses to take will very much influence the quality of measures. At the same time as the municipality has the planning mandate; there is little national guidance on a systematic and broad set of adaptation measures. There are also hardly any tools and structures for adaptation planning that actively involve citizens in Swedish municipalities (Wamslerand Brink, 2014).

France. The application of the FD at national level is delegated to the DREAL (Direction Regionale de l'Environnement, de l'Aménagement et du Logement) that is a State's national service. The Prefet, Government representative is in charge of applying the Directive in its Hydrographic District (*bassin*).

France already developed and reported about PFRA (2011) and FHRM (2013). To note that, from early 2000s, France elaborated several plans regarding different type of flooding (e.g. PSR, PPRi, PPRL, PAPI). Moreover, after Xynthia, another plan rose in the emergency circles, the Rapid Surge Plan (PSR for Plan de Submersion Rapides). It focused mainly on coastal surge, flash floods and dike breaching, providing priority action for citizen safety in exposed territories for this type of flooding.

The actual roadmap is to follow the requirements and deliver the FRMP. This will be the opportunity to merge all existing plans that have been elaborated so far at locale scale (Plan d'Action de Prévention des Inondations, Plan Prevention des Risques Littoraux, etc.). Indeed, The PSR started in 2011 and has been first evaluated in 2013, when vulnerability maps have been delivered. The plan will be finally evaluated again in 2015 once all other plans will be finished and presented as the final conclusions of the first cycle of the Floods Directive. The PGRI (Plan de Gestion des Risques d'Inondation) will be presented by the end of 2015.

United Kingdom. The competent authority for the implementation of the Floods Directive in the UK is the Environment Agency, which is under the Department of Environment, Food and Rural Affairs. The Flood Risk Regulations (2009) and Flood and Water Management Act (2010) transpose the Floods Directive into law in England. Under the Flood Risk Regulations 2009, the Environment Agency and the lead local flood authorities (LLFAs) prepared flood risk assessments by December 2011, which were published by the Environment Agency. Lead Local Flood Authorities (LLFAs) are county or unitary authorities, and have responsibility for managing local flood risk at the local level (particularly surface water risk), as defined under the Flood and Water Management Act (2010). The Environment Agency are responsible for reducing flood risk at the national level, and are responsible for sea, river and reservoir flood risks.

The United Kingdom already reported about all planned activities till now. In particular, maps are publicly available through a web portal. Flood Risk Maps for the whole country (coastal and riverine flooding), are already available.

The United Kingdom roadmap is not available but seems it will fulfil its duty as a Member State.

Through the following links, information about the implementation and maps can be found at:

- http://maps.environment-agency.gov.uk/wiyby/wiybyController?ep=maptopics&lang=_e
- http://www.promap.co.uk/maps-and-data/flood-data/environment-agency-national-flood-risk-assessment
- https://www.gov.uk/government/publications/preliminary-flood-risk-assessments-and-flood-risk-areas

Portugal. The Environment National Institute (APA) is coordinating and interfacing with the European Union. The regional hydrographic/environment institutions (former ARH, presently APA-Algarve for the Case Study area) are responsible for creating Flood Risk Maps and elaborating and implementing the Flood Risk Management Plans.

At a national level, the National Agency for Civil Protection elaborated a map of coastal inundation and overwash at a very coarse scale and without a clear mention of the adopted methodology. At local level overwash and coastal inundation was not considered by APA-Algarve.

For the case study of the Algarve Region, the ARH (present APA-Algarve) has produced a report including the areas subjected to risks of erosion but maps are not available. Regarding inundation maps, there are of fluvial inundation but not coastal, despite in the Decreto-Lei 115/2010 published in the Governmental periodic publication inundation also includes marine flooding.

The roadmap for the application of the EU Flood Directive is expressed in the Decreto-Lei 115/2010, which follows the time requirements expressed in the EU Directive. However, in practical terms, the timeline is respected for fluvial inundations while for coastal ones it is not, probably because of the lack of clearness in requirements, generating a vague application of the FD.

Spain. The national authority in charge of the implementation of the Floods Directive is the Spanish Ministry of Agriculture, Food & Environment. Due to the strong decentralization of the State, at the regional level the implementation is passed to several regional authorities, for river basins. Indeed, as the coast is public domain, the Ministry is responsible for its implementation in costal zones (coastal floods).

At present, Spain is in line with FD deadlines and already obtained, and reported about, Flood Hazard & Flood Risk Maps. To fulfil the requirement by December 2015, the development of Flood Risk Management Plan for each basin is on-going.

Bulgaria. In Bulgaria the Ministry of Environment and Water, through River Basin Directorates is the government body responsible for implementing the requirements of the Flood Directive 2007/60/ EU. There are four Basin Directorates: Danube Basin Directorate - Pleven, East-Belomor Basin Directorate - Plovdiv, West-Belomor Basin Directorate – Blagoevgrad and Black Sea Basin Directorate – Varna. The Flood Directive 2007/60/ EU was adopted for Bulgaria by means of legislation changes made into the Water Act in August 2010.

The Water Act states that flood risk management related activities fall within the jurisdiction of the Basin Directorates and are put into force by their respective Directors.

According to the implementation of the Flood Directive2007/60/ EU in Bulgaria the following terms were established and accomplished:

- Preparation of a report on Preliminary assessment of flood risk – December 2011;
- Flood hazard and risk maps– December 2013

As example, the Black Sea Basin Directorate – Varna has already prepared:

- Report on Preliminary assessment of flood risk;
- Flood hazard and risk maps for river basins and coastal areas with potential significant flood risks that are under the jurisdiction of the Basin Directorate

Finally, the roadmap includes the above mentioned stages (December 2011 and 2013), as well as flood risk management plans for areas with potential significant flood risks, which are being developed and should be ready by December 2015.

Belgium. The application of the EU Floods Directive is managed by the three Regions: Flanders, Wallonia and Brussels. There is no national responsibility for this. In Flanders, the application is managed by the Coördinatiecommissie Integraal Waterbeleid (CIW), the Brussels one by the Regering van het Brussels Hoofdstedelijk Gewestand (regional government) and the Wallonia district by Gouvernement Wallon (regional government). The three Regions separately act and report toward the Commission.

Belgium's Regions already reported about Competent Authorities, Unit of Management, Preliminary Flood Risk Assessment (PFRA) and Flood Hazard and Flood Risk Maps (FRHM).

At the moment, information about the roadmaps is only collected for Flanders, because it is the responsible management authority for the entire Belgian coast. The management authority is working on the Management Plan while public investigations are on-going (until 8th January 2015). The Flemish Government will then implement the remarks and will take decisions on the plan until the 22nd December 2015, when the Plans will become public. The report to the Commission will be delivered by March 2016.

6.2 National adaptation to Climate Change

The EEA Report 4/2014 (See Par. 4.2.3) outcomes were analysed to get an overview of Climate Change adaptation policy process in the RISC-KIT countries. Note that these results are given through a national self-assessment questionnaire.

In general, all European RISC-KIT countries adopted national or sectoral strategies/plans for Climate Change, except for Italy and Bulgaria (EEA Report 4/2014

p. 21). Motivations that drive the choice to adopt adaptation policies at national level were evidenced (EEA Report 4/2014 p. 24). The main factor is the perception of increase in the occurrence of extreme weather events. The EU policies are considered a trigger for the adaptation, as well as the high costs of damages due to disasters. The scientific research also play an important role. Other factors follows, such as the international agreements and media. On the other hand, barriers for the adaptation were highlighted and evidenced (EEA Report 4/2014 p. 26). The lack of money and uncertainties in the assessment of CC impacts are the main brakes, such as the unclear responsibilities in the adoption/implementation. A general lack of political commitment was also shown.

Focusing on coastal areas(EEA Report 4/2014 p. 24 and p. 82), a lack in the sectoral adaptation was highlighted. However, it is considered a priority sector for CC adaptation.

6.3 National adaptation to Hyogo Framework for Action 2005-2015

6.3.1 Official and RISC-KIT assessments comparisons

Methodology

A semi-quantitative analysis of the progress of the implementation of Hyogo Framework for Action at national level on Case Study Countries was implemented. The method is based on the analysis of outcomes from two different sources:

A. Official national reports collected through the web site www.preventionweb.net, for the period 2007-09, 2009-11 and 2011-13, where available;

B. Outcomes from an internal perception-based questionnaire, distributed to CSOs project partners.

Reports from source A, as mentioned before, are official and governmental documents. Names and organizations of people in charge of reporting to UNISDR are shown in Table 6.1.

Sources A and B are based on the Core Indicators (for more details on Indicators and assessment scale see Par.4.1.1). In particular, while in the official reports it was possible to directly obtain the value (1-5) for each indicator, the CSOs were requested to fill the questionnaire giving a percentage of achievement (0, 20, 40, 60, 80 and 100%) for each Core Indicator of each Priority for Action, basing on their technical point of view, adopting a national perspective, being absolutely independent from official outcomes and from other partners.

In order to compare results from sources A and B, a conversion function was used to convert the percentage given by RISC-KIT partners to the five level official scale. Considering that the official scale does not provide a mark for ‘No progress’, as Level 1 is defined as ‘minor achievement and presence of signs of planning of future improvements’, the adopted conversion was as shown in Table 6.2.

After the conversion, a mean of Core Indicators marks was calculated for each Priority for Action. Results will be shown through coloured maps for the EU RISC-KIT countries and through a coloured table for the non-EU RISC-KIT country (Bangladesh). The color scale is based on the five level assessment (marks) and defined as shown in Table 6.3.

Results

European maps for Priority for Action 1 are shown in Figure 6.2, Figure 6.3, Figure 6.4 and Figure 6.5, for assessments Official 2007/09, 2009/11, 20113/13 and RISC-KIT 2014 respectively. The same maps are shown for Priority for Action 2 (from Figure 6.6 to Figure 6.9), 3 (from Figure 6.10 to Figure 6.13), 4 (from Figure 6.14 to Figure 6.17) and 5 (from Figure 6.18 to Figure 6.21). The summary of the results for Bangladesh can be found in Table 6.4.

Discussion

General. As it can be seen from previous maps, official reports were not presented by Spain and Belgium for the years 2007/09, 2009/11 and 2011/13, for Portugal in 2007/09 and United Kingdom in 2009/11.

EU Priority for Action 1 (Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation). Looking at results for Priority 1, which can be seen from Figure 6.2 to Figure 6.4, official results showed a general good achievement for the United Kingdom, France and Germany that had marks higher than 4 between 2007 and 2013. During the same period, Sweden increased from 3.75 to 4, Italy remained stable at 3.50, Portugal slightly decreased from 3.75 to 3.25 (2009-2013), while Bulgaria began with 4 and ended with the same mark but showing a lower mark (3.50) in the years 2009/11.

The RISC-KIT assessment (Figure 6.5), compared to the last official review (Figure 6.4), confirmed the good status for the United Kingdom, Germany (both showed marks equal or higher than 4) and Sweden (3.75 instead of the official 4 in 2011/13). However, looking at southern European Members, the perception on the achievement of Priority 1 was consistently lower than official outcomes: France and Italy official achievement - 4 and 3.50 respectively – were not confirmed by the assessment of RISC-KIT Case Study Owners which showed 2.25 and 2.75 respectively. Furthermore, for Portugal and Bulgaria RISC-KIT marks were lower than 2. The assessment gave an idea of HFA Priority 1 implementation for Spain and Belgium, which Official reports are missed, showing 2 for Spain and 3.25 for Belgium, thus filling the gap present in the official documentation.

EU Priority for Action 2 (Identify, assess and monitor disaster risks and enhance early warning). Looking at outcomes from Figure 6.6 to Figure 6.8 about the implementation of Priority 2, official reports from 2007 to 2013 showed that Italy, United Kingdom and Germany remained stable with marks higher than 4 while Sweden improved passing from 3.25 to a good achievement level (mark 4 in 2011/13 report). Portugal (2009-2013) and France, through the same years, got slightly worse going from 4 and 4.25 to 3.75 and 3.75 respectively. A good improvement was shown for Bulgaria that started from 2.50 and got 4 in the last review.

Focusing on Figure 6.9, that shows results for the RISC-KIT assessment, United Kingdom and Italy confirmed a good status, showing marks of 4, slightly less than that of the official reports, but still high. Sweden did not confirm the good official status –

which officially was a mark of 4 in 2011/13 – obtaining a mark of 3.25. A bad status was assessed for France, Germany and Bulgaria, getting 2.50, 2.75 and 2.25, much less than official 3.75, 4 and 4, respectively. Even worst for Portugal, that went from official marks of 3.75 to 0.75. Spain and Belgium, which comparisons with official reports are not possible, as they were still missing, showed 2.25 and 3 respectively.

EU Priority for Action 3 (Use knowledge, innovation and education to build a culture of safety and resilience at all levels). Focusing on maps from Figure 6.10 to Figure 6.12, official results for Priority 3 showed that Italy had the best status with marks higher than 4 in the period 2007-2013. The United Kingdom follows with a final mark of 4. Sweden slightly increased from 3.50 to 3.75, while Germany, France (2009-2013) and Bulgaria showed stable marks: 3.75, 3.50 and 3.50 respectively. France dropped from 4.25 to 3.25 in the same period.

The RISC-KIT assessment (Figure 6.13), confirmed the general official status of Sweden, Germany and United Kingdom, even if marks are slightly lower than official ones. The other countries showed consistently low marks, less than 2: indeed Italy had a mark of 1.50, while the official one was 4; France 1.75, instead of the official 3.25; Bulgaria and Portugal had 1 and 0.75, respectively, while the official marks were 3.50 for both. Spain and Belgium showed 1 and 1.50, respectively. Looking at the map in Figure 6.13, Europe can be approximately divided into two areas: the northern part (United Kingdom, Sweden and Germany) with generally high implementation of Priority 3, and the southern areas, where States did not or badly implemented the Priority.

EU Priority for Action 4 (Reduce the underlying risk factors). Official results from Figure 6.14 to Figure 6.16 showed that in the period 2007-2013 the United Kingdom and Germany remained stable with marks 4 and 3.33 respectively. A certain grade of stability between marks 3 and 4 can be seen also for Sweden, France, Portugal (2009-2013) – that slightly decreased – and Italy – that slightly increased. Bulgaria decreased from 3.33 to 2.87.

RISC-KIT assessment outcomes (Figure 6.17) confirmed the mark 3.33 for Germany. The score for France (4.17) is better than the official one (3.50), while there is a slight decrease in the assessment for the United Kingdom (from 4 to 3.50) and for Sweden (from 3.50 to 3.17). Portugal, Italy and Bulgaria showed consistently lower marks – 1.17, 1.33 and 1.17, respectively - compared to the official ones – 3.83, 3.67 and 2.67, respectively. The implementation for Spain and Belgium was respectively assessed with marks of 1.83 and 1.33.

EU Priority for Action 5 (Strengthen disaster preparedness for effective response at all levels). Maps from Figure 6.18 to Figure 6.20 include the official reviews in the period 2007-2013 which evidenced stability for Germany and Italy – 4 and 4.50 respectively – and an increase for Sweden and France – from 3.75 to 4.25 for both. A slight decrease is shown for Portugal (from 4 to 3.75 in the period 2009-2013), while the United Kingdom and Bulgaria had a drop from 5 to 4.25 and from 4.50 to 3.50 respectively.

To note that the RISC-KIT results in Figure 6.21, confirmed the good status for the United Kingdom, Sweden and Germany – that had marks higher than 4 – but marks for Portugal, Italy and France were consistently lower than the official ones, getting 2, 2.75 and 2 in comparison to the officials of 3.75, 4.25 and 4.50, respectively. Bulgaria showed the worst mark (1.50) while it was (officially) supposed to be 3.50.

Bangladesh. Looking at Table 6.4, Bangladesh had medium marks (between 3 and 4) for each Priority in the period 2007-2013, except formarks for the period 2009-2013 for Priority 1 (which showed a mark of 4) and for the years 2007/09 for Priority 4 (which showed a mark of2.83). In general, the RISC-KIT assessment confirmed the improvement level for all the Priorities (marks between 3 and 4), with maximum absolute difference compared to official marks of 0.50.

Discussion summary. Increasing, stable or decreasing trends for each HFA Priority are presented hereafter for analysed countries on the basis of the official reporting in the period 2007-2013. A categorization on the official status from the last official report is proposed: good for marks ≥4, medium for marks between 3 and 4 and bad for marks lower than 3. The outcomes from RISC-KIT CSOs internal assessments were considered as a benchmark (BM) for countries' status. A symbology was associated for trends, status and benchmark definitions and can be found in Table 6.5:

- the official trends were defined as increasing (↑), stable (=) and decreasing (↓);
- the official status in 2013 were defined as good (V), medium (=)and bad (X);
- the RISC-KIT benchmark were defined as confirmed (V) and not confirmed (X).

The summary on the discussion results is shown in Table 6.6.

Table 6.1 People in charge of reporting: names and organizations.

Official Report	2007/09		2009/11		2011/13	
Country	Name	Organization	Name	Organization	Name	Organization
Italy	Dr Miozzo Agostino	Civil Protection Department	Luigi D'Angelo	National Civil Protection Department	Luigi D'Angelo	National Civil Protection Department
Germany	Mr Zentel Karl-Otto	German Committee for Disaster Reduction	Mr Zentel Karl-Otto	German Committee for Disaster Reduction	Axel Rottländer	German Committee for Disaster Reduction
Sweden	Mr BraskClae s-Uno	Swedish Rescue Services Agency	Ms MetteLindahl Olsson	Swedish Civil Contingencies Agency(MSB)	Ms MetteLindahl Olsson	Swedish Civil Contingencies Agency (MSB)
France	Mr Sébastien Michel	MEEDDAT	Mr François Gérard	Ministère de l'Ecologie, du Développement durable, des Transports et du Logement (MEDDTL)	Jacques Faye	Ministère de l'Ecologie, du Développement durable, des Transports et du Logement (MEDDTL)
UK	Mr. Barnes Steven	Civil Contingencies Secretariat(CC S)	-	-	Mr. Barnes Steven	Civil Contingencies Secretariat (CCS)
Portugal	-	-	Mr. Henrique Manuel CarvalhoVicencio	National Authority for Civil Protection, Ministry of the Interior	Mr. Henrique Manuel CarvalhoVicencio	National Authority for Civil Protection (ANPC)
Spain	-	-	-	-	-	-
Bulgaria	Mrs Vranovsk a Maria	Ministry of Emergency Situations	Mrs. AntoanetaBoyche va	DG Fire Safety and Civil Protection,Minist ry of Interior (MoI)	Mrs. AntoanetaBoyche va	DG Fire Safety and Civil Protection,Minist ry of Interior (MoI)
Belgium	-	-	-	-	-	-
Banglades h	Mr. K H Masud Siddiqui	Ministry of Food and Disaster Management	Mr. Ahsan Zakir	Disaster Management Bureau, Disaster Management and Relief Division, Ministry of Food and Disaster Management	Mr. Mohammad Abdul Wazed	Department of Disaster Management (DDM), Ministry of Disaster Management and Relief

Table 6.2 HFA and RISC-KIT assessment comparison scale.

HFA Official Five Level Assessment	RISC-KIT Assessment [%]
5	100
4	80
3	60
2	40
1	20
-	0

Table 6.3 Color scale definition.

Color	**Range of Level**
Grey	Not Available
Red	0-2
Orange	2-3
Yellow	3-4
Green	4-5

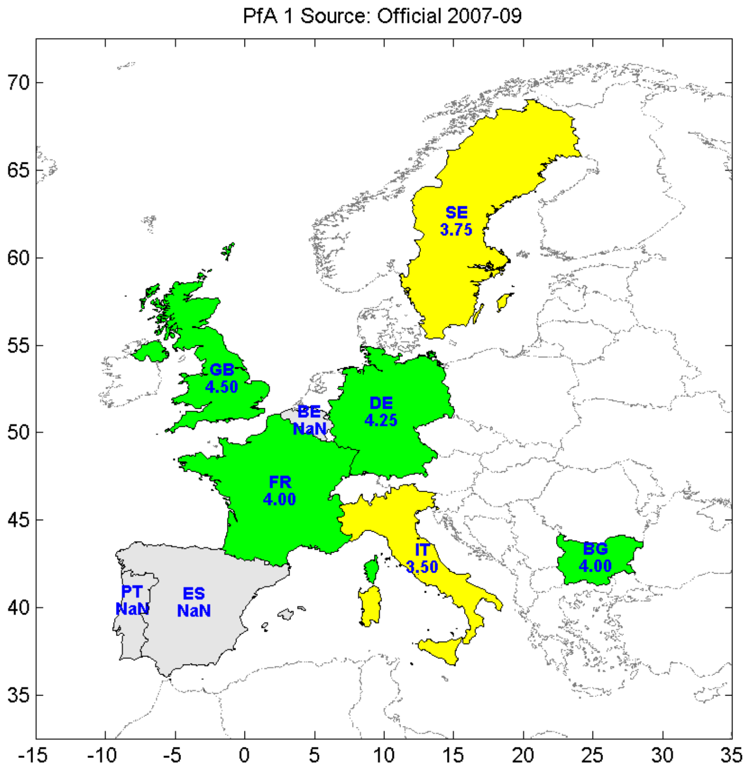

Figure 6.2 PfA 1 – Official report 2007/09.

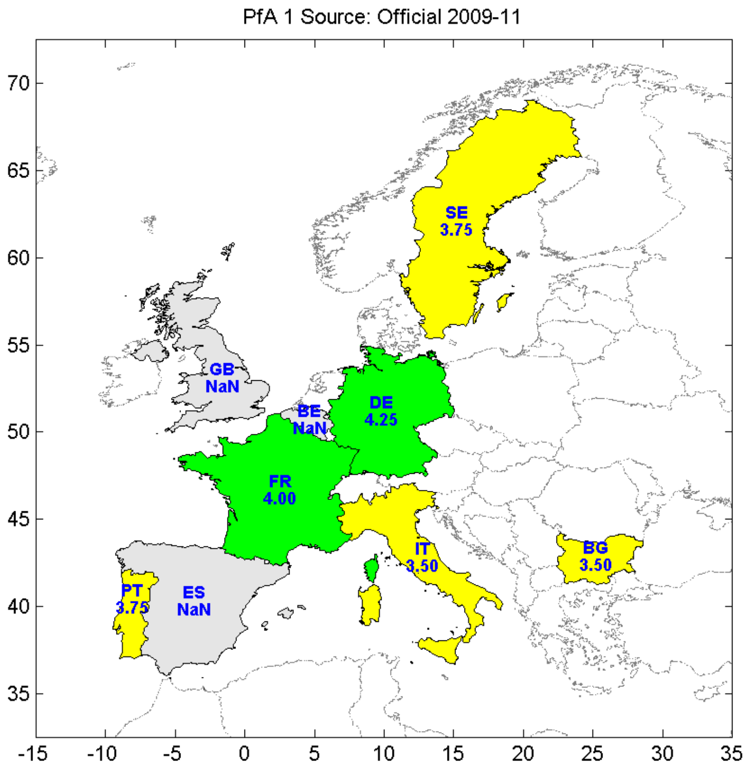

Figure 6.3 PfA 1 – Official report 2009/11.

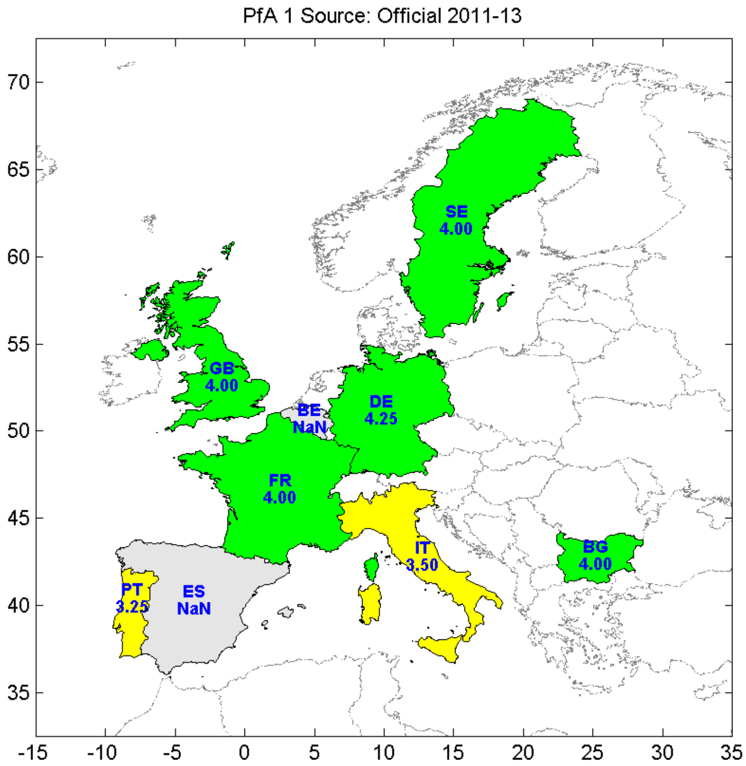

Figure 6.4 PfA 1 – Official report 2011/13.

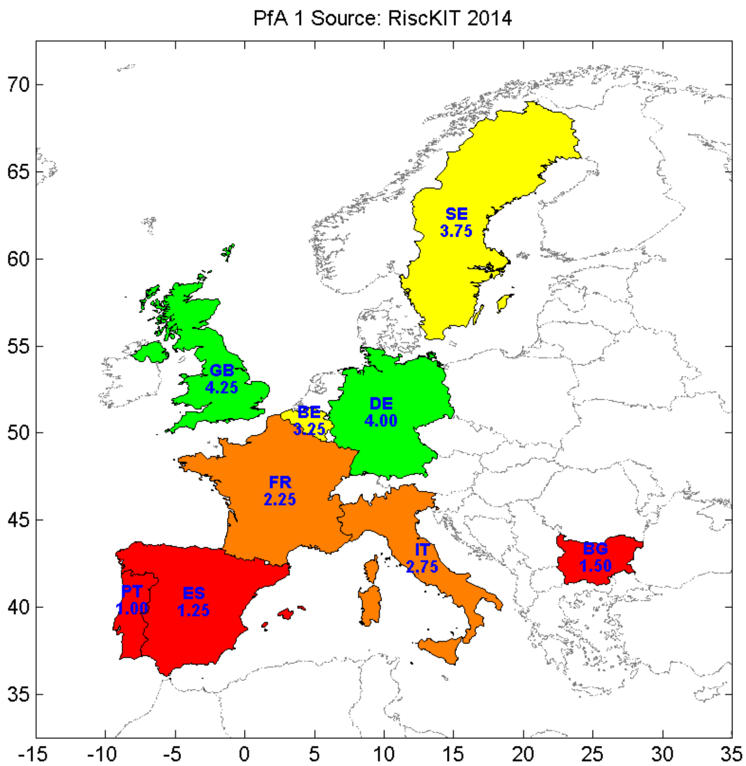

Figure 6.5 PfA 1 – RISC-KIT 2014.

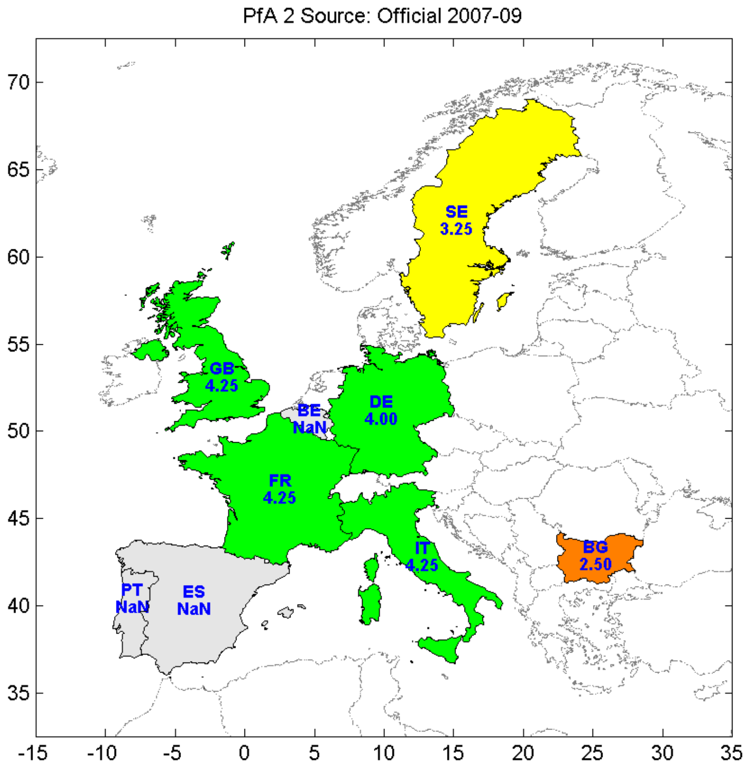

Figure 6.6 PfA 2 – Official report 2007/09.

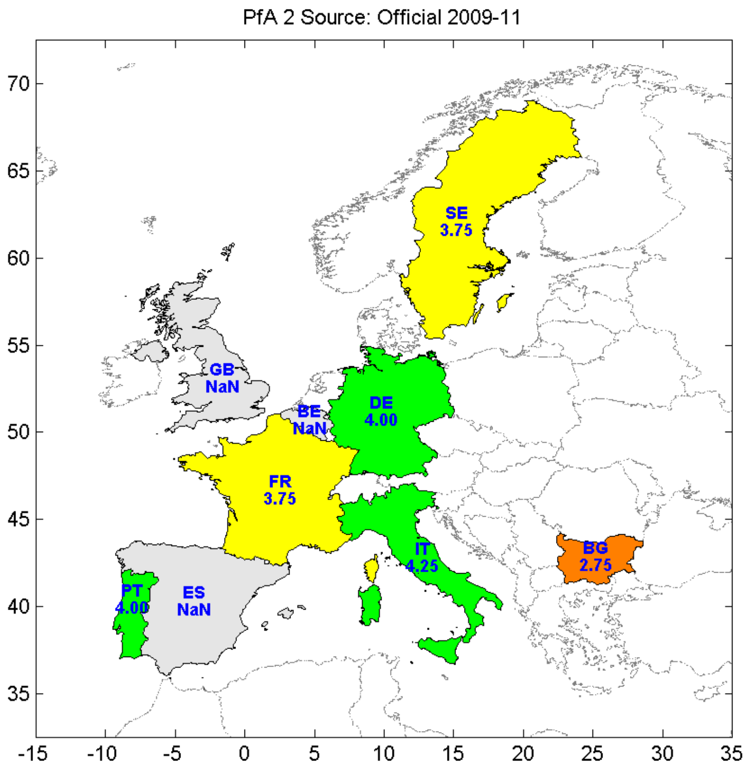

Figure 6.7 PfA 2 – Official report 2009/11.

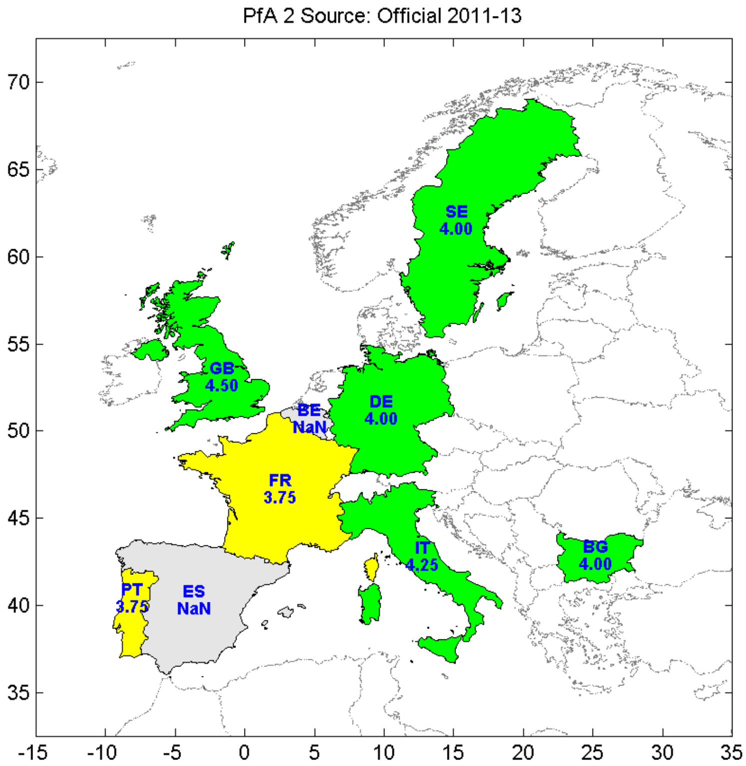

Figure 6.8 PfA 2 – Official report 2011/13.

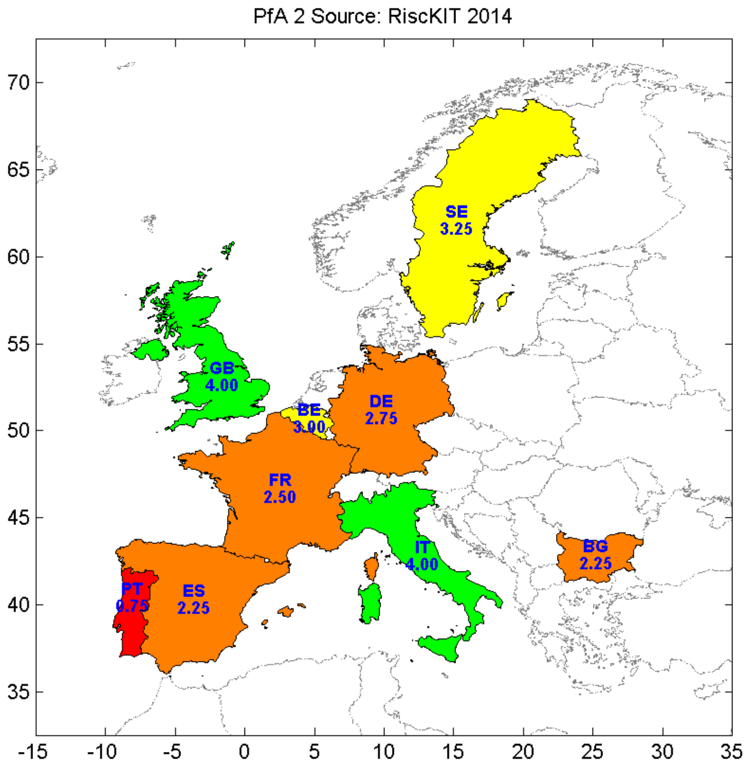

Figure 6.9 PfA 2 – RISC-KIT 2014.

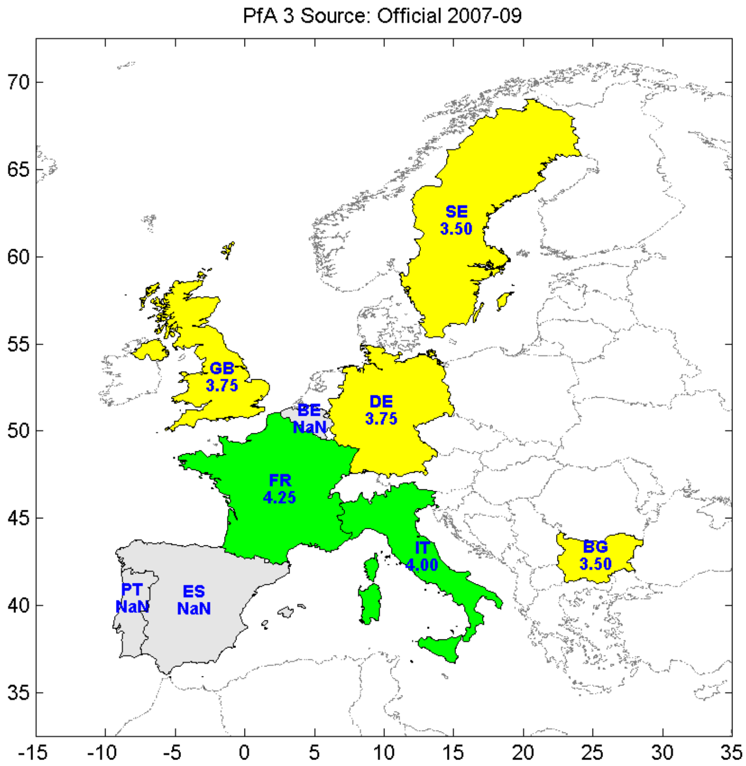

Figure 6.10 PfA 3 – Official report 2007/09.

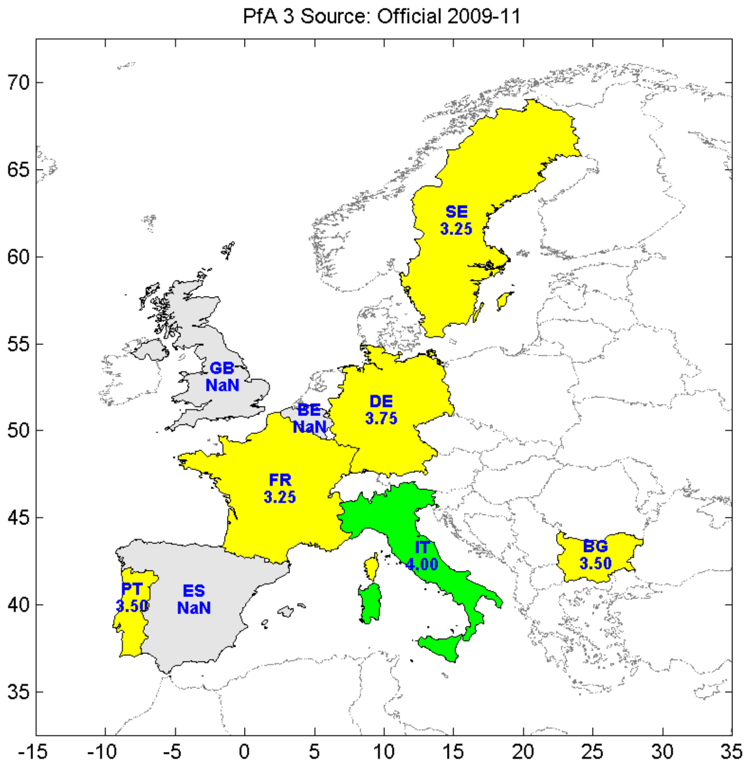

Figure 6.11 PfA 3 – Official report 2009/11.

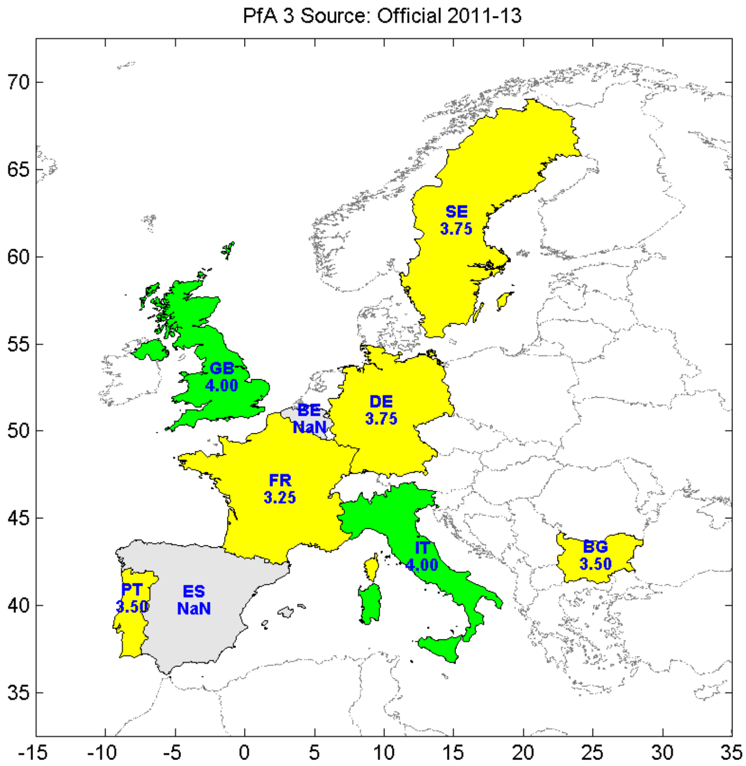

Figure 6.12 PfA 3 – Official report 2011/13.

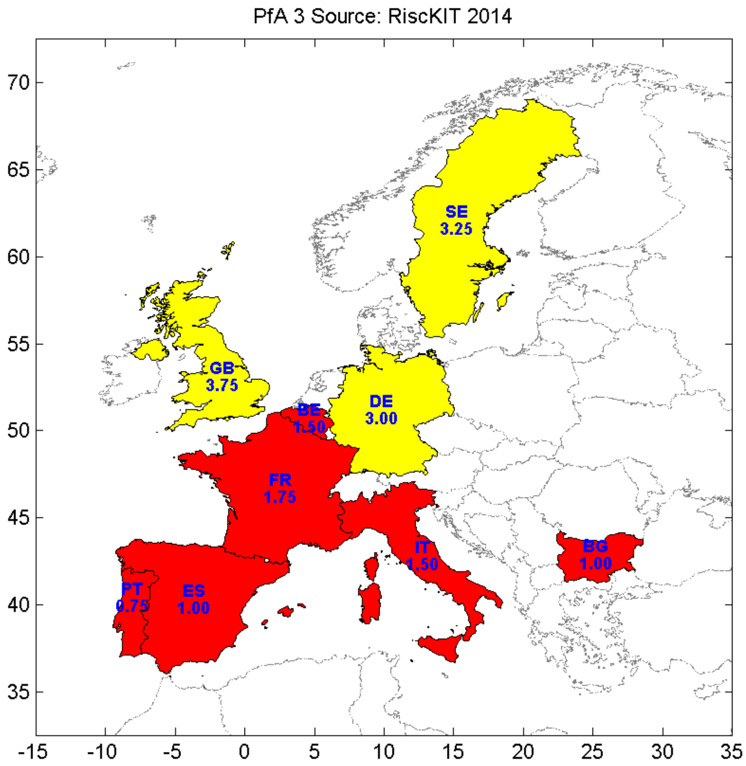

Figure 6.13 PfA 3 – RISC-KIT 2014.

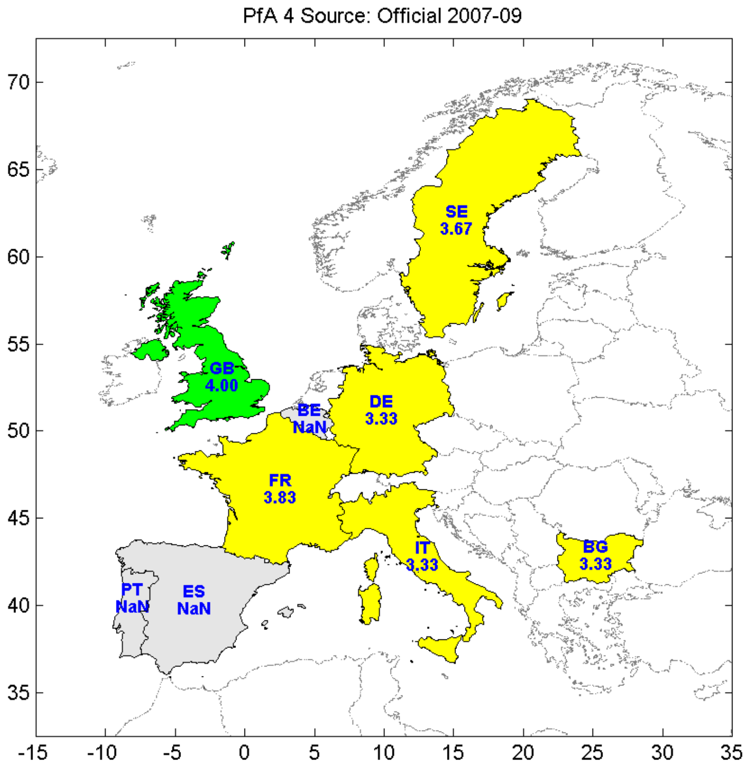

Figure 6.14 PfA 4 – Official report 2007/09.

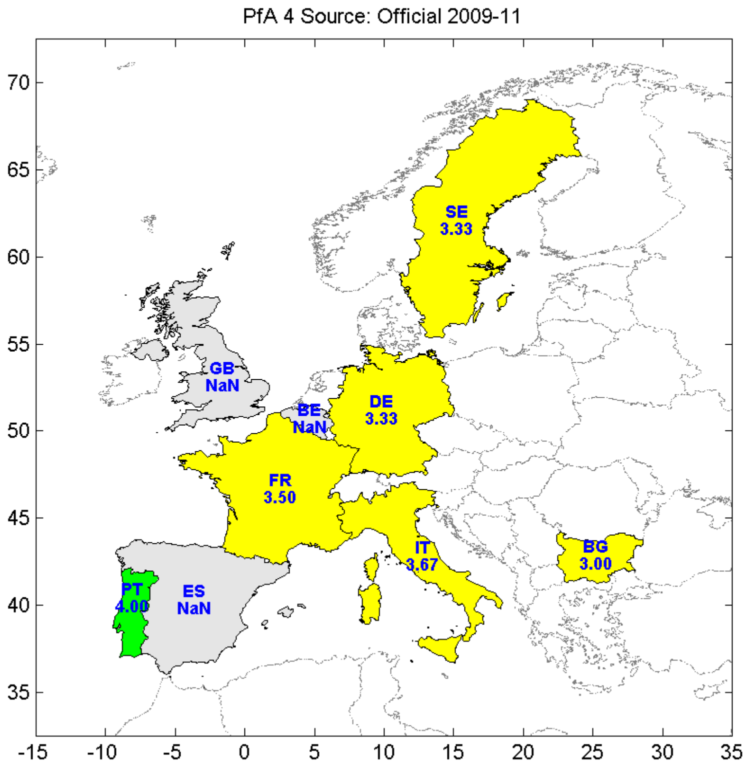

Figure 6.15 PfA 4 – Official report 2009/11.

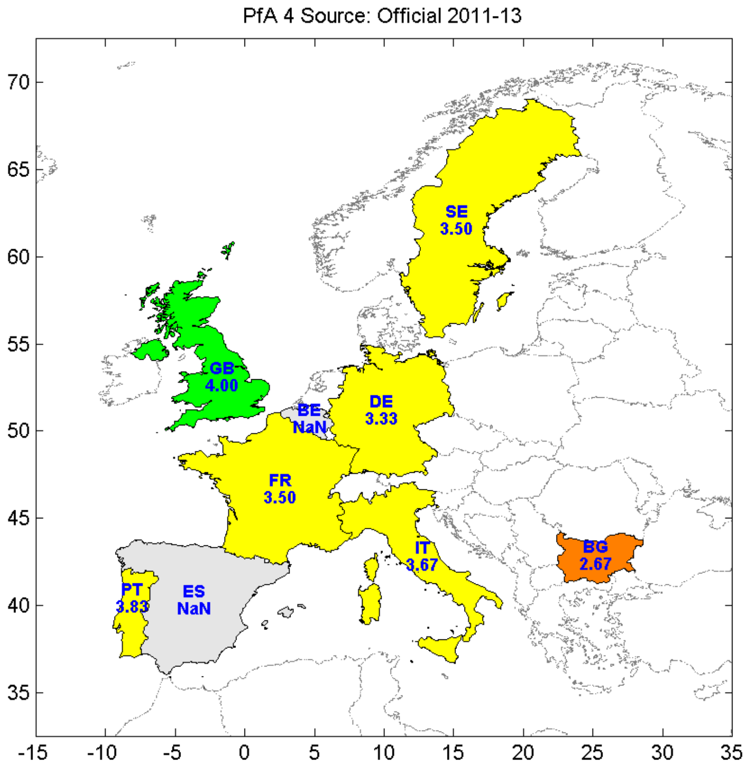

Figure 6.16 PfA 4 – Official report 2011/13.

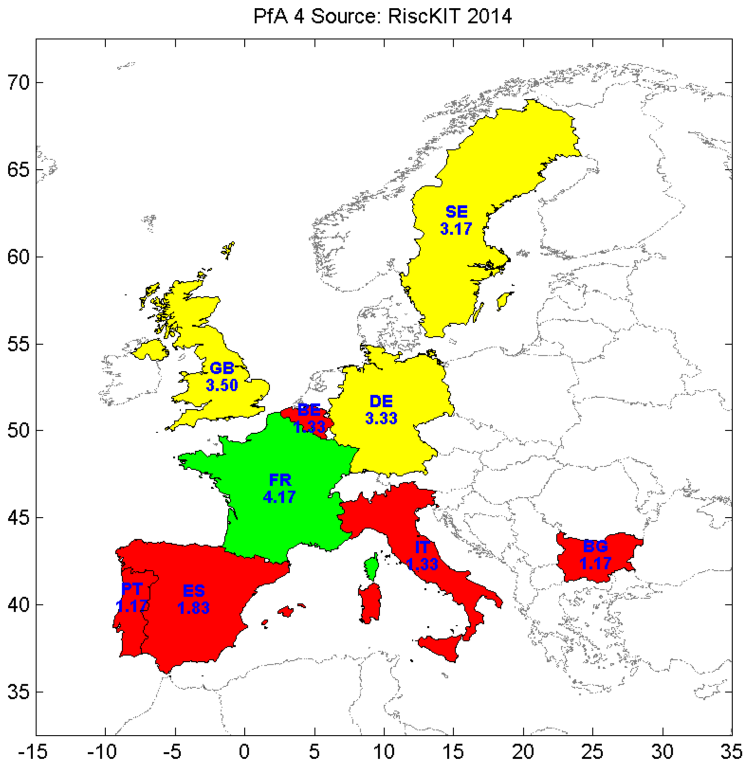

Figure 6.17 PfA 4 – RISC-KIT 2014.

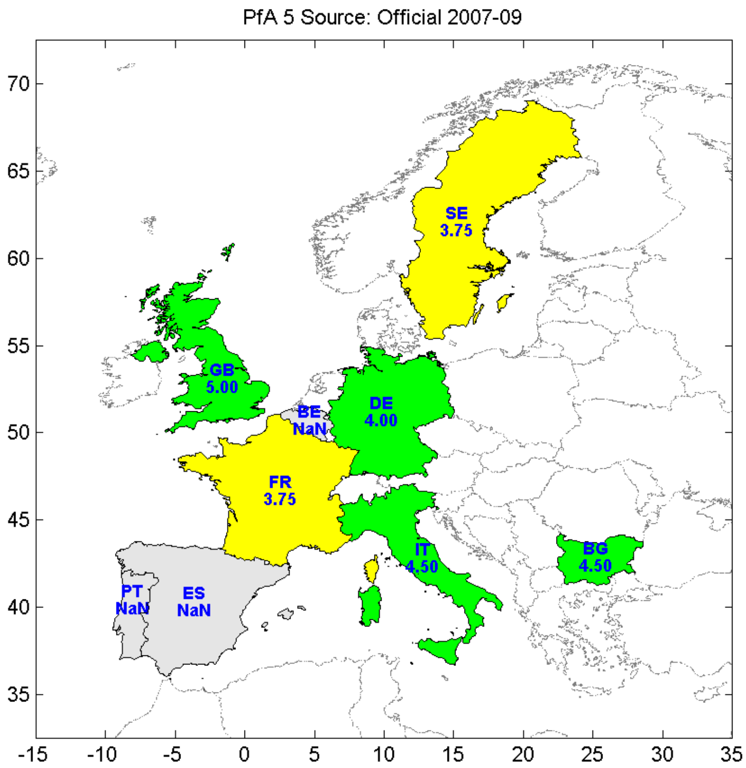

Figure 6.18 PfA 5 – Official report 2007/09.

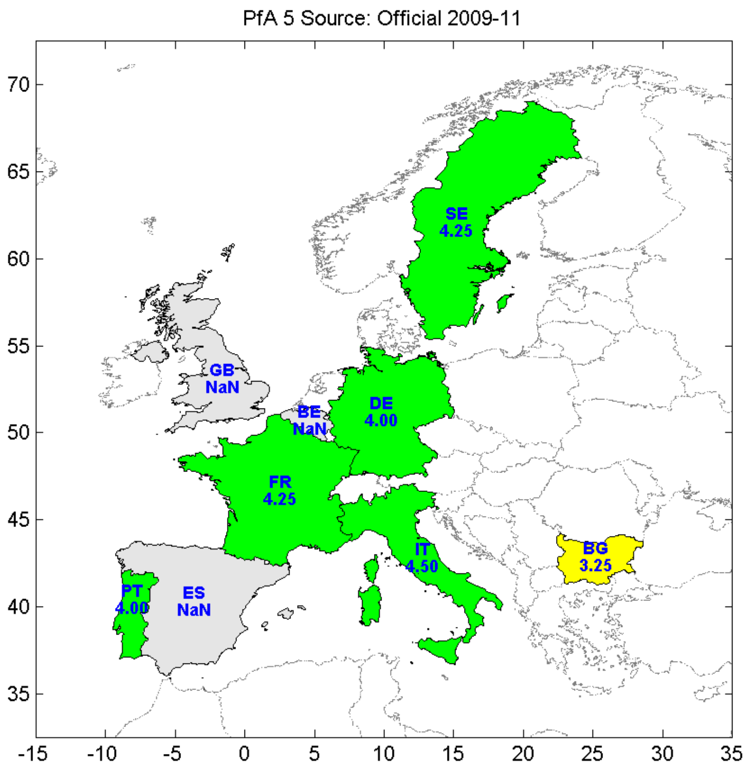

Figure 6.19 PfA 5 – Official report 2009/11.

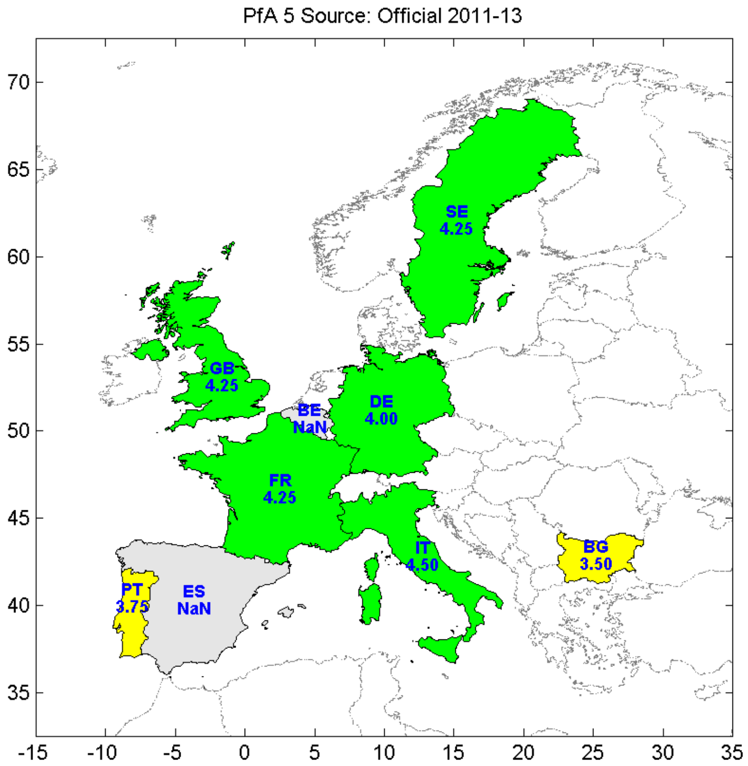

Figure 6.20 PfA 5 – Official report 2011/13.

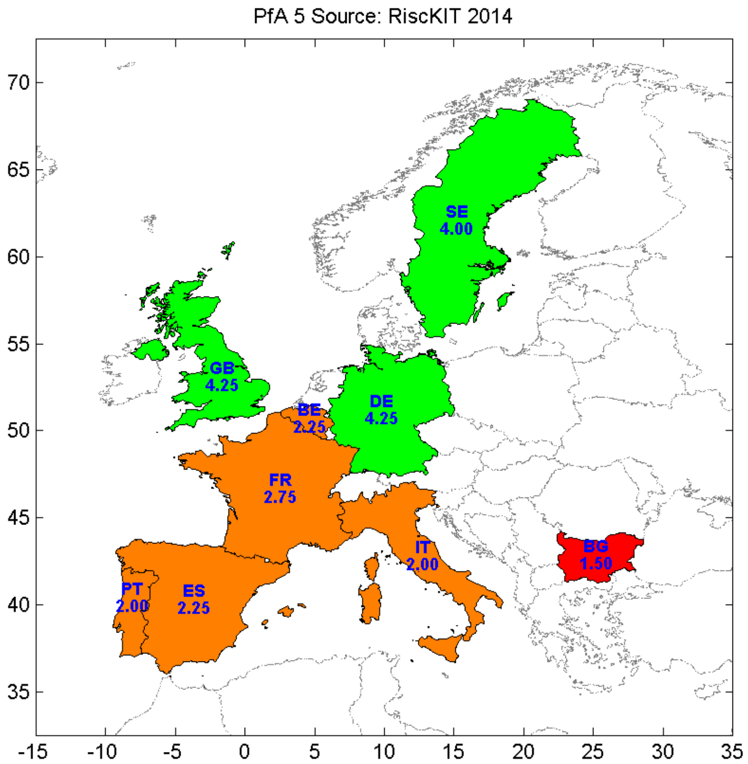

Figure 6.21 PfA 5 – RISC-KIT 2014.

Table 6.4 Bangladesh - PfA 1-5 – Official reports 2007/09, 2009/11 and 2011/13, RISC-KIT 2014.

Bangladesh				
Assessment	Official 2007/09	Official 2009/11	Official 2011/13	RISC-KIT 2014
PfA 1	3.25	4.00	4.00	3.50
PfA 2	3.25	3.50	3.75	3.25
PfA 3	3.25	3.25	3.75	3.50
PfA 4	2.83	3.17	3.33	3.17
PfA 5	3.50	3.75	3.75	3.25

Table 6.5 Trend, status and check symbology.

Official Trend 2007-2013		Official 2013 Status		**RISC-KIT 2014 Benchmark**	
↑	Increase	V	Good (≥4)	V	**Confirmed**
=	Stable	=	Medium (3÷4)	X	**Not Confirmed**
↓	Decrease	X	Bad (<3)	-	-

Table 6.6 Results discussion summary.

	PFA 1			PFA 2			PFA 3			PFA 4			PFA 5		
	Trend	Status	BM	Trend	Status	BM	Trend	Status	BM	Trend	Status	BM	Trend	Status	BM
Bangladesh	↑	V	V	=	=	V	=	=	V	↑	=	V	=	=	V
UK	=	V	V	=	V	V	=	V	V	=	V	V	↓	V	V
Germany	=	V	V	=	V	X	=	=	V	=	=	V	=	V	V
Sweden	↑	V	V	↑	V	X	=	=	V	=	=	V	↑	V	V
Italy	=	=	X	=	V	V	=	V	X	=	=	X	=	V	X
France	=	V	X	↓	=	X	↓	=	X	=	=	V	↑	V	X
Portugal	=	=	X	↓	=	X	=	=	X	=	=	X	↓	=	X
Bulgaria	=	V	X	↑	V	X	=	=	X	↓	X	X	↓	=	X

Conclusions

Some evaluations can be made, in general, on the official assessment. A general improvement moving from the first report (2007/09) to the last one (2011/13), was expected. However, our study of public documents showed quite a different story: several States showed decreasing or oscillatory marks in the period between 2007 and 2013.

Officially, all Member States included in the analysis showed a medium-high achievement of HFA Priorities, except for Bulgaria on Priority 4. In particular, the United Kingdom, Sweden, Germany and Italy achieved a high status for most of the Priorities.

However, looking at RISC-KIT check-assessment outcomes, only Bangladesh and the United Kingdom were confirmed in their status (medium and good, respectively) on all HFA Priorities. Germany and Sweden were confirmed with the exception of HFA Priority 2 achievement. For Italy, France, Portugal and Bulgaria the RISC-KIT CSOs were telling another story than the governmental outcomes, affirming that their States reached medium-bad status. Looking at Spain and Belgium, for which only the RISC-KIT assessment is available at the moment, the achievement of HFA Priorities was far away from the good status.

Focusing on Europe, a trend can be highlighted: northern Member States, with the exception of Belgium, are strongly implementing HFA Priorities and their governments are reporting on time. On the other hand, southern ones are not. In particular, governments of southern States reported positive about the application of the HFA, whereas our partner reported otherwise.

Limitations. To note that several limitations of the analysis have to be highlighted:

- The HFA RISC-KIT questionnaire was perception-based: RISC-KIT CSOs were requested to fill the questionnaire in an absolutely independent way, without contact between partners and, basing on their personal technical opinion and experience, but, even if they were requested to adopt a national point of view, their answers could be influenced by a local point of view (CS Sites);
- The RISC-KIT project and their partners deal with coastal hazards and flash floods, while the HFA takes into account all natural and man-made hazards: the questionnaire outcomes should be considered a benchmark for this topic;
- In order to cover all options, the RISC-KIT assessment scale included the option 'No Progress' correspondent to 0%, while the Official scale started with 1 that means 'Minor Progresses': the comparison function does not take into account this gap, as 1 was compared to 20% in the RISC-KIT assessment and that could lead to a slightly negative general assessment.

Recommendations. The unexpected oscillations and decreases in official marks could be due to the different perceptions or background of people responsible for monitoring and reporting to the EU, as well as the frequent change of the person in charge for reporting for some of the countries. Moreover, considering the outcomes of the RISC-KIT assessment, an hypothesis could be made that some kind of political pressure could have probably been put from governments on officers in charge of reporting to submit a ''positive'' report.

This hypothesis needs to be investigated through an analysis of methods followed by whoever was in charge of reporting in each given period, the political agenda of the government and the variability of the given official marks. This could lead to a better comprehension of several evaluation patterns that can be summarized below:

- Good marks in the first assessment followed by bad or very bad marks in the next report(s);
- Bad marks followed by very good marks, evidencing an increasing trend not consistent with the passed period from a report and another;
- Oscillations in the trend of marks, e.g. good marks in the first report, bad marks in the second one and again good marks in the last one, or viceversa.

PART II: Historical extreme hydro-meteorological events

7 Historical extreme hydro-meteorological events: analyses and lessons learned

Author: Paolo Ciavola.

Severe storms have historically affected European coastlines and the impact of each storm has been evaluated in different ways in different countries, often using local socio-economic impact criteria (e.g. loss of lives and damage to properties). Although the Xynthia storm was the largest European coastal disasters of the last 50 years, with 47 people killed in France only, similar events have previously impacted Europe. The 1953 storm surge in the North Sea, which resulted in over 2000 deaths and extensive flooding across the Netherlands, England, Belgium and Scotland, was the starting point of flood defence schemes that were carried out afterwards. On a longer timescale, we discover the impact of the very extreme storm of 1634 AD that devastated the Wadden Sea causing thousands of deaths along the coast (Fruergaard et al., 2013). Historical records can provide an important source of help in coastal risk studies. Camuffo et al. (2000), using historical sources, managed to correlate events across the northern Mediterranean during the last millennium. Garnier and Surville (2010) proved that the part of France hit by Xynthia was historically exposed to sea flooding; however, the presence of the embankment that protected the flooded urban areas was giving a "false sense of security", as the state of the century-old dikes was not known. Moreover, this "false sense of security" is strengthened thanks to the lack and/or loss of "historical memory" of the extreme events. Indeed, the population and their managers forget about high intensity events within one century. This "historical memory" has to be renewed through historical documents and records. Thus, there is scope for using historical records in a comprehensive way and/or for recreating complete time series through a mixture of data compilation and numerical reconstruction.

Previously to research activities carried out within FP7 (e.g. the MICORE Project-www.micore.eu), only limited information was available as publicly accessible databases. The European Union had indeed pioneered the assembly of a database on coastal storms with the project “A framework for the management of environmentally sensitive coastal areas along the Atlantic coastline of the European Union” (CODECS), funded in Framework 4. The project delivered a database of instrumental records for the last 300 years, and qualitative information for the last 1000 years. However, although the study area extended from 37°S and 58°N, the project restricted the database only to the Atlantic coast of Europe. During the previous FP6, the Hydrate Project (http://www.hydrate.tesaf.unipd.it/) tempted a similar exercise at European scale (6 member states) for flash floods.

A review of existing data and literature on marine storm impacts in Europe (9 member states) was then undertaken by the MICORE partnership that lead to their historical storm report edited by Ferreira et al. (2009) and to a number of scientific publications, see Ciavola et al. (2011) and Ciavola and Jimenez (2013) for a review. The assembled dataset included all forcing data, the morphological response, and the socio-economic impacts. An analysis of the existing coastal planning schemes was made in order to establish what actions are planned in each European country to reduce vulnerability and increase coastal resilience. An effort was made to integrate information on the entire regional coastline for each partner country.

The databases produced by the MICORE and the Hydrate projects were geographically driven rather than event driven. The RISC-KIT project progresses beyond that knowledge, essentially based on physical information for both marine storms and flash floods, through the expansion towards historical sources and the inclusion of socio-economic information on the events. Where possible, measured physical parameters (waves, winds, precipitation, river and sea water levels) have been used for event characterization, integrated with hindcasting information for winds and waves like the ERA-40 and HIPOCAS database.

The social and economic aspects of post disaster appraisal will also be examined as well as cultural and if necessary health related aspects like type of casualties occurred during and after the event. This approach is not new and was started by the FP7 Kultirisk project (http://www.kulturisk.eu/results/wp2) but only focused on sea-level rise, flash floods and marine flooding not considering other coastal threats like damage to coastal infrastructures or occurrence of extreme coastal erosion leading to failure of the first line of defense (dykes or dunes). The database compiled in RISC-KIT Project integrates data from the different hazards (storms, surges, winds, flash floods) in a systematic way, providing also historical data for the analyses presented in the current report.

The database is publicly available at the address http://risckit.cloudapp.net/risckit/#/. At the date of writing the database includes a total of 255 events as shown in Figure 7.1 and in Figure 7.2.

In the current report we will analyse historical large-scale events on the case study sites of the Norfolk Coast (UK), the Charente-Vendée coast (France), the Cinque Terre-Liguria, the Emilia-Romagna coast and the Ria Formosa coast (Portugal). In addition to these European cases, knowledge derived from recurrent high magnitude events like hurricanes and typhoons will provide an important understanding of the interaction between DRR elements such as prevention, mitigation and preparedness, and resilience. Thus, the review will be extended to non-European examples from areas exposed to tropical storms: tropical cyclones in Bangladesh (1991, 1997, 2011), New Orleans and the Louisiana coast (2005, 2008), New York City and New Jersey (2012), amongst others.

For each of the target area, the investigations collected information on the historical and recent occurrence of the extreme events that had impact on populations, infrastructures and activities. Several lessons learned were derived comparing the occurrence of the events with the evolution of the emergency measures and DRR. Thus, for each of the target area, a brief introduction is followed by three main sections describing (i) materials and methods, (ii) the historical and recent events occurrence and (iii) the lessons learned. To note that the sub-structure of each section depends on the available material and on the specificity of the area.

To note that the information related to the lessons learned in the following paragraphs, integrates and completes the investigations made for PART I. In particular, while in Chap. 5 an overview of the emergency response and DRR is shown at national level, in next paragraphs the investigations refers also to the regional and local levels.

Figure 7.1 RISC-KIT storm database: EU Case Study countries overview (22nd May 2015).

Figure 7.2 RISC-KIT storm database: Bangladesh overview (22nd May 2015).

7.1 North Norfolk, UK

Authors: Emmanuel Garnier, Anna McIvor and Tom Spencer.

The North Norfolk case study site is well documented, with records of floods and their impacts available over several hundred years. The RISC-KIT case study site corresponds to a region that was formerly of strategic importance to the English Crown against Spanish, Dutch and French threats. As a consequence, much archival material is available relating to historic storms. More recently, much has been written about how the east coast of England was affected by the 1953 storm, and this storm and its impacts are described in more detail below.

7.1.1 Materials and methods

Manuscript sources

This research has been largely based on the exploitation of primary sources consisting of textual archives. Early sources can be problematic to interpret because they use various palaeographies over the centuries. These sources are also varied and heterogeneous because they derive from different origins, such as the archives of the Bedford Level Corporation and the municipal archives of the cities of Norwich, Wisbech and King's Lynn.

Kept in the Cambridgeshire Archives (Cambridge), the archives of the Bedford Level Corporation are central to this exercise; for more than 200 years, the Proceedings and Order Book of the Conservators of the Level recorded all the business to do with the management of The Fens and of the estuarine embayment of The Wash. The records of their meetings begin in 1663. Very soon thereafter, both sets of records are full of complaints from owners of flooded lands; and full, too, of references to the rebuilding of broken banks, to the opening of blocked sewers, and to the improvement of difficult navigation. The series S/B/SP of the archives of Cambridgeshire contains 2,314 petitions. Of these, 260 concern problems of sea surges and floods. Drafted by several landowners who were victims of these extreme events, the petition is often precisely worded. As well as the names and places of residence of the authors, the records usually indicate the date (day and/or month) of the event, and then provide an exact description of the damage caused by the flood waters. When the damage needs to be repaired but this is expensive, petitions indicate the figures asked for by the victims and the favourable answer (or not) given by the persons in charge of the Bedford Level Corporation.

The municipal archives kept in the Norfolk Record Office and in the Cambridgeshire Archives allow us to study the floods in an urban frame, from the examples of the large city of King's Lynn and smaller coastal small towns such as Blakeney, Cley and Weybourne. In the first case, Hall or Congregation (assembly) Rolls and books include regular information on climatic extremes. This is because the elected representatives monitored these events in order to take measures (defence of dikes, taking care of victims) quickly when a flood threatened the city or its supply chain. Used in conjunction with the archives of the Bedford Level Corporation, these numerous city testimonies reveal information about storm surges that affected these urban and rural areas.

Printed sources

The Cambridge University Library holds some very rich documentation on this topic. These are mostly books dedicated to a specific locality within the case study site. Their authors are local scholars who tell the story of their parish. Some of the authors are scientists from the 19th or the beginning of the 20th centuries who were interested in this information for geological or meteorological reasons. The information concerning storms and storm surges is consequently random and very localised (a village is evoked) and it is not always easy to affirm that an extreme event arisen in a village affected the whole case study.

7.1.2 Historical overview

Historical floods at the regional scale

Early records of coastal flooding tend to be more general in area, so that it is not possible to know the exact stretch of coast affected by the flooding. Records exist from as early as 1099, when a "sea-flood" is recorded in the Anglo-Saxon Chronicle. As reported in the extract below, this event occurred on the festival of Saint Martin, in November:

> *A.D. 1099. ... This year also, on the festival of St. Martin, the sea-flood sprung up to such a height, and did so much harm, as no man remembered that it ever did before. And this was the first day of the new moon.*
>
> Source: The Anglo-Saxon Chronicle (Swanton (editor), 1998)

Sources and historians consider that the storm resulted in approximately 100,000 deaths, an assertion that is very difficult to verify because demographic data (censuses, parish registers) are not available for the 11th century. Available documentation suggests that the disaster affected the coast of Norfolk and The Netherlands.

There are also early records of sea defences being built along the Norfolk coast (although such records are not available within the RISC-KIT case study area until later). The estuary of The Wash was defended by a sea bank, known locally as the "Roman Bank" but thought to be of post-Roman origin. A second defence line was the Fens Bank (which retained fresh water). It has been suggested that climate change, which began with the Little Ice Age during the 14th century, led to a rise in sea level that resulted in the construction of such prominent flood defences in the Norfolk area (Hinman and Popescu, 2012).

The beginning of the 17th century was marked by two storms which affected the region, although it is not possible to be sure whether these affected the RISC-KIT case study area. On 20th January 1607, the sea broke through an old breach in the sea banks and in a quarter of an hour overflowed the marsh and the city of King's Lynn. Just a few people were drowned. The survivors called for boats and some floated on wooden planks. King's Lynn, as well as the marshland villages, suffered considerably from the flood, and the narratives relate that there was a "mighty tide" which washed away a part of Catt'bank (Baker, 1607).

Three years later, on 1st November 1611, a new disaster occurred with much more serious consequences. The flood was brought about by a violent north-easterly wind meeting a high spring tide. In their distress, the people of Terrington St-Clement (near King's Lynn) fled to the church for refuge (Dugdale, 1662). Terrington suffered severely. Among the losses were 1,876 sheep valued at £58; 120 beasts at £322; 80 acres (1,920ha) of corn at £720; corn in barns at £700; grass in fields at £50; and 13 houses completely ruined at £1,042.

Frequency and intensity of historical flooding in North Norfolk.

To estimate the frequency and the intensity of extreme flood events in North Norfolk, we used only those records known to have affected the RISC-KIT case study site. The earliest such record comes from 1665. The documentation for events from this time is more complete and this is why we consider that the chronology which follows is reliable.

The events since 1665 are shown in Figure 7.3. The severity of the impacts of these events varies through time, with the disaster of 31 January 1953 standing out as having the greatest impact. This storm surge event caused the deaths of over 300 people in the UK and more than 2,000 in total in north-east Europe. The storm surges of 1978 and 2013 resulted in very high water levels, comparable to those seen in 1953, and the lower severity of their impacts reflects the strengthening of coastal defences after 1953, the introduction of coastal storm surge forecasting and better levels of preparedness and crisis management.

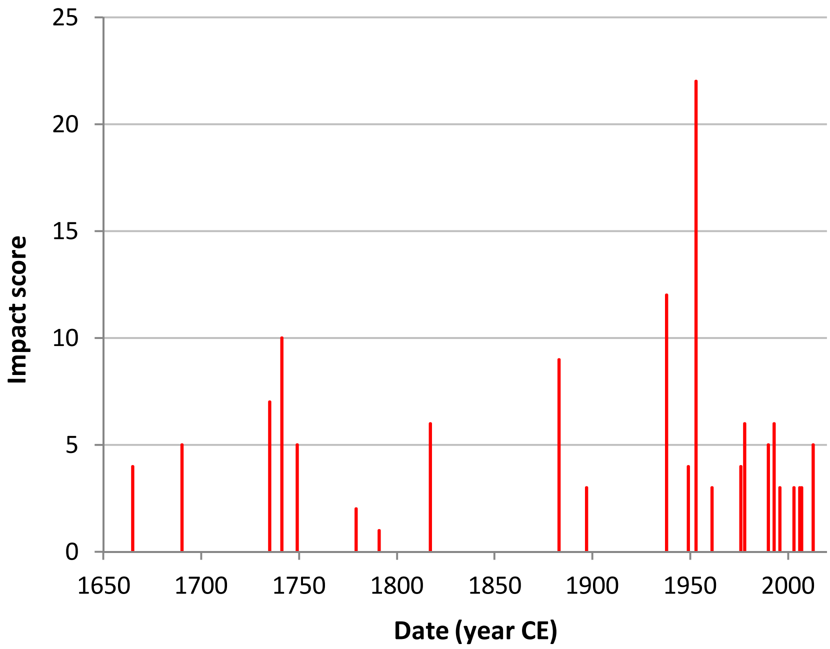

Figure 7.3 Frequency and intensity of storm surges on the North Norfolk coast. The impact score is based on records of various types of damage, such as flooding of buildings, loss of lives, loss of crops/livestock, area flooded, damage to infrastructure, erosion, and the financial cost of the event.

There is an apparent increase of the number of storms between 1976 and 2013, but this is likely to be an artifact of the increased availability of data over this time period. Additionally, the vulnerability, in other words what is exposed and what can be damaged, decreased after the disaster of January 1953 as coastal defences were strengthened.

Coastal flood events in the case study area between 1665 and 1897. On 25 November 1665, a storm surge driven by a north-westerly wind removed some of the marsh banks along the North Norfolk coast, and destroyed the wheat in the marshes. The storm also swept a ship right over the shingle bank from the North Sea into the Salthouse channel, which at that time ran from Salthouse Broad, behind the gravel barrier and out from the River Glaven. This channel disappeared sometime around 1850, blocked by the gradual landward movement of the gravel barrier (Cambridgeshire Archives, KSB/SP 1-2232).

25 years later, on October 8th, 1690, a north westerly gale associated with a high tide struck Cley. The bank broke and 66 acres (264ha) of wheat, presumably already winter sown, were covered under 6 feet (1.8 m) of water. The water reached a depth of 20 feet (6 m) at Cley quay and several houses, including the George Inn, were under 4 feet (1.2m) of water (Hooton, 1996).

Between 1735 and 1749, the coast between Wells, Blakeney, Cley and Salthouse was severely tested when it was subject to four violent storms. A north westerly storm sprang up on the night of Sunday 15th February 1735 and continued to blow until the following Tuesday morning when it coincided with a high spring tide. Cley was described as "almost demolished". 9 feet (2.7 m) of water covered the marshes while the route to King's Lynn was cut off (Gough Manuscript, British Library).

On February 7th, 1741, at about 6 am a very high tide flooded all the marshes on both sides of the channel at Cley, breaking down the greater part of the marsh banks, especially the East Bank which was almost wholly destroyed. It broke down the major part of the wall next to the Salthouse road. Witnesses stated that this tide was much greater than that in the year 1735.

Ten months later on 1 December 1741 a new storm hit the same area. While not as severe as the previous one, it flooded Cley marshes but spared the village of Blakeney. In Cley, many houses were flooded and the malthouses were considerably damaged.

Then in February 1749, a more serious sea flood occurred, but this was still not as severe as that in 1741. All along the coast at Wells, Holkham and Salthouse, the archives describe a similar disaster, with houses flooded.

After a long interval with no major events, the year 1883 was a dramatic year in the locality of Wells, which suffered a major flood, covering the quay and Freeman Street. This occurred on 11th March. 400 acres (1600 ha) of land owned by the Norfolk Estuary Company were flooded, as were many parts of King's Lynn; the water level at the dock reached 29 feet 11 inches (about 8.7 m) while the tide invaded St. Margaret's church during the evening service (Hillen, 1907).

14 years later, on November 30th 1897, Wells was again the victim of the sea. An exceptionally high tide flooded part of Freeman Street and also damaged the road leading from the quay to the Point and the Lifeboat House (Purchas, 1965).

Storm surges after 1900. The area continued to be affected by coastal floods caused by storm surges from the North Sea. Improved records mean that several surges have been recorded even when these surges have had little impact within the area. For example, high water levels were recorded on 26th August 1912, 12th February 1938, 8th January 1949 and 1st March 1949. These floods had minor impacts on the RISC-KIT case study area, although their impacts further round the coast were sometimes more severe (e.g. the 1938 flood caused major devastation at Horsey, which is to the east of the RISC-KIT case study site). The second storm of 1949 flooded houses and roads in and around Salthouse.

Then came the major storm event of 1953, which is described in more detail below. Further flooding events occurred on 20 March 1961 (Steers et al., 1979), 29 September 1969 (Steers et al., 1979), 1 February 1976 (Steers et al., 1979), 11 January 1978 (Steers et al., 1979), 12 December 1990 (tide gauge records from Cromer), 20 February 1993 (Pratt, 1995), 10 January 1995 (tide gauge data from Cromer), 19 February 1996 (tide gauge data from Cromer), 14 December 2003 (tide gauge data from Cromer), 1 November 2006 (Sea State Report – Norfolk 2006-2007, published 2009), 17 March 2007 (Norfolk Sea State Report – Norfolk 2006-2007, published 2009), 8 November 2007 (T. Spencer, pers. comm.) and 5 December 2013 (Spencer et al., 2015). Of these, the events in 1978 and 2013 had very high water levels in the RISC-KIT case study area, but their effects were much less severe due to changes in flood defences and flood preparedness, as discussed in the sections below.

The 1953 Storm Surge

On 31st January – 1st February 1953 a storm surge affected the east coast of the UK, resulting in over 300 deaths and causing damage from Scotland down to Kent. Along some parts of the east coast of the UK, the storm surge was higher than any previous surge in living memory (Grieve, 1959).

Meteorological origins of the storm surge. The following description shows how the storm evolved over the days and hours before the storm surge struck the east coast of the UK. This description is taken from Grieve (1959).

The storm that created this surge began as a depression approximately midway between Iceland and the Azores on the morning of Thursday 29th January. By the afternoon, the depression had deepened and was travelling north-eastwards at a rate of 17 to 23 mph (27 – 43 km/hr). At 6pm, pressure was 1000 mb (or 1000 hPa), at midnight 996 mb, and at 6am the following day it was 994 mb. It was still moving north-east, and was now tracking between Iceland and Scotland. By noon on Friday 30th January, the centre was just north-west of Scotland with a pressure of 988 mb, and by 6pm, it was south of the Faroe Islands with a pressure of 980 mb. The wind over the North Sea was still to the north east.

On Saturday 31st January the winds veered to the south and then south-east, driving water from the Atlantic towards the North Sea, and the direction of the depression shifted to the south-east, so that from midnight 30 January, it was advancing into the North Sea. The depression reached its lowest recorded pressure of 968 mb at 6 am on 31st January in the Orkneys, and this pressure was maintained until noon when the centre of the depression was 150 miles off the north-east coast of Scotland. Pressure remained very low, rising to 976 mb between 6pm and midnight.

Additionally, by noon on Saturday 31st, a strong ridge of high pressure reaching 1032 mb was moving east over the Atlantic. The steep pressure gradient between this ridge in the Atlantic and the depression over the North Sea resulted in strong winds blowing towards the south across the British Isles. These winds reached gale force, and were the strongest winds on record, with wind speeds of 90 mph (145 km/hr) on Orkney, and gusts of up to 125 mph (201 km/hr, equivalent to the highest level of 12 on the Beaufort Scale) between 9:30 and 10:30am on the Saturday morning. While less strong further south, winds were still very high, and in Southampton on the south coast it was considered too risky for an 81,000 ton liner to sail.

Between noon and 6pm the depression advanced across the North Sea in the direction of Denmark, but at about 6pm, it turned south into the Heligoland Bight (at the mouth of the Elbe River in Germany), bringing the strong winds that continued to drive the water in the same direction. The depression did not turn east again to move out of the North Sea until midnight, so that the rising tide had the winds behind it all the way down the east coast of the UK. These record-breaking winds blew in a southerly direction over the North Sea for many hours, pushing the water in the same direction, and resulting in a southerly moving "bulge" of water. The very low atmospheric pressure also contributed to raising water levels. The bulge of water occurred on top of a high spring tide (the tides in the North Sea also move in a southerly direction), resulting in the storm surge which caused flooding along the eastern coast of Scotland and England. In addition, the wind created large waves on top of the storm surge, adding to the destruction (Grieve, 1959).

Water levels along the East Coast. The following water levels and times are taken from Grieve (1959). In Aberdeen, water levels rose 2.5 feet (0.8 m) above the predicted level. At Leith, the highest water levels occurred after predicted high water, and were almost 3 feet (0.9 m) higher than predicted levels. Near the mouth of the River Tees, high water levels were 5.5 feet (1.7 m) above predicted levels. At Immingham in the Humber high water was predicted for 6:55pm, by which time water levels were 5.5 feet (1.7 m) higher than predicted levels and continued to rise some inches more. At Sutton-on-Sea the discrepancy between predicted and actual levels was 6.0 feet (1.8 m) and at Gibraltar Point, south of Skegness, it was 7.8 feet (2.4 m). At King's Lynn in The Wash it was 8.2 feet (2.5 m; the highest water level ever recorded there up to that time). From this point southwards, water levels consistently reached one to two feet (0.3 – 0.6 m) higher than ever previously recorded. From the Tyne down to Southend-on-Sea, all the automatic tide-recording devices were forced above the highest levels that they could record or were destroyed. Hence, the water levels during the event are not well known along these stretches of coast (Grieve, 1959).

The highest water levels along the North Norfolk coast, based on surveying the heights of debris lines and water level marks on buildings, were as follows: 5.34 m at Thornham, 5.37 m at Scolt Head Island (Norton Hills back-barrier), 5.49 m at Burnham Overy Staithe, 4.02 m at Holkham Marsh, 5.13 m at Warham Marshes, 5.13 at Wells, 4.57 m at Stiffkey, and between 4.27 m and 4.88 m with a maximum recorded height of 6.07 m at Blakeney (all heights are above Ordnance Datum Newlyn (ODN); Steers et al., 1979).

Immediate effects of the surge. The effects of the surge were felt along a long stretch of the eastern UK coast, from the sea defences of East Riding in Yorkshire which failed, down to Margate in Kent, where the 60-foot-high (18 m) lighthouse at the entrance to Margate Harbour was undermined and fell into the sea (Grieve, 1959).

Along the east coast, 307 lives were lost, 32,000 people were evacuated, 24,000 houses were damaged, 200 industrial premises were flooded including twelve gasworks and two power stations, eleven trunk roads were impassable, 200 miles of railway track were out of use, 160,000 acres of agricultural land were flooded and made unusable for between 1 and several years, and 9,000 sheep, 1,100 cattle, 2,600 pigs, 34,000 poultry and 70 horses died (Pollard, 1978; Summers, 1978). The damage costs were estimated to be £5 billion at 2003 prices (RMS, 2003).

Within the RISC-KIT case study area, the effects of the surge resulted in a variety of impacts at different locations. The following description of these effects along the North Norfolk coast is taken from Pollard (1978) except where other sources are noted.

Three lives were lost along the RISC-KIT stretch of the North Norfolk coast. Of the more than three hundred people who died in the UK, it is worth noting that many were elderly and vulnerable, alongside some younger people who died trying to rescue them. The larger towns (Lowestoft, Great Yarmouth and King's Lynn, which are all outside the RISC-KIT area) suffered fewer casualties partially because they could quickly muster enough manpower to mount rescue operations, and partially because the houses were more solidly built in the first place. However, between Hunstanton and Snettisham, on the eastern margin of The Wash, 65 lives were lost, one of 5 clusters of high mortality. These clusters were all characterised by timber or prefabricated bungalows, easily smashed by storm waves and with no first floor to escape to (these dwellings were never intended to be occupied during winter, but during the housing shortage after the war, many of them were occupied year round). It is also worth noting that planning decisions played a role in allowing these dwellings to exist in vulnerable locations. A budding shanty-type development near Burnham Overy Staithe had been removed only a year or two before the event, at the instigation of the Fifth Lord Leicester, and this probably saved the lives of whoever might have been living there at the time of this surge. The sea banks along this stretch had also been recently strengthened, and these did not give way, reducing damage and loss of life behind them (Pollard, 1978).

In several locations, the surge flooded roads, preventing passage. For example at Cley, the High Street was flooded and was passable only by boat. In Wells, Freeman Street became a torrent of water, and on Holkham Road, one man saw a wall of water coming towards him (presumably following the breaching of a bank) and was saved by sitting inside a stranded bus. In Wells, the station and train line was also flooded (Figure 7.4), and again, this happened suddenly so that two railway workers had to run and climb to safety to escape the water's sudden arrival. At Holkham Station, the railway embankment was washed away, and the line from Hunstanton and Burnham Market to Wells (including the stretch past Holkham) never reopened following the surge (Pollard, 1978; John Tuck, pers. comm.).

Figure 7.4 Wells immediately after the 1953 storm surge. Top left: Houses on Freeman Street, showing how the back walls had been destroyed by the surge. Top right: Large breach in the Great Wall on the western side of Wells Harbour. Bottom left: The railway station and tracks completely flooded. Bottom right: Dead livestock and other debris left from the surge. Photos provided by John Tuck, except top right from Steers, 1953.

Also in several locations, the sea embankments (commonly called sea banks in this region) were breached (Figure 7.4). In fact it was said that following the surge, not a single mile of bank was left unbreached. A breach in the bank at Burnham Overy Staithe caused severe damage to Holkham and the western end of Wells. Often the breaches were caused by water overtopping the banks and then eroding the landward face of the banks, until the banks collapsed, resulting in a breach (Pollard, 1978).

Large areas of farmland were inundated (many of these had originally been reclaimed from the sea so were very low-lying). For example, 1.5 square miles (388 ha) of farmland (reclaimed marshes) west of Wells were inundated (Grove, 1953). In some cases the marshes were inundated when sea banks gave way, in others by overtopping over the banks. The damage to the agricultural land was increased in those areas where old banks prevented the sea water from draining out, leaving some areas flooded until late February 1953 (Pollard, 1978). Many livestock were also lost, and there are reports of dead cattle everywhere (Figure 7.4). The Wells butcher Charles Ramm was also a farmer, and his pasture land was left unrecognisable by the surge, which had lifted an entire haystack onto one of the inner banks.

Many properties were flooded and some buildings destroyed. In Wells, water seeped through front doors and up stairs. Out-building were knocked over the force of the water, and the back walls of some houses along Freeman Street were torn away by the force of the water inside the buildings, once the water outside the buildings began to subside (Figure 7.4). In Blakeney, some houses put up their flood boards, while others were flooded (there is a record of the water reaching the fourth stair in one house).

The water pushed doors in and broke through windows. The villages of Salthouse and Cley were extensively damaged after the shingle ridge was breached in front of Salthouse, producing a gap about 30 yards (27 m) wide (Grove, 1953).

Many householders did their best to take their most precious possessions upstairs and then rode out the storm up there. However, for some this was not enough as the water followed them up to the first floor. At Old Farm in Salthouse, five people had to retreat to the roof spaces. They were eventually rescued by rope through a hole smashed in the roof. In both Blakeney and Wells the electricity supply was lost, and telephone lines were cut in many locations (Pollard, 1978).

In some places, the storm surge was funnelled inland along river channels, bursting the river banks. For example, the crossroads in Burnham Overy Town were flooded by surge water that had come in along the River Burn. The crossroads are over two miles (3.2 km) from the sea but only a few yards from the river (Pollard, 1978).

Coastal marshes were flooded and sand dunes and shingle ridges were eroded back. For example, at Blakeney, water levels were 6 to 8 feet (1.8 – 2.4 m) higher than the predicted tide, flooding the marshes behind Blakeney spit, so that waves were able to attack the old grassy cliffs on the south side of the coast road. This resulted in some slumps of these small cliffs. The waves and high water levels swept shingle over the crest of Blakeney spit onto the marshes, resulting in the spit being driven inland by 30 to 40 yards (27 – 37 m). Old marsh muds were exposed at the foreshore, and these were broken up by the force of the waves into 2 foot (0.6 m) thick blocks which were flung on to the top of the shingle ridge (Grove, 1953). The dunes at the western end were eroded, and on Far Point, two large sandhills were swept away and a new 10 yard (9 m) wide channel appeared through the shingle on which the sandhills had rested (Pollard, 1978).

The immediate aftermath. As the water started to go down, many people were still cut off and their lives still in danger from exposure to the elements. The wind continued to blow through the Sunday, with reports that people could not hear themselves speak and could barely stand up against the wind. Throughout the night and into the next day, numerous people risked their own lives to try to rescue those still trapped by the flood waters. Members of the British and American armed forces who had been stationed nearby were amongst the first to turn up to help. One American, Reis Lemming, brought 27 people to safety at Hunstanton before collapsing from hypothermia and exhaustion. For his bravery he was awarded the George Medal. The heroes of the night included local police, plumbers, electricians, farmers, firemen and other local people who did what they could, often showing extraordinary courage, and some paid with their lives (Pollard, 1978).

Where possible the clean-up began on Sunday. At Salthouse, US servicemen from Langham Camp helped move furniture and belongings to the village church which was on a hilltop (Pollard, 1978).

News of the floods was slow to get out, as telephone lines remained down on the Sunday. Many people were under the impression that it was a local disaster, until on Monday the news started to filter through into the newspapers, and the central government started to muster a response (Pollard, 1978).

On Sunday, there were many rapidly-convened meetings of local councils and various voluntary organisations who became involved in the clear-up, such as the Salvation Army, the Red Cross, the Women's Voluntary Services and the St John's Ambulance Brigade. The central government took longer to mobilise. The key department was the Ministry of Housing and Local Government (Pollard, 1978).

Eventually some level of order was restored and the necessary tasks identified and started. Amongst the urgent tasks were basic provisions for the rescued and evacuated families (many of whom had left their homes in their night clothes); emergency repairs of the breaches in the sea banks; emergency food supplies, water and fuel; restoring communications and electricity; surveying and restoring damaged property; pumping out water that had become trapped behind sea banks; collecting and disposing of the carcasses of dead animals (sheep and cows mainly) and getting surviving animals fed and watered (Pollard, 1978).

The most urgent task was the repair of the sea banks. At Wells, the sea continued to pour in through the breach in the sea bank for seven weeks, covering fields twice each day, causing further damage to the agricultural land. Sandbags and all available material were used to patch up the breaches, and people came in from across the country to help with this task. It is recorded that by 7th February, the East Suffolk and Norfolk River Board had 3,500 servicemen, nearly 1000 civilian labourers, fifty bulldozers, forty draglines and twenty-three water pumps working with them (Pollard, 1978).

Pumping out sea water was also a big issue: 2000 acres of Holkham estate remained under water for several months.

Gradually the basic services were restored. Of the 47,500 homes in East Anglia that had lost electricity, nearly two thirds had their electricity restored within 48 hours.

The process of returning to normality took a long time, and some elderly people never recovered. Others' lives were so disrupted that their life changed course. One school boy who lost most of his family missed many days of schooling, and then when he returned struggled to concentrate and was never able to catch up. A father was never able to work properly again because of ill health. Some reported having nightmares for years after the disaster (Pollard, 1978).

Many people felt let down by central government on two counts; first, there had been no warning, and secondly, there was a long delay before help started to arrive. The only ministry which received praise was the Ministry of Agriculture, which provided fair compensation and also advisors to help farmers get back on their feet. For example, Charles Ramm of Wells was provided with ample supplies of gypsum to treat the fields that had been affected by flooding to offset the effects of the salt. Nevertheless, it took 10 years for the farming side of his business to recover (Pollard, 1978).

7.1.3 Lessons learned

Longer term consequences of the 1953 event for coastal disaster risk reduction

The 1953 event resulted in major improvements in flood risk management policy and practice in the UK (Lumbroso and Vinet, 2011). Key changes included the creation of the Storm Tide Warning Service, improved standards for coastal defence structures and major improvements to existing structures, and new research into coastal processes, protection and funding (described in more detail below; Lumbroso and Vinet, 2011).

Soon after the 1953 storm surge, and under strong political pressure, the UK government established an investigation known as the Waverley Committee after its chairman, Lord Waverley. It was appointed on 28 April 1953 with four terms of reference: i) to examine the causes of the recent floods and the possibilities of a recurrence in Great Britain; ii) to consider what margin of safety for sea defences would be reasonable and practicable having regard on the one hand to the estimated risks involved and on the other to the cost of protective measures; iii) to consider whether any further measures should be taken by a system of warning or otherwise to lessen the risk of loss of life and serious damage to property; and iv) to review the lessons to be learned from the disaster and the administrative and financial responsibilities of the various bodies concerned in providing and maintaining the sea defences and replacing them in the event of damage; and to make recommendations (Baxter, 2005).

The Committee had two significant effects on subsequent UK coastal management policy, namely the inception and development of the Storm Tide Warning Service and the opening of discussion on London's flood vulnerability. The first of these was taken forward, before the publication of the Committee's final report in 1954, by the Advisory Committee of Oceanographical and Meteorological Research, organized by the Ministry of Agriculture and Fisheries (MAF). By 1959, a more national system of statistical forecasts had been developed and implemented, the Storm Tide Warning Service. Soon after 1953, a network of tidal gauges was installed around the British Isles coastline to provide accurate water levels to feed into the STWS system (Lumbroso and Vinet, 2011). Additionally, a system of sirens was used to provide warnings up to 12 hours in advance of an extreme surge (Lumbroso and Vinet, 2011; these sirens are no longer in operation now as other means of communication, such as e-mail and SMS messages are now available).

The Waverley Committee's final report also introduced the idea of a protective structure or barrier being built to protect London, and the Thames Barrier eventually became operational in 1982.

As well as these considerable direct impacts, it has been argued that the Waverley Report was responsible for many other, more subtle, pioneering shifts in policy implementation, terminology and report language. In its consideration of where and to what level to improve defences, it engaged with financial assessment and can therefore be regarded as a prototype of the modern practice of a cost-benefit approach to flood defence management. Furthermore, in using terminology such as 'fair, reasonable and practicable', it introduced a language and approach that anticipated the language and terminology of modern risk assessment and health and safety regulations.

Other changes in flood defence following the 1953 event included the setting of new design standards for flood defences, based on 1953 water levels (Lumbroso and Vinet, 2011). This level was set on the basis of what was politically acceptable as opposed to any scientific rationale for it. The 1953 flood also acted as a catalyst for major coastal defence improvement works, with some defences being raised by up to 2 m in areas of high risk. In many areas, coastal defences were built to withstand a 1 in a 1000 year flood.

A further change that occurred after the 1953 floods was an increase in research into coastal flood risk (Lumbroso and Vinet, 2011). The Proudman Laboratory at Liverpool University developed statistical models to help predict flooding for the east coast. Their research eventually led to the world's first storm-surge prediction system based on numerical models that simulate physical oceanographic processes.

Current flood risk management practice in the UK

Since 1953, the three highest storm surges affecting the region occurred in 1978, 2007 and 2013. While these resulted in damage, there was no loss of life. This is thanks to the many changes that were made in the aftermath of the 1953 surge, as described in the previous section. Here, we briefly describe the current flood risk management system within the UK, using these more recent surges to illustrate how the improvements since 1953 have contributed to reduced loss of life and damage to property and infrastructure.

Following on from the development of numerical models in the Proudman Laboratory, computer-based forecasting began to be developed, and the first operational surge forecasts were run in 1978 using a coarse grid (i.e. the spatial resolution of the models was low). The National Tide and Sea Level Facility (http://www.ntslf.org/) was established in 2002, with further integration with meteorological forecasting following the UK fluvial flooding of 2007. The current tide-surge model is maintained by the National Oceanographic Centre (Liverpool) and runs in real-time at the UK Met Office. A 12 km resolution shelf model (CS3X) is forced by 12 km grid resolution meteorological data from the UK Met Office North Atlantic European (NAE) weather forecasting model. Results are transmitted to the UK Environment Agency and used, together with data from the National Tide Gauge network, for flood warnings (Figure 7.5).

The response to the storm surge in 8 November 2007 provides an example of how the new early warning system and evacuation plans were successfully put into action. This surge was the highest tide since 1953 (it has since been surpassed by the surge in December 2013). Eight severe flood warnings were issued on 7th November, 23 hours in advance of the high tide. This resulted in 27,000 calls being made to local responders and residents, using Floodline Warnings Direct. In Great Yarmouth, 7,500 houses were identified by the Environment Agency as being at risk, while 10,000 houses were identified in Norfolk and Suffolk (including those in the RISC-KIT case study area). All these houses were called on by police to alert residents to the dangers of the impending surge tide. 1,050 people were housed in evacuation centres, and hundreds of others self-evacuated to friends and family. The Floodline number (08459881188) received 5,000 calls per hour, and the website received 457,419 hits on 8th November 2007. The Environment Agency activated demountable defences to protect a power station supplying 31,000 homes (demountable defences are defences that can be put into action when required; they are already present but are normally not in use, e.g. flood barriers that slide into place when needed). Water rescue teams were mobilised from as far away as Devon and Merseyside. The event was hailed as an example of "all the key agencies and voluntary organisations working closely together" to ensure that "the county's plans to deal with a major flood alert were successfully carried out" by Ian Macpherson, Chief Constable of the police in Norfolk.

Peak water levels during the December 2013 surge were higher than they had been in 1953 along much of the North Norfolk frontage (Spencer et al., 2015). The lack of deaths has been attributed to post-1953 strengthened defences, improvements in storm forecasting and co-ordinated crisis management plans, including a highly efficient early warning system, flood wardens and evacuation centres. In the 2013 event, 10 residential properties and 13 businesses were flooded in Wells, and 30 residential properties and 14 businesses were flooded in Blakeney, Cley and Salthouse. Since this time, many of these properties have installed additional flood defence barriers.

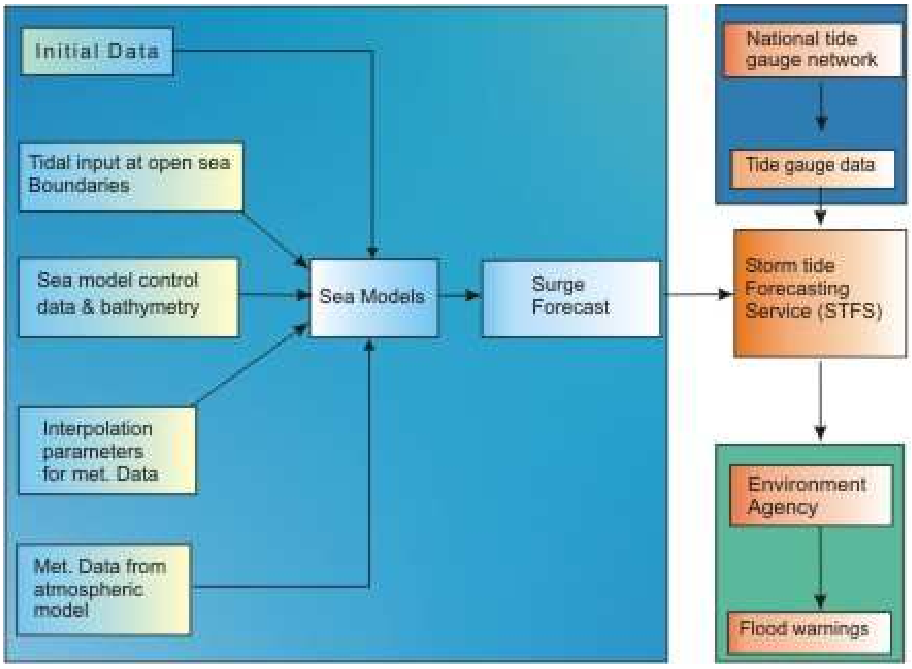

Figure 7.5 Schematic diagram of the UK storm surge forecasting and flood warning system (Source: http://www.ntslf.org/numerical-modelling/storm-surge-model).

7.2 Ria Formosa, Portugal

Authors: T.A. Plomaritis, Emmanuel Garnier, Susana Costas and Oscar Ferreira.

The historical research for data was complex because the current site of Ria Formosa remained uninhabited till the beginning of the 20th century. From 1900s, the population is very limited and consists of tuna fishing communities settlements located mainly on islands and peninsulas, and near to inland located canneries. As a consequence, very few historical sources concern directly the 55 km length of barrier islands. It was thus necessary to widen the research area to historical population centres as the cities of Faro, Olhão and Tavira and the village of Fuzeta, located along this coast. Indeed, until the development of the littoral urbanization from 1960s, it was inconceivable to settle down near the sea for safety reasons. People were then afraid of the coastal risks but also the characteristic diseases of the wetlands (mainly malaria).

The second major difficulty is the absence of instrumental data concerning storms. Once more, the low human density of the region explains very probably the absence of local information on barometric pressure, and wind speed, before the beginning of the 20th century.

7.2.1 Materials and methods

The majority of the historical data collected on the spot results from archives of the Portuguese Navy kept in the library of «Departamento Marítimo do Sul» of Faro. In the same place, the maritime museum «Almirante Ramalho Ortigão» presents the techniques of fishing and the everyday life of the local fishermen in the first half of the 20th century. Reports and books dedicated to the naval activities in the region as well as collections of old photos regarding housing and coastal landscape were found, consulted and used. The archives of the district of Faro (Arquivo Distrital) contain the archives of fishing companies since the 1900s. In particular, the compensations paid to the fishermen victims of meteorological extreme events, such as storms, have been found there. The local press was also used as a source of information; several newspapers (Povo Algarvio, O Algarve, Folha de Domingo) published very detailed articles on the cyclone of February, 1941. Certain articles were not available on Faro, and it was necessary to ask for reproductions to the municipal library of Porto, which keeps all Portuguese publications, including newspapers. Finally, religious paintings called ex-voto, kept in the church of Tavira, were also analyzed. These religious paintings were offered by the fishermen or the inhabitants close to the coast to thank God for protecting them from meteorological disasters. They give an interesting dimension of the cultural perception of storms (including coastal storms) in the region of Ria Formosa. To address the lack of reliable instrumental data, the contents of archives offer a solution to estimate these natural events for which we have mostly textual descriptions. Our evaluation is based on an indexed scale of severity directly built according the descriptive contents of the storms. Naturally, this results from a systematic inventory of the impacts engendered by the extreme event on infrastructures and societies (seawall, dunes, flooded territory, cattle and human losses).

7.2.2 Historical overview

Occurrence and severity of storms between XIX and XX centuries

The available historical material provided a list of 13 coastal/marine storms from the beginning of the 19th century (Figure 7.6). For the previous centuries, historical information is scarce because the coast was uninhabited.

Between 1816 and 1860, the region was hit by 4 storms. That of the 1816 is described in archives as a very violent storm associated with very powerful waves which struck the coast of Tavira. The wind sank two fishing ships, took the roofs of numerous houses and uprooted trees. On the coast, the huts of the fishermen were totally destroyed. These descriptions of damage correspond approximately to a wind of strength 10 on the Beaufort scale.

On January 1st, 1840, another severe storm is retained in the local memory as shown by the ex-voto of Tavira which shows a fishing boat submerged by waves (Figure 7.7). The storm caused important damage at Tavira and nearby islands. Fishermen's huts were taken by the sea and numerous roofs were torn away.

In November, 1853, Olhão and nearby islands were destroyed by a storm and archives describe a «horrible storm» and waves which strike houses and cause the collapse of the stone walls.

On November 19th, 1860, a new disaster occurs and archives evoke a «cyclone». It lasts two hours and cause damage very important for the constructions in the entire region of Faro and in all the islands.

Ria Formosa faces a long period free of high intensity storms during almost a century. The rough break of this long episode occurs in 1941 when the entire Iberian Peninsula faces one of the largest natural disasters of the last 200 years.

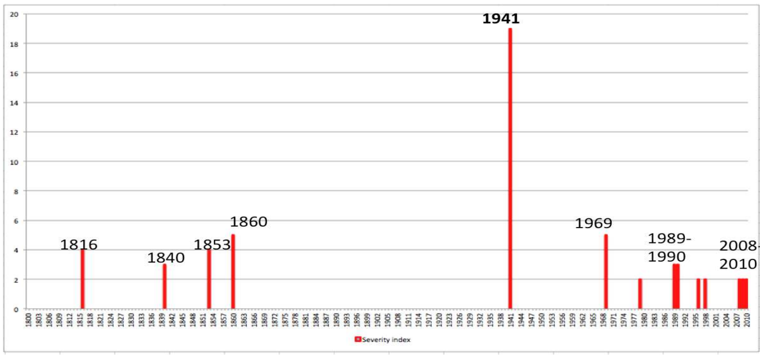

Figure 7.6 Occurrence and intensity of storms in Ria Formosa.

Figure 7.7 Ex-voto of Tavira showing the effects of the storm in 1840.

The "cyclone" of February 15th, 1941

February 15th, 1941, reports of the navy indicate that since morning the coast had been hit by a violent wind coming from the southwest associated with a deluge accompanied with downpours and with hail which destroyed the inland fields of broad bean and wheat.

A barometric pressure of 713mm (948.29hPa) was recorded by the meteorological services on February 15th, the lowest pressure recorded in Algarve since 1854. The wind speed was estimated as having 127 km/h (35.28 m/s), a force wind of 12 on the Beaufort scale[4]. Thousands of trees were torn away. Zinc plate roofs were lifted as paper sheets while eucalyptus and pines were torn away and thrown on the ground. More important, it is mentioned that the sudden rise in the water level covered a big part of the islands and the 'armações', the fishermen buildings where the tuna fishing nets were kept, were flooded. For example the population of Cabo de Santa Maria (tuna fishing camp) within the Barreta Island was totally destroyed. At Ancão Peninsula a new inlet was opened. The same storm destroyed the "armação" of Medo das Cascas close to Tavira and one of the most important in the region (Santos et al., 1989).

Within the eastern part of the system, the opening of an inlet almost 1000 meters wide (Cochicho Inlet, former Cabanas Inlet) provoked the destruction of Cabanas Island (Freitas and Dias, 2013). This significant change in the island morphology triggered the subsequent sedimentation and closure of the Tavira artificial inlet (opened in 1927) and the disappearance of the internal canal that ran parallel to the island (Freitas and Dias, 2013), which had impacts to the socio-economic tissue. Despite such large geomorphological changes on the islands and the disappearance of three fishing camps, there were no casualties, only material damage for the barrier islands.

Archives evoke 'gigantic' waves which invaded the island of Ancão and threatened 130 people[22]. On the island of Culatra, dozens of fishermen's houses disappeared. The sailors lost their boats taken by the sea as well as their fishing equipment. A mill was destroyed and the southern part of the cannery Balsense collapsed. On the island of Tavira, the sea destroyed the largest part of the huts which were taken by the currents[23]. In Faro, the wind destroyed the houses of the guards in the Avenida da República. Everywhere, in Faro and in the countryside, street lamps, telegraph and electric poles were destroyed, preventing the communications between the province and the capital[24].

The losses were catastrophic for the fishing and merchant fleets. In the afternoon of February 17th, ship «Maria Joana» was surprised by the storm near Faro[25]. A tanker of the transport company of Guadiana disappeared during the cyclone. Other boats

[22] O Algarve Newspaper, 23/02/1941

[23] Records of the Departamento Marítimo do Sul, Faro

[24] Records of the Departamento Marítimo do Sul, Faro

[25] Povo Algarvio Newspaper, 23/02/1941

transporting sugar and coffee sank[26]. Sometimes boats crossed over dikes and quays crashing 100-200m inland.

The social and economic consequences of the above storm were very important and damaged seriously the resilience capacity of the inhabitants. For example, the authorities inoculated, as a matter of urgency, the inhabitants of the islands after the appearance of smallpox. More than 100 people (women, children, men) were victims of the disaster on what we call currently the beach of Faro (Praia de Faro). In Fuzeta, a part of the population was invaded by the sea. Hundred houses were flooded and boats suffered severe consequences. The fishermen lost almost all their equipment for fishing octopus. Consequently, the unemployment increased and the scarcity affected many families[27]. The overall cost of the disaster was of 80,000 contos (approximately 400,000 €, by that time) in the district of Algarve. The storm had an important effect over the economy of the region of Algarve with around 150 thousand of euros of damage costs (Muir-Mood, 2011).

The victims very quickly benefited from the national solidarity. During the disaster, the inhabitants of Ancão (Praia de Faro)were saved by the gunboat "Mondovy" which evacuated them to Faro. These victims were taken by the maritime department of Faro that supplied them 2 meals a day because they lost everything. Newspapers call for donations and the archives indicate the massive arrival of donations from all Portugal. In Lisbon, the students native of Algarve collected donations.

On the spot, a committee of the district of Faro was in charge of helping the victims. It listed the victims to access well the needs of the affected population. It also supplied food aid and collected donations. The English community of Algarve was particularly generous.

Recent years and Xynthia 2010

A detailed investigation of the wave record and hindcast at the study site (1953-2014) was used to identify 11events that generated damages. The wave dataset used was a synthetic record constructed by joining hindcast (SIMAR) and measured(wave buoy of Faro) data. These events consist of both isolated storm events and groups of storms. The latter are logged as a single event with multiple storms of short period of time in between. Storm groups frequently reach the Ria Formosa and their impact has been studied (Vousdoukas et al., 2012). The regional wave climate is dominated by two main incident wave directions, west–southwest directions (W-SW) are present for the 71% while east-southeast direction for 23% of the record (Costa et al., 2001). This pattern is also repeated in the major event list, with 6 cases of W-SW direction and 4 of E-SE, while one event (group of storms) includes both directions. The cuspate shape of the Ria Formosa system produces two areas with different orientation that results in distinct exposure directions. Hence, both wave directions are responsible for coastal hazards such us erosion, overwash and breaching. The W-SW (Atlantic) storms mostly affect the western flank of the study area and the E-SE (local storms) the eastern flank. The mean significant offshore wave height of the 11 selected events is

[26] Records of the Departamento Marítimo do Sul, Faro

[27] Folha do Domingo Newspaper, 30/03/1941

4.8 m with the maximum reaching 7.1m. The storm duration spans from an average of 2 days for individual storms to several week for large groups of storms.

The major recent event at Ria Formosa was the group of storms that took place from the 22nd February until the 4th March 2010. This event includes the pass of the extratropical cyclone Xynthia. Xynthia crossed rapidly the Western Europe between the 27th February and the 1st March 2010. It was originated from a low-pressure zone located in the middle of the Atlantic Ocean and followed a SW-NE storm track (Figure 7.8) towards the NW corner of the Iberian Peninsula, creating a storm that impacted the Portuguese coastline (Bertin et al., 2012).

Xynthia was not as energetic as previous storms that hit Western Europe like Martin (27th of December 1999) or Klaus (23th January 2009)during which maximum wind speeds exceeded 50–55 m/s. The stronger winds observed during Xynthia over Ria Formosa did not exceed 19 m/s and had S-SW direction. However, its storm track (Figure 7.8) provoked an important impact over the Iberian Peninsula both as a windstorm(mainly over inland areas) and as wave storm (over the coastline, as it impacted the south and west coast of the Iberia Peninsula). The associated sea level pressure (SLP) at the centre of the storm was 975 hPa when the storm was passing at the south of Portugal.

The widespread impact of Xynthia across the entire Western Europe was only part of an extreme energetic winter that started on the 22nd of December 2009 and terminated at the beginning of March. During that period the large scale atmospheric conditions over the Atlantic Ocean were characterized by strong negative NAO values and positive EA pattern values. Such conditions has been reported to enhance the probability of the storm tracks to deflect to southern latitudes towards the Iberian Peninsula (Plomaritis et al., 2015).

As a result, another storm was observed soon after the passing of Xynthia (referred hereafter as post-Xynthia storm) on the 3rd March. This storm followed a W-E storm track with latitude 38.5 (Figure 7.8) and made landfall in south Portugal impacting Ria Formosa. Despite the fact that the SLP at the core was higher than Xynthia as the storm approached the study area (995 hPa) the generated wind at the South of Portugal was of similar strength to the previous event due to the proximity to Ria Formosa.

Reanalysis data (SIMAR) obtained from Spanish Port Authorities on two locations close to the study area (Faro Buoy and Praia de Faro, hotspot) for the period 20/02/2010 – 13/03/2010 are shown in Figure 7.9. Both location represent deep water waves. The variation of the significant wave height (Hs), wave period (Tp) and wave direction (Dir) is presented. The post-Xynthia event had the largest wave height with values reaching almost 6m and associated Tp close to 14 s. Xynthia on the other hand, was less energetic with maximum Hs of 4.5 m and associated periods that did not exceeded 10 s. Both storms generated similar wave directions, i.e. W-SW directions, the change in wave direction during the onset of the storm suggest that probably during the storm the wave spectra energy is bimodal.

Despite the fact that the two storms produced similar wind patterns close to the Ria Formosa, the distinct storm tracks produced different wave fields. Xynthia storm moved rapidly over the study area and from a greater distance. On the contrary, the post-Xynthia event remained stationary at 20W, 38N before start approaching the Portuguese western coast, generating a wave field with larger significant wave height (Hs) and period (Tp) that propagated to the east and impacted Ria Formosa coastline. The arrival of a large storm event after a prolonged period of storminess had as a result large damages to buildings and the opening of a new inlet (see following Section). The storm track of the 1941 storm, which was the most significant historical storm at the region; had a similar storm track to Xynthia. However, as it was mentioned in the previous section, the pressure system was lower (948 hPa) and the generated winds stronger reaching more than 35 m/s.

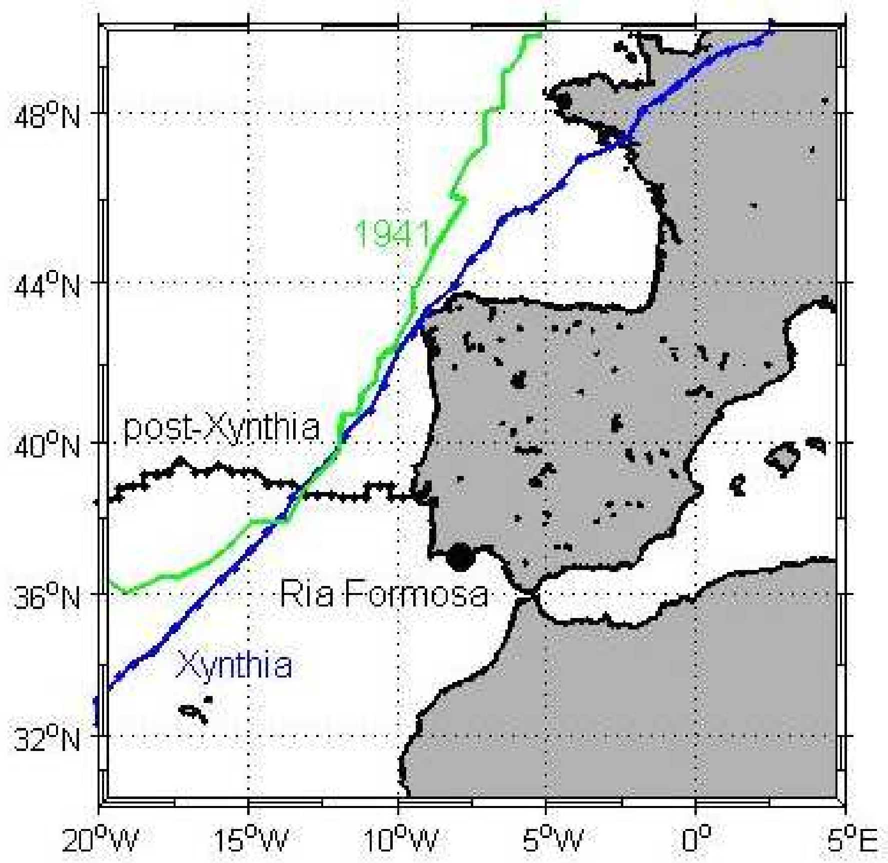

Figure 7.8 Storm track of the Xynthia and post-Xynthia events.

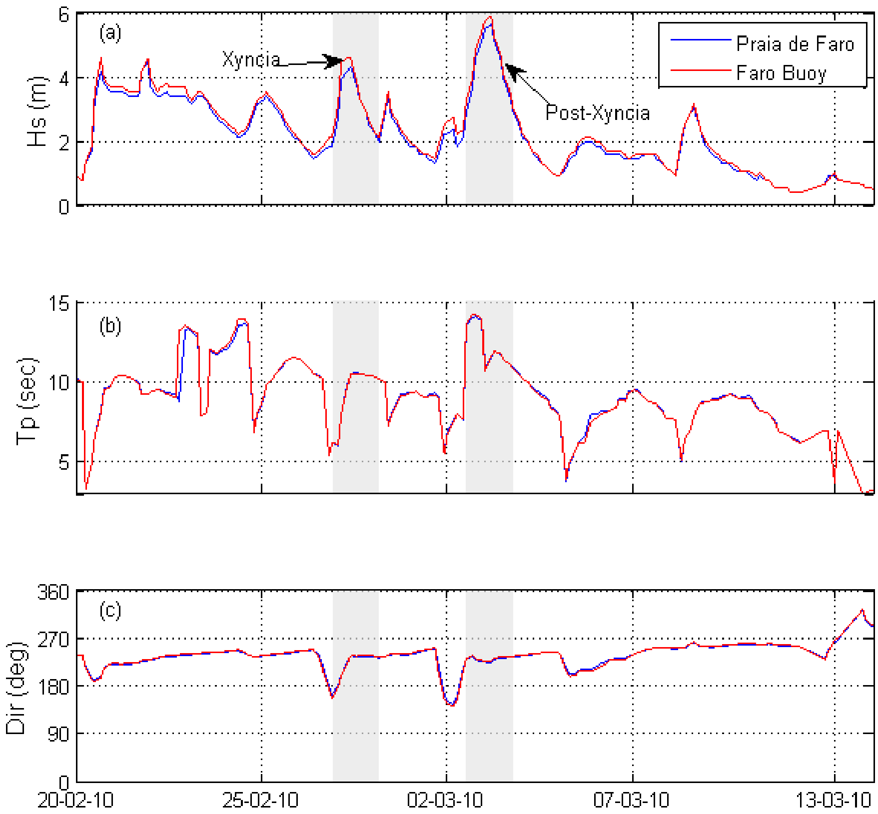

Figure 7.9 Hydrodynamic conditions during the 20/02/2010 – 13/03/2010 group of storms: (a) significant wave height; (b) peak wave period; (c) mean wave direction. Data are results of hindcasting modelling (SIMAR) corrected according to (Almeida et al., 2011).

Impacts

Storms approaching the Ria Formosa may directly impact in the barrier islands provoking overwash, erosion and/or breaching. The magnitude and combinations of all those processes will determine the impact of the storms over the socio-cultural dimension. Traditionally, more frequent impacts over the region have observed in Praia de Faro. However, significant impact has also been reported to other barriers island such as Fuzeta.

Storms between 1960s and 2002. The "armação" located in Cabanas Island was destroyed at the beginning of the sixties due to the shift of the inlet and the breaching of the barrier island.

During the end of the seventies there were also severe storms that affected the hinterland populations of Faro, Olhão, Fuzeta and Tavira (winter 1978/1979).

In Praia de Faro, during February/March 1978, the populated area was overwashed with minor damages (Freitas, 2010).

During autumn 1989 and winter 1989/1990, new storms hit the barrier islands with important consequences not only over the natural sand barriers but also over the artificial infrastructures and houses. Praia de Faro suffered intense overwash and shoreline retreat together with the partial destruction of seawalls and houses.

During the winter 1996 and 2002 the entire wall from Havana to Zé Maria restaurants was damaged and destroyed. Overwash reached the lagoon.

A new series of storm events occurred in winter 1998 provoking the overwash of few houses and shoreline retreat (Almeida et al., 2012).

Storms between 2008 and 2010.The last series of storms with major impact on the barrier islands of the Ria Formosa occurred during the winters of 2008/2009 and 2009/2010. During the latter, overwash was enhanced and erosion provoked the partial destruction of few houses of fisherman in Praia de Faro while in Culatra Island the waves overwashed the Farol settlement surpassing the seawall and destroying one Bar (mar Amais).

During the 2008/2009 winter, highly destructive storms threaten and partially destroyed some houses at the small population of Fuzeta (Ilha de Armona). This situation worsened during the following stormy 2009/2010 winter when a total of 44 of the 71 private buildings in Fuzeta were destroyed and a new inlet was opened[28].From those 44 buildings, 7 were destroyed during December 2009, 11 in January 2010, 17 in February 2010, which include the impact of the tropical storm Xynthia and 9 during March during post-Xynthia event.

7.2.3 Lessons learned

Emergency management actions

Actions between 1960s and 2002. Due to the lack of actual management strategies to prevent damages derived from the effect of storms, most of the times the measures taken to manage or reduce the risk are taken once the storms impacted the area causing some damages (emergency measures).These include the construction or accumulation of rocks and sands (Dias et al., 2004), the accumulation of sand dredged from the adjacent channels, and finally the removal of sand from the tidal terrace and lower beach face to the upper beach (near the dune toe) to protect threatened houses during storms. The latter is done by bulldozers during intense storm periods.

During autumn 1989 and winter 1989/1990, Praia de Faro suffered intense overwash and shoreline retreat whose major consequence was the construction of protection structures in the beach (emergency rock construction).Besides, the storms obligated the authorities of local civil protection to close the bridge for several days. Therefore, the only access to Praia de Faro was in an army barge[29].

During the winter 1989/1990 a seawall was built and afterwards partially destroyed (230 m of the seawall collapsed, Dias et al., 2004). The damaged areas (road, walls and

[28]See http://www.publico.pt/ciencia/noticia/requalificacao-da-ilha-da-fuzeta-devera-estar-concluida-no-inicio-da-epoca-balnear-1433719

[29]Own surveys and ARH Algarve (Teixeira, 2009).

buildings), were rebuilt exactly at the same spots (Figure 7.10).New replenishment actions to nourish the beach were carried out during January and February 1991 following the impact of the storms during the 1989/1990 winter.

Dias (1993) and Dias et al. (2004) pointed out that the first management plans in the area included also the destruction of some illegal properties and were carried out by the central government in the 1980's by the state secretary Macário Correia, responsible at that time for the State Secretary of the Environment (Secretaria do Estado do Ambiente). Within this framework, circa 80 houses were demolished to the East of the road at the Natural Park area, not at the Council area. Those houses were illegal and second houses.

Recent actions. Following the winters of 2008/2009 and 2009/2010 the decision making institution (ARH Algarve; Hydrographic Regional Administration from the Algarve, presently APA - Algarve) decided to apply the management plan at Fuzeta based on the Plan for the Regional Coastal Management and developed by the POLIS, which involved the total demolition and removal of all the private buildings within the settlement. The removed buildings were second residence houses (holidays and beach houses) or buildings used as a support for fishing and shell fishing activities. None of the houses was used as permanent house. The people affected by the plan did not support the decision of the ARH. The responsible for the demolitions and contacting the owners was the POLIS Ria Formosa. The area was requalified afterwards with nourishment and installation of supporting facilities e.g. bars, WCs.

DRR polices

DRR policies regarding storm action for Ria Formosa and Praia de Faro have been implemented in an *ad hoc* way and often as a response to a specific problem. That was the case, for instance, of:

- The hard protection (seawall) in front of Farol village(in order to protect the lighthouse and surrounding houses).
- The nourishments at Praia de Faro in 1990/91 after the storm events of 1989/90 winter.
- The riprap seawalls placed in front of the parking place and in front of the western fisherman houses at Praia de Faro.
- The removal of Fuzeta Island houses.

Several other coastal management actions have been planned and executed in an integrated way, including channel dredging, dune recovery, inlet relocation and beach nourishment (Dias et al., 2003). Those actions where, however, mainly devoted to environmental recovery (i.e. ecosystem recovery, improvement of water quality) and not implemented as DRR measures. The recent POLIS Plan considered, as a DRR measure, the overall removal of all houses identified at risk at Praia de Faro, followed by dune and beach nourishment. The plan application was not approved by the coastal managers (namely the councils) and the vast majority of the houses remain at the dune ridge, with only some second houses being removed at the areas under the Natural Park jurisdiction.

As a consequence, it can be stated that there have not being found relevant signs of "learning from past events" in the area. Conversely, it has been documented that people living/owning properties in Praia de Faro started building houses within the lagoon margin (first occupations) and later (when the use of the beach for pleasure purposes and the bridge was built increasing the population/construction density) they decided to advance seaward, and to stay closer to the actual oceanic beach. In fact, with few exceptions, following major stormy events with significant consequences over the infrastructures, the people living there and the council rebuild the damaged infrastructures (e.g. houses, seawalls, promenades) in the same position despite shoreline retreat (Figure 7.10).

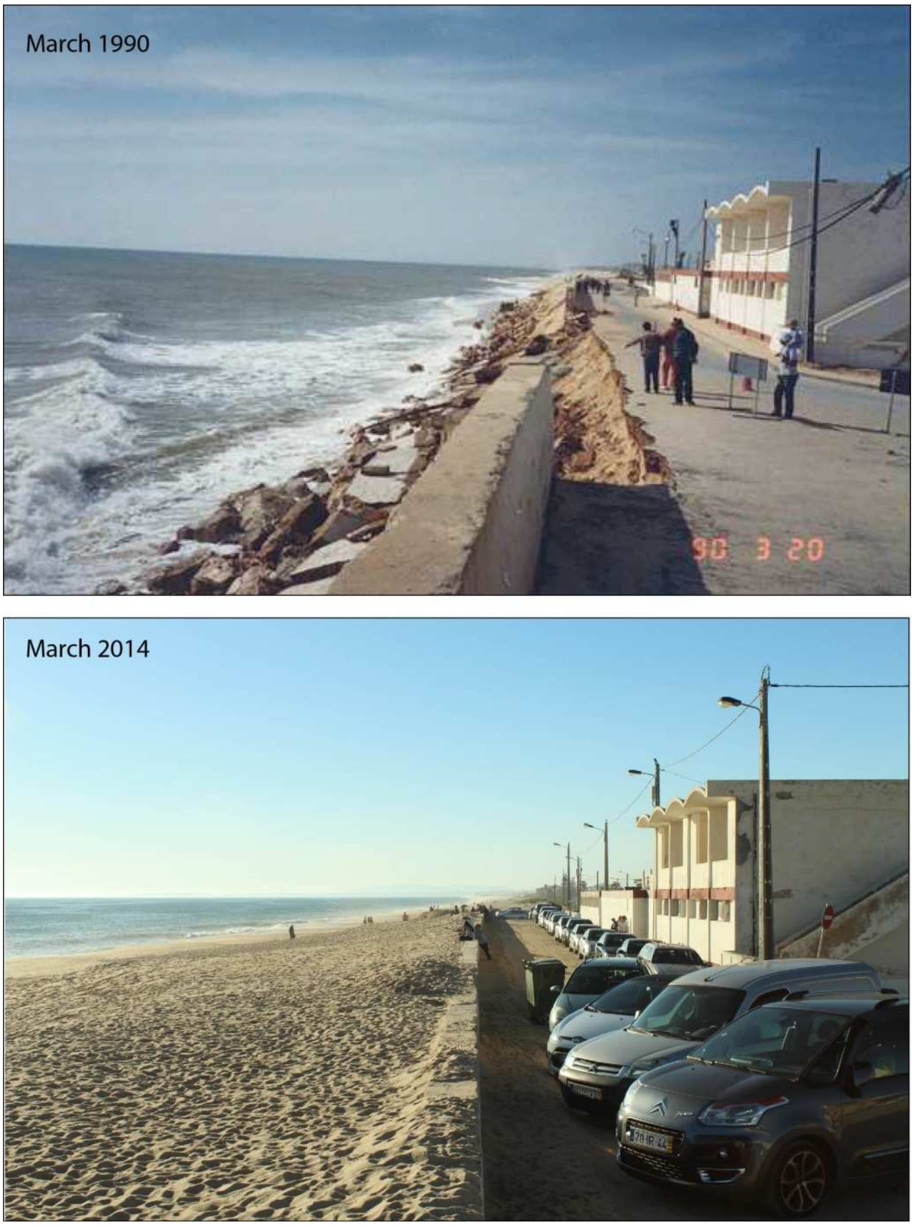

Figure 7.10 Praia de Faro after the 1990 storm where the road was damaged and presently.

Illegal houses have been constructed all over along decades, are reconstructed when destroyed and often increased in dimension (including several floors). People with a first house or a "beach house" at the islands, in general defend the (hard) protection scheme maintaining the present level of occupation, while visitors and beach goers are prone to a more building with nature approach.

A few exceptions occurred however on lessons learned, namely at areas managed by the Natural Park, and never at areas managed directly by municipalities. Those exceptions include:

- Dismantling and removal of about 80 second houses located at the dune ridge at Praia de Faro in 1987 (to the east of the road).
- Dismantling and removal of 3 houses (including relocation of one family) near the artificially opened Ancão Inlet in 1997.
- Dismantling and removal of about 40 houses occupying the dune ridge at Fuzeta Island after inlet breaching (March 2010).
- Dismantling of about 90 second houses at the East and West sides of Praia de Faro in 2015 as a part of POLIS Program. Several others are still planned to be destroyed as an environmental recovery action more than as a DRR measure.

Other DRR policies often used in the Algarve, at occupied areas, like direct beach and dune nourishment were not used (or to a very small extend) in front of occupation at risk, namely Praia de Faro. Monitoring is not performed on a regular base but exists before and after specific measures (eg., nourishment, dredging, inlet opening).

7.3 Liguria, Italy

Authors: Emmanuel Garnier, Nicola Rebora and Laura Rossello.

Leading historical researches on the RISC-KIT case study site of Bocca di Magra is a real challenge because the valley welcomed a permanent population only at the beginning of the 20th century, especially after the World War I[30]. Indeed, until 1920s, the local population respected strictly the precautionary principle with regard to the natural risks. It concentrates since Antiquity and the Middle Ages in perched villages (Ameglia, monastery of Santa Croce) either in cities created in Antiquity (Sarzana, Luni) on Piedmont, thus not easily flooded.

Fiume di Magra (valley of the river Magra) is then a very vast swampy zone which peoplefled for medical reasons (malaria) but also because the mouth was very exposed on the military (pirates attacks) and natural (flashfloods and seasurges) levels. Consequently, these extreme events were not recorded on the Bocca di Magra's site because they did not cause grave damage for the communities which lived in a safe place. Besides, the navigation on the river resulting from the extraction of the Carrara marble from the 16th century did not leave tracks in the regional archives. They would have been able to supply information on the storms which disrupted this trade.

[30] Storti Maristella, *Il territorio attraverso la cartografia*, Luna Editore, La Spezia, 2000.

7.3.1 Materials and methods

The richest documentary site is the archives of the State of Spezia (Archivio di Stato della Spezia). Archives Collections of the Prefecture (Fondo Prefettura) are undoubtedly the most interesting ones because it contains the archives of the company of drainage and irrigation of the Lunense canal, called «Consorzio di irrigazione del Canale Lunense». It covers a period between the end of the 19th century and 1950s and evokes natural disasters arisen in the valley. All concern floods, generally flash floods which destroyed the valley by taking dikes and by flooding the cultivated land.

On the other hand, no historical data corresponds to a storm either to a sea surge. Old numerous maps were found for the last 300 years, in particular military maps of the "Istituto Geografico Militare" which began to map the zone at the end of the 19th century. Finally, the archives of the State also possess old very interesting photos showing the evolution of the landscape of the mouth of Magra until 1940s.

Several libraries were also visited. In la Spezia, «biblioteca Civica Mazzini» is remarkable because it holds the local newspapers (Gazetta della Spezia, Il Lavoro. Giornale di Spezia, La Spezia, Stampa) from 1860s. Some of them evoke natural disasters in the mouth of Magra. At the municipal library of Sarzana, numerous books were studied and compared with the general history of the valley of Magra. Mainly, these books insist on the agrarian colonization, the floods and on the techniques of drainage and irrigation. Unfortunately, no historical data mentions the effects of storms.

Events occurred at local and regional scales are reported in the RISC-KIT Database. The database contains forcing factors, observations and hindcast data, observed impacts and quantitative and qualitative socio-economic, cultural and environmental data on each event, where possible. We have collected 23 relevant event in the last 400 years. The first historical storm reported dates back to the 11th November 1613 while the last one happened the 19th March 2013. This database includes also the Cinque Terre flood event of 2011. A summary of the events is reported in Table 7.1. For a description of each event: http://risckit.cloudapp.net/risckit/#/.

Table 7.1 Relevant historical event for the Liguria Region (Source: RISC-KIT Storm Database, http://risckit.cloudapp.net/risckit/#/).

Date (dd/mm/yyyy)	Place (in Liguria Region)
11/11/1613	Genoa harbour
17/01/1636	Liguria coastline
18/12/1886	Liguria coastline
27/11/1898	Genoa Harbour
20/10/1901	Bocca di Magra
17/11/1905	Liguria coasline
24/11/1927	Magra riverine flood
18/11/1940	Flash flood in Sarzana
18/02/1955	Liguria coastline
01/12/1976	Central and Eastern Liguria coastline
25/02/1989	Liguria coastline with major damages in the city of Savona and in the Camogli town
27/02/1990	La Spezia Provinc
26/12/1999	Liguria coastline
06/11/2000	Liguria coastline
30/10/2008	Liguria coastline between the towns of Celle Ligure and Sestri Levante
21/10/2009	Liguria coastline
30/11/2009	Central/eastern part of the Liguria coastline
01/01/2010	Liguria coastline
04/05/2010	Liguria coastline in particular its western part (town of San Remo)

25/10/2011	Cinque Terre
15/12/2011	Liguria Coastline in particular its eastern part (between the cities of Genoa and La Spezia)
26/10/2012	Eastern part of Liguria coastline
19/03/2013	Liguria coastline

7.3.2 Historical overview

This section firstly focuses on the landscape evolution of the area. This overview is useful to understand the different perceptions on the historical storms/floods over the time. Then, a specific section follow on the occurrence of storms and floods (flash floods) in the area of Liguria (regional scale) and Bocca di Magra (local scale).

The landscape evolution of Bocca di Magra between XVII and XX centuries)

The map of the valley of Magra in 1626 reveals the organization of the territory between Sarzana and Bocca di Magra (Figure 7.11). The valley was totally depopulated and occupied by wetland, meadows and fields. On the other hand, cities and villages (Sarzana, Castelnuovo and Luni) were settled on Piedmont or at the top of hills. At that time, no indicator of drainage of these wetland can be observed in the lanscape.

The situation is appreciably the same on the map of 1834 (Figure 7.12). The populating is similar (Piedmont and hills) and the valley is not drained. The sinuous course of the Magra river was characterized by numerous meanders, islands and floods. The mouth opened on an island of triangular shape which translated a strong floods due to a moderate flow of the river.

The landscape visible on the map of 1928 is very different from previous times (Figure 7.13). It is the time of the landscape break which began in reality at the end of the 19th century with the systematic drainage of the wetland within the framework of the works led by the company of drainage and irrigation of the Lunense canal, called "Consorzio di irrigazione del Canale Lunense". We see so perfectly the network of the pipes of drainage and irrigation on the north bank of the river which was occupied by swamps and meadows since the 17th century.

On the map of 1928 an island is visible while on the photo of 1930, two islands appear in the mouth of the river. They will disappear in the 1950s. Banks are uninhabited and they welcome the transport ships of the marble. The urbanization is very marginal on the map and on the photography and limits itself to some islands consisted of farms and barns (orange circles). It is only on the map of 1938 (Figure 7.14) that appears the urbanization core of Bocca di Magra and Fiumaretta with some isolated houses.

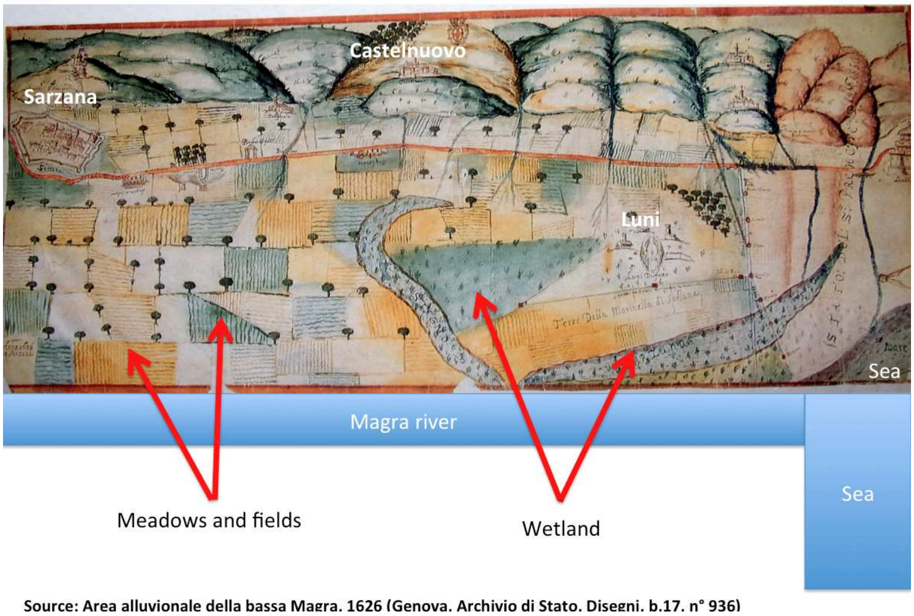

Figure 7.11 Map of the alluvial valley of Magra between Sarzana and Bocca di Magra in 1626 (Source: Area alluvionale della Bassa Magra, 1626. Genova, Archivio di Stato, Disegni, b.17, n°936.).

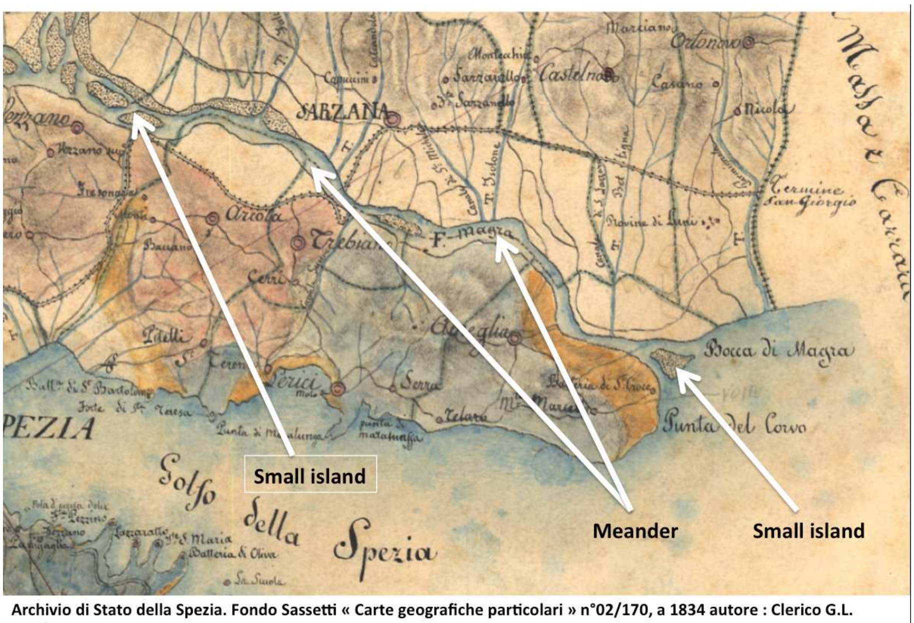

Figure 7.12 Magra valley in 1834 (Source: Carte geografiche particolari, fondo Sassetti n°02/170, a 1834, Archivio di StatodellaSpezia).

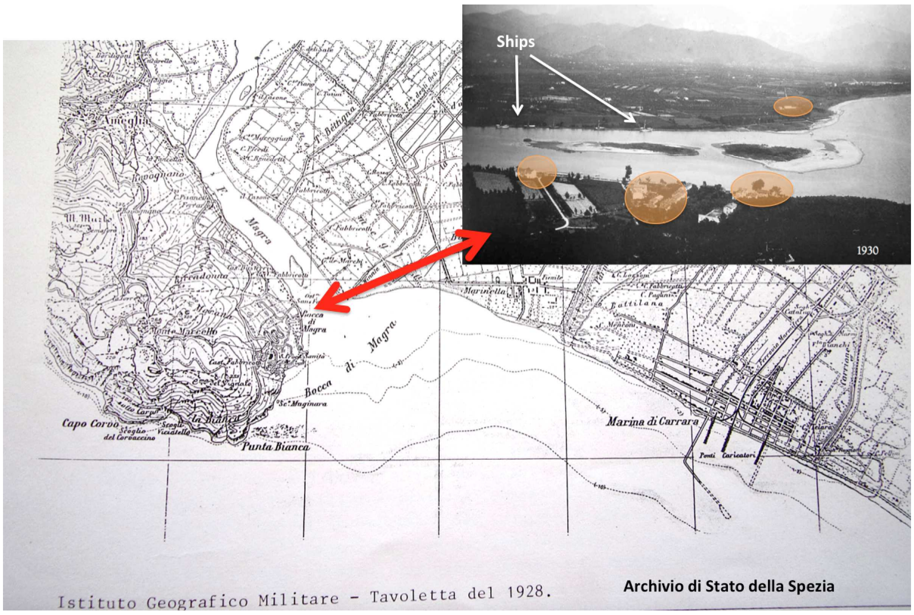

Figure 7.13 Valley of Magra in the 1930s (Source: Fondo Vecchio Catasso Fabbricati « Mappe Antiche », La Spezia Mappa n°171 Ameglia/Fiumaretta, Sec XXes).

Figure 7.14 Map of Bocca di Magra's mouth in 1938. The red circles indicate the cores of urbanization of Bocca di Magra and Fiumaretta (Source: Archivio di Stato della Spezia).

Historical extreme events

Two types of natural risks threaten Bocca di Magra for centuries. Indeed, storms and floods (flash floods) hit the area since XVII century.

The storms. Only six historical storms were extracted from the historic documentation between the 17th century and the mid-20th century. The first one occured on November 11th, 1613 and struck, according to the historical sources, the whole Liguria, in particular the city of Genoa. The engraving of the German artist Joseph Furttenbach describes a very impressive «mareggiata» in the harbour (Figure 7.15)[31]. Probably exaggerated, the engraving shows waves of several meters which caused the wreck of caravels and galleys within the harbour. To the right and at the bottom of the scene it can be noted that the sea broke the dike and ìtook people.

On January 17th, 1636, a severe wintry storm hit Liguria. In Genoa, the damages were important but it is difficult to know if the coast underwent a sea surge[32].

Figure 7.15 Engraving of the storm of November, 1613 in the harbour of Genoa (Joseph Furttenbach, Newes Itinerarium Italiae, 1627. 110x155mm).

If this extreme event struck Genoa, we cannot assert that it affected Bocca di Magra sector, for lack of finding proofs in the local archives.

The following storm occured much more late because it is mentioned in the documentation on December 18th, 1886. For the first time, the event concerned an

[31] Joseph Furttenbach, Newes Itinerarium Italiae, 1627. 110x155mm.

[32] Gallino, S., Benedetti, A., Onorato, L., Wave Watching. Lo spettacolo delle mareggiata in Liguria, HOEPLI, 2011.

area close to Bocca di Magra. More exactly, it involved a violent hurricane associated with «almighty» waves which submerged the ligurian coast and sank a ship coming from Sardinia. At Lerici, waves breached a part of the dike and submerged rip-rapsand a part of the city was flooded.

A new storm ravaged the ligurian coast on November 27th, 1898. Dozens of ships were sunk or grounded far inlands because of the strength of waves. In Genoa, the sea caused a 24 meter breach in the Lucedio dike (Figure 7.16).

Figure 7.16 Photography of the Lucedio dike (Genoa) damaged by storm of November, 1898 (Source: unknown).

The first example of storm having affected directly the site of Bocca di Magra is mentioned in the newspaper *Gazetta della Spezia*. It occurred at night of October 20th, 1901 and the press article seems to indicate that it did not concern the rest of the Liguria. «Maestrale» (Wind from NW) would have played a major role in the disaster. The alert was given at 3 o'clock in the morning by the semaphore of Monte Marcello and at 6 o'clock in the morning, the authorities of la Spezia were informed about the storm and about its catastrophic effects. More exactly, 38 boats called «Navelli» and «tartanes» which transported the marble were taken towards the sea while others were grounded on the banks of Bocca di Magra.

There was no deaths because the sailors often preferred to jump on the ground since boats moored on banks. The help were late because the valley was still uninhabited at the beginning of the 20th century. Consequently, the help came from the Italian navy since the arsenal of la Spezia, the Carabinieri and police of the finances (Guardia di Finanza) from Santa Croce. The mayor of Carrara sent on-the-spot a doctor and police lieutenant to help the shipwrecked sailors. However, the social consequences of the disaster were important. Numerous local families got unemployed because of the loss of boats transporting the marble. An expertise made by the secretary of the treasure of Castelnuovo Magra (7 km in the northeast of Bocca di Magra) estimated the amount of the losses at 150,000 liras (value of 1901).

Bocca di Magra faced finally a violent storm on February 19th, 1955 which is well documented by archives and press. Meteorological Offices specified that the speed of winds was more than 100 km/hour and that the pressure reached 739.2 hPa. Graver, waves from 10 to 13 meters broke out on the region and Genoa and took the dike.

The floods. The floods of the 19th and the 20th century are mentioned but not described in detail by archives because they damaged only farmlands. On the other hand reports are clearer from 1920s with the populating of the valley and the construction of the port of Carrara.

In November 27th, 1927 after very violent rains, torrents rose and flooded the valley of Magra. The river Magra invaded all its bed and numerous bridges were destroyed between Villafranca and Bocca di Magra. Roads were also cut[33].

About the flood of the November 18th, 1940 archives and testimonies describe pouring rains for 24 hours. The waters destroyed the dikes of the Magra valley. All the region of Sarzana up to the sea was flooded. Numerous peasant houses built recently in the plain were destroyed. The bridge connecting Romito with Sarzana was destroyed. Soldiers and sailors in boats helped the victims as well as the cattle[34].

7.3.3 Lessons learned

The Liguria Region, where the case study of Bocca di Magra is located, is a narrow strip of land between the Ligurian Sea (south) and the Ligurian Appennine (north). This geographical configuration make it prone to many natural hazards, and in particular Floods/Flash Floods, Storm, Forest Fires and Landslides.

Floods and Storms are the two natural hazards that are considered in the RISC-KIT project and among the most relevant for the region.

Historically, the widespread awareness of flood/storm risk dates back to the second part of 20th century. For three main reasons:

1. Political stability in Italy after World War II that generates an increase of wellbeing in the population
2. Boost of human interaction with the territory in order to answer to the increasing request of spaces and buildings due to the industrial development. This was particularly true in the harbour areas of Genoa, La Spezia and Savona.
3. Awareness of natural hazard raised up by flooding events.

In previous sections is described the historical evolution of the landscape in Bocca di Magra that is a good snapshot of the evolution of Liguria coast in the last centuries.

The first solutions adopted (from 1950 to 1990) were mainly related to structural measures (e.g. dikes in front of the harbours) that helps in the local mitigation of hazards .

[33] Archivio di Stato della Spezia (Fondo Prefettura).

[34] Birolli, G., *Bocca di Magra*, Milano, 1998

However, triggered by critical events such as the Genoa flood in 1970, along with the structural measures and land-use planning the need of adopting non-structural measures become more important and urgent.

It is paradigmatic the case of the Bisagno river. The need of space for the development of the city suggested to gain room using the only way available: covering the last part of the Bisagno. But this action, despite allowing for more room, changed in a dramatic way the flooding probability in the area. It is important to notice that the awareness of flood risk (especially in the population) came tens of years later, when the major flood events occurred. And flood events still occur because the structure of the city cannot be changed in a significant way.

This example shows how non structural measures, such as Early Warning Systems, alert procedures and emergency plans at local level are among the most effective and state-of-the-art procedures for dealing with flood and storm risk in the recent years.

The time needed for implementing significant structural measures is now of about 10-20 years and very subject to political changes. On the other way, non-structural measures, such as effective civil protection procedures, can be implemented quickly and are most cost-effective. For this reason they are of paramount importance in managing the natural hazards and risks.

For these reasons, from the 1990's on, the non-structural, green and soft measures became a fundamental pillar for implementing effective DRR policies, at local, regional and national level.

As an example of operational non-structural measure, we show in the following all the information (both in real time and procedural) that is available on the Liguria ARPAL/Civil Protection website http://servizi-meteoliguria.arpal.gov.it/protezione-civile/index.html (in Italian).

For what concerns the marine storm hazard, in case of persistent and intense waves along the coasts, two risk scenarios are identified. Each scenario is associated to a levels of surveillance that are: WARNING (most severe) and ATTENTION (least severe).

For the marine situation (as in other meteorological phenomena such as heavy showers and thunderstorms, wind, physiological discomfort) regional procedures do not provide the enactment of a state of alert, but refer to Warnings to be taken at local and individual self-protection measures .

In the following we report a summary of the information for the population associated to each level of surveillance. In Table 7.2 the information related to the WARNING scenario. Similar information is available for the ATTENTION case.

Riverine flood alert procedures follow the same lines presented in Table 7.2 but in this case the risk is associated with diffuse rains that for their characteristics of persistence and/or intensity can generate different risk scenarios on the ground and the subsequent enactment of levels of surveillance/warning that are ALERT 2 (the highest), ALERT 1 and WARNING (the lowest).

The way forward in dealing with storms/floods is mainly based on a variety of measures especially non-structural ones dealing with increasing local awareness and improvement in the policies.

The proposed measures address the most relevant threats, floods, flash floods, landslides, storm surge, wave action and beach erosion. The main gaps are the lack of "last mile" policies/actions able to really reach the citizens and very local stakeholders. These actions are related to prevention, preparedness and mitigation measures.

There is still the need of complete the implementation of the existing risk reduction measures or management plans, program of training and exercises with the citizens of different towns, increase the awareness of this type of risks in people and informing them about the behaviour to follow in emergency situations.

RISC-KIT will meet the gaps and shortcomings related to coastal risk assessment and implementation of combined EW/DSS systems. On the other hand, it is expected RISC-KIT to contribute to find suitable solutions with respect to storm/flood/flash floods on a decision support level rather than in terms of early warning. In this case indeed the alert system defined by National and Regional Civil Protection is already working with good scores since many years.

Table 7.2 WARNING scenario: information for the population.

WARNING
SCENARIO: very rough seas with possible intense storm surges. Danger for bathing and water sports, with damage along the exposed coasts and ports to vessels and structures.
SELF-PROTECTION MEASURES: 1. Avoided beach activities and water sports; 2. Depart promptly from the coastline and from areas potentially accessible from the storm; 3. If you can not get away from the affected areas in time, go to the top floors of the buildings and wait for the arrival of relief; 4. Avoid covering the roads or paths near the coast, both on foot and with any kind of vehicles 5. Do not connect appliances to the power grid in the areas covered by water.
MESSAGES AVAILABLE: 1. WEATHER ALERT with forecasts of weather risk emanating from ARPAL 2. BULLETIN LIGURIA issued by ARPAL

7.4 Emilia-Romagna, Italy

Authors: Emmanuel Garnier, Clara Armaroli and Enrico Duo.

The original name of the place is "Porto di Magnavacca". It took the name "Garibaldi" at the beginning of the 20th century in memory of the disembarkation of the great Italian national hero Giuseppe Garibaldi who landed on the site in 1849. Today, Porto Garibaldi is part of the municipality of Comacchio (Figure 7.17).

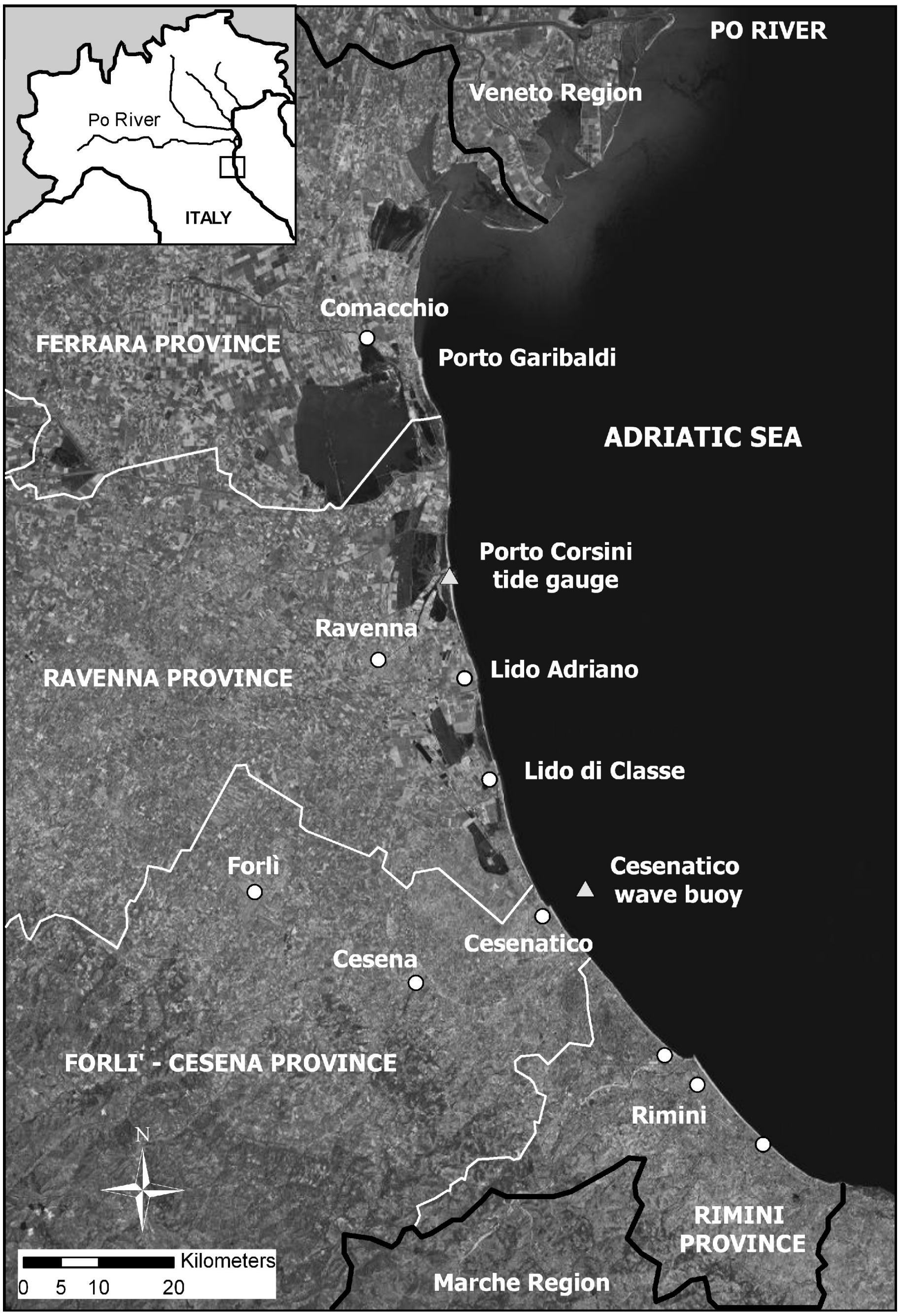

Figure 7.17 The Emilia-Romagna coastline: the location of sites cited in the text are highlighted.

7.4.1 Materials and methods

Despite its very belated creation in the early 20th century, the coastal city of Porto Garibaldi paradoxically offers abundant historical documentation. This documentary reality is explained by the fact that this territory is the only coastal outlet of the old Comacchio city. In fact, Porto Magnavacca (present territory of Porto Garibaldi) enabled Comacchio to export its salt production and fishing since the Middle Ages.

Thanks to this economic advantage, Comacchio became a powerful city, competing with Venice until the 13th century. Due to its economic power, it early adopted a municipal bureaucracy providing an exceptional historical documentation. Municipal archives (Archivio storico del Comune di Comacchio) contain particular municipal acts. These were drafted after each meeting of the council, especially during natural disasters. Although they are primarily interested in flooding from the neighbouring rivers (Po, Reno, Goro Sennio, Savio and Montone) in the city and in the marshes, these deliberations regularly mention the damage caused by the sea in the area of Magnavacca.

The regional press was also examined because it recorded the historical storms and flooding. Information is given for the "Mareggiata" (storm surge) in 1927 by the local newspapers *Gazzetta Ferrarese*, *Corriere delle Romagne* and *Corriere Padano*. Finally, the libraries of Ferrara (Biblioteca Ariostea) and Ravenna (Biblioteca Classense) keep archives on regional flooding since the 17th century and old maps outstanding collections. They allow to observe the evolution of the coast of Magnavacca from the 16th century to the 1960s and to understand the geological consequences of the storms in Porto Garibaldi for a 400 year time-span. Maps of the area are also conserved by the Kriegsarchiv (War Archives) of Vienna.

7.4.2 Historical overview

Variations and intensity of extreme events: 16th-century mid 20th century

The literature reveals that Porto Garibaldi and Comacchio region are threatened by two types of major risks: river floods and "mareggiata", Italian name for storm. Regularly, this is the situation of the two phenomena causing real disaster for the residents, because the strong waves prevent rivers from flowing into the sea. It is therefore difficult to ignore one or the other extreme events because of their close link.

<u>Method</u>. A major problem is the lack of instrumental data (river flow, pluviometry, water levels) in archives previous to 1850s in this part of Italy. It is thus very difficult to properly quantify the floods and the storm surges from written archives. We thus propose another way to quantify flooding by taking into account the contents of archives and the documentation. The method addresses the problem by using 6 grades, of which one is a negative (Table 7.3). The five positive grades (from 1 to 5) estimate the flood according to its geographical, social, material and economic impact. The grade -1 corresponds to a flood for which it is impossible to know its exact date, its duration and its socioeconomic impact. This negative grade allows us to keep this type of event in the chronological series even if its severity cannot be estimated.

Results and discussion. Fifteen major events were identified in regional archives between 1562 and 1927 (Figure 7.18)[35]. 7 floods(blue in Figure 7.18), 2 storms (red in Figure 7.18) hit the territory of Comacchio and Magnavacca between 1562 and 1927. Moreover, 6 events (green in Figure 7.18) presented both flood and storm impacts.

Table 7.3 Method of assessment of the severity of historical floods before the instrumental period.

Category	Type of damage according with historical archives
5	Exceptional event because of its geographical scale (local, regional and national), financial and social (scarcity, riots, mortality)
4	Very big damage on a regional scale: hydraulic plants, bridges, farms, cattle, harvests, lines of communication
3	Important damage, but limited to some localities or to a city: cost, scarcity, cattle drowned, human mortality
2	Little important and localised damage: some villages, farmlands, wetlands, neighbourhood of the river
1	Mentioned in sources, not much damage, local event
-1	Mentioned in sources, absence of further information

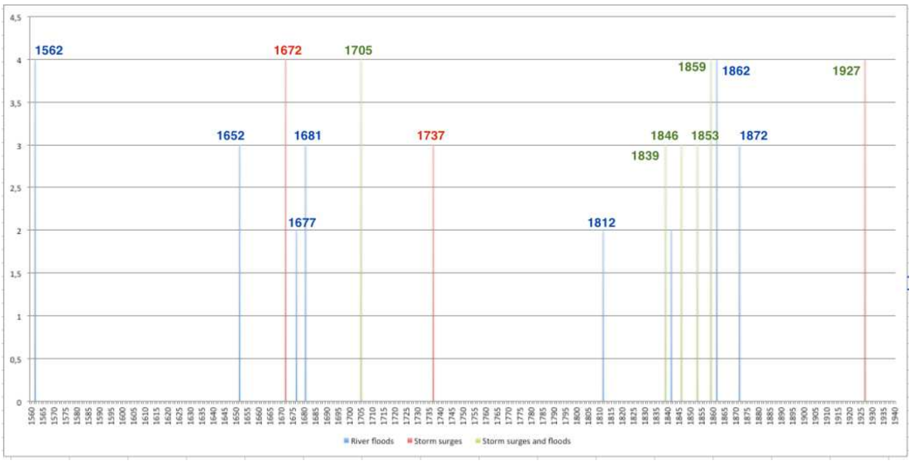

Figure 7.18 Variation and intensity of extreme events in Porto Garibaldi and Comacchio region between 16th century and mid-20th century: the blue dates correspond to floods, red dates to storms and green dates to the concurrent happening of a flood and a storm.

[35] For more details, see 'WP1 Physical Data Table Porto Garibaldi'.

In terms of variations, large disparities appear. The 1550-1650 period undergoes only one event: a flood in 1562. This lack of extreme events can be explained through two reasons. The first would be gaps in the documentation, an implausible hypothesis because municipal deliberations do not contain gaps during this hundred years. Therefore, if a disaster occurred, it would have been recorded in the municipal archives. The second possibility, more likely, is landscape and climatic hypothesis. The years 1550-1650 represented a kind of climax of the Little Ice Age, in other words a colder episode that would have limited rainfall and decreased storms in the Adriatic Sea. De facto, this assumption is fully supported by the work of the historian Dario Camuffo about the frequency of sea surges in the Adriatic[36]. It perfectly shows the decrease in frequency from the middle of the 16th century to the 1650s. Furthermore, during this period, the marshes of Comacchio valley rather remained protected despite some limited drainage works (Figure 7.19). A natural dune about 450 meters wide separated the sea to the marsh, while the current site of Porto Garibaldi hosts only a small port and a military defence tower also used as lighthouse. Thus, the natural character of the site probably contributed to a better water regulation.

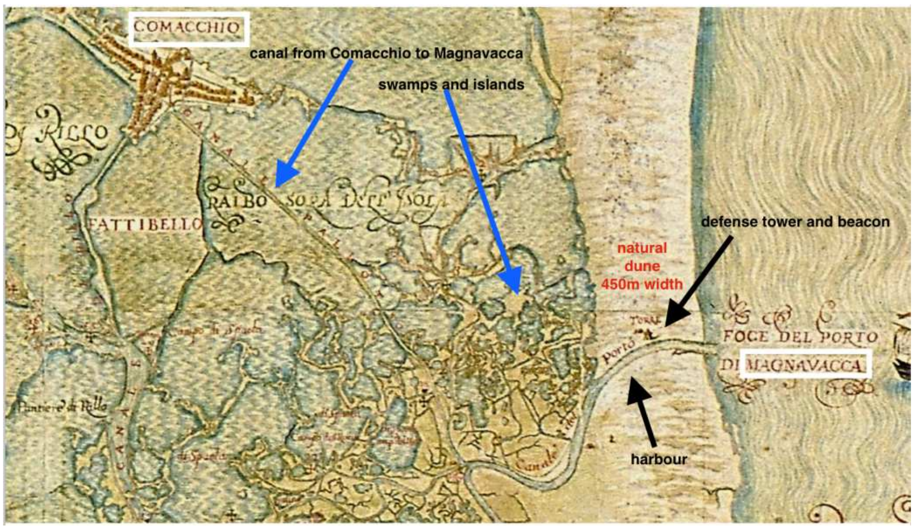

Figure 7.19 Magnavacca and Comacchio map 1600-1650 (Mappa dell'Ardizzoni, Archivio di Stato di Modena, 1:15.000).

A second period of moderate frequency (6 events) can be observed between 1650 and the 1730s. Climatically, the period is marked by a relative lull in the Little Ice Age and a higher frequency of climate extremes. Once again, the work of Camuffo et al. (2000) confirms this observation. Four floods (1652, 1677, 1681 and 1705) and three storms (1672, 1705 and 1737) affected the case study.

A real time breakdown can be observed between the 1840s and 1870. During this 30 year long period 7 extremes are recorded of which four storms. The peak is overall the more remarkable, as it suddenly dropped after the 1870s. The site enjoyed a long

[36] Camuffo D, Secco C, Brimblecombe P and Martin-Vide Javier, 'Sea storms in the Adriatic sea and the western mediterranean during the last millennium', *Climatic Change*, 46 : 209-223, 2000.

remission 55 year long until 1927, the year of the disastrous “mareggiata” in Porto Garibaldi.

The Comacchio Valley was deeply modified by massive drainage and by the creation of a huge private saltwork in the early 19th century (Figure 7.20). The width of the dune significantly decreased (approximately 200 m compared with the 17th century). Behind the dune, the soil was drained to develop farmlands. In the 20th century, these new farmlands will host the city of Porto Garibaldi.

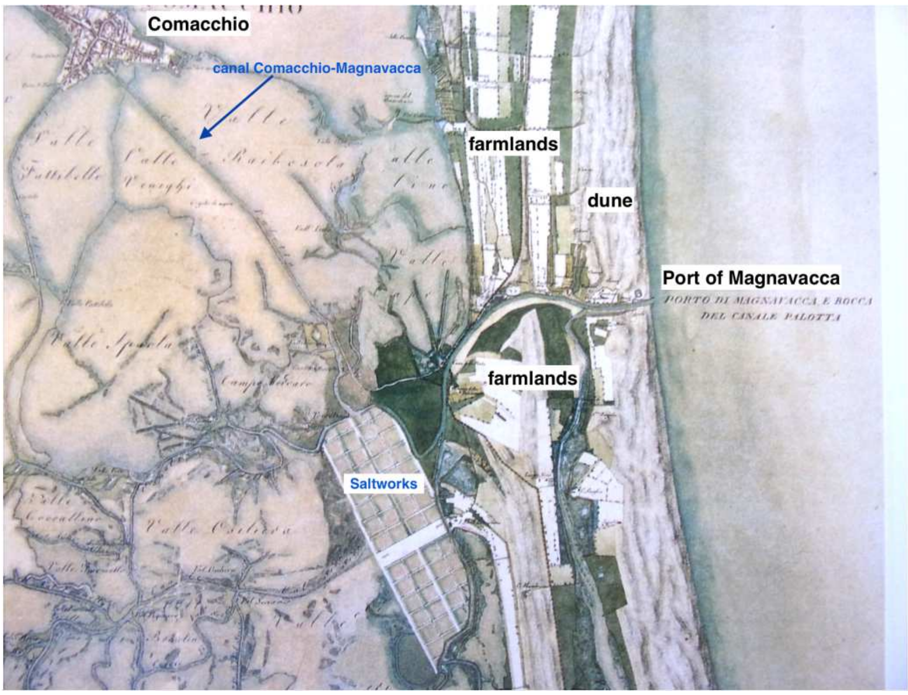

Figure 7.20 Map of the region of Porto Garibaldi (Magnavacca on the map) in 1860 (Topografia del territorio ferrarese, Vienna, Kriegsarchiv)

A major event: the “mareggiata” on 22nd February 1927

The catastrophe of 1927 is fortunately well documented in local newspapers and in the literature of the time. Indeed, weather stations already existed in the northern Adriatic (Venice, Ferrara, Bologna, Rimini).

Historical sources talk about a meteorological episode extremely bad throughout Italy (North and South).Heavy rain and thaw snow in the Apennines affected the entire Emilia-Romagna region. In Porto Garibaldi, meteorological reports explain that because of the heavy rain and a powerful “Tramontana” (the North to South wind), the onshore coastal current met the powerful flow of the harbour channel[37]. The double phenomenon therefore provoked flooding from both river and sea. Floods do not spared the neighbouring towns. Rimini was a victim of the overflow of rivers Ausa and Marecchia while water invaded the streets of Comacchio. On the atmospheric level,

[37] Gazetta Ferrarese newspaper, 22/01/1927 and Gli Annali Idrologici 1927.

hydrological Annals registered in Venice a barometric pressure of 1002 hPa (Figure 7.21).

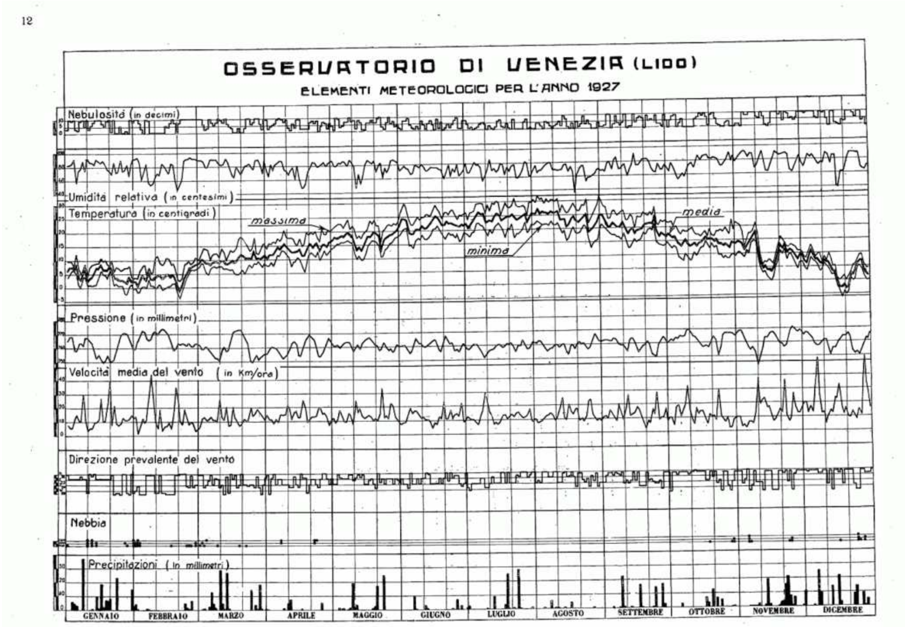

Figure 7.21 Extract weather observations from January 1927 in Venice (Gli Annali Idrologici).

In the catalogue of Camuffo et al. (2000), the 1927 event is one of the highest "Acqua Alta" recorded in Venice since the year 782. Moreover, this storm surge coincided with very strong North winds and high outflow from the Porto Canale.

Damage caused by the storm should be evaluated with caution because of fascist propaganda (Benito Mussolini government) that took advantage of the disaster to promote the government's action. However, the technical content of the reports and newspapers gives a reliable idea of the losses and costs. On-site, the waters of the sea and the canal flooded the docks channel while powerful waves broke most of the breakwaters.

The beach, situated on the left-hand side of the harbour, suffered a strong erosion and other beaches were also strongly damaged. Dunes were severely damaged as well. The restaurants and *Bagni* (private beaches and facilities) "Apollo", "Esperia" and "Nettuno" were totally demolished by waves.

The line of houses behind the beach was struck by the sea and a report states that certain houses "seem to have exploded" and some witnesses dared a comparison with the explosion of grenades. Besides, the coastal road was cut and Porto Garibaldi got almost isolated from the rest of the region. Financially, the balance sheet was very heavy for the time as the authorities estimated it to be € 516,000. However, no source mentions deaths among the local population.

The 4th November 1966 event

The storm was particularly critical for the Emilia-Romagna coastline and caused extensive erosion and flooding due to marine water ingression and river overflow from the persistent heavy rainfall. The event was characterized by very high water levels (in Venice the highest level ever observed was recorded at 1.94 m above reference datum; in Goro, at the boundary between the Veneto Region and the municipality of Ferrara, the recorded water level was 1.20 m MSL); wave heights reached around 6-7 m offshore (estimated wave height, gauging stations not present at that time). The high surge level was caused by persistent and strong winds from the south-east (named Scirocco).

The whole coastline suffered from erosion and inundation, especially in the province of Rimini (southernmost province in Emilia-Romagna, Figure 7.22). The Po river delta area, Veneto Region, was inundated and agricultural activities were deeply affected by the event. The majority of farmers and their families moved away from the area, leaving their land abandoned, to find work at industrial sites in other regions (Piemonte and Lombardia). Between 1961 and 1989 the population decreased from 14 to 11 thousand people.

Considering the whole coastline of the Ferrara province, between Goro and Lido di Spina, a total of 8600 hectares of land were flooded. Porto Garibaldi was inundated by both marine and fresh water through the navigational channel of Porto Garibaldi itself. The flooding caused damage to structures and particularly to the main coastal road (the SS Romea). Regarding the case study site (CSS), i.e.: the area between Porto Garibaldi and the Reno river mouth, a significant erosion of the beach occurred, particularly at Lido di Spina.

During the storm several urgent interventions were carried out by the Fire Brigade, Police and local residents. At Goro, the northernmost town of Emilia-Romagna at the boundary with the Veneto Region, sand bags were placed along the retaining wall that separates the port from buildings, to reduce the water inflow. Almost 80 families were moved away from their homes.

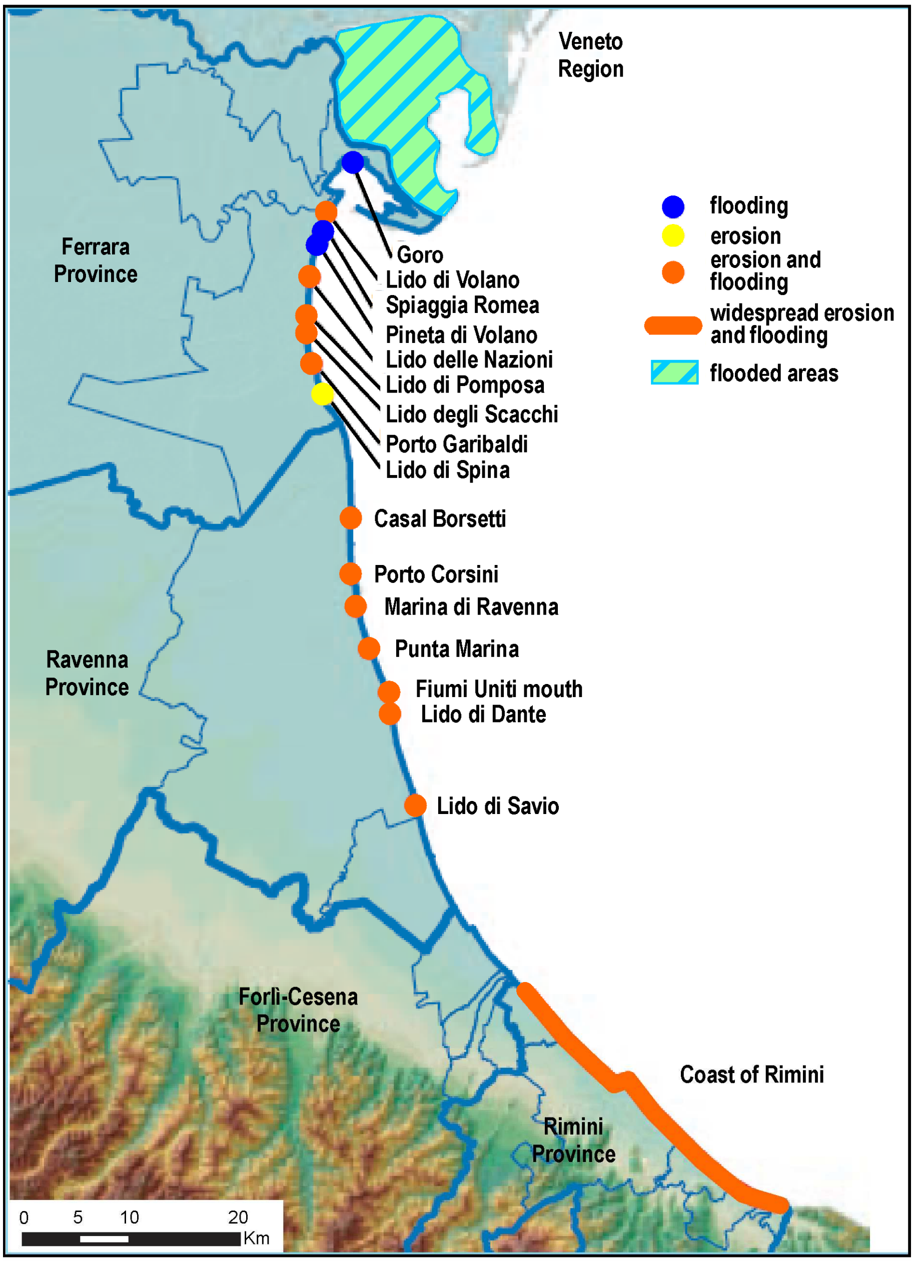

Figure 7.22 Impacts of the 1966 storm along the regional coastline. The eroded and flooded areas are highlighted. The polygon named "flooded areas" represents the portion of the Veneto territory flooded by the Po river overflow coupled with marine flooding (modified from Perini et al., 2011).

The 22nd December 1979 storm

The storm was characterized by high water levels (1.66 m in Venice; 1.64 m in Porto Corsini, Ravenna and 1.96 m in Rimini) due to persistent south-easterly Scirocco winds. The estimated wave height was around 4-5 m offshore.

The whole coastline was affected by erosion and flooding (Figure 7.23). The Ravenna coastline was the most affected province, where bathing establishments were destroyed by the sea, with the water in some areas reaching the first floor of beachfront buildings, roads were covered by debris, mud and sand. Pine forests and agricultural activities were also damaged. In Marina di Ravenna and Lido di Classe the drinking water supply was interrupted. In Lido Adriano there was the interruption of electricity and gas supply as well as drinkable water. One of the most important consequences of the storm was the inundation of both the AGIP Electric Station in Porto Corsini and the AGIP oil company industrial plant in Lido Adriano, which had to be temporarily shut down. Many factories were flooded with the consequent damage to stored goods (the monetary loss was estimated at 1 million Euros). It was reported that one person died because of an heart attack (a driver trapped in his car was hit by waves and high water levels). In the Rimini Province there was flooding, damage to structures at sea and further inland as well as beach erosion. The port of Riccione, which is located at the mouth of and along a navigation channel, was closed because its entrance was obstructed by sand and debris and other loose material brought by the waves or delivered to the canal from inland.

The Ferrara Province registered mainly flooding and damage to structures. The most significant inundation points were caused by the overflow of both the navigation channels of Goro and Porto Garibaldi. The water level above the Goro port embankments reached 1.5 m while in Porto Garibaldi it reached 0.2 m above a road nearby the channel. Lido di Volano was severely flooded and marine water reached the pine forest behind the village (almost 100 hectares of forest were inundated). Many bathing establishments were severely damaged. Damage to the CSS were not reported. During the storm several urgent interventions were carried out by the Fire Brigade and local authorities.

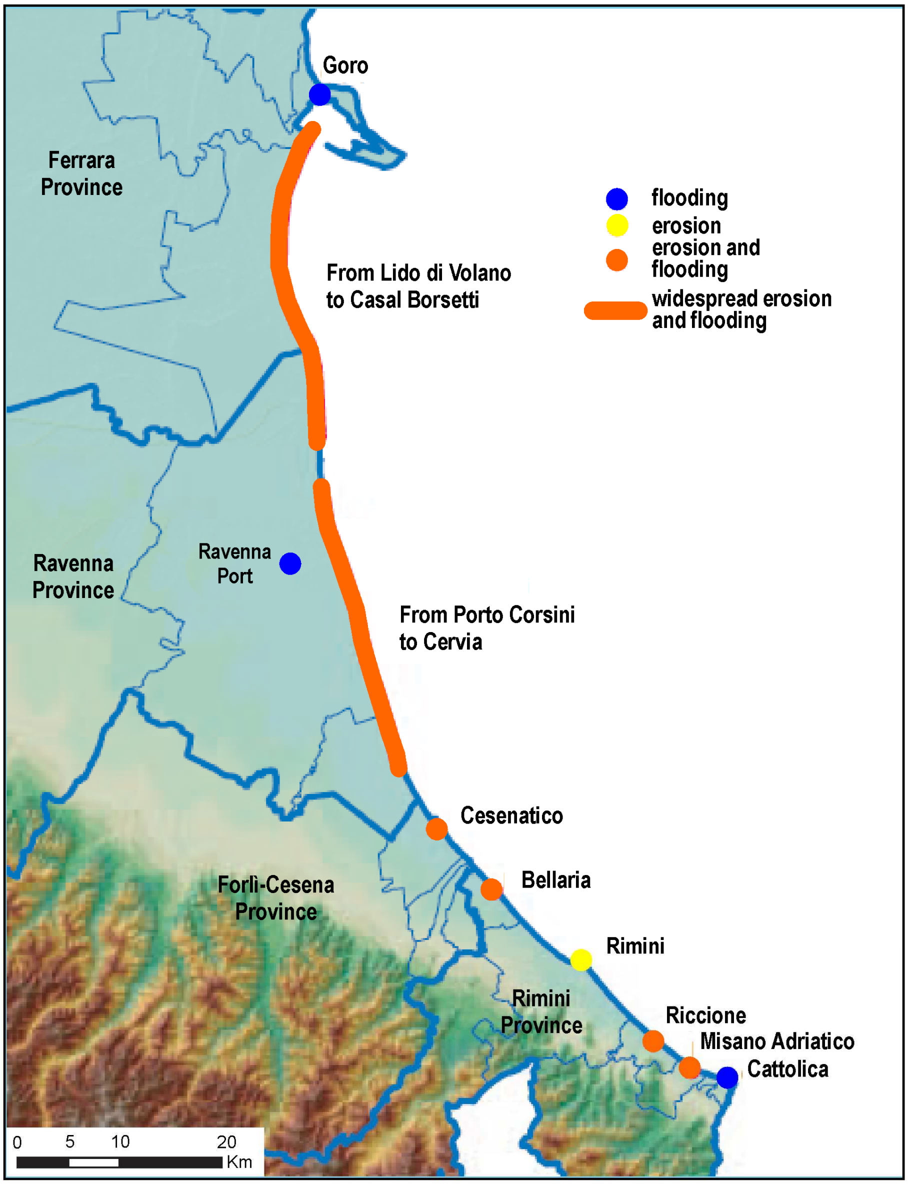

Figure 7.23 Impacts of the 1979 storm along the regional coastline. The eroded and flooded areas are highlighted (modified from Perini et al., 2011).

7.4.3 Lessons learned

Strategies and policies for disaster risk reduction have changed through time according to the increasing urbanisation of the coastal area and the growing number of tourist activities and tourist presence in the summer season. Before 1900s, tourist activities and number of inhabitants along the coast were limited. The site was mostly uninhabited and coastal buildings were rare. The 1970s boom of tourist activities led to the implementation of new measures to protect the coastal area, i.e. to maintain the beach wide enough for recreational activities in the summer season, to reduce the impact of storms during the winter season, to reduce subsidence rates due to water extraction, etc (Regione Emilia-Romagna, 2004).

In the context of the described historical storms, the 1927 event was particularly devastating for the Porto Garibaldi area where beach facilities and buildings located close to the sea were damaged and flooded. Nonetheless, most of the coast was in a natural state and, consequently, records of defence intervention are not available. The analysis of the 1943 Royal Air Force flight (RAF, regional coastal database[38]) shows that the bathing establishments located northward of the navigation channel of Porto Garibaldi were already protected by hard defence structures at that time, i.e. three shore parallel breakwaters, as well as dikes at the river mouth and along the navigation channel (Figure 7.24). The mentioned structures are also visible in an antecedent tourist picture from 1920s (Figure 7.25). In 1943 the only beach facilities along the CSS were on the left hand side of the navigation channel, among which there were likely the *Bagni* damaged by the 1927 storm (see the previous section). On the other hand, from 1927 up to present coastal vulnerability and expose have increased, leading to increasing socio-cultural and economic costs.

The 1966 storm had significant consequences on both the population and the territory and damages were widespread all over the regional coastline. The most affected area was the Ferrara Province where flooding from both rivers overflow and high surge levels were able to inundate a large portion of the territory (8600 hectares due to the marine flooding only). In order to prevent such impacts, in 1968, two years after the event, a 16 km-long earth embankment was built between Goro and Porto Garibaldi named “difesa degli Acciaioli”, in order to protect rear areas from flooding (Figure 7.26). The +3 m embankment was placed at varying distances from the shoreline, ranging from 0.5 km to 1.5 km. Its width was between 7 m and 9 m and its eastern side (facing the sea) was covered with bitumen. The coastline northwards from Porto Garibaldi was in a natural state.

[38] Available at https://applicazioni.regione.emilia-romagna.it/cartografia_sgss/user/viewer.jsp?service=costa

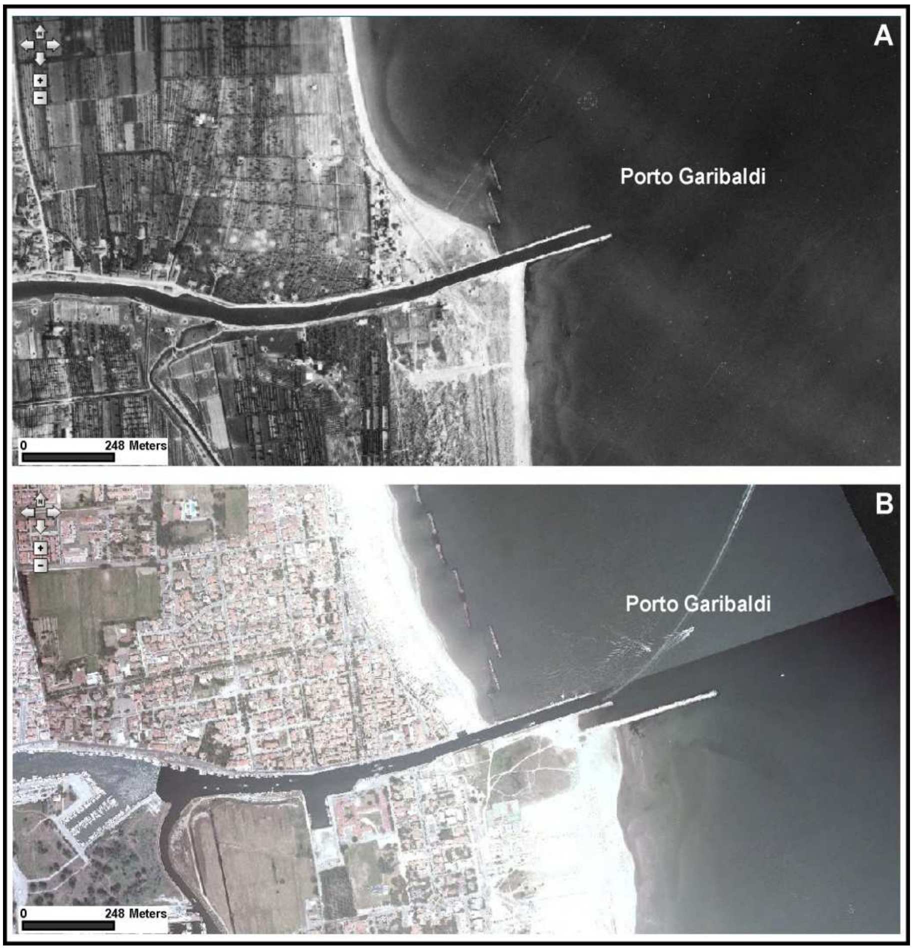

Figure 7.24 Comparison between the 1943 RAF aerial photograph, where shore-parallel breakwater were already present, and the 2005 GAI flight image of Porto Garibaldi.

Figure 7.25 Photo of a beach at Porto Garibaldi in the 1920s. In the background breakwaters are visible (Source: Alessandro Pierotti, Magnavacca. Storie di un lungo viaggio, 2012).

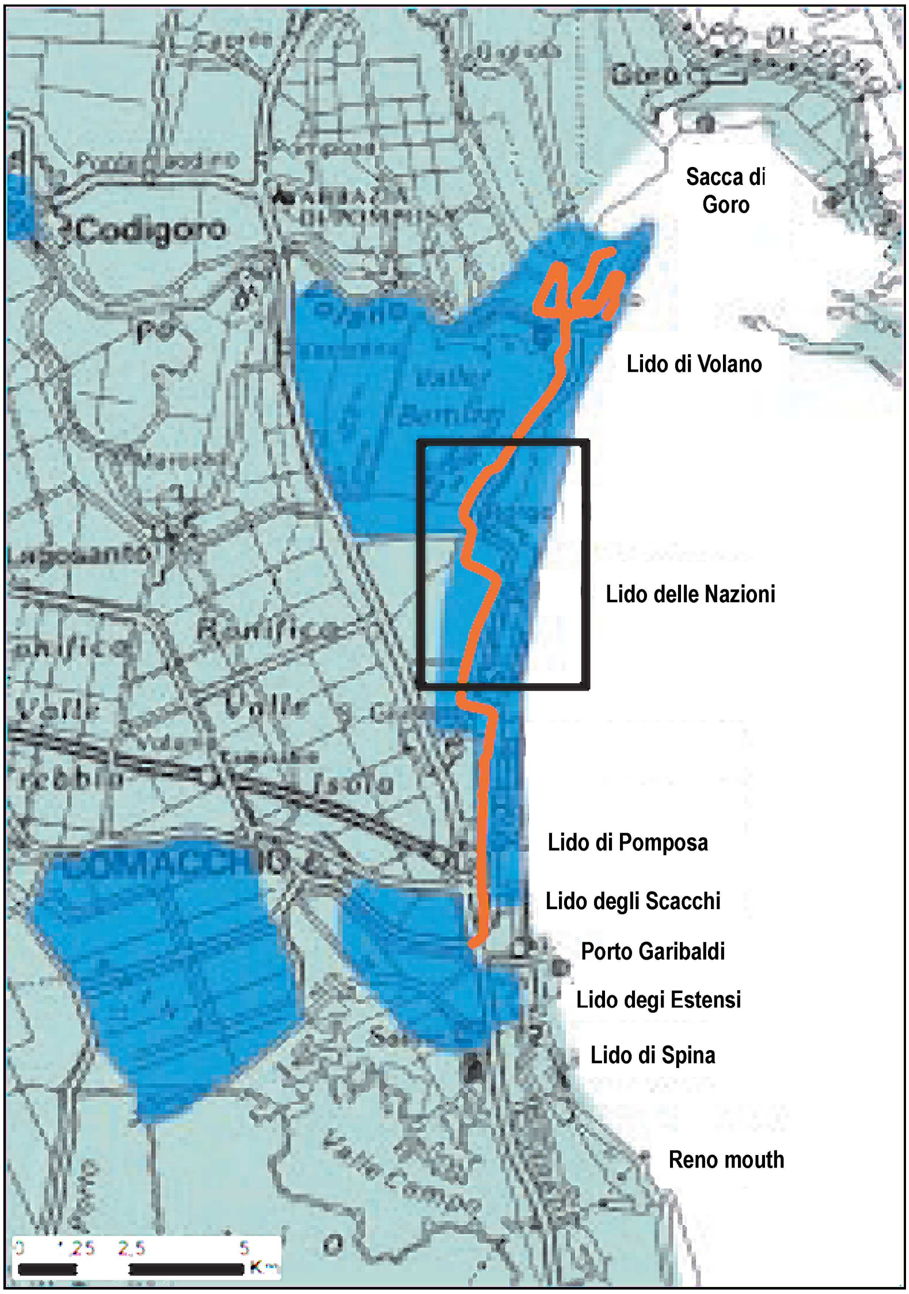

Figure 7.26 1966 flood extension and location of the "difesa degli Acciaioli" dyke (orange line, modified from Perini et al., 2011).

In the 1970s and 1980s, when the economic boom of tourist activities along the coastline reached its peak, the 1966 storm memory was vanished and several tourist villages were built between the earth embankment and the sea (e.g. Lido degli Scacchi, di Pomposa, Nazioni and Volano). Buildings and tourist facilities already present at the time of the storm were maintained and widened. An increasing larger portion of the coast was protected by hard defence structures, especially the Ferrara and Forlì-Cesena provinces, the area of Lido di Classe and Savio in the Ravenna province and the southern part of the Rimini province (evidences from the 1978 Regional Technical Chart, regional coastal database[39].

The 1979 storm was also devastating. After the event a large number of coastal defence structures were built (attached rubble mound slopes, groins and offshore breakwaters), increasing the length of the coastal area protected by hard engineering structures. The structures already in place were maintained and some others were added, especially in the Ferrara and Ravenna provinces (evidences from the 1982 aerial photographs, regional coastal database39[39]). In 1984, with the effects of the 1966 and 1979 storms in mind, a regional plan for the protection of the coastline was issued by IDROSER (IDROrisorse per lo Sviluppo dell'Emilia-Romagna), a regional engineering and environment agency (IDROSER, 1984). The plan contained a large study of coastal characteristics such as its morphological and socio-economic evolution through time, the forcing components analysis of the North Adriatic Sea, characteristics of river discharge, defence structures, etc. A series of interventions were proposed to protect beaches from erosion and avoid inundation. Both the 1966 and 1979 events are mentioned in the plan to highlight the importance to protect the coast and the need to find effective solutions able to mitigate the impacts. The proposed alternatives include both hard structures and soft solutions such as dune reconstruction and nourishments.

A practice carried out after the impact of the 1966 and 1979 storms was the construction of artificial dunes. To provide a short historical excursus, it is important to outline that artificial dune ridges were constructed well before the analysed storms. An example is represented by the Cervia area (Ravenna province) where, after World War II, the National Agency to manage State Forests financed the construction of artificial dunes. They consisted of embankments that were located between the rear part of the beach and the villages at the back and composed of fine to medium sand. The artificial dunes had different elevations and were stabilised with vegetation that was artificially planted. In the Ferrara province, after the 1966 storm, the Po Delta Authority decided to re-build the natural dune ridge, deteriorated by the large number of tourists walking over them and associated economic activities, with a 2 m high artificial dune. Furthermore, because the artificial dune in Cervia proved to be effective to avoid inundation of rear villages during the 1979 storm, the Ravenna municipality decided, after the impact of the 1979 storm, to build in Lido Adriano a 3 km long and 2.5 m high artificial dune that was then stabilised with vegetation.

It must be noted that along the Emilia-Romagna coastal area there is a very important common practice identified as the "winter dune" construction that is the construction of sand mounds to protect establishments from damages and inundation during the winter season through sand scraping from the foreshore (Harley and Ciavola, 2013). Winter dune construction is a traditional *ad hoc* measure that has demonstrated to be, in some cases, useful to avoid marine ingression. This practice begun to take place around the late 1970s, especially in the Forlì-Cesena and Rimini provinces. Winter

[39] Available at:

https://applicazioni.regione.emilia-romagna.it/cartografia_sgss/user/viewer.jsp?service=costa dunes are temporary protections whose construction takes place seasonally. They are located between bathing establishments and the sea. Bathing establishment owners initially carried out the construction and, successively, the practice was regulated and performed also by municipalities. The elevation, width and location of winter dunes was, and still is, decided based on personal owners' experience (not "scientifically" based but according to traditional methodologies handed down through time) and bulldozers are used to move and accumulate the sand. In past years the sand was exclusively taken from the beach itself, scraping the lower part of the foreshore to elevate 2 m high mounds. The practice was carried out on long coastal tracts (order of km; IDROSER, 1984).

At present, the mounds construction is performed along a large part of the coast and building permits regulates it (Regione Emilia-Romagna, 2011). The request for permission is done by owners, or consortium of owners, to the municipality that forwards the request to the Technical River Basin Service that then asks the Regional Touristic Service that gives the permit, following the ordinances given by the Technical River Basin Service. The sand is taken either from outside the beach and/or from the beach itself (from the swash/intertidal area). The costs to buy the sand are usually paid by the owners but in some areas regional authorities or municipalities provide the sand. The practice was regulated through guidelines (not compulsory) issued in 2006 that state that the artificial dune should be <= 2.5 m height from its base, with a 1:4 seaward slope and located outside the usual influence of modal storms (i.e. 1-in-1 year return period). In the guidelines it is proposed to substitute winter dunes with wind barriers that can favour sand accumulation due to wind transport thus acting as protection for coastal structures. Moreover it is stated that the sand should be taken from outside the beach or from the rear part of the beach. These guidelines were issued to avoid erosion problems usually related to the construction of artificial mounds. In fact the use of the sand taken from the lower part of the beach leads to an increase of beach slopes (= higher run-up elevations during storms), to the lowering of the intertidal zone and loss of beach sediments that are removed from the artificial dunes by storm waves.

An aspect to highlight is that some stakeholders adopted self-protection measures to decrease the vulnerability and exposure of their properties. These interventions can affect positively and/or negatively both private properties and the local community.

An example is the Bagno Jamaica concession, located in the southern part of Lido di Spina (Figure 7.27). The concession and its issues are clearly described in the paper by Nordstorm et al. (2015). The self-protection measures adopted by the owner of the establishment, which is affected by serious erosion and flooding issues, began at the same time as its construction in 1990s, through self-paid sand nourishments carried out along with nourishments performed by the regional authorities. Because sand nourishments and urgent intervention carried out by regional authorities after major storms were no more sufficient to provide protection to the concession, in 2014 the owner decided to build and pay out of his pocket two hard defence structures (a rock groin and a rubble mound attached slope). Regional Authorities approved the works because they consider the concession as the last defence against flooding and damage of the areas at its back (Spina Lake, Spina Camping Village, southern part of the Spina village). It is important to point out that the Regione Emilia-Romagna continues to maintain the wooden groins at the concession and the earth embankment between the Bagno Piramidi and Bagno Jamaica (Figure 7.27). Moreover, the Regione undertakes regular nourishments (back-pass form Lido degli Estensi), in order to protect the structures and recreate the beach that is severely eroded after major storms (almost every winter, C. Armaroli, personal communication). However, Nordstorm et al. (2015) suggest and support the retreat strategy instead of defending the concession with regional and private founds.

Figure 7.27 South of Lido di Spina and BellocchioNatural Area: the Bagno Piramidi and Bagno Jamaica are evidenced (Source: Nordstorm et al., 2015)

Another example of self-adaptation is the adoption of pump systems around buildings. This measure is implemented at public and private levels. The watchperson of the Lighthouse of Porto Garibaldi reported no damages to the lighthouse and his home after the strong storm that occurred in February 2015 (the event is not reported in this document). The pump system, that was built last year, prevented the inundation of the buildings (E. Duo, Personal communication). A further example from the February 2015 storm is a fishing shop in Porto Garibaldi: while the garden in front of the shop was flooded, the building was saved thanks to the private pump system (E. Duo, Personal communication).

The examples described above give a brief overview of self-protection measures adopted in the study area. They can be also used as examples, to underline the possible positive or negative effects on the local community. Self-protection measures like the hard structures at the Jamaica concession, even if they can have a positive feedback in terms of protection of the concession, could negatively affect northern areas, blocking the south to north sediment transport. Moreover, the proximity of the concession to a natural area could negatively influence the morphodynamic behaviour of the beach and the ecosystem. The side effects of the protection measures should be investigated for the years to come and also if they are effective to improve the resilience of the concession. On the other hand, measures such as the pump systems have a very positive feedback, although local, reducing the negative impact of storms for those who have adopted such self-protection solutions.

To note that concepts such as "managed retreat" or "land-use change" are not yet fully accepted within the local community and by the stakeholders, even if they will be identified in the regional legislative framework, that will be adopted to fulfil the EU Floods Directive requirements, as key measures (L. Perini, personal communication).

7.5 Charente-Vendee, France

Authors: Emmanuel Garnier, Xavier Bertin and Gael Arnaud.

The historical approach to the study of storm tides and past extreme event on the site of La Faute-sur-Mer is extremely difficult because this coastal city did not exist at administrative level before the second half of the 20th century. Indeed, La Faute-sur-Mer became a municipality in 1953 only. The populating of the site began only in the 19th century under the shape of some fishermen's houses forming a hamlet (Garnier, 2014). As a consequence, it seems unrealistic to propose a definitive chronology of storms for the 17th and 18th centuries. Certainly, archives evoke disasters before 1800 but it is impossible to affirm that they directly affected the case study site.

It is thus necessary to discriminate certain events, for which we have precise historical data which concerns the site directly, from the uncertain events. The latter definition indicates storms that had a regional impact (departments of Charente-Maritime and Vendée) not knowing whether or not they had an impact on La Faute-sur-Mer.

7.5.1 Materials and methods

For the previously evoked administrative reasons, the historical documentation directly linked to La Faute-sur-Mer is limited, especially before 1850. They are kept in the departmental archives (Archives départementales) of Vendée, nowadays situated in La Roche-sur-Yon. Before the middle of the 19th century, no archive quotes a storm and a flood from the sea taking place in La Faute-sur-Mer. The closest site and most regularly quoted before 1850 is the city of l'Aiguillon-sur-Mer (Figure 7.28) among which the municipal archives and the chronicles mention extremes (Archives

Départementales A-). From the second half of the 19th century, when La Faute-sur-Mer existed administratively, the registers of the Prefecture and the General Council (Conseil Général) of Vendée get more frequent and precise information (Archives Départementales B-). However, they concern mainly the region of Aiguillon-sur-Mer.

Figure 7.28 Satellite image of La Faute-sur-Mer in 2010 and the neighbour municipality of L'Aiguillon-Sur-Mer on the other side of the Lay River (source Google Earth).

On the other hand, the contents of the documentation grew considerably rich during the first half of the 20th century thanks to the development of the local press. The newspaper *L'Ouest-Eclair* published articles on the occasion of storms. These articles evoke the damage undergone at the site of La Faute-sur-Mer. Besides the indication of the flooded surfaces and of the damaged dikes, these press articles contain photos taken a few hours after the storm. In particular, they evidence that storms affected only uninhabited farmland.

Finally, the documentation authorizes a landscape approach of the coast and its evolution since the 18th century. Numerous maps are indeed available in the archives of the French Army (Service Historique de la Défense or SHD) of Vincennes and of the Institut Géographique National (Paris). The oldest ones are military maps (Army and Navy) which give a precious perspective on the occupation of the territory of La Faute-sur-Mer and the route of the coast, more particularly of the "Pointe d'Arçay" where the city was built after 1950 (IGN). These maps can be completed by the cadastral maps of the municipality of La Tranche-sur-Mer where it was situated the current territory of La Faute-sur-Mer until 1953 (Archives Départementales C-).

Published at a very large-scale(1:5000), they describe exactly the housing environment, the plots of land and the nature of the ground (swamps, dunes, wood; Garnier et al., 2012). The instrumental observations (surge maximum, wave height, wind intensity), covered a similar area but mostly originate from ports (La Pallice, Le Verdon, etc.) distant dozens of kilometers from La Faute-sur-Mer. It is thus difficult to transpose these rare instrumental observations to the case study (see WP1_Physical Data Table). Alternatively, for the storms that affected the study area from 1941, we also provided quantitative data obtained through historical numerical hindcast, validated with field observations of wind, atmospheric pressure and sea-level measured in La Rochelle, Oléron and Ré Island meteorological stations (23 to 33 km from La Faute-sur-Mer, respectively).

7.5.2 Historical overview

Historical Overview of regional scale events

On the 9th of December 1711, during almost 9 hours, Vendée and Charente-Maritime were struck by a powerful storm surge which occurred under a tidal range of about 5.20 m in La Rochelle. Sea level reached 6.34 m in the morning. Very big damage were reported in the region. Archives evoke the destruction of numerous seawalls and the flooding of saltworks which were vital for local prosperity. The authorities of the time estimated the cost of the disaster at 1.19 million because it was necessary to reconstruct seawalls during several years. If the event is certain on a regional scale, on the other hand, no historical source allows affirming that it stroke the site of La Faute-sur-Mer which was totally uninhabited in 1711. Archives talk especially about La Rochelle and about the Île de Ré which were severely affected.

The storm of the 21th February 1788 was probably one of the most violent storms in the maritime history of the region (Charente-Maritime and Vendée; Garnier and Surville, 2010). Caused by south-westerly storm winds during the full moon (Spring Tides), which corresponds to a tidal range of about 5.70 m at La Rochelle, the storm submerged the coast in several places. The barometric pressure observed in La Rochelle was 976.4 hPa in the afternoon. In this city, several districts close to the port were flooded by the sea. The floods also affected islands (Oléron, Ré) and the city of Les Sables d'Olonne. Almost everywhere, seawalls were broken. It is likely that this storm tide affected the current sector of La Faute-sur-Mer. However, no historical proof can be found because the site was totally deserted at the time (Figure 7.29).

Figure 7.29 Site of La Faute-sur-Mer in 1768 (Source: Archives départementales de Vendée, 24 Fi).

As shown in the map, in 1768 the current site of the city of La Faute-sur-Mer was located at the mouth of the Lay River because the Arçay Spit (Pointe d'Arçay) was not formed yet, although an hooked-shape embryonic landform was already present. Certainly, the fact that no house was visible explains the absence of historical documentation. The Aiguillon-sur-Mer village did not exist either and the closest city was Saint Michel-en-l'Herm, situated at about 4 km.

The storm tide of the 1st of January 1877 was associated with a tidal range of 5.60 m in La Rochelle on December 31st in the evening. It was recorded in the registers of the Conseil Général de Vendée and in the archives of the city of l'Aiguillon-sur-Mer. It most probably affected La Faute-sur-Mer (Archives départementales de Vendée D-). Again, historical proofs are lacking for La Faute and archives describe only the damages caused in the municipality of La Tranche-sur-Mer. The map of dunes from 1878 by the Forestry commission shows for the first time a core of about ten habitations, essentially fishermen's huts according to the reports of the foresters (Figure 7.30). These habitations were located on the Arçay Sanspit, which already looked much more developed compared to the 1768 map. However, probably because La Faute still remained almost uninhabited, the authorities prefered to describe the flood-induced damages in the closest municipality: l'Aiguillon-sur-Mer, just in the other side of the Lay River.

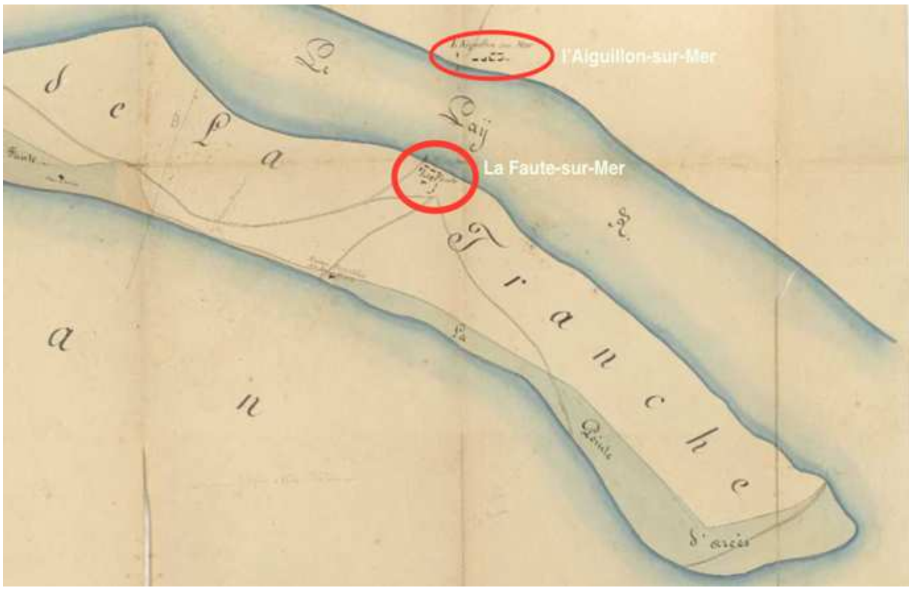

Figure 7.30 Plan of the dunes of La Faute-sur-Mer in 1878 (Source: Archives départementales de Vendée, 7 M).

Storm tides at the local scale

The first storm tide that led to flooding mentioned by archives in La Faute-sur-Mer occurred on the **27 th of October 1882**. During high spring tides (5.90 m tidal range in La Rochelle), the swamps were submerged by the sea from the Pointe d'Arçay to the hamlet of La Faute and the Port Puaut (Archives départementales de Vendée E-). Archives report 44.4 ha flooded and 40 meters of seawall cut.

The storm-tide of **the 23-24th of March 1928** corresponds to a major disaster for the village of La Faute-sur-Mer, as proved by the media of the time(Archives départementales de Vendée F). The available instrumental datasets are numerous. The wind was coming from southwest and the tidal range was of the order of 6.30 m in La Rochelle. Collapses of sand occurred on the left bank (l'Aiguillon-sur-Mer) of the Lay River. Sources do not report evacuation of the population. The village of La Faute-sur-Mer was divided from the inland. The threat was so grave that more than 450 inhabitants of the nearby municipalities (l'Aiguillon, Grues, Saint-Denis) were mobilized to check the seawall of Fenouillet, which protected 7,000 ha of farmlands.

On the spot, archives and press (Figure 7.31 and Figure 7.32) stated that the sea dug a channel in the dune and that it opened a 200 m breach which allowed inland flooding. The second breach was opened and waters threaten the farm of "La Violette". The result was heavy damage. The sea flooded more than 120 ha of farmlands and cut the road between La Faute and La Tranche-sur-Mer from 1.5 km (Archives départementales de Vendée G-). Dunes collapsed and almost disappeared whereas pines planted by the forestry commission were uprooted and taken by waves.

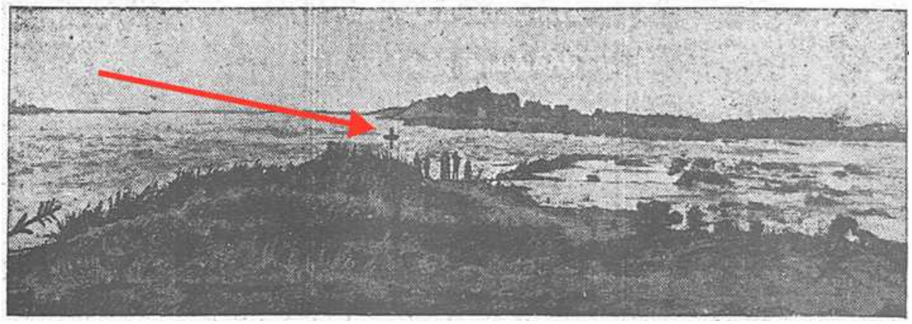

Figure 7.31 Picture of the newspaper L'Ouest-Eclair showing the breach in the dunes of La Faute-sur-Mer (Source: L'Ouest-Eclair Newspaper du 25 mars 1928).

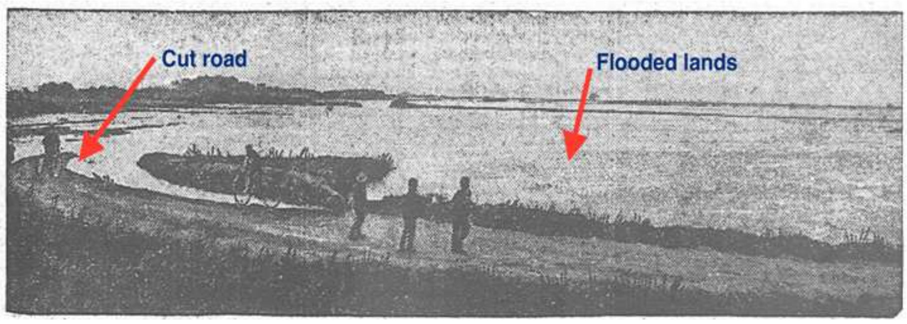

Figure 7.32 Picture of the newspaper L'Ouest-Eclair showing the flooded fields and the road cut between La Faute and La Tranche-sur-Mer (Source: L'Ouest-Eclair Newspaper du 25 mars 1928).

The second event that occurred at La Faute-sur-mer was the storm tide of the **13th March 1937** but only caused limited damage. Indeed, the storm hit all of the French Atlantic Coast (from Brittany to the Spanish border) and caused very big damage (Garnier et al., 2012). At the meteorological level, the event corresponded to a violent storm in phase with a large spring tide (5.80 m tidal range in La Rochelle). In La Faute, a seawall protection breached over 20 m but was quickly repaired thanks to the help of soldiers and inhabitants. These urgent measures limited the flood to the low fields situated behind the seawall (Archives départementales de Vendée I-).

A few years later only, La Faute-sur-Mer was again victim of a storm on **February 16th, 1941** (Archives départementales de Vendée H-). South-West winds and a tidal range of 5.30 m in La Rochelle flooded the polders of the right bank of the river Lay, upstream from the bridge of l'Aiguillon. Performing a historical numerical hindcast of the storm surge associated with this storm, Breilh et al. (2014) revealed that this storm had a track and produced wind fields and waves very similar to those of Xynthia (see next sections). Combining historical water levels and numerical measurements, these authors also stated that the storm surge exceeded 1.5 m in La Rochelle, although the maximum water level was probably slightly lower than during Xynthia. The road between La Faute and La Tranche-sur-Mer was submerged by 0.60 m of water and the river Lay overflowed. Strong erosion was also observed in the right seawall of the Lay River and it was also necessary to remove the sand accumulated against the dike for 2 meters in height.

During the night between the **14th and the 15th of February 1957**, a severe storm coming from the North-West occurred in the central part of the Bay of Biscay, with wind gusts reaching 40 m/s. The lowest pressure and strongest winds were recorded to the North of Oléron Island with 988 hPa and 28 m/s from the West, respectively. Although this storm induced a moderate surge in the order of 1 m according to Breilh et al.(2014), the surge peaked at the same time as the highest astronomical tidal ranges (about 6 m in La Rochelle). The marshes of the Marais Poitevin bordering the Aiguillon Cove were particularly affected by flooding and it was even reported that "The sea gained in 15 minutes the area it lost in seven centuries" (Archives Départementales de la Vendée J-). To the West of La Faute sur mer, this storm produced a significant erosion of the dunes of several hundred meters. The dikes breached at many locations along the Lay River and induced a significant flooding in the nearby municipality of l'Aiguillon, but damages were very limited in La Faute-sur-Mer (Sud-Ouest, 1957).

On the **27th December of 1999**, a very violent storm called Martin stroke the central part of the Bay of Biscay. The minimum sea-level pressure reached 965 hPa at landfall and 10 minute-mean wind from the West reached 42 m/s on Ré Island (25 km to the SW of La Faute-sur-Mer). Maximum gusts over 55 m/s were also recorded to the North of Oléron Island (33 km from La Faute-sur-Mer), which constitutes the largest values ever recorded in this region. This storm induced a surge estimated to be more than 2.0 m in La Rochelle by Breilh et al. (2014) but fortunately peaked at high tide during moderate tidal range (4.2 m in La Rochelle). The numerical hindcast of the associated waves revealed that offshore significant wave height exceeded 10 m for peak periods of 15 s. This extreme meteorological setting caused a severe erosion along the coastline located to the West of La Faute sur Mer, ranging from 1 to 4 m as well as many direct wind-related damages. Martin also produced a significant flooding around La Faute-sur-Mer but the flooding fortunately mostly affected farmlands.

In the night between the **27th and the28th February 2010**, a storm called Xynthia crossed the Bay of Biscay from SW to NE and made landfall 150 km to the North of La

Faute-sur-Mer with a minimum atmospheric pressure of the order of 970 hPa. Xynthia generated storm winds from the SW of the order of 25 to 30 m/s in the Bay of Biscay with maximum gusts of the order of 40 m/s to the North of Oléron and Ré Islands. Although this storm was substantially less severe than Martin, Xynthia produced a storm surge of the order of 1.6 m in La Rochelle, which corresponds to the largest value ever recorded in La Rochelle, although the tide gauge was not operating during Martin (1999). Bertin et al. (2012, 2015) explained this abnormally high storm surge by the presence of very short period waves, which strongly increased the surface stress and thereby the storm surge. This particular sea state was explained by the particular track of Xynthia, which restricted the fetch to a few hundred km in the Bay of Biscay. This large storm surge peaked at the same time as a high spring tide (5.5 m tidal range in La Rochelle) and the subsequent extreme water level caused the flooding of hundreds of km^2 in the central part of the Bay of Biscay (Bertin et al., 2014). In la Faute-sur-Mer, the dikes were overflooded locally up to over 0.5 m and locally breached and a massive flood occurred in the village (Figure 7.33). Some houses were flooded with more than 1.5 m of water such as in the so called "cuvette de la mort" and 27 peoples tragically died. Huge material damages also occurred, with 24 million euros of indemnified damage (André et al., 2014). Moreover, the shorelines located to the West of La Faute-sur-Mer suffered several meters of erosion and a breach in the dune developed, allowing the Belle Henriette lagoon to be connected to the sea for several weeks.

Figure 7.33 Aerial picture of La Faute-sur-Mer on the 28/02/2010, showing that 12 h after the catastrophe, the village was still largely flooded (Source: Crédit Ouest-France).

7.5.3 Lessons learned

Contrary to what we could believe, the historical European archives are numerous and available very early (since the 17th century at least), this statement being particularly true for the central part of the Bay of Biscay. The large amount of historical data that we recovered opens many perspectives, particularly for the area of La Faute-sur-Mer where many storm-induced flooding occurred over the last century. Immediately after Xynthia, where 27 people died from flooding, French authorities and local elected representatives claimed that the event was totally unpublished since a century and was thus unpredictable. This dramatically illustrates that there was a loss of memory because we found that the site had already undergone 4 floods between 1900 and 2010. The studies available before Xynthia estimated the local return period for extreme water levels based on a 30 year time series of water levels at La Rochelle and suggested that the water level reached during Xynthia had a return period of several millennia. The main limitation of this time series is that it did not include any of the event that we have identified here, partly because of instrument malfunctioning or power failure during major storms. Recent studies under evaluation that include water levels inferred from historical archives yield much more realistic estimates with return periods of 50 to 100 yr for the storm surge associated with Xynthia (Hamdi et al., personal communication) and 400 year for the total water level (Bulteau et al., personal communication). However, it should be noted that the water level does not have to be as high as during Xynthia to produce a flooding. Hence, a water level 0.5 m below that of Xynthia will induce a marine flooding while having a return period less than one century, which is consistent with our historical findings. As a consequence, nowadays in France, municipalities (at the request of the State) design their strategy of defense (seawalls) on a horizon of 50 and 100 years.

Disaster Risk Reduction measures have been based mainly on protection structures, maintenance and development during the past events. Over the last centuries, levees have been extended toward the sea and some intertidal areas have been reclaimed mainly for agriculture purposes. These newly created lands have an altitude locally close to mean-sea level and are thus highly vulnerable to flooding in case of dike failure or overflowing. Probably because people knew that these new lands could be flooded, no houses were built there until the sixties and so very few casualties occurred during the past storms mentioned in the archives. During the second half of 20th century, the town of La Faute sur Mer knew a fast urban development with people originating from inland and big cities who started to settle down in La Faute-sur-Mer. During almost the same period (1957-1999), there were no major floods so that, these new residents were unaware of flood and oceanic storm hazards. This combination led to a lost in flood and hazard memory. Some unsafe lands started to be constructed and people started to settle in these hazardous areas. This configuration led to the Xynthia event where 27 fatalities occurred in the town of La Faute-sur-Mer. This kind of event and several others in France in general, led to national DRR plans measures. Mainly two plans concern our study case: The local DRR plan so called PPRi (Plan de Prevention des Risques Innondation – Prevention Plan for flooding Risks) and the Communal safety Plan PCS (Plan Communal de Sauvegarde), which will be detailed in WP4.

7.6 Bangladesh

Author: S.H.M. Fakhruddin.

The Bay of Bengal is a region of the world that is frequently affected by storm surges associated with tropical cyclones. Statistics show that about 5% of the global tropical cyclones form over the Bay of Bengal (Debsarma, 2009). On average, five to six storms form in this region every year. Storm casualties in the region, however, make up 80% of global casualties(Karim & Mimura, 2008). Loss of life and property are mainly attributed to storm surge flooding.

Bangladesh is situated at the northern tip of the Bay of Bengal. The main causes of the highest and longest duration of storm surges in this region include the wide continental shelf and the shallow bathymetry of the North Bay of Bengal (Figure 7.34), the Northward-converging nature of the Bay, complex coastal geometry with many kinks and islands (Figure 7.35), high astronomical tidal range between east and west coasts of Bangladesh(Frank and Hussain 1971). The cyclones usually originate in the southern parts of the Bay of Bengal or in the Andaman Sea, from where they move westward before curving to the north and northeast. The country was struck by 154 cyclones (including 43 severe cyclonic storms, 43 cyclonic storms, and 68 tropical depressions) during the period 1877–1995. Since 1995, five severe cyclones hit Bangladesh's coast, which occurred in May 1997, September 1997, May 1998, November 2007 and May 2009 (Aminuzzaman, 2009). A severe cyclone strikes Bangladesh every three years on average. Moreover, the frequency of natural disasters like floods and cyclones has increased significantly over the last decades, particularly along the coastline of Bangladesh(Rasid & Paul, 2013).This is considered an impact of climate change. The tropical cyclones, storm surges and severe floods are likely to become more frequent and severe in the future as a result of climate change, making Bangladesh even more vulnerable.

The geographical location and geomorphological conditions of Bangladesh have made the country one of the most disaster prone areas in the world. Bangladesh is situated at the interface of two different geographical environments, with the Bay of Bengal to the south and the Himalayas to the north. This peculiar geography of Bangladesh leads to not only life-giving monsoons but also catastrophic ravages of natural disasters like storm surges. Most of the country, aside from the northeast and southeast regions, has a very low and flat topography. About 10% of the land is hardly 1 m above mean sea level, and one third is under tidal excursions (Ali, 1999). The country has three distinct coastal regions, namely the western, central, and eastern coastal zones.

Tropical cyclones occur most prominently during the pre-monsoon season (March-May) and the post-monsoon season (October-December). The distribution of tropical cyclones over the Bay of Bengal is shown in Figure 7.36.The monthly frequency of cyclonic storms shows two maxima, i.e. in May and November Figure 7.37. In

Table 7.4, the occurrence of cyclones in last 200 years is shown. In Table 7.5, the occurrence over several coastal spot is shown for the period 1582-1997.

The Bay of Bengal tropical cyclones more often usually strike the Bangladesh coast in May and November, the Orissa-West Bengal coast in October, the Andhra coast in November, and the Tamil-Nadu coast in December. About 58 percent of the tropical cyclones in the Bay of Bengal strike different parts of the east coast of India, 17 percent strike the coasts of Bangladesh, 9 percent strike Myanmar, only 3 percent strike the east coast of Sri Lanka, and about 13 percent dissipate over the sea itself (WMO, 2009).

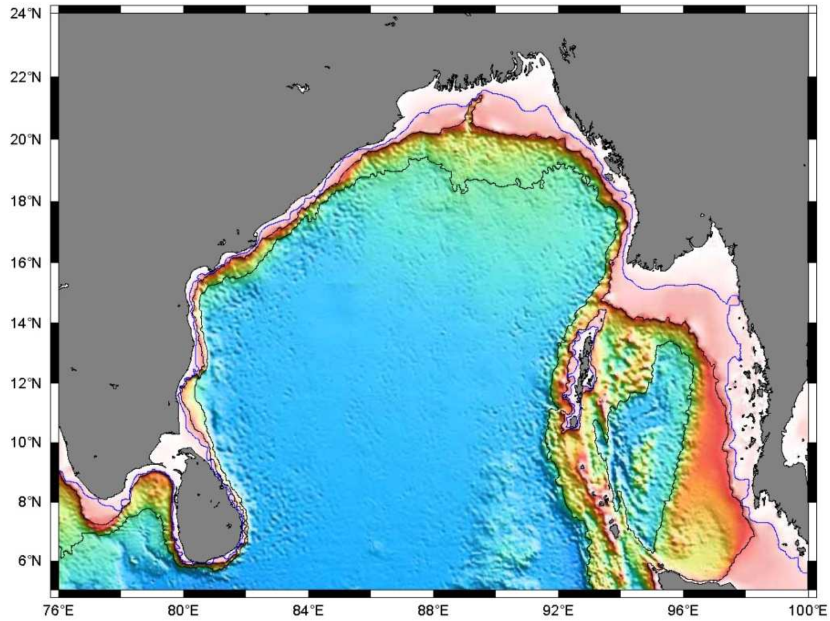

Figure 7.34 Bathymetry of the North Bay of Bengal (http://cmtt.tori.org.tw/data).

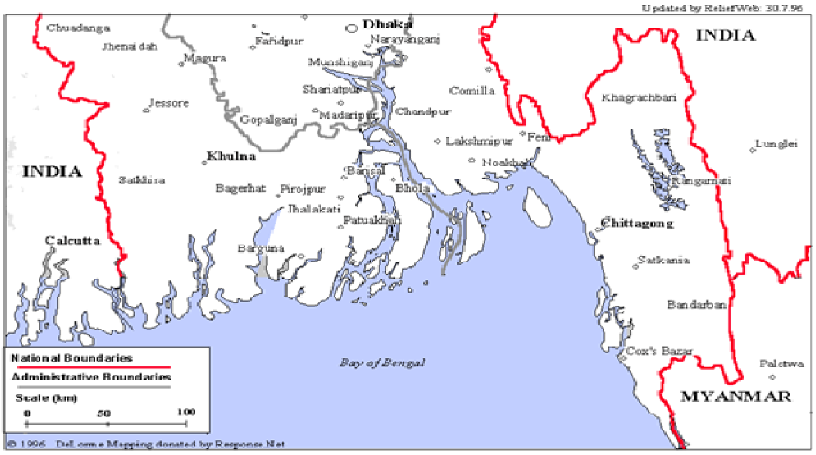

Figure 7.35 Coastal region of Bangladesh.

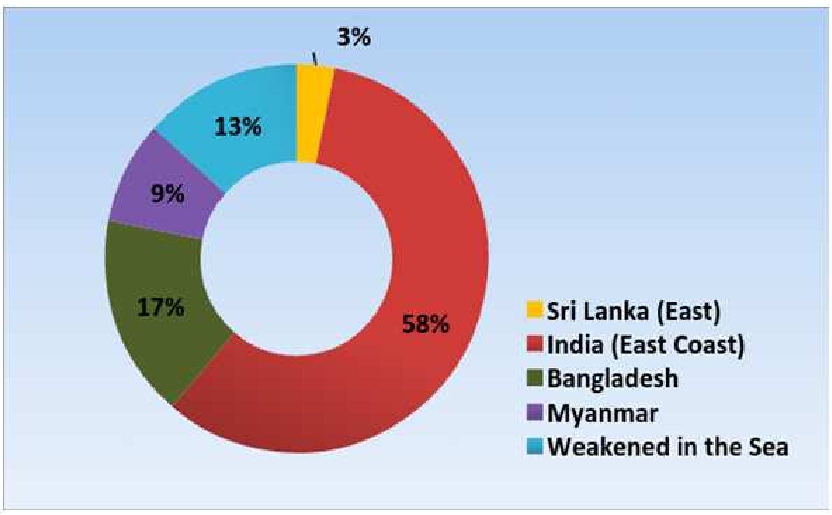

Figure 7.36 Distribution of Tropical Cyclones over the Bay of Bengal.

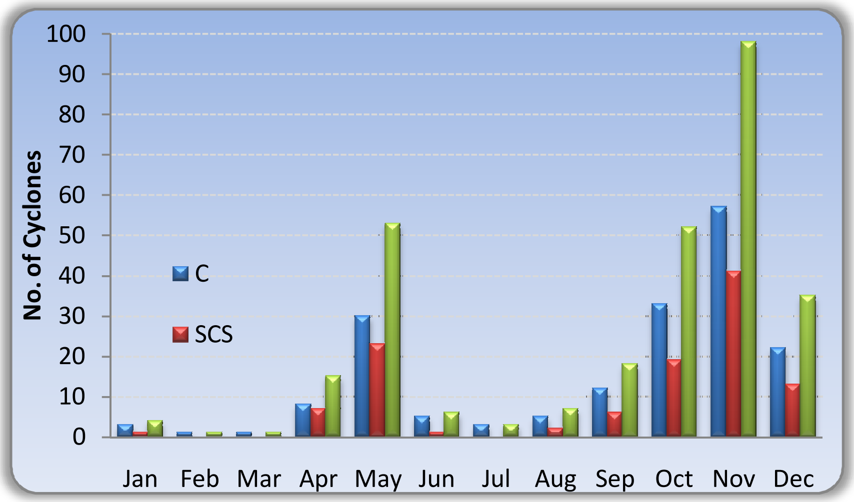

Figure 7.37 Frequency of cyclones/severe cyclones over the Bay of Bengal in different months during 1891-2010.

Table 7.4 Recorded cyclones over the last 200 years (Sources: BBS, 1993, BBS, 2002 & BMD 2012).

Period	Occurrences of major cyclones
1795-1845	3
1846-1896	3
1897-1947	13
1948-1998	51
1999-2011	3
Total	73

Table 7.5 Distribution of cyclone landfall over the coasts and months in the period 1582-1997 (Source Rahman, 2001).

Month	Khulna - Sundarban	Barisal/ Patuakhali - Noakhali	Noakhali - Chittagong	Chittagong - Cox's Bazar	Frequency (%)
January	0	0	0	0	0
February	0	0	0	0	0
March	0	0	0	0	0
April	0	0	1	3	5
May	1	3	11	6	26
June	1	2	5	1	11
July	0	0	0	0	0
August	0	0	0	0	0
September	4	0	2	0	7
October	5	5	8	5	28
November	1	2	6	4	16
December	1	2	0	3	7
Total	13	14	33	22	100

7.6.1 Materials and methods

Data were collected and analyzed from both existing information and consultation with National Agencies of Government of Bangladesh. In the first step, after a systematic literature review and historical storm database were analyzed. Consultations were made through workshop and individuals.

7.6.2 Historical overview

Severe Cyclonic Storm, 24-30 November, 1988

The formation of this the tropical cyclone in November 1988 was preceded by a sustained surge of the northeast winter monsoon and a low-level convergence across the Malay Peninsula. The system (Figure 7.38 and Figure 7.39) was formed as a depression over the southeast Bay and adjoining southwest Bay neat latitude 10°N and longitude 93°E at 03 UTC on 24th November 1988. The system concentrated into a deep depression near latitude 11.5°N and longitude 92.5°E at 00 UTC of 25th November. On the same day, the system intensified into a cyclonic storm at about 06 UTC near latitude 12°N and longitude 92°E. The storm turned northward, where conditions allowed for continued development. The storm became a severe cyclonic storm near latitude 12.5°N and longitude 91°E at 12 UTC on 25th November, and it continued to strengthen as it moved further northwards and intensified into a severe cyclonic storm with a core of hurricane winds near latitude 13°N and longitude 88°E at 12 UTC on 26th November. Further moving northwards and then north-north-eastwards, the system finally crossed the Sundarbans coast of Bangladesh near Raimangal River at 19 UTC of 29th November. The cyclone caused thousands of deaths and severe damage to properties in Bangladesh and adjoining India (Table 7.6). The recorded maximum wind speed was 160 km/h with a reported storm surge height of approximately 14.5 feet (4.4m).

Figure 7.38 Track of Severe Cyclonic Storm, 24th-30th November 1988.

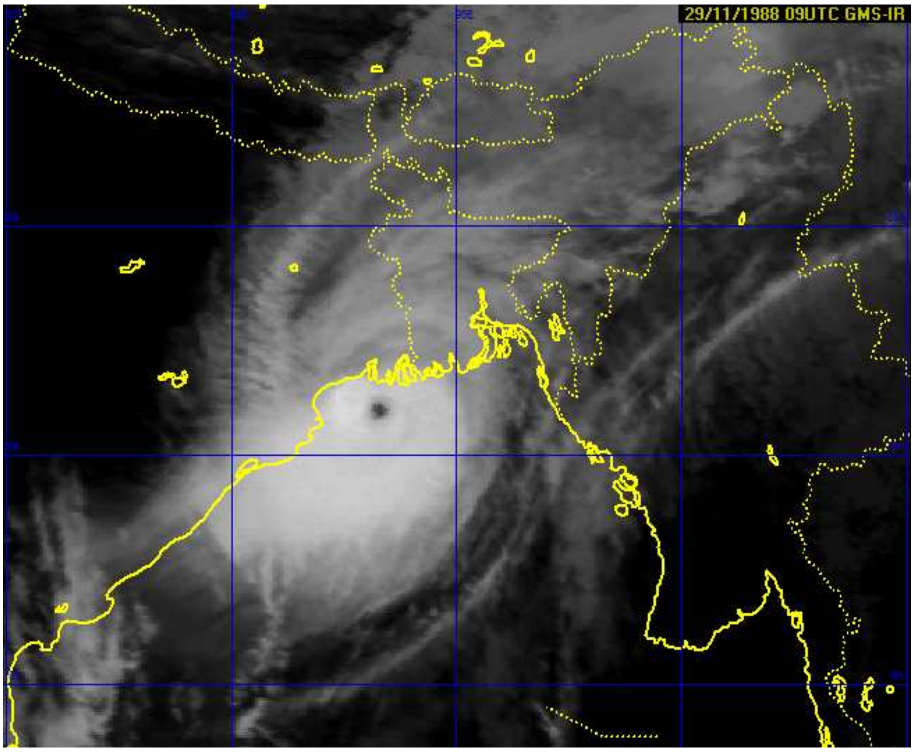

Figure 7.39 Satellite image of Severe Cyclonic Storm with clear eye at 09 UTC of 29 November 1988.

Table 7.6 Damage due to Severe Cyclonic Storm over Bay of Bengal during 24-30 November 1988.

People killed	6,215 (Bangladesh and India)
People missing	6,000
Deer killed	15,000
Royal Bengal tigers killed	9
Cattle killed	65,000
Crops damaged	118 million USD
Fishing equipment damage	1.8 million USD

Severe Cyclonic Storm, 24-30 April 1991

The severe cyclonic storm in April 1991 was detected as a low-pressure area over the Bay and adjoining Andaman Sea on the morning of April 23 (Figure 7.40). The system concentrated into a depression over the southeast Bay of Bengal on the afternoon of 24 April 1991. The depression, which moved slowly in a northwesterly direction and intensified into a cyclonic storm by the evening of 25th April. The system apparently intensified under the influence of a large-scale, low-level wind surge across the equator. Moving further westwards, the cyclone became severe by the evening of the 26th near southeast Bay and adjoining southwest Bay. Then the severe cyclonic storm moved slowly in the northerly direction and intensified further. On the evening of the 27th, the system had reached the West-Central Bay and adjoining area as a severe cyclonic storm with a core of hurricane winds. Then the cyclone slowly curved north-north-eastwards and intensified further. The system attained its peak intensity on the morning of 29th April over the northwest Bay and adjoining area. The central pressure of the cyclone was estimated to be 920 hPaAat. Continuing to move in a north-northeasterly direction and maintaining its hurricane intensity, the system crossed the Bangladesh coast near Chittagong in the early morning of 30th April. The central pressure of the 1991 cyclone was as low as 938 hPa (Figure 7.41), as measured at Chittagong.

This lowering of pressure, in conjunction with the full moon, was sufficient to raise tidal levels to the highest of the normal range. The storm surge (surge plus tide) was 4 to 8 meters high in different areas. Vast areas in the districts of Cox's Bazar, Chittagong, Noakhali, and Bhola were submerged. The depth of water at Chittagong Airport exceeded 2m.

Fatality figures caused by the April cyclone vary between 130,000 (Bangladesh Bureau of Statistics, 1991) to 200,000 (Rashid,1991). Human casualties were almost exclusively caused by the storm surge (Khalil, 1993). Casualties in the unprotected islands were on the average 40-50% of the total population of the areas affected by the storm surge. On islands protected by embankments, the figure may have been 30-40%; while on the mainland coast, which faced the fury of the surge, deaths were probably 20-30% of the population. Recorded maximum wind speed was 225 km/h and the reported storm surge height was 3-6.5 meters (12-22 ft). An overview of the damages is shown in Table 7.7.

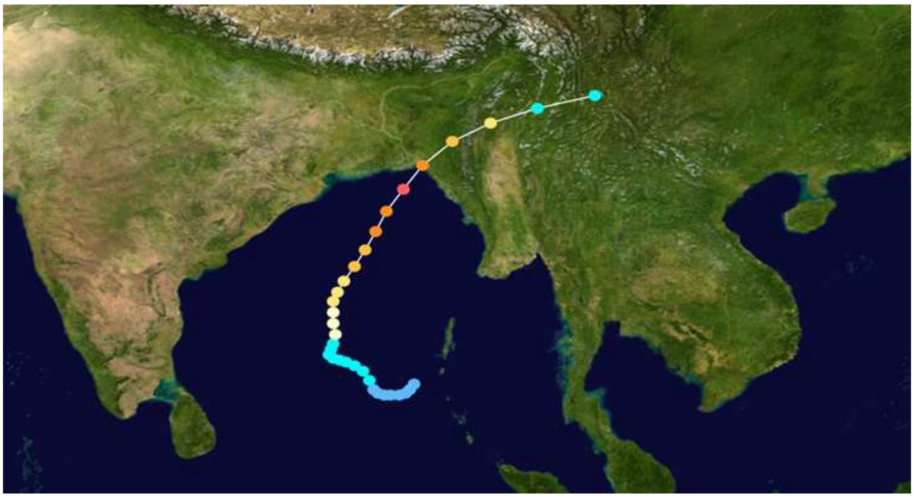

Figure 7.40 Track of Severe Cyclonic Storm, 24 -30 April1991.

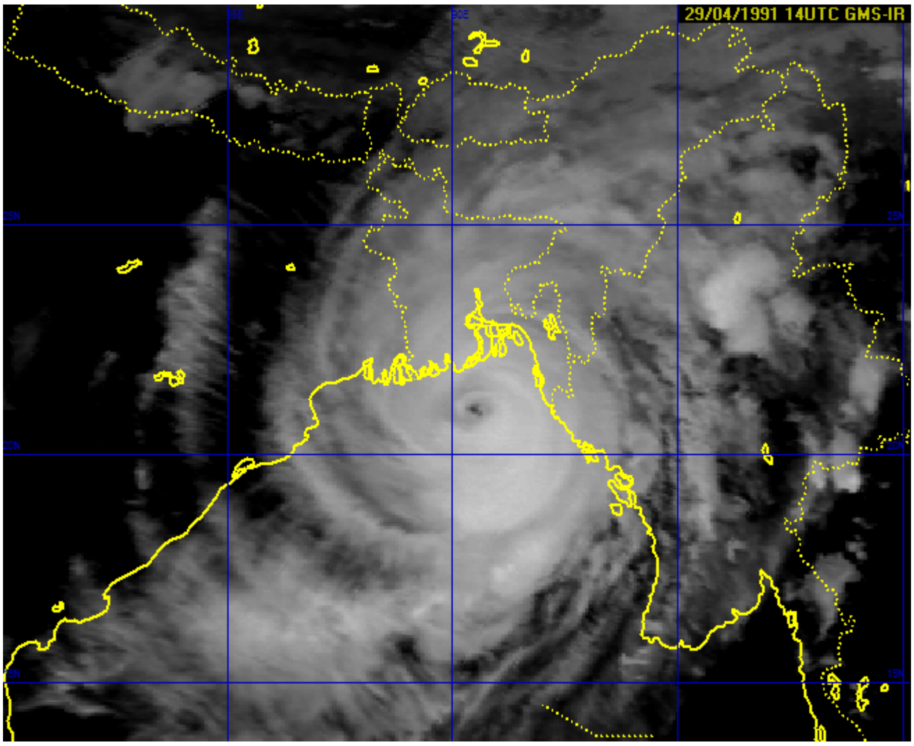

Figure 7.41 Satellite image of severe cyclonic storm with clear eye at 14 UTC of 29 April 1991.

Table 7.7 Damage due to severe cyclonic storm over the Bay of Bengal during 24-30 April 1991.

People Killed	138,882
People wounded	1,390,540
No. of affected Districts	19
No. of affected Thana	102
No. of affected Municipalities	9
No. of affected Population	10,798,275
Damage to crops fully	133,272 acres
Damage to crops partly	882,705 acres
No. of house destroyed fully	819,608
No. of house destroyed partly	882,705

Severe Cyclonic Storm, 15-20 May 1997

The severe cyclonic storm of May 1997system (Figure 7.42) was detected on the morning of 15 May 1997 as well-marked low pressure over southeast Bay of Bengal and adjoining the south Andaman Sea in the morning of 15 May 1997. Moving northwards, it concentrated into a depression at 06 UTC of the same day over southeast Bay and adjoining area. Moving further northward, the system intensified into a cyclonic storm by the morning of 16th May over the same area. At this point, it started to move in a north-northeasterly direction up to the evening of 17th May and intensified further into a severe cyclonic storm at about 09 UTC. Later, it changed its course towards a north-northwesterly direction and moved fast toward the east-central Bay at a speed of 08 kts till 03 UTC of 18 May over east-central Bay. Over the next 15 hours, it moved in a northerly direction, then it changed its course again into northeasterly direction and centered over North Bay. Around 00 UTC of 19th May, it acquired the peak intensity of t-5.0. The eye of the cyclone was seen continuously from 00 UTC of 19thMay onward in satellite imagery until the landfall. By 12 UTC of 19th May it came close to Chittagong's coast and crossed the coast near Sitakunda by the afternoon of 19th May. Further moving in a northeasterly direction inland, it weakened rapidly into a depression by midnight of the 19th and into a well-marked low pressure area over Mizoram of India and neighboring areas by the morning of 20 May 1997.

The system moved in an almost northerly direction in spite of the easterly upper airflow between 3200 to and 2300 hPa. It appears that the system was steered by the resultant mid-level south westerlies and upper-level easterlies.

The severe cyclonic storm caused heavy to very heavy rainfall over the coastal areas of Bangladesh. The lowest pressure, 966.1 hPa, was recorded at Chittagong at 12 UTC of 19th May. The highest maximum wind speed of 232 km/h was recorded at Sitakunda observatory at 09 UTC of 19th May and the reported surge height was 15 feet (5 meters). The cyclone caused a huge loss of lives and large amounts of severe property damage in Bangladesh (Table 7.8).

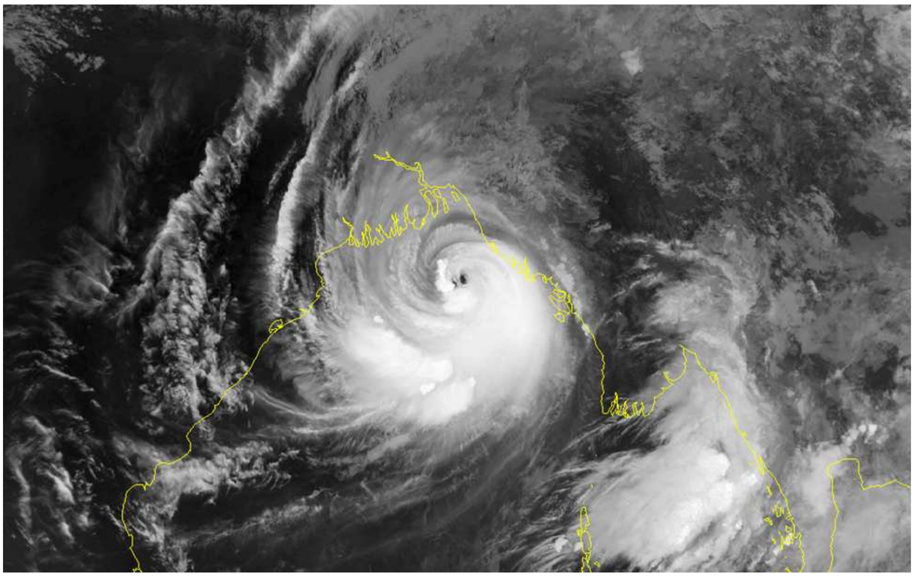

Figure 7.42 Satellite image of severe cyclonic storm with clear eye at peak intensity on 19 May 1997.

Table 7.8 Damage due to severe cyclonic storm over Bay of Bengal during 15-20 May 1997.

People killed	155
People wounded	9,663
People affected	2,835,472
Families affected	541,586
Districts affected	10
Livestock killed	3,118
Houses damaged (fully)	112,160
Houses damaged(partly)	99,557
Crops damaged(fully)	19,173 acres
Crops damaged(partly)	78,160 acres
Roads damaged (fully)	53 kms
Roads damaged (partly)	162 kms
Betel vines damaged	60,000 acres
Shrimp projects affected	600 acres
Embankmentsdamaged	6 kms
Bridges and culverts damaged	165

Fishing trawlers damaged	26
Educational and religious institutions damaged	1,480
Cyclone shelters damaged	718

Severe Cyclonic Storm SIDR, 11-16 November 2007

On 8-10 November 2007, an upper air cyclonic circulation lay over southeast Bay of Bengal and the adjoining area of south Andaman Sea during 8-10 November 2007 (Figure 7.43). Initially, moderate upper-level wind shear inhibited organization of the system, while strong diffluence aloft aided in developing convection. During this period, an easterly wave was also active and vertical wind shear decreased significantly as the circulation became better defined. Under the influence of these factors, a low pressure area formed at 0300 UTC of 11 November over southeast Bay of Bengal and neighboring areas. It concentrated into a depression and subsequently into a deep depression on the same day. Moving in a northwesterly direction, it intensified into the cyclonic storm Sidr and lay centred at 0300 UTC of 12 November, about 220 km southwest of Port Blair. It further concentrated into a severe cyclonic storm at 1200 UTC and a very severe cyclonic storm at 1800 UTC, while moving in a north-northwesterly direction. It continued to move in north-northwesterly direction till 0000 UTC of the 13th. It then moved in a northerly direction and lay centred at 0300 UTC of 15 November near latitude 18.0°N and longitude 89.0°E. The system then moved rapidly and lay centred at 1200 UTC of 15 November near latitude 21.0°N and longitude 89.0°E. It then started to move north-north-eastwards and crossed the west Bangladesh coast around 1700 UTC and lay centred at 1800 UTC near latitude 22.5°N and longitude 90.5°E, about 100 km south of Dhaka, Bangladesh. It weakened rapidly into a cyclonic storm, while moving north-eastwards. It further weakened into a depression and lay centered at 0300 UTC of 16 November, about 50 km north of Agartala. It lay as a well-marked low-pressure area over northeastern states at 1200 UTC of 16 November and became unimportant at 1500 UTC of the same day.

On the morning of 15 November, the cyclone intensified to reach peak winds of 215 km/h (135 mph) according to the IMD, and a peak of 260 km/h (160 mph) according to the JTWC best track. The storm surge was reported at about 5 meters (16 ft).

An overview of the damages is shown in Table 7.9.

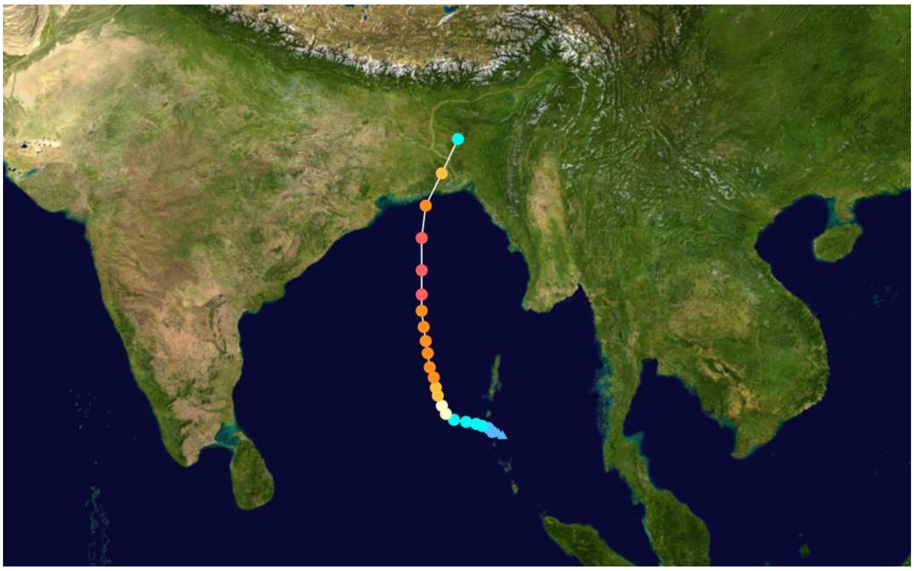

Figure 7.43 Track of severe cyclonic storm Sidr, 11-16 November 2007.

Table 7.9 Damage due to severe cyclonic storm Sidr during 11-16 November 2007.

Damages Sector	**Quantity**
No. of affected districts	30
No. of affected families	20,64,026
No. affected people	89,23,259
Fully damaged crops	7,42,826 acr.
Partially damaged crops	17,30,116 acr
No. deaths	3,406
No. of injured people	55,282
No. missing people	871
No. of livestock deaths	17,78,507
No. of fully damaged educational institutions	4,231
No. of partially damaged educational institutions	12,723
Fully damaged roads	1,714 km
Partially damaged roads	6,361 km
No. of damaged bridges/culverts	1,687
Embankments damaged	1,875 km

Severe Cyclonic Storm AILA, 22-26 May 2009

The southwest monsoon set in over the Andaman Sea and adjoining south Bay of Bengal on 20 May 2009. Under its influence, the southerly surge over the region increased. It resulted in an increase in the horizontal pressure gradient and the north-south wind gradient over the region. Hence the lower level horizontal convergence and relative vorticity increased gradually over the southeast Bay of Bengal. It led to the development of the upper air cyclonic circulation extending up to the mid-tropospheric level on 21st May over the southeast Bay of Bengal and associated convective cloud clusters persisted over the region. Under the influence of the cyclonic circulation, a low pressure area formed over the southeast Bay of Bengal on the morning of 22nd May. It lay over the east central and adjoining west central Bay of Bengal on the evening of the 22nd. It concentrated into a depression and lay centered at 06 UTC of the 23rd near latitude 16.5ºN and longitude 88.0º E.

The depression moved mainly in a northerly direction and intensified into a deep depression and lay centered at 03 UTC of 24th near latitude 18.0ºN and longitude 88.5ºE. It further intensified into the cyclonic storm Ailaat 12 UTC of 24th May and lay centered near latitude 18.5ºN and longitude 88.5ºE. It continued to move in a northerly direction and intensified into a severe cyclonic storm at 06 UTC of 25th May and lay centered over the northwest Bay of Bengal near latitude 21.5ºN and longitude 88.0ºE close to Sagar Island (Figure 7.44). The system crossed the West Bengal-Bangladesh coast close to the east of Sagar Island between 08 to 09 UTC as a severe cyclonic storm with wind speed of 100-110 km/h. The lowest estimated central pressure was about 967 hPa at the time of landfall. After the landfall, the system continued to move in a northerly direction and gradually weakened into a cyclonic storm at about 15 UTC of 25 May over Gangetic West Bengal and the adjoining area. While it continued its northerly movement, it further weakened into a deep depression in the morning of 26th May over Sub-Himalayan west Bengal and Sikkim, close to Malda.

According to satellite estimations, the sustained maximum wind at the time of landfall was about 112 km/h. The wind recorded by anemometers, anemographs, and AWS sensors confirmed winds of a similar magnitude.

According to media reports, a storm surge of 3 m (10 ft) impacted the western regions of Bangladesh, submerging numerous villages. The Sunderbans was reportedly inundated with 6 m (20 ft) of water. Considering the astronomical tidal wave at the time of landfall, which was about 4-5 meters, the maximum storm surge over the Sunderban area may be estimated at about 2 m.

An overview of the damages is shown in Table 7.10.

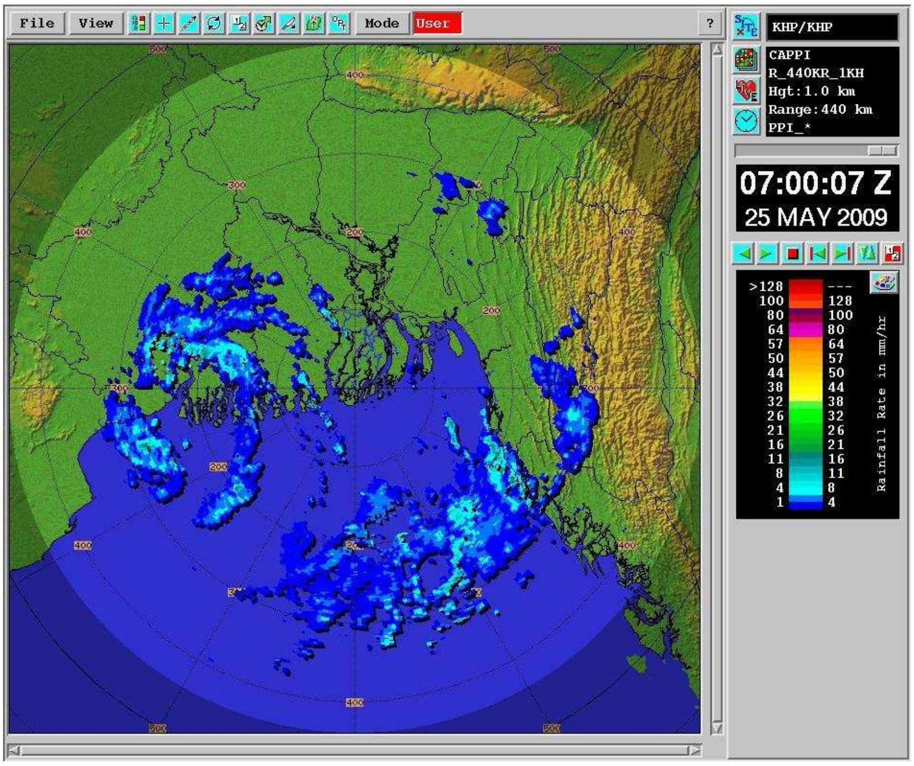

Figure 7.44 Doppler radar image of severe cyclonic storm Aila crossing the coast on 25 May 2009 (Khepupara Radar, BMD).

Table 7.10 Damage due to severe cyclonic storm Aila during 22-26 May 2007.

Damages Sector	Quantity
No. of affected districts	11
No. affected upazillas	64
No. affected people	4,826,630
No. deaths	190
No. of injured people	7,103

7.6.3 Lessons learned

Disaster management in Bangladesh has gone through a process of significant reforms. Since independence, the focus has been limited to relief and rehabilitation activities. Following the devastating floods of 1988 and the cyclone of 1991, which created massive economic destruction in the economy, the focus has shifted towards a holistic approach that embraces processes of hazard identification and mitigation, community preparedness, and integrated response efforts. As a result, a short-term project entitled "Assistance to Ministry of Relief in Coordination of Cyclone Rehabilitation: BGD/91/021" was implemented after the killer cyclone of 29 April 1991.

The GoB established the Department of Disaster Management (DDM) formerly the Disaster Management Bureau (DMB) in April 1993 as the successor of the Disaster Coordination and Monitoring Unit. Additionally in 1993, the GoB established disaster management councils and committees from the national level down to the field level. The DDM was assigned to perform specialist support functions, working in close collaboration with district and upazila authorities and the concerned line ministries, under the overall authority of high-level Inter-Ministerial Disaster Management Co-ordination Committee (IMDMCC). The DDM is also responsible for creating public awareness on the severity and risks associated with natural and human-induced hazards, and to formulate programs and projects that will better prepare at-risk communities and public officials to mitigate their consequences. As a technical arm to the Ministry of Food and Disaster Management, the DDM coordinates all activities related to disaster management from the national to the grass-roots level. It is also entrusted to effectively liaise with government agencies, donors and NGOs to ensure maximum cooperation and coordination in all aspects of disaster management.

The main mission of the Government is to bring a paradigm shift in the country's disaster management approach from conventional response and relief to a more comprehensive risk reduction culture. This includes promoting food security as an important factor in ensuring the resilience of communities. In May 2004, the name of the Ministry of Relief and Rehabilitation was renamed as the Ministry of Food & Disaster Management (MoFDM). Ministry of Food and Disaster Management has the responsibility of food management and (a) planning, coordination, monitoring and evaluation of matters relating to relief activities and disaster management, (b) co-ordination among the different organizations for pre-disaster, during-disaster, and post-disaster activities, including preparation of disaster management guidelines, (c) provision of assistance to disaster-related ministries and organizations to prepare action plans, (d) formulation of policy and its implementation on matters relating to the preparation, monitoring, and evaluation of food-assisted projects and programmes, (e) coordination of matters relating to the distribution of external food aid and other relief assistance, and (f) other concerned matters of concern relating to food, relief and disaster management.

As a continuation of the paradigm shift process, the Comprehensive Disaster Management Programme (CDMP) has been designed as a long-term programme of the MoFDM with multi-agency involvement. The programme was launched in November 2003 to optimize the reduction of long-term risk and to strengthen the operational capacities for responding to emergencies and disaster situations including actions to improve recovery from these events.

The idea of a Cyclone Preparedness Programme started in 1965 when the National Red Cross Society, now the Bangladesh Red Crescent Society (BDRCS), requested the International Federation of Red Cross and Red Crescent Societies (IFRC) to support the establishment of a warning system for the population living in the coastal belt. In 1966 IFRC and the Swedish Red Cross began the implementation of a pilot scheme for cyclone preparedness, which consisted of warning equipment such as transistor radios, sirens, etc. and of training the local militia (Ansars).

Following the withdrawal of IFRC as a direct implementation partner in July 1973, the GoB and the Bangladesh Red Crescent Society created a partnership that led to a new programme management structure in the form of joint partner venture. Both parties signed an agreement stating that programme operations would remain primarily under the leadership of the Red Crescent, would increase involvement of local communities, and would be known as the Cyclone Preparedness Programme (CPP) of the Bangladesh Red Crescent Society. A Policy Committee and an Implementation Board were created to jointly administer and implement the Programme. A seven-member Policy Committee headed by the Minister of the MoFDM was constituted to provide policy directives and to allocate resources for the Programme. The implementation board is tasked with implementing the policy directives from the Policy Committee. The Director of the Bangladesh Meteorological Department is one member of the 15-members Implementation Board.

Governance and Institutional Arrangements (national to local levels)

The Government of Bangladesh's regulative framework for disaster management provides for the relevant legislative, policy, and best practice framework under which disaster risk reduction and emergency management activities in Bangladesh are managed and implemented (see Figure 7.45 for a schematic flow diagram). The framework includes:

Disaster Management Act. A Disaster Management Act was enacted with a view to create the legislative tool under which disaster risk and emergency management actions are undertaken in Bangladesh and providing the legal basis for which activities and actions are identified, undertaken, and managed. It also establishes roles and responsibilities of ministries, committees and appointments. The objectives of the Act are to:

a) Assist communities in mitigation of potential adverse effects of hazardous events,

b) Prepare for managing the response to the effects of a disastrous event,

c) Assist in effectively responding to and recovering from a disaster or an emergency situation,

d) Prepare for and adapt to potential adverse effects of climate change,

e) Provide for effective disaster management for Bangladesh,

f) Establish an institutional framework for disaster management, and

g) Establish risk reduction as a core element of disaster management.

National Plan for Disaster Management. The National Plan for Disaster Management is prepared by the Ministry of Food and Disaster Management (MoFDM). This plan supports a culture of prevention by:

a) Introducing disaster management in school curricula,

b) Enhancing the capacity of disaster managers through improved training facilities, and

c) Creating a massive awareness at all levels to involve people at the grassroots, particularly those who are more vulnerable, to improve preparedness and response. This should encourage community level initiatives for disaster preparedness.

Appropriate zonal regulations, design standards, building codes and performance specifications are developed for safe constructions. All development schemes in vulnerable areas include a disaster mitigation analysis, whereby the feasibility of a project is assessed with respect to the area's vulnerability. Disaster mitigation components are built into all development projects financed under the Plan, as part of approved project costs.

National Disaster Management Policy. A National Disaster Management Policy is formulated to define the national perspective on disaster risk reduction and emergency management, and to describe the strategic framework, and national principles of disaster management in Bangladesh. It describes the broad national objectives and strategies for disaster management.

Standing Orders on Disasters. Standing Orders on Disasters (SOD) describe, in detail, roles and responsibilities of committees, ministries and other organizations involved in disaster risk reduction and emergency management activities, and establish the necessary actions required to implement Bangladesh's Disaster Management Model. An updated SOD is under active consideration by the GoB.

Guidelines for Government at All Levels (Best Practice Models). Guidelines for Government are implemented at all levels and are based on best practice models, and are used to assist directorates, institutions and divisions under the ministries, NGOs, disaster management committees and civil society in implementing disaster risk management. Following is a list of guidelines and templates prepared to assist in the EWS process:

a) Disaster Impact and Risk Assessment Guideline
b) Local Disaster Risk Reduction Fund Management Guidelines
c) Emergency Fund Management Guidelines
d) Indigenous Coping Mechanism Guidebook
e) Community Risk Assessment Guidelines
f) Damage and Needs Assessment Methodology
g) Hazard Specific Risk Assessment Guidelines
h) Emergency Response and Information Management Guideline
i) Contingency Planning Template
j) Sectoral Disaster Risk Reduction Planning Template
k) Local Level Planning Template
l) National Risk Reduction Fund Management Guideline
m) National Disaster Reduction and Emergency Fund Management Guideline
n) Local Disaster Management Fund Guideline

o) Guideline for Road and Water Safety

p) Guideline for Industrial Safety

q) Guideline for Disaster Shelter Management

r) Monitoring and Evaluation Guideline for the Implementation of the Plan

s) Guideline for International Assistance in Disaster Emergencies

National to local emergency planning and related linkages to EWS. Bangladesh is one of the most vulnerable countries for coastal disasters. Fourteen of the nineteen coastal districts of Bangladesh are high or moderate cyclone-risk areas. These exposed districts are currently the home of around 30.5 million people. To ensure the safety of residents in the coastal areas, the government is investing considerable effort into developing a suitable approach to manage cyclone and flood emergencies. The Bangladesh National Plan for Disaster Management provides the overall guidance under which relevant sectors and disaster management committees at all levels can prepare and implement their specific plans. The Ministry of Food and Disaster Management (MoFDM), being the focal ministry for disaster risk reduction and emergency management, will take the lead role in disaster risk reduction and emergency management planning. Additionally, there will be a few hazard-specific management plans, such as the following:

a) Flood Management Plan

b) Cyclone and Storm Surge and Tsunami Management Plan

c) Earthquake Management Plan

d) Drought Management Plan

e) River Erosion Management Plan

f) Disaster management plans for each District[40], Upazila[41], Union[42] and Paurashava[43] and City Corporation of the country.

A district disaster management plan will be the compilation of the upazila disaster management plans of the district. Similarly an upazila disaster management plan will be the compilation of the union disaster management plans of that upazila prepared by the union DMCs. So DMCs at the union and paurashava levels will be responsible for conducting the risk assessments and preparing the ground level plans. Once developed, those will be sent to the DMCs one level higher – upazila DMCs, whose role will be to verify and

[40] District: Bangladesh is divided into six administrative divisions under which there are 64 districts.

[41] Upazila: a district is divided into several Upazilas.

[42] Union: an Upazila is divided into several unions and a union is divided into several villages.

[43] Pourashava: the municipality of a small town. Municipality of a large town (i.e. city) is a City Corporation.

compile the union plans and identify the resource requirements for the upazila.

Disaster Management Plans. The disaster management-planning framework in Bangladesh is presented in Figure 7.46. The national plan is a dynamic document and is reviewed and evaluated annually to ensure consistency with national initiatives and government priorities. Key performance indicators are monitored and reported annually to assess the implementation progress of the Framework. The Department of Disaster Management (DDM) is responsible for carrying out evaluations in coordination with its stakeholders, which includes the BMD.

The Inter-Ministerial Disaster Management Coordination Committee (IMDMCC) guides MoFDM for monitoring the progress of implementation of this plan at the national level. The MoFDM, through the Department of Disaster Management Bureau is responsible for monitoring at the local level.

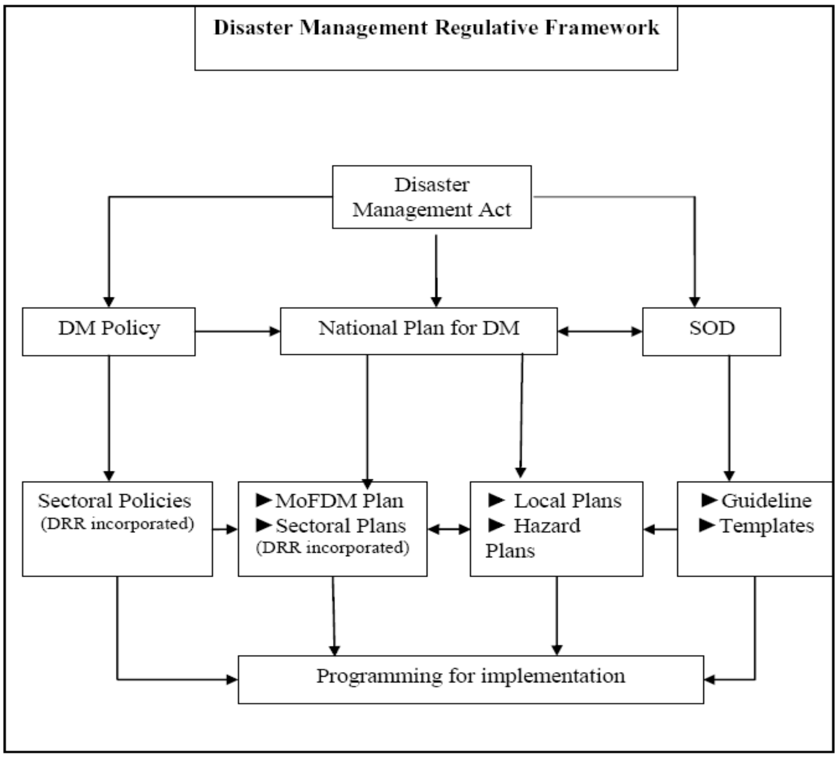

Figure 7.45 Inter-linkages between various regulative instruments and programming for implementation.

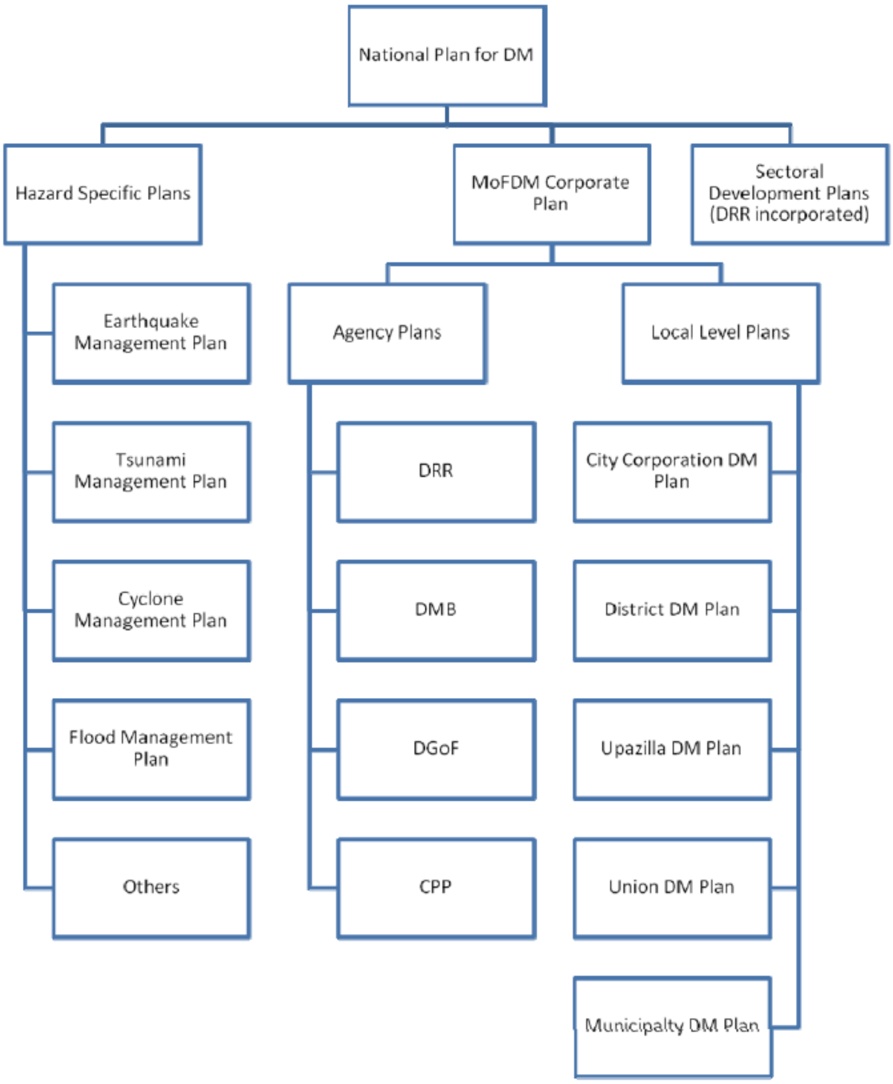

Figure 7.46 Disaster management planning framework.

7.7 USA

Authors: Paolo Ciavola and Grit Martinez.

The US states bordering the Gulf of Mexico and the East coast (e.g. Texas, Louisiana, Florida, South Carolina) have historically a record of tropical storm impact generated by hurricane force winds and surges. These weather systems are generally generated by large-scale circulation from depressions moving across the southern Atlantic Ocean, with a distinct seasonal distribution (Figure 7.1).

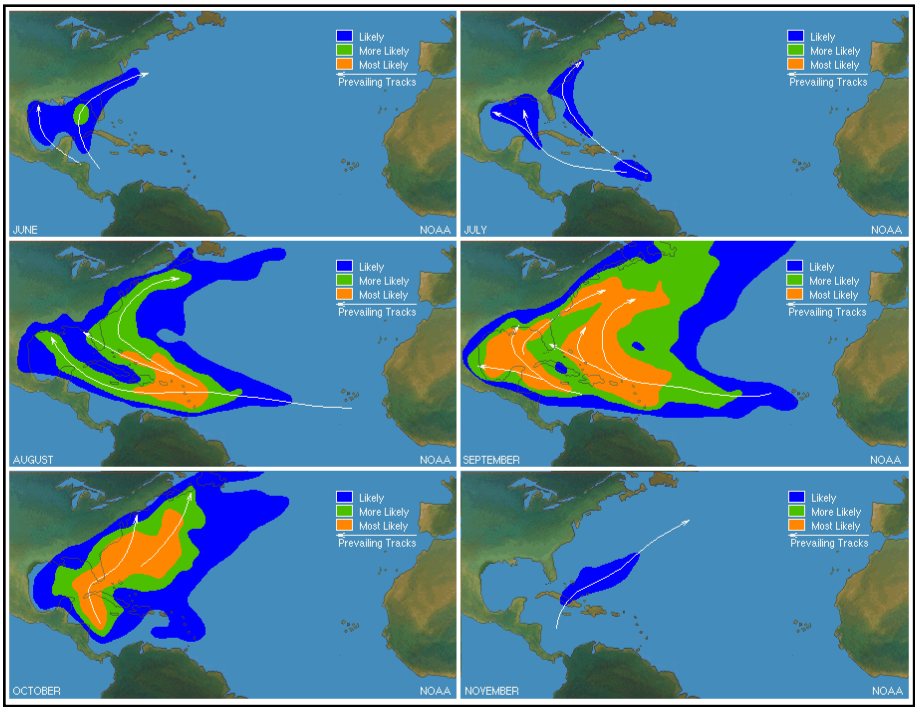

Figure 7.47 Tropical storm climatology of the southern and eastern coast of the USA (NOAA, 2014).

While in the early summer months the tropical storms generate locally in the Gulf of Mexico and the Caribbean, in the period from August to September the storm track starts from the western coast of Africa, crossing the Atlantic gaining energy due to high water temperature, already hitting the Caribbean with strength and then gaining further strength as the storm deviates along the south-eastern coast of the USA. In October phenomena turn again to be generated locally in the Gulf of Mexico while in November the probability of occurrence in generally low.

Table 7.11 presents an inventory of events since the 1900 century, when land occupation of the US coast started to increase. To notice that most of the tropical storms had an impact on southern states but it is not that unusual that NY and NJ experienced both hurricanes (e.g. 1938, 1954, 1972, 2004, 2011, 2012) and extra-tropical super storms (the “Perfect Storm of 1991”).

Table 7.11 Major U.S. Coastal Storms since 1900 (NRC, 2014)[44].

Type	Name	Year	Location	Estimated Damage	Casualties	Category
				billions $		Saffir - Simpson
Hurricane	Sandy	2012	Florida to Maine	65.9	286	2
Hurricane	Irene	2011	Puerto Rico, NC, mid-Atlantic coast, New York City, NY	7.2	41	1
Hurricane	Ike	2008	Galveston Island, Texas	22	82	2
Hurricane	Wilma	2005	Naples, FL; Upper Keys, FL; Marathon, FL	20	5	3
Hurricane	Rita	2005	Texas, Louisiana	11.9	7	5
Hurricane	Katrina	2005	Buras, LA	129	1,500	5
Hurricane	Dennis	2005	Gulf coast, FL	2.7	3	3
Hurricane	Jeanne	2004	Puerto Rico,	8.5	3	3
Hurricane	Ivan	2004	Southeastern U.S.	17.5	25	4
Hurricane	Frances	2004	Florida	11	8	2
Hurricane	Charley	2004	Florida, New Jersey	18.5	10	2
Hurricane	Isabel	2003	Mid-Atlantic	3.8	17	5
Storm	Allison	2001	Texas, North Carolina	6.6	41	Tropical

[44] Saffir-Simpson category provided at the first landfall on the U.S. coast. Sources: Data from the National Hurricane Center and the National Weather Service of the National Oceanic and Atmospheric Administration (NOAA, 1992; http://www.nhc.noaa.gov/outreach/history; http://www.weather.gov; http://www.ncdc.noaa.gov/oa/satellite/satelliteseye/cyclones/pfctstorm91/pfctstdam.html; http://www.erh.noaa.gov/er/lwx/Historic_Events/StormsOfCentury.html)

Hurricane	Floyd	1999	North Carolina	9.6	56	2
Hurricane	Opal	1995	Florida	4.6	9	3
Hurricane	Andrew	1992	Lower east FL coast; Gulf Coast	44	23	4
Hurricane	Iniki	1992	Hawaii	3	7	4
Storm	"Perfect Storm"	1991	Florida through Maine	0.343	ND	Extratropical
Hurricane	Hugo	1989	Puerto Rico; Charleston, SC; Hatteras, NC	13.2	21	4
Hurricane	Alicia	1983	Galveston, TX	4.7	21	3
Storm	Claudette	1979	Texas, Louisiana, Oklahoma	1.3	1	Tropical
Hurricane	Agnes	1972	East coast of Florida, Pennsylvania, New York	11.7	122	1
Hurricane	Camille	1969	Gulf Coast	8.9	256	5
Storm	Ash Wednesday	1962	East coast from Cape Hatteras, NC to Rhode Island	1.5	40	Extratropical
Hurricane	Donna	1960	Puerto Rico, Florida, North Carolina, New England	3	50	4
Hurricane	Audrey	1957	Texas, Louisiana	1.2	390	4
Hurricanes	Connie & Diane	1955	North Carolina	7.6	184	3 to 1
Hurricane	Hazel	1954	South Carolina, North Carolina	2.4	95	4

Hurricane	Carol	1954	North Carolina, Virginia, New York	4	60	3
Hurricane	Great Atlantic	1944	North Carolina to Maine	1.3	46	3
Hurricane	New England	1938	North Carolina, New York,	5	600	3
Hurricane	Labor Day	1935	Florida Keys, South Florida	0.102	408	2
Hurricane	San Felipe	1928	Lake Okeechobee, Puerto Rico, Florida	0.341	1,836	4
Hurricane	Great Miami	1926	Miami, FL	91.3	373	4
Hurricane	Atlantic Gulf	1919	Florida, Texas	0.296	600-900	4
Hurricane	Galveston	1900	Galveston, TX	0.821	6,000-8,000	4

7.7.1 Materials and methods

The NOAA Historic Hurricane and Storm Database[45], is the main source of information on US hurricane and storms. It was used to derive the following description of hurricanes Katrina and Ike (and their impacts) while, the hurricane Sandy investigation one was mainly based on Blake et al. (2013) and on NOAA (2013). Other articles, documents and multimedia are cited in order to integrate information and derive lessons learned. The complete list of references and sources can be found at the end of the report.

7.7.2 Tropical storm overview

Hurricane Katrina (2004)

The following description is largely based on the event description available in the NOAA historical hurricane and storm database, which is available at http://www.nhc.noaa.gov/outreach/history. Katrina was one of the most devastating hurricanes in the history of the United States. It is the deadliest hurricane to strike the United States since the Palm Beach-Lake Okeechobee hurricane of September 1928. It produced catastrophic damage - estimated at $75 billion in the New Orleans area and along the Mississippi coast - and is the costliest U. S. hurricane on record.

This powerful tropical cyclone formed from the combination of a tropical wave, an upper-level trough, and the mid-level remnants of Tropical Depression Ten. A tropical depression formed on 23rd August 2004 about 320 km southeast of Nassau in the

[45] Available at: http://www.nhc.noaa.gov/outreach/history;

Bahamas. Moving northwestward, it became Tropical Storm Katrina during the following day about 120 km east-southeast of Nassau. The storm moved through the northwestern Bahamas on 24th-25th August 2004, and then turned westward toward southern Florida.

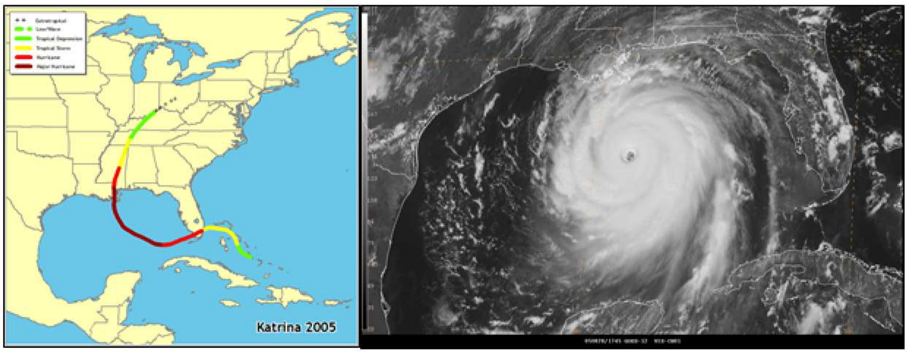

Figure 7.48 Track of Hurricane Katrina as it approaches the southern and eastern coast of the USA (left); (right) GOES-12 visible image of Hurricane Katrina over the central Gulf of Mexico at 1745 UTC 28th August 2005, near the time of its peak intensity (http://www.nhc.noaa.gov/outreach/history/#ike).

Katrina became a hurricane just before making landfall near the Miami-Dade/Broward county line during the evening of 25th August 2004. The hurricane moved southwestward across southern Florida into the eastern Gulf of Mexico on 26th August 2004. Katrina then strengthened significantly, reaching Category 5 intensity on 28th August 2004. Later that day, maximum sustained winds reached 280 km/h with an aircraft-measured central pressure of 902 mb while centered about 310 km southeast of the mouth of the Mississippi River. Katrina turned to the northwest and then north, with the center-making landfall near Buras, Louisiana at 1110 UTC 29th August with maximum winds estimated at 200 km/h (Category 3). Continuing northward, the hurricane made a second landfall near the Louisiana/Mississippi border at 1445 UTC with maximum winds estimated at 190 km/h (Category 3). Weakening occurred as Katrina moved north-northeastward over land, but it was still a hurricane near Laurel, Mississippi. The cyclone weakened to a tropical depression over the Tennessee Valley on 30th August. Katrina became an extratropical low on 31st August and was absorbed by a frontal zone later that day over the eastern Great Lakes.

Katrina brought hurricane conditions to southeastern Louisiana, southern Mississippi, and southwestern Alabama. The Coastal Marine Automated Network (C-MAN) station at Grand Isle, Louisiana reported 10-minute average winds of 140 km/h at 0820 UTC August 29th with a gust to 180 km/h. Higher winds likely occurred there and elsewhere, as many stations were destroyed, lost power, or lost communications during the storm. Storm surge flooding of 7.6 to 8.5 m above normal tide level occurred along portions of the Mississippi coast, with storm surge flooding of 3 to 6 m above normal tide levels along the southeastern Louisiana coast. Hurricane conditions also occurred over southern Florida and the Dry Tortugas. The National Hurricane Center reported sustained winds of 110 km/h at 0115 UTC 26th August with a gust to 140 km/h. Additionally, tropical storm conditions occurred along the northern Gulf coast as far east as the coast of the western Florida Panhandle, as well as in the Florida Keys. Katrina caused 254 to 355 mm of rain over southern Florida, and 203 to 305 mm of rain along its track inland from the northern Gulf coast. Thirty-three tornadoes were reported from the storm.

Katrina is responsible for approximately 1200 reported deaths, including about 1000 in Louisiana and 200 in Mississippi. Seven additional deaths occurred in southern Florida. Katrina caused catastrophic damage in southeastern Louisiana and southern Mississippi. Storm surge along the Mississippi coast caused total destruction of many structures, with the surge damage extending several miles inland. Similar damage occurred in portions of southeastern Louisiana southeast of New Orleans. The surge overtopped and breached levees in the New Orleans metropolitan area, resulting in the inundation of much of the city and its eastern suburbs. To note that the design criteria for the levee system of the city was for a strong Category 3 storm and Katrina was only a weak Cat. 3 storm and the structures should have held. A combination of pressure burst (17th and London Avenue Levees), overtopping and scour (9th Ward) led to the flooding of the city (A. Trembanis, personal communication). Wind damage from Katrina extended well inland into northern Mississippi and Alabama. The hurricane also caused wind and water damage in Miami-Dade and Broward counties.

According to the storm description by Knabb et al. (2005), the massive storm surge produced by Katrina, can be generally explained by the huge size of the storm. Katrina had on 29th August a large (about 46-56 km) radius of maximum winds and a very wide swath of hurricane force winds that extended at least 140 km to the east from the center. Even though Hurricane Camille (1969) was more intense than Katrina at landfall while following a similar track, Camille was far more compact and produced comparably high storm surge values along a much narrower swath. Also, Katrina had already generated large northward-propagating swells, leading to substantial wave setup along the northern Gulf coast, when it was at Category 4 and 5 strength during the 24 hours or so before landfall. In fact, buoy 42040, operated by the National Data Buoy Center (NDBC) and located about 100 km mi south of Dauphin Island, Alabama, reported a significant wave height of 9.1 m as early as 0000 UTC 29th August. This buoy later measured a peak significant wave height of 16.8 m at 1100 UTC that matches the largest significant wave height ever measured by a NDBC buoy. Overall, Katrina's very high storm surge is attributable mainly to the large horizontal size of the hurricane, with the total water level being further increased by waves, including those generated the previous day when Katrina was at Category 5 strength.

According to Froede (2007) despite the extended distance, the storm impacted Dauphin Island with waves that completely overwashed and flattened most of the western low-lying areas. The hurricane also segmented Dauphin Island into two distinct barrier islands, the undeveloped Dauphin Island West, and the residentially developed Dauphin Island East. Immediately following the storm, the Town of Dauphin Island recognized the need to take action to protect low-lying residential property on the western segment of Dauphin Island East. Previoulsy, beach nourishments were implemented as temporary measures (Trembanis and Pilkey, 1998; see also the Beach Nourishment Viewer from Western Carolina University[46]). After the event, a sand berm was built as DRR measure starting on 29 January 2007. However the berm was severely eroded at many points before construction being completed in May 2007. To notice that this practice of berm construction as temporary flood protection measure is common to other places like for example the northern Italian coastlines along the Adriatic (cf. Par. 0 on Emilia-Romagna, IT). However, as recently noted by Harley and Ciavola (2013), the absence of design criteria (e.g. height, width, angle of the berm) may jeopardize its efficiency.

The most important point to consider about the impact of the event, and the failure of DRR emergency measures were later highlighted in a report commission to a special ASCE council of experts (Andersen et al. 2007). Their words are clear in sending the message: "There are serious deficiencies in the Southeast Louisiana hurricane protection system that must be corrected if the New Orleans area is to avoid a similar catastrophe when the next major hurricane strikes. There are flaws in the way the hurricane protection system was conceived, budgeted, funded, designed, constructed, managed, and operated".

The results of the study cited above can be summarized using the following bullet points:

- **Keep safety at the forefront of public priorities**. All responsible agencies in New Orleans and elsewhere should re-evaluate their policies and practices to ensure that protection of public safety, health, and welfare is the top priority for the infrequent but potentially devastating impacts from hurricanes and flooding. The U.S. Congress should establish and fund a program for nationwide levee safety and rehabilitation, much as we do for major dams.
- **Quantify the risks.** The USACE IPET should complete the work necessary to quantify risk as soon as possible, and because risk assessment is not static, should periodically update the assessment of risk. This risk assessment approach should be extended to all areas of the nation that are vulnerable to major losses from hurricanes and flooding.
- **Communicate the risks to the public and decide how much risk is acceptable.** Local, state, and federal agencies should create and maintain quality programs of public risk communication in New Orleans and other areas threatened by hurricanes and flooding.
- **Rethink the whole system, including land use in New Orleans**. Local, state, and federal leaders should review the overall strategy and systems approach, integrating hurricane protection tactics, land use considerations, and emergency response strategies into a coherent and well thought out system.
- **Correct the deficiencies**. Local, state, and federal leaders should continue the work necessary to correct the deficiencies in the hurricane protection system, and bring this work to completion with urgency.

[46] Available at: http://beachnourishment.wcu.edu/

- **Put someone in charge**. Local, state, and federal leaders should agree to assign to a single individual the responsibility for managing critical hurricane and flood protection systems such as the one in the New Orleans area.
- **Improve inter-agency coordination**. All agencies involved in the hurricane protection system should implement far better and more effective mechanisms for coordination and cooperation.
- **Upgrade engineering design procedures.** The engineering community should review and update engineering design procedures for hurricane and flood protection systems to ensure that these updated procedures take all reasonable steps to protect the public safety, health, and welfare.
- **Bring in independent experts.** Agencies responsible for design of hurricane and flood protection system and other critical life safety structures should engage independent experts in high-level review of every project.
- **Place safety first.** ASCE, working in partnership with the USACE and other engineering organizations should reinforce the need to place the safety, health, and welfare of the public first, and should communicate that public safety must always take precedence.

In conclusion, Katrina unfortunately provided a landmark in DRR policy in the US. Basically the town was not properly protected from an engineering viewpoint and the Disaster Management structure was not ready for an event like this. If one compares the EU Flood Directive and the UN Hyogo framework for action application described in the first part of this report, it is striking how strong the reaction was in Europe which inevitably led to better preparedness.

Hurricane Ike (2008)

The following description is largely based on the event description available in the NOAA historical hurricane and storm database, which is available at http://www.nhc.noaa.gov/outreach/history. Hurricane Ike was a long-lived and major Cape Verde hurricane that caused extensive damage and many deaths across portions of the Caribbean and along the coasts of Texas and Louisiana (Figure 7.49). It originated from a well-defined tropical wave that moved off the west coast of Africa on 28th August 2008 and then became a tropical depression on 1st September 2008 about 1240 km west of the Cape Verde Islands. The depression quickly strengthened to a tropical storm later that day. Ike became a hurricane on 3rd September 2008, and reached an estimated peak wind intensity of over 230 km/h (Category 4) on 4th September 2008 when it was located 885 km northeast of the Leeward Islands. After weakening briefly, Ike regained Category 4 status just before moving across the Turks and Caicos Islands on 7th September 2008. Ike then passed over Great Inagua Island in the southeastern Bahamas at Category 3 strength.

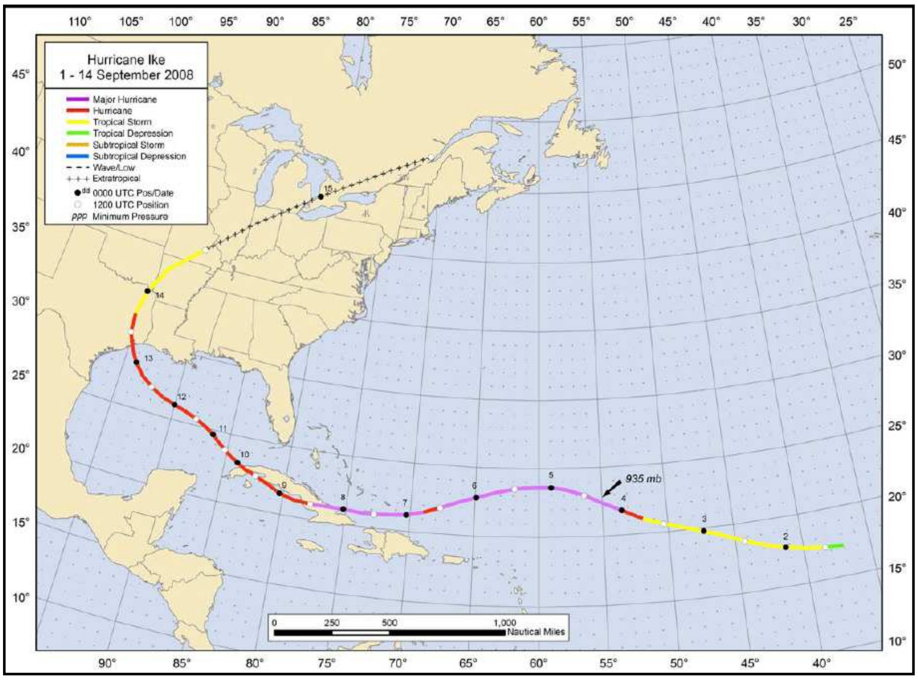

Figure 7.49 Track of Hurricane Ike as it approaches the southern and eastern coast of the USA (http://www.nhc.noaa.gov/outreach/history/#ike).

Ike turned westward and made landfall along the northeast coast of Cuba in the province of Holguin early on September 8 with maximum sustained winds estimated near 217 km/h (Category 4). Ike made a second landfall in Cuba over the extreme southeastern part of the province of Pinar del Rio on September 9th, with winds of 129 km/h (Category 1). It moved into the southeastern Gulf of Mexico later that day.

Ike developed a large wind field as it moved northwestward across the Gulf of Mexico over the next 3 days, with tropical-storm-force winds extending up to over 440 km from the center and hurricane-force winds extending up to 185 km from the center. The hurricane gradually intensified as it moved across the Gulf toward the Texas coast and a NOAA buoy located 330 km south of South-west Pass recorded offshore wave heights of 9 m (Doran et al., 2008). Ike made landfall over the north end of Galveston Island (LA) n the early morning hours of 13th September 2008 as a Category 2 hurricane with maximum wind speeds of almost 180 km/h. As it made landfall at Galveston the NOAA buoys recorded waves of 6 m (Doran et al., 2008). The hurricane weakened as it moved inland across eastern Texas and Arkansas and became extratropical over the middle Mississippi Valley on 14th September 2008. It then moved rapidly through the Ohio valley and into Canada, producing wind gusts to hurricane force along the way.

Grand Turk Island reported winds of 187 km/h as the center of Ike crossed the island. According to the observations of the FEMA Mitigation Assessment Team Report, storm surges of 4.6-6.1 m above normal tide levels occurred along the Bolivar Peninsula of Texas and in much of the Galveston Bay area (Figure 7.50), with surges of up to 3 m above normal occurring as far east as south central Louisiana (Figure 7.51). Storm total rainfalls from Ike were as much as 483 mm in southeastern Texas and 356 mm in Cuba.

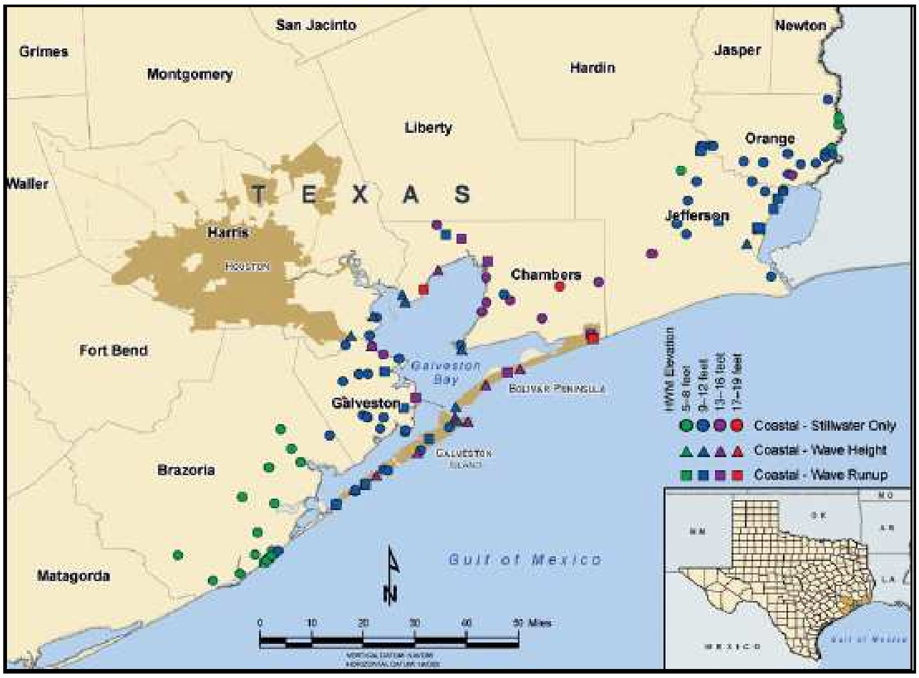

Figure 7.50 Total water levels surveyed by FEMA in Texas (http://www.fema.gov/media-library-data/20130726-1648-20490-1790/757_ch1_final.pdf).

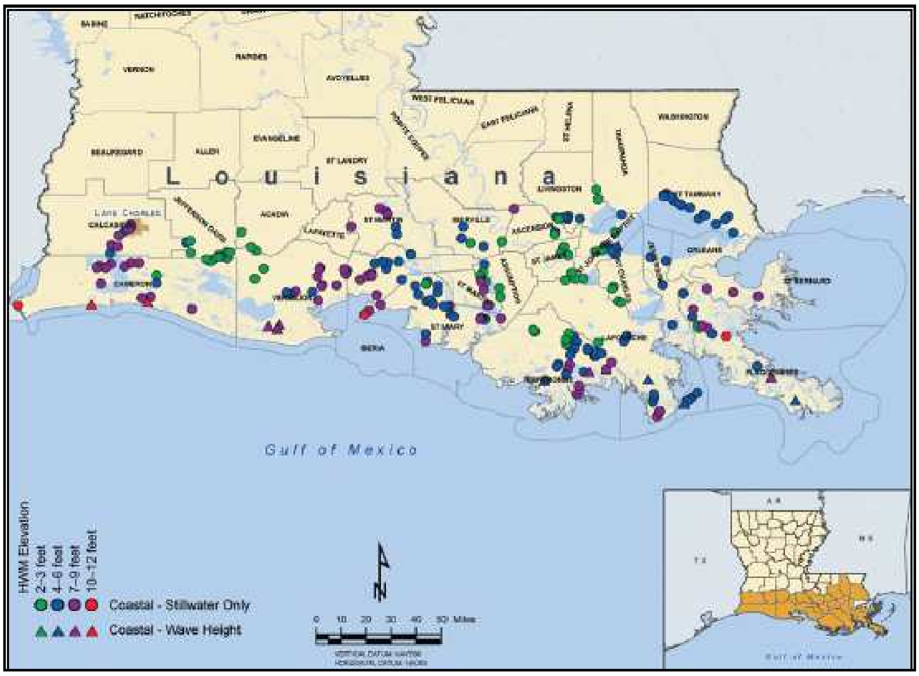

Figure 7.51 Total water levels surveyed by FEMA in Louisiana (http://www.fema.gov/media-library-data/20130726-1648-20490-1790/757_ch1_final.pdf).

Ike was the second deadliest hurricane of the last years for the US territory. Outside the United States, it is estimated that flooding and mud slides killed 74 people in Haiti and 2 in the Dominican Republic, compounding the problems caused by Fay, Gustav, and Hanna. The Turks and Caicos Islands and the southeastern Bahamas sustained widespread damage to property. Seven deaths were reported in Cuba. Ike's storm surge devastated the Bolivar Peninsula of Texas, and surge, winds, and flooding from heavy rains caused widespread damage in other portions of southeastern Texas, western Louisiana, and Arkansas.

Following the event FEMA deployed a MAT (Mitigation Assessment Team) to assess damage to private and public buildings and infrastructure. Damage was observed to single- and multi-family buildings, manufactured housing, commercial buildings, and historic buildings. In addition, critical facilities, such as Emergency Operations Centers (EOCs), fire and police stations, hospitals, nursing homes, and schools were also evaluated in order to document building performance as well as loss of function from Hurricane Ike (Figure 7.52).

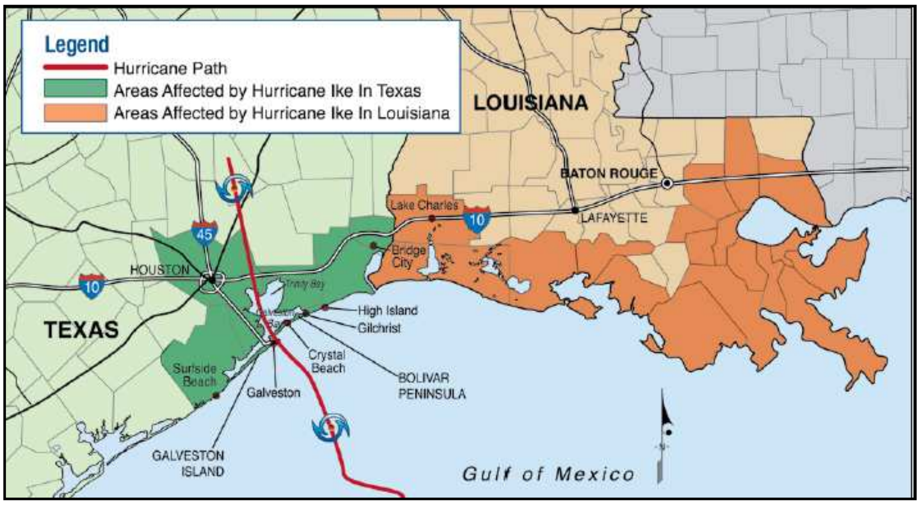

Figure 7.52 Impacted areas in Texas and Louisiana (http://www.fema.gov/media-library-data/20130726-1648-20490-1790/757_ch1_final.pdf).

Twenty people were killed in these areas, with 34 others still missing. Property damage from Ike as a hurricane is estimated at $19.3 billion. Additionally, as an extratropical system over the Ohio valley, Ike was directly or indirectly responsible for 28 deaths and more than $1 billion in property damage.

The following description of coastal damages is based on the USGS report published by Doran et al. (2008) following detailed post-event investigations which included LiDAR flights and oblique air photography.

In the following paragraphs the impact of the hurricane is described moving from the south-western sectors to the north-east (Figure 7.53). Only the most significant images captured during the flights presented by Doran et al. (2008) are discussed.

In the area of Surfside Beach a San Luis Pass (Texas) located well westward of the hurricane landfall, the main impact was dune erosion with formation of dune scarps and overwash of the dune ridge (Figure 7.54). In this area the main impact of the hurricane was habitat loss as it is undeveloped. Ike hit the Galveston area on 13th September 2008 and here because of the coastal urbanization the damage to private homes and infrastructures was much higher. Galveston Island experienced damage to coastal structures and two high-rise buildings can be seen in Figure 7.55 as becoming virtually located on the shoreline. Clearly at the construction phase nobody had considered the possibility of sudden retreat. Along the Bolivar peninsula damage was even higher, where entire coastal villages were wiped out (Figure 7.55).

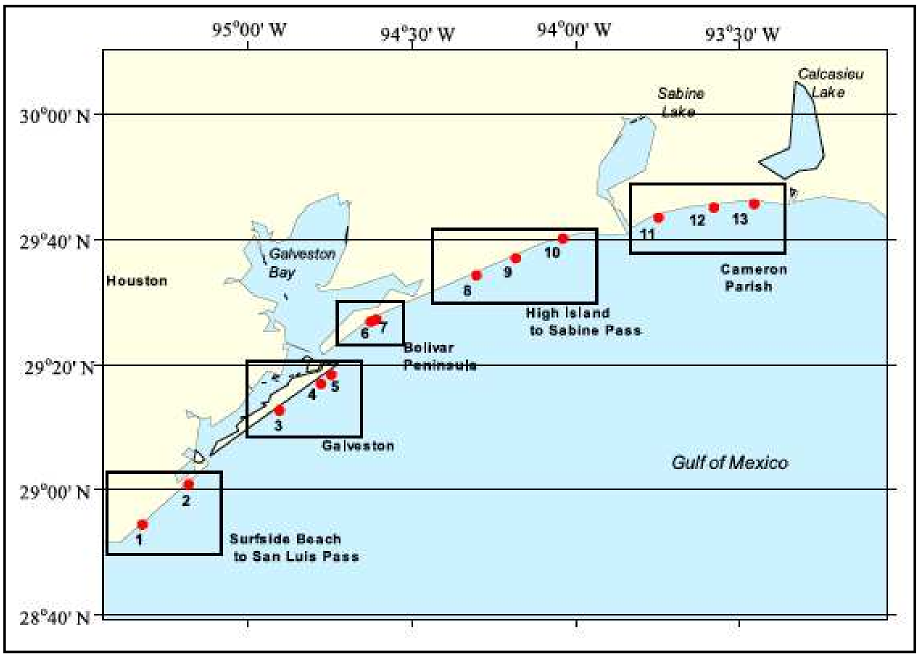

Figure 7.53 Impacted coastal areas in Texas and Louisiana. Location of examples shown in Doran et al. (2008).

Figure 7.54 Dune erosion at location 1 of Figure 7.53 (left) and overwash of coastal road at location 2 of Figure 7.53 (right)(Source: Doran et al., 2008).

Figure 7.55 Pier destruction at location 3 of Figure 7.53 (left) and overwash of coastal village at location 6 of Fig. Figure 7.53 (right)(Source: Doran et al., 2008).

Hurricane Sandy (2012)

The following description of the event is largely based on Blake et al. (2013) and on NOAA (2013). According to the report of Blake et al. (2013) Sandy was a classic late-season hurricane in the southwestern Caribbean Sea (Figure 7.56). The cyclone made landfall as a category 1 hurricane (on the Saffir-Simpson Hurricane Wind Scale) in Jamaica, and as a category 3 hurricane in eastern Cuba before quickly weakening to a category 1 hurricane while moving through the central and northwestern Bahamas. Sandy underwent a complex evolution and grew considerably in size while over the Bahamas, and continued to grow despite weakening into a tropical storm north of that archipelago. The system strengthened again into hurricane force as it moved northeastward, parallel to the coast of the southeastern United States, and reached a secondary peak intensity of 85 knots while it turned northwestward toward the mid-Atlantic states. Sandy weakened somewhat and then made landfall as a post-tropical cyclone near Brigantine, New Jersey with 7 knots maximum sustained winds. Significant wave heights of over 7 m with wave periods of 14 second were recorded in situ off the coast of Delaware where pronounced scour of the seabed and damage to an artificial reef system were observed from the near bed orbital velocities of over 1.5 m/s (Trembanis et al., 2013). Because of its tremendous size, however, Sandy drove a catastrophic storm surge into the New Jersey and New York coastlines.

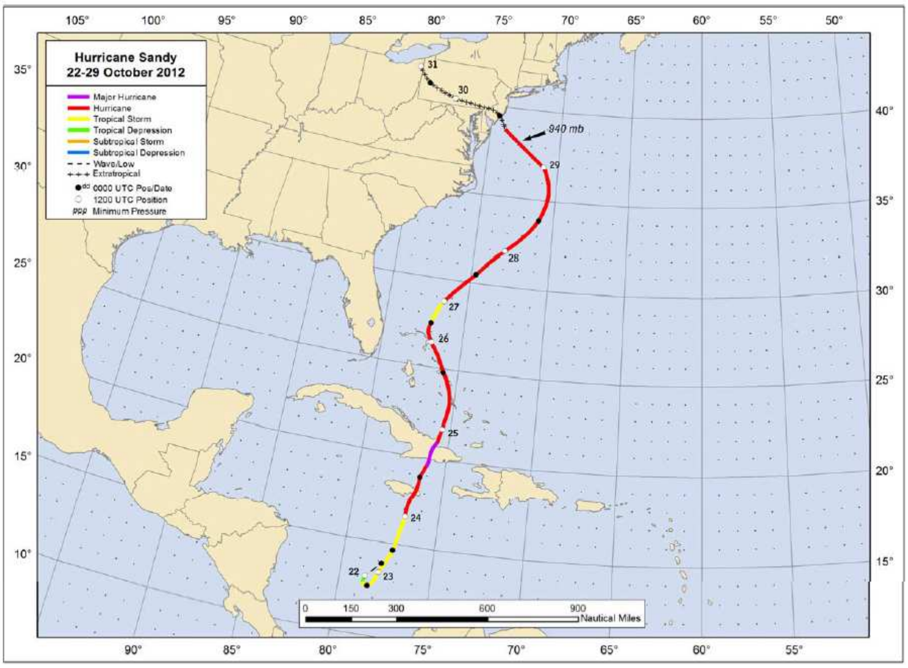

Figure 7.56 Best track positions for Hurricane Sandy, 22nd - 29th October 2012 according to Blake et al. (2013).

It is rather interesting that even across US agencies who worked on the topic there is some debate if the phenomenon had to be considered a hurricane or an extra-tropical storm of tremendous strength. NOAA's report (2013) states that Sandy was unique in many ways. Its historically unprecedented track approached New Jersey and New York from the east; storms typically approach from the south. Sandy also made an atypical transition to post-tropical status. The storm evolved when a tropical cyclone merged with an intense low-pressure system and dramatically increased in size before landfall. Unlike most hurricanes that hit the eastern US coast, Sandy did not steer to the northeast – blocking high to north and did not lose strength – increase energy from cold artic air forcing jet stream to south. Trembanis et al., (2013) noted that storm conditions similar to those produced from Sandy occur on the inner shelf with a return interval of about 2.8 years, which challenges some interpretations of the rare nature of the storm dynamics. The reader should consult Greene et al. (2013) for a discussion of the system dynamics.

According to NOAA (2013), Sandy caused water levels to rise along the entire East Coast of the United States from Florida to Maine. The highest storm surges and greatest inundation, which reached record levels, occurred in New Jersey, New York, and Connecticut, especially in and around the New York City metropolitan area. In many of these locations, especially along the coasts of central and northern New Jersey, Staten Island, and southward-facing shores of Long Island, the surge was accompanied by high waves. According to the NOOA's report, NOS tide gauges at the Battery in Manhattan and at Bergen Point West Reach on Staten Island recorded water level values of 9.0 feet and 9.53 feet above Mean Higher High Water (MHHW), respectively. The estimated inundation in those areas is presented in Figure 7.57.

As stated by the Deputy Under Secretary for Operations of NOAA, "Storm surge created some of the most devastating impacts, including flooding in New York City's subway tunnels, water overtopping runways at La Guardia and Kennedy airports, and damage to the New Jersey Transit System estimated at approximately $400 million". Sandy's storm surge, in addition to occurred together with high waves, devastated large portions of the coasts of New Jersey in an unprecedented in the state's history.

The damage in the villages of Mantoloking highlights the severity of the storm surge and waves across this region. A majority of structures there were flooded, badly damaged, or destroyed. The surge created two new inlets across the island (Figure 7.58). In Seaside Heights, historical recreation structures were destroyed (Figure 7.59). Long Beach Island, a barrier island of the central New Jersey coast, suffered catastrophic damage with nearly every house on the seafront extensively damaged.

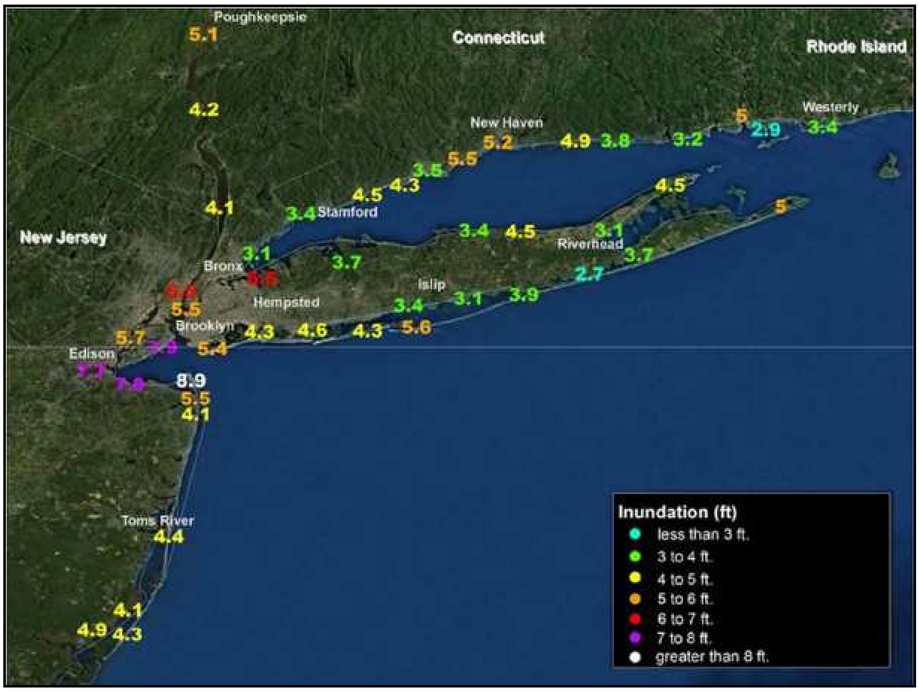

Figure 7.57 Estimated inundation (feet, AGL) calculated from USGS high-water marks and NOS tide gages in Connecticut, New York, and northern New Jersey. Source: NHC TCR in NOAA (2013).

Figure 7.58 (a) Before and after images of a portion of the coast in Mantoloking, NJ, showing the effect of storm surge flooding. (b) Before and after image of a portion of the coast near Rockaway, New York, in Queens County. Source: Blake et al. (2013). All images are courtesy of the U.S. Geological Survey.

Figure 7.59 a) Image of a rollercoaster sitting in the Atlantic Ocean in NJ Fun Town (courtesy of Getty Images), b) the Lexington Avenue subway station flooded (courtesy Wzohaib/Flickr) c) storm surge penetrating the lower East Side in Manhattan, New York City, on 29 October 2012 (courtesy Twitter/nycarecs) , d) photo from a surveillance camera that shows a PATH station in Hoboken, New Jersey, as it is flooded around 9:30 p.m. EDT 29 October 2012 (courtesy AP/Port Authority of New York and New Jersey) (Source: Blake et al., 2013).

7.7.3 Lessons learned

Hurricanes Katrina, Ike and Sandy mark records in the history of the U.S. in terms of their deadly impacts and property damages. In addition, "super storm" Sandy was the largest Atlantic hurricane on record as measured by diameter, with winds spanning across North America affecting 24 states in the U.S.

It is important to notice that even between researchers there in no full agreement between the damage induced by these events. Blake et al. (2013) for example report for Katrina 1833 deaths, $108 billion (costliest natural and worst civil engineering disaster), for Ike 125 deaths, $8.9 billion (4th costliest hurricane) and for Sandy 72 deaths, $75 billion (2nd costliest hurricane, even if many consider it a "super-storm" and not an hurricane). According to the NRC Report (2015) for Katrina the deaths were 1500 with an extimated damage of $129 billion. For Ike the NRC report indicates 82 deaths with $22 billion of damage. For Sandy NRC report 286 deaths and $65.9 billion of damage. The disagreement may be due to the methods used for forensic investigation of casualties as well as the method for financial loss extimation which still is not completely standardized for natural hazards, see Kreibich et al. (2013) and Meyer et al. (2014) for recent reviews on these topics.

Although only in the case of hurricane Katrina major deficits in the quality in the flood-control system (different levee breaches in greater New Orleans submerged most of the city and water reaching dozens of kilometer from the beach inwards) account for a high proportion of the disaster, in all three extreme events a major break down of public risk communication and early warning before, during and after the event signals the need for wide improvements in early warning and risk awareness communication in the U.S.

Lessons learned at local, regional, federal level

The United States National Response Plan (NRP) classifies disaster response and planning as local government responsibility that can be backed up with country level and federal government resources if necessary.

Shortly after Hurricane Katrina's landfall, an intense public debate arose about the local, state and federal governments' role in the preparations for and response to hurricanes placing the responsibility for the disaster on all three levels of government. Nevertheless, the mayor of New Orleans and the governor of Louisiana were criticized for failing to implement New Orleans evacuation plan and for delaying the emergency evacuation order. Moreover, in 2006 in a hearing before the United States Senate Subcommittee on Energy and Water, the Corps of Engineers testified that there were system design flaws in the materials of the levees. In reaction to that, in 2007 the American Society of Civil Engineers (ASCE) Hurricane Katrina External Review Panel issued the investigational report “Hurricane Katrina: One year later. What must we do?” In the report ten critical actions were formulated which aimed to shift the thoughts and approaches in understanding risk, evaluating protection systems and stressing engineering quality and improvement of the management of the systems (Andersen et al., 2007).

The storm's devastation also prompted a Congressional investigation, which found that many of the problems that arose during Hurricane Katrina had developed from inadequate planning and back-up communication systems at various levels leading to insufficient integration of federal, state, and local emergency plans and operations for evacuations (i.e. communication problems, insufficiently articulated roles and responsibilities among local, state, and federal authorities). It was also found that the Federal Emergency Management Agency (FEMA) and the Red Cross were lacking logistics capacity for catastrophic events (U.S. Government, 2006). In addition, Hurricane Katrina raised other, more general public policy issues about emergency management, environmental policy, ethnicity, poverty, and unemployment.

During Hurricane Ike potential danger and possible death warnings were more effectively and timely communicated to residents. The former president Bush made an emergency declaration for Texas three days before landfall. More than one million people evacuated in advance of Hurricane Ike. About 10% of the inhabitants refused to be evacuated (Cutter et al., 2009). The Texas Water/Wastewater Agency Response Network (TXWARN) activated its member utility mutual aid network and began coordination with the State Emergency Operations Center and the Texas Commission on Environmental Quality (TCEQ) to begin preparations and notifications to utilities to prepare for Ike. In addition to the orders of local and state officials, federal officials were involved in evacuation decisions and special needs populations were flown out on military planes

As with Hurricane Katrina, defects in communications became again a major lesson to take away from "super storm" Sandy. In the areas that were ordered to evacuate in New York and New Jersey, 70 percent of people did not evacuate. Compared to Katrina, in the areas ordered to evacuate in New Orleans, 80 percent of people complied (Worrall, 2012). One major reason has been reported (Worrall, 2012) as the following: "As soon as Sandy became something other than a hurricane, the National Hurricane Center literally couldn't forecast the storm or issue advisories. Their software packages wouldn't allow it.... So they decided at the 11th hour that they were going to hand off responsibility for forecasting to the local weather service offices. Once that happened, you had this complete breakdown". Nevertheless social media service provider such as Twitter and others provided people the opportunity to post real-time information, pictures, and video and to post requests for assistance. Another lesson confirmed the vulnerability of infrastructure such as power and gas supply lines and the problematic management of shortages after key infrastructure broke down (Neuman, 2012).

Local, regional and federal responses

Post-event appraisal. FEMA (Federal Emergency Management Agency) along with responding to disasters and providing assistance to people and communities affected by disasters, conducts building performance studies after disasters to better understand how natural and manmade events affect the built environment. Following a Presidentially declared disaster, FEMA determines the potential need to deploy one or more MATs (Mitigation Assessment Teams) to observe and assess damage to buildings and structures, as caused by wind, rain, and flooding associated with the storm.

For example in the case of Hurricane Ike, FEMA's Mitigation Division deployed a MAT to Texas and Louisiana on 15 October 2008, to evaluate both building performance during Hurricane Ike and the adequacy of current building codes, other construction requirements, and building practices and materials.

Infrastructure. At the local level a significant proportion of levees have been reconstructed in New Orleans/ Louisiana since the time of hurricane Katrina with an emphasis on to modern building code standards (i.e. replacing I-walls with T-walls. T-walls have a horizontal concrete base for protection against soil erosion underneath the floodwalls (Crenson, 2015). Nevertheless funding battles over the remaining levee improvements remained years after the event.

Early Warning Systems/ Evacuation planning. At federal level, much of the post-Hurricane Katrina legislation provided for grants for state and local agencies to develop evacuation plans targeted towards special needs populations (i.e. households with no transportation, household with pets and service animals) and to improve risk planning and communication. Although it is recognized that evacuation management in general improved, increasing evacuation response of local residents is an ongoing challenge.

Further efforts are investigations in GIS combined with aerial photography to create a real-time application such as "Virtual Alabama" (See the YouTube video at https://www.youtube.com/watch?v=a-1I0JTWiIY). There are also citizen-evacuation system being developed that employs radio-frequency identification (RFID) and wireless technologies to help individuals during emergencies and disasters.

Legislations. Prior to Hurricane Katrina, evacuations were a state and local responsibility, with limited federal involvement. According to the National Response

Framework (NRF) the federal role in evacuations has become more active since Hurricane Katrina. For instance, the amendments to the Stafford Act (Post Katrina Emergency Management Reform Act of 2006) provide for federal assets to assist in transporting evacuees out of the affected areas and back again as they return to their homes (Lindsay, 2008).

After Hurricane Sandy the Governor's Office of Storm Recovery (GOSR) utilized approximately $3.8 billion in flexible funding made available by the U.S. Department of Housing & Urban Development's (HUD) Community Development Block Grant Disaster Recovery (CDBG-DR) program to concentrate aid in four main areas: Housing, Small Business, Infrastructure, and the Community Reconstruction Program (Governor’s Office, 2015)

After the release of the post-Sandy report by the USA Army Corp of Engineers, an Executive order directed federal, state and local government agencies to adopt stricter building standards to reflect the capacity to deal with scientific projections of future flooding. Federal funds were made available for adaptation strategies (Eilperin, 2015).

8 Conclusions and highlights

8.1 Emergency and DRR at national and supra-national levels

Authors: Enrico Duo and Paolo Ciavola.

Policies overview. Although intergovernmental, supra-national and national polices exist, it is quite difficult to get a complete overview of their structure and mutual relations. The perception is that there is a large amount of documentation on the topic but no sources can be considered complete.

Moreover, especially at the supra-national level, the number of Strategies, Directives, Guidelines and Tools related to the Disaster Management and DRR measures topics is uncountable. A significant effort to try to coordinate policies may not be able to identify a clear roadmap for citizens and policy-makers.

On the other hand, at the national level, even when there is a clear intent to solve and face the issue in a comprehensive and integrated way, administrative and political matters identified in the analyses make it difficult. Comparisons and standardization processes of the approaches seems to be far away from the target.

This report collects information on policies identifying links where possible in order to drive the users to a deeper research based on their needs. Moreover, it gathers several links to web tools, mainly informative tools, that were published, but limited dissemination makes them unknown to the majority of the population and policy-makers.

Implemented analysis. The implemented analyses on national adaptation to intergovernmental and supra-national policies were made to understand whether States are following the requirements or not. However, they were necessarily limited in time and space. On the other hand, RISC-KIT members were requested to adopt a point of view as objective as possible, focusing on national level assessment and trying to be free from official outcomes and local perspective.

At EU level, the analyses evidenced that, although best practices for the implementation of the Floods Directive can be found over Europe (e.g. Italy and UK) and the MSs are in line with the requirements, criticisms were evidenced in the practical terms, especially at local level, evidencing consistent differences in the application that should be, on the other hand, standard. Moreover, while riverine applications of the FD are clear and implemented, the coastal aspect is often secondary and unclear or incomplete. Thus, the integrated basin perspective is often missing.

At UN level, all States officially included in the analysis showed a medium-high achievement of HFA Priorities, with some exceptions. In particular, the United Kingdom, Sweden, Germany and Italy showed a good adaptation to the intergovernmental policy.

However, looking at the RISC-KIT self-check assessment outcomes by the Case Study Partners, only Bangladesh and the United Kingdom were confirmed in their status (good and medium, respectively). Germany and Sweden were confirmed in a good-medium status with some exceptions. For Italy, France, Portugal and Bulgaria the RISC-KIT CSOs were disagreeing from the governmental outcomes, affirming that their States reached a medium to poor achievement status. Spain and Belgium, for which only the RISC-KIT assessment is available at the moment, the achievement of HFA Priorities was far away from the good status.

Focusing on Europe, a pattern can be highlighted: northern Member States, with the exception of Belgium, are strongly implementing HFA Priorities and their governments are reporting on time. On the other hand, southern ones are not. In particular, governments of southern States reported positive outcomes about the application of the HFA, whereas our RISC-KIT CSOs reported otherwise.

Vision. Several shortcomings in policies, in terms of clearness, consistency and coordination were evidenced. Complex systems of emergency response and management at national level were highlighted. Moreover, a general discordance from official national adaptations claims and what the CSOs technical perception of the reality is in coastal risk management, was evidenced.

Our view is that RISC-KIT will help to evidence and better support these outcomes, making end-users aware how to improve policies, coordination and measures. RISC-KIT will take responsibility to publish and disseminate these outcomes making them accessible to the wider public.

8.2 Lessons learned from historical large-scale events

Authors: Paolo Ciavola and Emmanuel Garnier.

The historical analysis considered a time span for the frequency of storms that at some sites extended over 300 years backwards. Although the sources of impact record may be qualitative for what concerns the physical data forcing (e.g. wave and tide records do not extend beyond the XX century in most cases), impact data can be considered reliable as these events normally generated large impact, controlling societal changes like large migrations or changes in land-use.

The use of long historical records may allow scientists to estimate the real frequency of storms over a centennial sample and the presence of cycles induced by large scale-circulation phenomena. While correct from an engineering viewpoint, the concept of the probability of occurrence (e.g. the return period) is based on fitting a probability distribution to data series and physical scientists generally limit their analysis to datasets often shorter than 30 years.

As time passes after an event, there is the growing "false sense of security" in the population. If I build a dike after a flood and 100 years pass, I may feel safe because I am protected by a dike, forgetting that the only reason why I am safe is that the 100 year event may not have occurred.

Within the framework of the RISC-KIT project, the historical researches undertaken at five case studies (Ria Formosa, Porto Garibaldi, Bocca di Magra, North Norfolk and Faute-sur-Mer) discuss to what extent it is correct to describe a recent disaster (e.g. occurred in the last 20-30 years) as anew and unpredictable event. In the case of the French example of la Faute-sur-Mer, where 27 people died during the Xynthia storm of

February 2010, we notice that the site had already undergone four floods between 1900 and 2010. Nevertheless, the French authorities and the inhabitants stated immediately after the disaster that the event had never happened for at least 100 years and thus was unpredictable.

Today, the authorities use the estimations of modellers to predict the future risk of this type of disaster. The scientists normally estimate return periods of surges using extremes of 50 to 100 years and only in countries such as the Netherlands probabilistic approaches reach the once per thousands of years per annum probability.

On the other hand, if we take into account the historical record of the area of la Faute-sur-Mer (four extreme storms in 100 years), the return period of a 100-year flood decreases of a factor of three, becoming 32 years. We must understand how the communication of this risk to the exposed population can be very different according to the approach used, e.g. historical *vs* fully probabilistic (25 years for an historian and more than 50 years for an engineer). *De facto*, today in France, municipalities (at the request of the State) design their strategy of defence (dikes) on a horizon of 50 and 100 years. In the French Antilles (Garnier and al. 2015), the period of return of a hurricane is estimated in 21 years and is not clear how the design should be considered compared to mainland France..In the paper cited above, historical analyses back to the 17th managed to also detect a change in the frequency of cyclones, that should be taken into account for future coastal defence design.

The contents of historical archives also provide important knowledge relative to the nature of the damage and to extent of the territories affected by storms. If the instrumental data (wave height, wind speed, water level) are rare before 1900-1950 on the other hand, archives provide a lot of information on the nature of the damages caused by an historical event. For example the number of uprooted trees, the number of damaged public buildings (city halls, churches, restaurants, etc.) or still the houses flooded by the sea. As a consequence, it is possible to estimate the impact of historical events developing a “severity index” (exposed stakes), which is well documented in historical sources. Modelers can then take into account historical events in the estimation of the period of return.

The value of this approach was proved by Baart et al. (2011) who extracted quantitative information on surges using paintings of a coastal church tower from the 18th century, dated shell lags in dunes left over by surge events, and floodmarks in written literature sources. Using inverse morphological modelling techniques, they reconstructed the water levels during the three largest storm surges of that century (1717, 1775,1776). Such an approach allows going beyond “traditional” probabilistic analyses, towards the 1/10 000-year event required by Dutch regulations.

We believe that the current report provides an important guideline on how to exploit historical datasets of storm records merging them with recent and high quality observations. Our review strongly builds arguably the most complete dataset on marine storm impacts available for the European Union and Bangladesh, with its current strength (as of May 2015) of 217 extra-tropical storm events for Europe and 38 tropical storms for Bangladesh.

References

PART I: Emergency response and DRR measures at national and supra-national levels

International policies, directives and guideline documents

Main International polices, directives and guideline documents:

- UN Hyogo Framework for Action
- EU Floods Directive 2007/60/EC
- EU Water Framework Directive 2000/60/EC
- EU Climate Change Adaptation Strategy (2013)
- EU Marine Strategy Framework Directive (2008/56/EC)
- EU Maritime Spatial Planning Directive (2014/89/EU)
- EU Recommendation on ICZM (2002/413/EC)
- EU Proposal for the Directive on Maritime Spatial Planning and Integrated Coastal Zone Management - COM(2013) 133 final

Other cited International polices, directives and guideline documents:

- EU "Indicators of Progress: Guidance on Measuring the Reduction of Disaster Risks and the Implementation of the Hyogo Framework for Action", 2008
- EU 6th Environment Action Programme of the European Community (2002-2012)
- EU Biodiversity Strategy
- EU Common Fisheries Policy
- EU Strategic Environmental Assessment Directive (2001/42/EC)
- EU. (2012). Links between the Floods Directive (FD 2007/60/EC) and Water Framework Directive (WFD 2000/60/EC).Resource Document. Draft version 1 (28.09.2012)
- EU Europe 2020
- EU Global Approach to Migration and Mobility (GAMM)
- EU Global Climate Change Alliance (GCCA)
- EU Habitats and Birds Directives (92/43/EEC and 2009/147/EC)
- EU Horizon 2020
- EU Integrated Maritime Policy
- EU Motorways of the Sea Initiative
- EU Renewable Energy Directive
- EU Resolution (73) 29 on the protection of coastal areas

- Resolution on the European Charter (1982)
- Resolutions 92/C 59/01 and 94/C 135/02, in 1992 and 1994 respectively
- UN Programme of Action producted as a report of the Earth Summit of Rio de Janeiro in 1992, also known as Agenda 21
- UN Framework Convention on Climate Change (UNFCCC)
- UN Yokohama Strategy for a Safer World: Guidelines for Natural Disaster Prevention, Preparedness and Mitigation and its Plan of Action
- UNESCO (2009): Hazard Awareness and Risk Mitigation in Integrated Coastal Management (ICAM)". Intergovernmental Oceanographic Commission. IOC Manual and Guides No. 50, ICAM Dossier No. 5, Paris.

National polices and guidelines

Due to the large amount of cited national, regional and local laws, decrees and guidelines, no specific list will be provided. Some of them are listed in the section "Others".

Others

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Bakker, M.H.N, Green, C, Driessen, P, Hegger, D, Delvaux, B, Van Rijswick, M, Suykens, C, Beyers, J.C, Deketelaere, K, Van Doorn-Hoekveld, W & Dieperink, C (2013): Flood Risk Management in Europe: European flood regulation, STAR-FLOOD Consortium, Utrecht, The Netherlands. ISBN: 978-94-91933-04-2.

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European Commission – Intergated Coastal Zone Management: http://ec.europa.eu/environment/iczm/home.htm

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European Commission – OURCOAST Database: http://ec.europa.eu/environment/iczm/ourcoast.htm and http://ec.europa.eu/ourcoast/

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To note that several links were inserted as reference in footnotes. However, due to the local nature of them, they were not listed in the main list above.

Pictures and video

All pictures sources were cited in the text and captions.

PART II: Historical extreme hydro-meteorological events

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Pictures and video

All pictures sources were cited in the text and captions.