1

Coastal Storms and Flooding: Regulatory Framework and Science–Policy Interactions

1.1. Introduction

Coastal storms and flooding are areas of increasing concern, owing to growing urbanization and the related increased vulnerability to extreme climate events [IPC 14]. The increasing exposition of populations to such hazards leads to challenges linked to the development and implementation of regulations and management practices which take into account the adaptation to climate change. Actions related to improved risk prevention and reduction of climate-related hazards are embedded nowadays into international, European Union and national regulations and related management frameworks. In the case of coastal zones, however, although the prevention of hydrometeorological hazards is recognized as a priority at national level in many countries, the precise definition of these risks and hence their relations with the existing policy framework remains unclear [LAR 15]. The identification of coastal hazards (mainly storms and floods) concerns several

Considerations expressed in this book represent the sole views of the authors and do not reflect the formal position of any EU institution

domains other than the environment; in particular, urbanism, forestry, the insurance sector, tourism and civil protection, which are addressed by different types of regulations and codes of practice. This fragmentation is reflected from the EU to the national/regional levels. In addition, coastal risks are not subject to specific regulations despite being often mentioned, e.g. in research projects (see section 1.5) and texts related to territorial management plans.

Natural hazards in coastal zones can be separated into different types of risks [CAN 14], either of marine origin, e.g. submersion/flooding, storms, erosion, tsunamis, waves due to tornados, or of geological nature, e.g. land subsidence, earthquakes, landslides. In the context of this book, the focus will essentially be on coastal storms and flooding related to marine submersions, which may result from a combination of different phenomena such as wind, waves, high tide coefficients, low atmospheric pressures (leading to an elevation of the marine level) and abundant rainfalls. Marine submersions are considered as cumulative phenomena leading to either (or both) rapid or progressive flooding. The case of the Xynthia storm, which occurred along the West coast of France in February 2010, deals with both cases, i.e. a flash flood in the North (La Faute-sur-Mer) and progressive flooding in the South (Oleron island, Fouras, etc.). In each case, such submersion may lead to displacement of populations, significant modifications of land occupations and uses, losses of land as well as various environmental perturbations in wetlands and lagoons with modifications of the local ecosystems (e.g. salinization of freshwater resources and disappearance of beaches). Socio-economic and environmental impacts related to natural hazards in coastal zones, and notably coastal flooding, are therefore highly significant and subject to many controversial debates and studies. In reference to Xynthia, consequences of this storm generated many enquiries,

scientific studies, historical research, etc., which all pointed out limitations of knowledge about coastal risks and their social nature. Adversely, policymakers and politicians did not express themselves very much at all, despite media controversies flourishing in relation to inadequacies of the regulatory framework. Chapter 3 refers to this specific case which is also described in details (in French) in the literature [GAR 13, LAR 15]. The present chapter provides a general background about the existing regulatory and EU-funded scientific framework and discusses difficulties in establishing interactions among the scientific and policy-making communities.

According to IPCC [BAT 08], observational records and climate projections provide abundant evidence that observed warming over several decades has been linked to changes in the large-scale hydrological cycle (e.g. effects on atmospheric water vapor content and changes of precipitation patterns with consequences on extreme floods and droughts). The consequences of climate change, in particular the increased frequency and severity of extreme hydrometeorological events, may alter the reliability of current water management systems. While quantitative projections of changes in precipitation, river flows and water levels at the river-basin scale remain uncertain, it is very likely that hydro(meteo)logical characteristics will change in the future. These considerations lead to the development of a complex policy framework which plans adaptation and mitigation options to tackle impacts of global warming on water resources and risks to society and assets. These options are closely linked to a range of policies. This chapter gives an outline of some policies relevant to hydrometeorological events, with no pretention of exhaustiveness. Some considerations have been adapted from previous publications [QUE 11a, QUE 11b, QUE 14].

1.2. Natural hazards and risks in coastal zones: needs to build-up a "culture of risks"

1.2.1. *Introduction*

Coastal zones were unoccupied for centuries as they were considered as dangerous areas by populations. This has changed only recently with the establishment of populations along coastlines, increasing their exposure to natural hazards (e.g. flash floods, seismic risks associated with tsunamis, marine submersions and erosion). Nowadays the littoral zone is very much in-demand and is confronted with a growing demography. The United Nations even estimates that, at the 2020 horizon, around 80% of the world population will live in a territorial stretch less than 100 km from the sea. As a result, natural hazards in coastal areas will increasingly threaten human societies, their assets and activities. These threats will be exacerbated by climate change which has an influence not only the sea-level rise but also on rainfall regimes and storm severity [LAR 15]. In less than 20 years, the awareness about climate-related risks has led to a huge development of research activities (see section 1.5).

A natural risk is generated by the conjunction of a threatening phenomenon which is identified as a hazard, and related human challenges characterized by their vulnerability to this hazard. In a way, human societies' awareness of natural hazards has certainly played a major role in the development of environmental policies, originally aimed toward the prevention of disasters rather than the protection of the environment itself. This policy sector has hence led to establishing founding principles of what may be referred to as a "culture of risks", which is being developed at policy level as well as in the collective consciousness [LAR 15].

In parallel, coastal zones present the paticularity of gathering several environmental compartments, which generates legal discussions that are reflected in specific environmental policies, with the risk of fragmentation. Considering the diversity of natural hazards, their intensity and potential impacts which may vary from region to region, the regulatory framework and its implementation may have different socio-economic and environmental dimensions, and the specific regulations have to be properly coordinated in order to manage the risks efficiently.

1.2.2. *Contribution of environmental policy to the development of a "culture of risks"*

According to Michelot in [LAR 15], the "culture of risk" can be defined as "the ensemble of perceptions and behaviours adopted by a society facing risks". It is associated with the society's memory about risks, i.e. a system of maintenance of the legacy of knowledge from the past and its consideration for reduction of today's vulnerability. This presents the idea of highlighting the need to better understand hazards and their impacts, and of developing the information, the education and the memory of risks. In a sense, developing a "culture of risks" is closely related to a democratic decision-making process on both an individual and collective scale. Every citizen should have the possibility to freely access information about the risks to which he/she is exposed as well as objective information on what is done to protect his/her security. The Civil Society, enterprises and representatives of national authorities should also be in the position to respond to citizen's expectations regarding their security.

This awareness carries greater significant nowadays with the increased frequency of natural hazards, some of them leading to disasters. This risk awareness is, however, not new. In the marine sector, the risks for navigation were well

identified and related to dangers that were not linked to human actions [EWA 86]. Until the 19th Century, the notion of risk was linked to natural events. This changed with the industrial revolution, which led us to consider human activities as generating risks as well which had to be understood, managed and even anticipated [LAR 15].

Before speaking about environmental policies and their links to the "culture of risks" for coastal areas, it is useful to recall the role of policies in the establishment of this culture of risks. In a sense, we might argue that policies should include risk components and related objectives. This is the principle followed more largely by the DPSIR approach (Driver-Pressure-State-Impact-Response), which includes the notion of risks and responsibilities regarding the "responses" to address them. Environmental policies have the peculiarity of repositioning the relationship with risks in a holistic manner. In other words, many different branches of policies are mobilized in a given area to identify, assess and more generally manage risks or the related responsibilities. An example of integrated policy is the EU Water Framework Directive, which follows the above mentioned DPSIR principle, starting from risk assessment and mapping, to monitoring responsive actions to meet well-defined objectives [QUE 11a]. An important aspect which is not easy to tackle is the way society handles risks in the light of a policy framework, which is often far from people's direct prerogatives. This embeds not only risks for the environment, but concerns policies related to working rights, consumer rights and health as well which all have to be taken into consideration regarding risk management, in particular prevention.

Environmental policies may be a useful way to better frame the question of risk. Indeed, the above-mentioned DPSIR approach readily addresses risks and their impacts, taking societal (and economic) impacts into account at

different scales (from international, national to local). When reading international, European and national environmental policies in general, it becomes clear that risks are being addressed with a view to limit their impacts on the environment. The terminology may, however, differ in relation to different situations, e.g. “potential impacts”, “major accidents”, “disasters”, etc., which often leads, notably at EU level, to a hierarchy of actions related to responses to identified risks.

Policies related to natural disasters have been developed in a fragmented way, concerning soil, land use management, environmental and civil protection policies. This fragmentation illustrates the difficulty to build up a “culture of risks” through the development and implementation of policies which are themselves sectoral and elaborated in different contexts. At European Union level, the first Environment Action Programme in 1973 included “problems to which coastal zones are confronted” in relation to urbanism and land use management. Later, the EU used the terms of threats or disasters affecting coastal areas, and the term “risk” become associated in particular to flood management. The Green Paper released in 2006 [EUR 06] developed for the first time a systematic approach for identifying coastal risks, either of natural or accidental nature. In the international policy context, the term “risk” mainly appears in the framework of cooperation in case of critical situations for fighting against marine pollution, implying that a capacity exists to evaluate the extent of the pollution risk and its impacts.

Environmental policies rely on a series of concepts and principles which are driven by new expectations of the society at risk. In this context, precaution and prevention principles are built up in relation to risks. Regarding prevention, policies have been developed in many different branches, including social policies, which concern well-

identified risks. The precautionary principle, however, applies in cases of potential risks of which the occurrence is hypothetical [LAR 15]. From these two principles, various policies have been developed at international level, including EU regulations and involve initiatives related to knowledge development, transmission and access to information. In the international policy framework (e.g. Sendai Framework for Action described below), international cooperation is closely linked to actions related to prevention and precaution.

These principles have extended to environmental policies, but also to other fields such as health policies. Prevention and precautionary principles are complementary with the principle of information and participation of the public in environmental decisions. In this respect, environmental policies are closely related to the Aarhus Convention (1998) on information access, public participation in decision-making processes and access to justice, principles which have been embedded into environmental policies such as the Water Framework Directive. This convention which can be considered historical in environmental international policy requests Member States to gather information and make it accessible to the public. Public participation is guaranteed for all activities, which may have an important impact on the environment. Finally, the Convention foresees access to justice, notably for rejected information requests or contestations related to the legitimacy of any activity or legal act.

Other important principles provide a capacity for environmental policies to participate in the building up of a "culture of risks". The principle of integration of environmental policies in public policies enables this culture of risk to be disseminated and made operational [LAR 15]. The question is now posed whether the environmental policy framework is well adapted to the protection of coastal areas.

Coastal zones represent more than 2 million kilometers of coastline for all the continents combined, including islands. The majority of these coastal environments are still in a natural state and are moderately or not at all affected by anthropogenic activities. In the areas which are strongly impacted by anthropogenic pressures, ecological challenges are very significant, in particular regarding biodiversity. In addition, owing to the predicted sea-level rise linked to climate change, human pressures will likely increase with additional impacts on natural habitats. Action programmes related to environmental policies have therefore been developed with the objective of protecting vulnerable coastal areas, including the conception of integrated management approaches which align littoral land use policies with the management of the marine environment. One of the commonly accepted definitions of the Integrated Coastal Zone Management (ICZM) relates to a governance system, which consists of a legal and institutional framework stating that land use development plans of coastal areas take due consideration of marine environment protection objectives and are developed with the support and consultation of stakeholders and populations concerned [EUR 09].

1.2.3. *Toward an integrated management of coastal zones*

The UN Convention on the Law of the Sea (UNCLOS) of 1982 [UNI 82] introduced the notion of marine environment with related principles of preservation and protection. It also set the principle of international and regional cooperation regarding prevention. Ten years later, the UN Conference on Environment and Development (UNCED) held in Rio de Janeiro [UNI 92] introduced, in Agenda 21, a chapter about the protection of oceans and all seas and coastal zones, and the protection and sustainable use of their biological resources. The integrated management of coastal zones has a prominent place in this agenda with the objective to generate new strategies of management and exploitation of coastal

areas, from a national to a worldwide level, which are targeted toward precaution and prevision. One of the seven fields of intervention foreseen in this agenda concerned the assessment of "fundamental uncertainties concerning the management of the marine environment and of climatic changes" [UNI 92]. Conventions derived from this Summit also integrated the need to develop an ICZM approach for the management of risks, with a focus on the protection of biodiversity in line with the Ramsar Convention on the protection of wetlands (http://www.ramsar.org/).

1.2.4. *Regional instruments*

The first specific consideration of coastal zones at European level was made by the Council of Europe, which adopted Resolution 29 of 26 October 1973, setting the principles of sustainable management of coastal zones which aimed to be implemented at national level. The OCDE also looked into the ICZM question with a recommendation expressed by its Council on 23 July 1992. A wide range of regional organizations then became aware about the need to develop management methods and tools for coastal zone management with a focus on the coast–land interface. The European Union thus developed an EU Strategy for ICZM through a Communication adopted on 6 May 1994 [EUR 94] and a reflection paper 5 years later [EUR 99]. In addition, from 1996 to 1999, the Commission undertook a demonstration programme for ICZM which implemented a number of experimental practices through the LIFE project [LIF 96]. Two documents were adopted on the basis of the conclusions of this programme, first the Commission Communication and European Parliament on "ICZM: A strategy for Europe" [EUR 02] and second a recommendation by the Council and European Parliament about the implementation of ICZM in Europe (30 May 2002). In this recommendation, Member States were invited to develop a strategic approach to the consideration of the threat that

climate changes represent for coastal zones, the dangers of sea-level rise and the increase of frequency and severity of coastal storms [LAR 15].

In 2006, the Green Paper on the future European Maritime Policy clarified the input of ICZM to the management of natural hazards. The paper highlighted that the links which exist among coastal and maritime issues at the land/sea interface represent a challenge at EU level for the success of the ICZM, which *ipso facto* turned it into a reference framework for risk prevention management. In particular, it dealt with the integration of risks in decision-making related to planning and investing. As a follow-up, a Commission Communication on ICZM evaluation in Europe (7 June 2007) underlined the increasing pressures on coastal zones and the risks linked to climate change, and questioned the purely environmental approach of ICZM. The communication stressed that ICZM should better take account of the objectives of sustainable development and social considerations. Finally, the EU Regulation 1255/2011 of the European Parliament and the Council of 30 November 2011, which established a programme in support of the development of an integrated maritime policy, confirmed that the maritime scope of ICZM embeds important instruments for the sustainable development of marine and coastal zones and contributes to objectives of ecosystem management and the development of land/sea relationships. From the strict viewpoint of natural hazards, the regulation encourages actions aiming to attenuate climate changes on the marine, coastal and island environment and underlines that particular attention will be given to the most vulnerable zones.

These vague dispositions are in contrast with specific actions set by the EU Directive relative to Flood Risks adopted in 2007 [EUR 07], referred to in section 1.3.2.4. The European Union is also involved in the Regional Seas

Conventions promoted by the Marine Strategy Directive 2008/56/EC of 17 June 2008 [EUR 08] which preceded the implementation of the Barcelona Convention for the protection of the marine environment and coastal zone of the Mediterranean, as well as the Oslo and Paris Conventions for the protection of the North-East Atlantic and the Helsinki Convention for the protection of the Baltic Sea (see [QUE 11b]) for further details about these conventions). It also recommends that Member States of a same marine basin collaborate and act together to respect obligations and commitments resulting from international agreements. Among these instruments, the Madrid Protocol on ICZM includes, in Article 5e, objectives to prevent and/or reduce the impact of natural hazards, in particular related to climate changes, which may be related to natural or human activities [EUR 09]. EU Member States obviously have to implement EU regulations that they have themselves adopted, along with international conventions. Some of them, however, transpose the minimum technical requirements of European Directives, which is the case, for example, for the EU Flood Directive in the case of, e.g. France [LAR 15].

In consideration of the above legal framework, it is worth mentioning that these instruments have often been developed on an *ad-hoc* basis without global perspective and means adapted to implementation at national level. As a consequence, the management of natural hazards in coastal zones relies on different evaluation steps and follow-up, which are not always foreseen in environmental regulations that essentially focus on environment protection. It should be noted that the increased awareness about ecological risks has led to a repositioning of the environmental legal framework for the management of coastal zones. It is actually questioned whether this legal framework disposes of instruments, concepts and means to face challenges related to a “culture of risks” [LAR 15].

1.2.5. *Emerging "culture of risk" beyond the environment legal framework?*

Risks affecting coastal zones present peculiarities despite sharing common features with fluvial risks, which are linked to hydrological phenomena. Maritime natural hazards include hydrometeorological, climatic and geophysical risks. Hydrological phenomena are primarily linked to the variations of sea level, for which we may distinguish several elements: the mean level, the level of theoretical tide and the height above or below the mean sea level (which corresponds to the differences between the theoretical tide and the observed water level). Tsunamis lead to long period wavelengths provoked by non-meteorological phenomena (e.g. submarine landslides, earthquakes and volcanic eruptions). Similarly, coastal risks, as they are considered in coastal risk prevention plans, are not really linked to hydrological phenomena. They include principally submersion risks, risks of coastline retreat, as well as risks related to invasion of dunes. The prevention of these risks may actually lead to a fragmentation of legal instruments. At the moment of the Xynthia occurrence particularly, numerous public and private actors considered that the risk of marine submersion was not comparable to any other risk of natural origin. These phenomena can actually be linked, e.g. erosion can lead to a reduction of natural coastal defenses, thus enhancing the coastal vulnerability to marine submersions [LAR 15].

Our knowledge about coastal risks is improving and guiding us toward studies of vulnerability of coastal zones, to not only build up knowledge and a memory of risk, but also an "intelligence of risks". With the support of research, we could develop conceptual approaches that would go beyond the possible "predictions" of threatening events by science, i.e. turning this conception into "social constructions" with the mobilization of instruments that would give more decision-making power to the people and enhance their

responsibilities. Research trends related to these efforts are described in section 1.5.

Environmental policies have been developed in consideration of a conception of risks being as realistic as possible. Numerous legal instruments related to coastal risks underlined the importance of research and expertise as well as citizens' access to information. Studies carried out by IPCC in the field of climate change and the progress which has been and is currently being made thanks to their conclusions illustrate this approach. However, environmental policies have progressively developed into a precautionary approach which has introduced an element of uncertainty in the decision-making process. In [LAR 15], Michelot underlines that the way of perceiving and taking account of risks has been modified, moving toward a socialization of risks that has to be explored to face the ecological, social and economic consequences of disasters. The question is whether the perspectives opened by the environmental policy framework are adapted to the social challenges of modern society.

1.2.6. *Ecosystem services: a new orientation of environmental policies or an opportunity of risk socialization?*

The European Union has adopted an action programme, the objective of which is to stop the degradation of ecosystem services on its territory from now until 2020 [EUR 12]. At international level, research activities are multiplying in support of international conventions, in particular concerning biodiversity and wetlands (Ramsar Convention, see above). The action plan of the Convention on biodiversity includes among its objectives the aim to guarantee the continuous function of ecosystem services.

Ecosystem services are increasingly present in the legal framework and introduce new ways to tackle natural hazards

with different interpretations of their impacts. The understanding of coastal risks in the light of ecosystem services, i.e. looking at services provided by nature, may modify the perception of these risks in that it modifies what could (or should) be the knowledge-base needed to manage these risks. However, by introducing the term "services" in place of "functions", one also introduces the question "to whom, and for whom?" This may, in principle, require a legal approach to establish responsibilities related to ecological damages but it does find responses, in particular in the framework of the EU Directive on Environmental Responsibility (2004), in which ecological services are defined as "functions assured by a natural resource in benefit to another natural resource or the public" (quoted by Michelot in [LAR 15]). The question is how do we choose services to be preserved and in relation to whom? What "level" of service do we need to take into account (international, national and local)? It is obvious that the challenges and interests are not the same for risk managers and policymakers. Ecosystem services undoubtedly lead to the modification of risk perception, but do not necessarily tackle ecological or social inequities nor preserve the security of people and goods in the event of coastal hazards. In addition, these services do not provide a consensual approach for risk management by the different actors concerned [LAR 15].

1.2.7. *The international society facing (coastal) natural hazards: between protection of human rights and challenges of international security*

According to the IPCC, the vulnerability of risks lies on three main components: the exposition to hazards and impacts of climate change, the resilience of the environment to these impacts and the response capacity of society. It is, however, established that human actions regarding land-use management as well as the perception of risks may enhance or reduce the exposition to natural hazards.

Facing large-scale risks, the international society has deployed a range of tools and instruments to respond in an international cooperation framework which goes beyond the sole environmental dimension set at the UN Conference held in Rio in 1992 and the Johannesburg summit in 2002 where one of the objectives dealt with the reduction of the number and effects of natural- and human-related disasters. The United Nations have primarily decided to adopt a 10 year work programme (1990–1999) leading to the Yokohama Action Programme for the reduction of disaster risks, which has been continued by the adoption of the Hyogo Framework for Action (2005–2015) of which the main objective was to substantially reduce the loss of human lives and damages related to (natural) disasters. This is now pursued by the Sendai Framework for Action adopted in March 2015 for another period of 10 years (see section 1.3). Even if these international conventions do not lead to specific responses to coastal risks, they set a priority for UN Member States to reduce disaster risks from prevention/ preparedness to response/ recovery. This action framework aims to include risk reduction actions in national policies and reinforce the coordination of actions engaged at international and national levels.

In the UN framework, a range of organizations work for the development of a "disaster culture" for the international society. The UNDP (UN Development Programme) strives to ensure that disaster risks are taken into consideration in the development programmes of UN Member States and that they are engaged in a process of risk and vulnerability reduction for the future. The UN Environment Programme (UNEP) supports the dissemination of environmental information and rapid alert systems related to environmental risks on an international scale. Other organizations such as UNESCO and the WMO (World Meteorological Organisation) also contribute under their remit to feed this "disaster culture"

through the development of studies and scientific activities (including alert systems) which enable us to anticipate risks and hence to save lives and limit material damages.

In parallel, climate change has become an international security challenge, considering that most of the humanitarian crises at international level are related to events linked to extreme climatic events. Debates are on-going concerning the implications of climate change on international security, and on a "society of risk" to face threats of destabilization related to the impact of climate change conflicts about resources, territory losses and border conflicts, threats to critical infrastructures, migration related to environmental threats, tensions linked to energetic provisions, pressures on worldwide governance, etc. In relation to coastal zones, the intensity and probability of risks are exacerbated. Sea-level rise and the increase in frequency of natural disasters represent a serious threat to numerous regions in the world.

1.3. Policy background

1.3.1. *International policies*

While climate change's impact on water resources and proactive management efforts are recognized worldwide, it is only recently that the concept of a "global policy" dealing with prevention/adaptation measures related to hydrometeorological events linked to climate change has been discussed. This need has been clearly expressed with regard to other factors related to water resources by the UN Economic Commission for Europe (UNECE) in a guidance document published in 2009 [UNI 09]. The key messages were along the same lines as recommendations expressed in the IPCC Technical Paper on water [BAT 08], in particular concerning the negative impact on nearly all UNECE countries linked to increased frequency and intensity of

floods. UNECE recommended that any policy needs to consider climate change (and related extreme events) as one of the many pressures on water resources (others include population growth, migration, globalization, changing consumption patterns as well as agricultural and industrial developments). Effective adaptation in this respect was stressed as well as the necessity of a cross-sectoral approach, on a trans-boundary level, of in order to prevent possible conflicts between different sectors and consider trade-offs and synergies between adaptation and mitigation pressures. The guidance insisted on the fact that legislation should not present barriers for adaptation and should be flexible enough to accommodate continuing environmental and socio-economic changes. Besides national legislation, a number of international agreements include provisions that can support the development of adaptation strategies (see below), and trans-boundary cooperation and policy certainly might build upon this basis. Finally, the UNECE guidance stressed that uncertainty should not be a reason for inaction and highlighted that action, knowledge and experience sharing, and research on adaptation should be pursued simultaneously and in a flexible way.

As mentioned in section 1.2, a key policy trend in the last decade has been represented by the Hyogo Framework for Action 2005–2015 (HFA), which was adopted by 168 nations committed to substantially reducing the loss of life and livelihoods from natural disasters (including coastal storms and floods). The implementation of the HFA has been under the responsibility of the United Nations International Strategy for Disaster Reduction (UN-ISDR) which is the central point in the UN system for the coordination of disaster reduction and the establishment of synergy among the disaster-reduction activities of the UN and regional organizations, and activities in socio-economic and humanitarian fields. This framework is now continued by the Sendai Framework for Action which has set priorities for

the 2015–2025 period, among which the promotion of a better understanding of disaster risk management through the building, sharing and development of knowledge and the strengthening of the policy–science interface at local, national, regional and global levels [UNI 15]. The Sendai Framework for Action sets out an ambitious set of priorities to position disaster risk reduction as a key element of sustainable development efforts, to define further steps to reduce existing and emerging risks and foster disaster resilience. These objectives are supported by IPCC recommendations expressed in the special report on extreme events (STREX Report).

1.3.2. EU policies

A wide range of sectors and policies cover issues related to the security, safety and resilience of society (therefore including impacts of natural hazards such as coastal storms and floods) in a direct or indirect way, either by providing legally binding frameworks of actions by EU Member States in the form of Directives, general frameworks in the form of Communications or technical specifications in the form of Decisions, for example. Figure 1.1 gives an illustration of the different "families" of EU General Directorates in charge of various policies as well as Intergovernmental Agencies.

Crisis Management policies follow an integrated approach for the management of natural and man-made hazards focusing on disaster risk reduction (prevention and preparedness) and disaster response. The policy is mainly represented by the EU Civil Protection Mechanism (UCPM) represented by DG ECHO [EUR 13a], and the operational dimension is coordinated by the Emergency Response Coordination Centre (ERCC). Disaster risk management is also addressed through the EU Internal Security Strategy [EUR 10] and the resulting European Agenda on Security adopted in April 2015 [EUR 15] represented by DG HOME

and Consumer Health Protection policies [EUR 13b] represented by DG SANCO). In addition, climate-related disasters are covered by environmental and climate policies (DG ENV, in particular the Flood Directive [EUR 07] and DG CLIMA through the EU climate change adaptation strategy [EUR 13c]). Finally, intergovernmental agencies are also involved in security policies, e.g. the European External Action Service (EEAS) – which implements the EU Common Foreign and Security Policy – and Europol – which is the EU Law Enforcement Agency. Both agencies assist EU Member States. There are also links with the Council Decision 2014/415/EU on the arrangements for the implementation by the solidarity clause Union, which covers response, situational awareness as well as analysis and threat assessment at Union level.

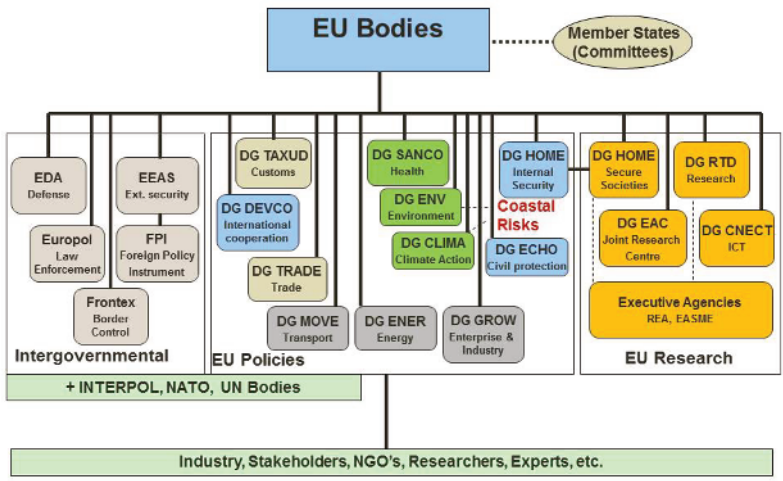

Figure 1.1. *The EU policy landscape. For a color version of this figure, see www.iste.co.uk/quevauviller/storms.zip*

Other key EU policies concern industrial competitiveness and innovation, namely, the EU Industrial Policy [EUR 12a] represented by DG GROW which aims to boost industrial

competitiveness and innovation (thus the access to market of developed technologies) and the EU research policy represented by Horizon2020 (see section 1.5). To complement this figure, let us mention policies related to Energy Infrastructure and Transport Networks (DGs ENER and MOVE), Customs (DG TAXUD), Environment and Industrial Risks (DG ENV) and International Cooperation (DG DEVCO).

Complementary to EU policies, international policies are also active in Disaster Risk and Crisis Management. Their implementation represents a complex and ambitious challenge as they involve a wide variety of players, each Member State followsing specific national approaches (national action plans) for dealing with crises and organized differently in terms of disaster risk management capabilities. The EU framework represents a means and a real opportunity to discuss possible ways to improve coordination among the various national approaches and develop a common EU vision strengthened by a joint strategy in this field.

Compared to many international river basins worldwide with no legally enforceable management framework, the situation in the European Union is developing toward a robust, risk-based management system for tackling environmental hazards including coastal threats, with legal instruments being in place or development. This section examines concrete policy steps that are either implemented or being developed in Europe.

1.3.2.1. *EU Civil Protection Mechanism and related international policies*

The Union Civil Protection Mechanism (UCPM) under DG ECHO aims to facilitate reinforced cooperation between the EU and Member States and to facilitate coordination in the field of civil protection, in order to improve the effectiveness

of systems for preventing, preparing for and responding to natural (including coastal storms and floods) and man-made disasters. It supports and complements the efforts of the Member States in the protection primarily of people but also of the environment and property, including cultural heritage, in the event of natural and man-made disasters, acts of terrorism and technological, radiological or environmental accidents, including marine pollution. Built upon these policy instruments, the UCPM is about developing an integrated approach to disaster management. The EU action is based on the principles of solidarity. The overall mechanism takes due consideration of laws and international commitments, and exploits synergies with relevant Union initiatives such as the European Earth Observation Programmes (Copernicus), the European Programme for Critical Infrastructure Protection (EPCIP) and the Common Information Sharing Environment (CISE). The mechanism is based around the Emergency Response Coordination Centre (ERCC) and the European Emergency Response Capacity (EERC) in the form of a voluntary pool of precommitted capacities from the Member States, trained experts, a Common Emergency Communication and Information System (CECIS) managed by the Commission and contact points in the MS. It also recognizes the role of regional and local authorities in disaster management. Outside the Union, disaster response is coordinated with the United Nations (in close interaction with the Sendai Framework for Action) and other relevant international actors related to humanitarian aid. Finally, the use of military means under civilian leadership as a last resort may constitute an important contribution to disaster response.

On a technical level, the UCPM is working toward a general policy framework on disaster risk prevention aimed at achieving a higher level of protection and resilience against disasters by preventing or reducing their effects and by fostering a culture of prevention. From this perspective, it

promotes the review of risk assessment, risk management planning conducted at national/regional level and the development of an integrated approach, linking risk prevention, preparedness and response actions. The UCPM is also financing actions related to preventing, preparing for and responding to disasters, including civil protection training programmes, large-scale exercises, interaction of experts, prevention and preparedness projects (through annual calls for applications), logistical and transport support for response missions, deployment of coordination, etc.

1.3.2.2. *Critical Infrastructure Protection*

The new approach to the European Programme for Critical Infrastructure Protection (EPCIP) under DG HOME aims to ensure a high degree of protection for EU infrastructures and increase their resilience against all threats and hazards [EUR 13d], including coastal threats. The sector-focused approach of the programme represents a challenge to a number of EU Member States as in practice the analysis of criticalities is not confined to sectoral boundaries and follows rather a "system" or "service" approach (e.g. hospitals). There is a need for the development of a cross-sectoral approach. In practical terms, development of preparedness strategies is based around contingency planning, stress tests, raising awareness, training, joint courses, exercises and staff exchange. The programme also promotes dialogue between the operators of the critical infrastructures and those who rely upon them in order to better prepare responses to events affecting European critical infrastructures. The gaps identified in the review of the EPCIP led the Commission to incorporate its new approach in the implementation of the EPCIP in 2013, with a greater focus on interdependencies and proposing practical work with four critical infrastructures of a European dimension (Eurocontrol, Galileo, the electricity transmission grid and the gas transmission network). These

are linked to the trans-European energy infrastructure as such and the EPCIP stipulates that the Union's energy infrastructure should be upgraded in order to prevent technical failure and to increase its resilience against such failure, natural or man-made disasters, adverse effects of climate change and threats (including coastal storms and floods, and their possible cascading effects) to its security. It is also related to EU transport policies covering a wide range of security and safety policies in the air, road, maritime and rail areas which all relate to technical standards for preventing/detection risks and responding to major threats, including natural disasters.

1.3.2.3. *EU Adaptation Strategy to Climate Change*

The EU Adaptation Strategy to Climate Change under DG CLIMA highlights the consequences of climate change and the need for adaptation measures. It focuses on early, planned and coordinated action rather than reactive adaptation. The communication highlights the need for systematic exchanges of best practice on how to best adapt to climate change. The strategy takes account of global climate change impacts such as disruptions to supply chains or impaired access to raw materials, energy and food supplies. The overall aim is to contribute to a more climate resilient Europe by enhancing the preparedness and capacity to respond to the impacts of climate change at local, regional, national and EU levels, developing a coherent approach and improving coordination. This strategy is closely linked to national adaptation strategies, which are considered as recommended instruments by the UN Framework Convention on Climate Change (UNFCCC). Close coordination between climate change adaptation and disaster risk management/policies is also required. Development is planned based on guidelines of minimum standards of good practice for disaster prevention.

1.3.2.4. *Water and Marine policies*

Linked to the above, specific policy instruments are in place in the water sector related to extreme hydrometeorological events such as floods and droughts under DG ENV. Complementing the Water Framework Directive (WFD), flood prevention and management are tackled by the Flood Directive which requires EU Member States to assess and manage flood risks, with the aim of reducing adverse consequences for human health, the environment, cultural heritage and economic activity associated with floods in Europe [EUR 07]. This directive has to be coordinated with the implementation of the WFD [EUR 00] from the second river basin management plan onward (2015–2021). It therefore provides a comprehensive mechanism for assessing and monitoring increased risks of flooding (including coastal floods), taking into account the possible impacts of climate change, and for developing appropriate adaptation approaches.

In line with the subsidiarity principle, this directive leaves a large margin of judgement and implementation to the EU Member States, providing a framework which sets the method to be followed while imposing a holistic approach to risk management. It initially involves the identification and reporting of flood risk areas followed by a preliminary evaluation of the risks and then the reduction of consequences of floods. Besides the texts oriented toward the management of coastal and/or marine areas, the EU has developed a network of protected areas through the Natura 2000 network, an application of the Bird Directive of 2 April 1979, which enables the classification of zones requiring special protection for territories most significant for the conservation of wild birds. The Habitat Directive of 21 May 1992 complements this framework with the creation of specific conservation zones, among which, coastal habitats.

Finally, while the protection of the (coastal) marine environment is covered by the WFD, EU environmental policymakers considered there was a lack of strategy underpinning the policies to protect the marine environment. A strategy was thus developed in the sixth Environmental Action Programme (2002–2012), which resulted in the establistment of environmental objectives for the marine environment. The related protection regime is regulated under the EU Marine Strategy Directive [EUR 08].

1.4. Science–policy interactions

1.4.1. *Scientific foundation of coastal risk policies*

The need to strengthen links among scientific outputs and policy-making activities in overall water-related risk management has been subject to on-going debates in the last 10 years, and specific discussions in the water and marine sectors have examined concrete developments [QUE 10], which can be extrapolated to coastal risks. They tend to show that a conceptual framework for a science–policy interface among scientists, policymakers and stakeholders is required *inter alia* in the water and marine sectors. This section explores general considerations about science and policy interfacing needs (following on from [QUE 07]). In a first instance, let us recall that key steps of the "environmental (including marine and coastal) policy chain" related to protection against pollution and natural hazards are based upon a scientific foundation and basic technical knowledge; these steps can be summarized as follows:

– Describe what you want to protect;

– Measure or describe actual (pre-event) situation;

– Define level of protection according to well-defined objectives (related to infrastructures, assets and populations);

– Identify pressures;

– Quantify relationship between pressure and environmental response;

– Quantify relationship between social and economic cost and pressure;

– Identify lowest cost pathway;

– Define policy instrument;

– Implement the policy instrument and assess response;

– Take appropriate measures (control and remediation);

– Review policy on the basis of scientific/technological progress.

The reliability of the overall chain will indeed depend upon the effectiveness of the integration of scientific and technological knowledge in a timely manner at each step of the policy development, implementation and review. The knowledge of "environmental interfaces", i.e. interactions between different compartments, represents a basic feature for understanding the impacts of natural or anthropogenic pressures on various (marine) environmental compartments. It therefore has a direct impact on the way policy and related monitoring are designed, developed and implemented. This knowledge should, in principle, be tackled in a "holistic" manner. In other words, it is hardly possible to understand the overall impact of a specific pressure on coastal zones by looking only at one compartment [QUE 07]. Coastal risks depend upon a variety of environmental factors such as the climate, hydrology (water flows), hydromorphology, etc. In this respect, it is hardly possible to understand a given risk by looking at a single environmental compartment and through only one discipline. To date, knowledge of environmental interfaces is still limited by the lack of sufficient multidisciplinary studies. Progress is on-going

in the framework of various EU-funded projects (see section 1.5), but the scientific foundation is not considered to be sufficiently developed to be able to effectively assess the effectiveness of coastal risk-related policies in a holistic context. It is worth mentioning that, among research projects and related on-going activities, gathering of an increasing number of monitoring data (linked to EU policies and/or international programmes) and the development of models now provide a much better vision of the problems to be tackled and the way to approach them.

1.4.2. *EU Scientific framework in support of coastal risk-related policies*

The Treaty establishing the European Union indicates that Research Framework Programmes have to serve two main strategic objectives. First, they provide a scientific and technological basis for industry and encourages its international competitiveness. And second, they promote research activities in support of other EU policies. To this end, Framework Programmes are designed to help solve problems and respond to major socio-economic challenges faced by society. The Research Framework Programme (FP) is the European Union's main instrument for funding research and development. In this context, the European Commission has been supporting marine (and coastal) research for several years through its successive Framework Programmes (FP) for Research and Technological Development (RTD). The FP aims to foster scientific excellence, competitiveness and innovation through the promotion of better co-operation and coordination. It also aims to produce advances in knowledge and understanding, and to support the implementation of related European policies. The FP is implemented through open 'calls for proposals', and successful projects are selected after an evaluation procedure carried out with the help of external independent experts.

Priority areas reflecting EU research needs are sectors such as health, food and agriculture, information and communication technologies, nanosciences, energy, transport, socio-economic sciences, space and security. Environment and climate change is also part of these priorities. More specifically, the research areas address pressures on environment and climate, impacts and feedback, environment and health, conservation and sustainable management of natural resources, evolution of marine environments, environmental technologies, understanding and prevention of natural hazards, forecasting methods and assessment tools, and earth observation. Details on the current framework programme (Horizon 2020) and examples of EU-funded projects are given in section 1.5.

1.4.3. *Identification of research needs in the coastal risk-related policy sectors*

It is not always possible to establish a clear distinction between "basic" and "applied" research. Also the timing aspect (short-, medium- and long-term) is intimately linked to the way research instruments are operated. The identification of research need is of course fed by advances in scientific knowledge, but is also directly influenced by the evolution and requirements of policies. The need for ensuring coincidence of research and policy agendas may depend upon the stage of development of the policy in a given thematic area. In this respect, one may distinguish three different categories of needs in the policy sector related to coastal risks, depending on timing considerations [QUE 07]:

– *Short term* (~1–2 years): needs basically concern the accessibility of research knowledge required for the development of policies on a short-term basis. Timing is not adapted to develop new types of research (unless very

specific needs are identified, which may be developed in a 6–12 months period). Policy development also requires efficient and user-friendly access to background scientific information and archives; a typical example is thematic strategies such as the ones covered by the EU Environment Action Programmes. In this context, the time needed for the design, approval and operation of *ad hoc* calls for proposals makes it difficult to respond to short-term research needs, e.g. related to a coastal storm or flood requiring scientific input. In other words, a specific research need expressed at a given time will rarely be met through a project selected under a call for proposals the year after. Therefore, to date, such needs may only be tackled through research actions carried out by, e.g., national research organizations, having been identified in their annual work-programme. In the future, short-term needs could also be partially fulfilled through a coordination of national research calls for proposals coordinated by Joint Programming Initiatives.

– *Medium term* (~2–5 years): the timing of medium-term research is adapted to responses of needs expressed in relation to the implementation agenda of well-defined policies (representing a "stable platform" for building strong partnerships among policy implementers, the scientific community and various stakeholders). This is the case of the framework directives (e.g. the WFD, the Marine Strategy Directive, etc.) in support of which research activities have been carried out since the time of their adoption, in response to needs linked to, e.g., analysis of pressures and impacts. For the forthcoming policy milestones, the formulation of medium-term research needs will have to take into account technical requirements related to the implementation of the policies and their revision. This requires that a detailed description of research needs is made by policymakers and that a follow-up of projects is done in close coordination with the scientific community to guarantee a successful uptake and application of research to the policy-making process.

RTD projects running over a 2–3 year period may also fulfill medium-term research needs.

– *Long term* (~5–10 years): scientific progress in this respect supports either policy milestones which are clearly identified at the 10 year horizon, or the review process of the legislation. Long-term research needs may be linked to the development of action programmes. They may also concern the review process of the technical requirements detailed in a given directive, e.g. in the case of the WFD or the EU Flood Directive, the end of each River Basin Management Plan cycle (6 years). Research activities may respond to either well-defined milestones of the thematic policies or review of the legislation.

1.4.4. *Interactions with the scientific community*

At the start of projects which have been identified as relevant to coastal risk-related policies, there is certainly a need to clarify policy issues by describing the aims, milestones and technical challenges to the RTD project coordinators so that they understand what the policy expectations are over the duration of their project. These exchanges of information/knowledge rarely occur, which may lead to divergent directions being taken by the projects in comparison to policy orientations [QUE 07].

1.4.4.1. *Synthesis needs*

At the end of research projects, the most critical issue is the way the scientific information is "digested" so that it may be efficiently diffused to policy end-users and possibly applied. This integration phase is certainly the weakest link of the science–policy chain. Indeed, only a small percentage of RTD projects are known by policy implementers, which illustrates the need to not only improve awareness about RTD outputs, but also to encourage policy actors to reflect on research needs linked to their portfolios. This may be

translated into needs to carry out synthesis works in the form of "policy digests" (addressed to the scientific community from the policy implementer's side) and "science digests" (prepared by the scientific community for the policy implementers).

1.4.4.2. *Exchange platforms*

As a follow-up to research or capacity building projects, useful interactions may occur at yearly meetings. Participation of policy officers in all project meetings may not be practicable due to a lack of resources, but efforts are needed to organize regular joint meetings focusing on specific themes. This is already happening in the WFD sector [QUE 07] and should be systematized.

1.4.4.3. *Toward a "science–policy interface"*

At the present stage, efforts are lacking for presenting results of research and demonstration projects in a form that policymakers may easily use, e.g. "science-digest" policy briefs. On the reverse side, the consideration of research results by the policy-making community is not straightforward, mainly for political reasons and difficulties integrating the latest research developments in legislation. The difficulty is enhanced by the fact that the policy-making community is probably not defining its role as "client" sufficiently well. In other words, the dialogue and communication are far from being what one would hope to ensure an efficient flow of information. In this respect, improvements could be achieved through the development of a "science–policy interface" based on a coordination of relevant programmes/projects with direct relevance to the policy implementation. In other words, strategies should identify needs for short-, medium- and long-term scientific developments and should establish an interface so that R&D results are synthesized in a way that can efficiently feed the implementation and further review of policies.

This interface should include:

– a screening phase evaluating which type of research is needed (background information or tailor-made research and demonstration) in accordance with the policy step of concern (e.g. implementation issues and reviewing). This is already happening through regular contact between Commission services and the scientific community;

– a mechanism to ensure that the most promising research projects in support of the policies are "validated" through demonstration activities, disseminated efficiently and applied at the appropriate level (regional, national or EU);

– a management scheme involving both scientists and policymakers to discuss the corresponding research and policy agendas from the very beginning in order to ensure a more structured communication at all appropriate levels of policy formulation, development, implementation and review. This is hardly operational to date.

More than dissemination and application, the interface should establish strong links between the different funding mechanisms existing at EU level and the thematic policies. This would enable us to promote pilot projects combining the implementation of results of successfully completed research or demonstration projects with the implementation of related policies. This would allow us to form new and innovative partnerships by combining various instruments (research, capacity-building, structural funds, education and training) and regional/national funding mechanisms, as well as the establishment of a collaborative partnership involving scientists, policymakers, managers and other stakeholders, for the effective integration of science outputs into policy and management decisions. At present, however, examples show

that such coordination is still not operational. A developing "Community of Users" (see section 1.6) might facilitate an improved interfacing in the future.

1.4.5. *Science-based development of an integrated coastal risks policy*

One may ask the basic question: is our scientific (multi-disciplinary) knowledge sufficient to develop a more integrated policy able to efficiently tackle coastal risks? The on-going discussions show that the scientific base is likely still not sufficiently consolidated at this stage, but that a tight coordination mechanism and tailor-made developments in the H2020 programme (see section 1.5) could lead to the establishment of an operational science–policy interfacing mechanism at the 2020 horizon.

Apprehension about scientific uncertainty is growing in importance. Such misgivings seek to invoke the standard of evidence that 'guilt' must be demonstrated 'beyond a reasonable doubt'. However, given the complexity of coastal threats and pathways, this would mean that the reality of coastal risks would not be accepted until they had actually happened. This is against the prevention principle and is not acceptable. In the light of the precautionary principle, however, where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures aimed at preventing environmental degradation.

In the context of coastal risks, the following observations can be made:

– Coordinated reporting and data sharing about coastal risks should constitute the core basis for policy implementation and review within the next decade. In the

light of increasing considerations about climate change (and its impact on coastal risk management), one may wonder whether this data sharing should not expanded at a global scale in close interactions with the Copernicus programme;

– Building-up coastal databases should enable us to test/validate existing models and develop new models able to better evaluate coastal risks linked to climate extreme events, and thus better evaluate the efficiency of policy responses. This is closely linked to the knowledge-based considerations expressed in this chapter;

– Risk assessments and programmes of measures need to be coordinated in the light of effective implementation of policies in force (in the different sectors).

The consequence of better integration of scientific knowledge and policies should have a positive impact on the way coastal risk (disaster) management will be implemented in future, i.e. a better knowledge-based appraisal of risks in the context of concerted planning (e.g. at river basin level) should facilitate the design of surveillance and detection programmes (avoiding duplication and focusing on specific features) and the elaboration of proper prevention/ preparedness strategies as well as response programmes. The way international policies (such as the Sendai Framework for Action) are being developed pave the way for an increasing integration, which should be pursued and linked to a sound and validated scientific foundation.

1.5. Research trends

1.5.1. *Introduction*

Research related to coastal threats (storms and floods) is needed to improve understanding and modeling of climate changes related to extreme hydrometeorological events on scales that are relevant to decision-making (possibly linked

to policy). At present, scientific information about coastal risks and their links to climate change is not sufficient, especially with respect to understanding and the assessing of key drivers and their interactions in order to better manage and mitigate risks and uncertainties. Arising questions concern scientific outcomes that are sufficiently mature to be taken aboard policy development and which are key research topics that need to be addressed at European level.

Scientifically sound data and other information are essential for making climate projections while reducing their uncertainties, particularly for vulnerable groups and regions, in relation to coastal storms and floods. This includes issues encompassing all aspects of the hydrometeorological cycle; taking into consideration the needs of end-users and including social and economic information. For instance, early warning systems are essential for preparedness for extreme weather events and should be developed at the trans-boundary level. They should also be closely linked to seasonal and long-term climate and weather forecast systems, as well as monitoring and observation systems.

1.5.2. *EU-funded instruments*

The European Commission is funding research through its Framework Programme for Research and Technological Development. In this context, projects of the sixth Framework Programme (2002–2006), in particular, projects funded under the "Global Change and Ecosystems" sub-priority and the seventh Framework Programme (2007–2013) or FP7, in particular, projects funded under the "Environment (including climate change)" theme, largely contributed to gathering knowledge relevant to natural hazards knowledge base, including for coastal storms and floods. As highlighted in section 1.3.2, EU research funding is orchestrated by different "research families", namely,

various programmes of DG RTD, DG CNECT and DG HOME (see Figure 1.1), as well as research actions undertaken by the Joint Research Centre (JRC). Other funding instruments focus on capacity-building and training (e.g. prevention, preparedness and response projects in disaster risk management funded by DG ECHO and security-related projects funded by DG HOME), but they will not be discussed in this book. While research programming and policy responsibilities lay with the respective General-Directorates of the European Commission, the management of projects is increasingly delegated to "sister" agencies, namely, the Research Executive Agency (REA) and the Executive Agency for SMEs (EASME).

Horizon 2020 is the largest EU Research and Innovation programme ever with nearly €80 billion of funding available over 7 years (2014–2020) – in addition to the private investment that this money will attract. It promises more breakthroughs, discoveries and world-firsts by taking great ideas from laboratory to the market. It is the financial instrument implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness. By coupling research and innovation, Horizon 2020 is helping to achieve this with its emphasis on excellent science, industrial leadership and tackling societal challenges. The goal is to ensure that Europe produces world-class science, removes barriers to innovation and makes it easier for the public and private sectors to work together in delivering innovation. Horizon 2020 will contribute to the implementation of many policy goals, among which the Union Civil Protection Mechanism, environmental and climate policies. The primary aim of the Work Programme on "Secure societies – Protecting freedom and security of Europe and its citizens" is to enhance the awareness, preparedness and resilience of our society against natural and man-made disasters.

The current EU Framework Programme for Research and Innovation is built upon achievements of the seventh Framework Programme, whose mapping focused on and embedded several programmes of direct and indirect relevance to secure, safe and resilient societies, namely:

– health, demographic change and wellbeing;

– food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the bioeconomy;

– secure, clean and efficient energy;

– smart, green and integrated transport;

– climate action, environment, resource efficiency and raw materials;

– Europe in a changing world – inclusive, innovative and reflective societies;

– secure societies – protecting freedom and security of Europe and its citizens.

1.5.3. *Examples of research trends*

Most of the research projects listed in this section directly or indirectly support policies related to coastal storms and floods in the areas of disaster prevention, preparedness and response.

1.5.3.1. *Climate change impacts on the water environment and cycle*

Specific research on climate change impacts on the global water cycle has been carried out under the FP6 WATCH (global change and water) project (www.eu-watch.org) which united different expertises (hydrologists, climatologists and water use experts) to examine the components of the current and future global water cycles, evaluate their uncertainties

and clarify the overall vulnerability of global water resources related to the main societal and economic sectors. Current generation of large-scale models (e.g. climate models and global hydrological models) were tested against more detailed (hydrological) models to explore their ability to predict droughts and floods. Other FP7 projects on climate change impacts on water resources are described by Quevauviller [QUE 12].

1.5.3.2. *Floods research*

The project most relevant to flood research carried out within the years 2004–2009 at EU level in support of the Flood Directive is certainly the FP6 FLOODsite (integrated flood risk analysis and management methodologies) Integrated Project, which gathered interdisciplinary, integrating expertise from across the environmental and social sciences, as well as technology, spatial planning and management. The notion of "integrated" flood risk management evolved from flood defense to flood risks being managed, but not eliminated. The project developed robust methods of flood risk assessment and management and decision support systems which were largely tested in pilot sites. Regular contacts with EU policymakers enabled the policy community to be informed about progress on flood risk management. More than 100 research reports were made available for public download on the project website.

Albeit not focusing on coastal floods, the FP7 IMPRINTS project (http://www.imprints-fp7.eu) developed methods and tools to be used by emergency agencies for improving the preparedness and the operational risk management for flash floods and debris flow generating events, as well as contributing to sustainable development through reducing damages to the environment. Impacts of future changes, including climatic, land use and socio-economic were

analyzed in order to provide guidelines for mitigation and adaptation measures. Systems were tested on five selected flash flood prone areas supervised by risk management authorities and utility company managers in duty of emergency management. One major result of the project will be an operational prototype including the tools and methodologies developed under the project. This prototype was designed under the premise of its ultimate commercialization and use worldwide.

Also in FP7, the FLOODIS project ("Integrating GMES Emergency Services with satellite navigation and communication for establishing a Flood information service" - http://www.floodis.eu/) provided accurate location-based application for portable devices, closing a critical gap for disaster management teams, civil protection and field/emergency response units to better address and mitigate crisis situations arising before, during and after heavy flooding. Access to open-source, location-based smart phone application for the general public to enable the capacity for individuals to take precautionary actions, therefore, vastly reduces the likelihood of human and economic loss. The project also considered rescuers relying on professional terminals and legacy communication channels. This combined Earth Observation and GNSS (GPS, Galileo, EGNOS/EDAS) technologies deliver alerts and interactive maps on flooding risk/events to users in the geographical area at risk.

1.5.3.3. *Risk assessment of climate-related hazards*

Complementing the above, risk prevention and reduction of climate-related disasters have been subject to major research efforts, namely, by the FP7 KULTURISK project (http://www.kulturisk.eu/) which developed a culture of risk prevention by means of comprehensive demonstration of benefits of prevention measures through enhanced memory and knowledge of past disasters, communication and

understanding capacity of current and future hazards; awareness of risk and preparedness for future events. Measures included early warning systems, non-structural options (e.g. mapping and planning), risk transfer strategies (e.g. insurance policy) and structural initiatives. Focus was on water-related hazards with case on floods, debris flows and landslides, and storm surges.

More recently, the FP7 INTACT project ("Impact of Extreme Weather on Critical Infrastructures") assessed regionally differentiated risk in EU associated with extreme weather, identified, classified on EU wide basis critical infrastructures and assessed their resilience to extreme weather events. The project identified potential measures, technologies to consider, implement, be it for planning, designing and protecting critical infrastructures or for effectively preparing for crisis response and recovery. It brought together a community of climatologists, civil protection operators and meteorologists, with those of owners/operators of critical infrastructure planners to develop prevention of major disasters in cascading effects.

Within Horizon2020, several topics responded to research needs in support of the climate change adaptation strategy with consideration of extreme events, namely, topics dealing with "Science and innovation for adaptation to climate change: from assessing costs, risks and opportunities to demonstration of options and practices", "Mitigating the impacts of climate change and natural hazards on cultural heritage sites, structures and artifacts" and a study on "Impact of climate change in third countries on Europe's security", as well as "Crisis management topic 1: potential of current measures and technologies to respond to extreme weather and climate events". At the time of writing this book, research projects issued from these topics had not yet been selected and were aimed to start by mid-2016 for a period of 3–5 years.

1.5.3.4. *Coastal risks induced by storm events or flooding*

Coastal risks tend to be funded by several projects. The FP7 MICORE project ("Morphological Impacts and COastal Risks induced by Extreme Storm events" - https://www.micore.eu/) developed probabilistic mapping of the morphological impact of marine storms and produced early warning and information systems to support long-term disaster reduction. A review was carried out of historical storms that had a significant impact on nine sensitive European sites including wave exposure, tidal regime and socio-economic pressures. Monitoring over the course of one year to collect new data sets enabled us to develop and test numerical models of storm-induced morphological changes, linking wave and surge forecasting models to set-up a real-time warning system and to implement its usage within Civil Protection agencies. The project enabled the conception of Storms Impact Indicators (SIIs) with defined threshold for the identification of major morphological changes and flooding associated risks.

In parallel, the FP7 SIM.COAST project ("Numerical Simulation Tools for Protection of Coasts against Flooding and Erosion" - http://www.simcoast.eu/) contributed to improved process understanding, new knowledge, methods, new and improved numerical tools, resulting in decision support systems serving decision making at protection of coasts against flooding and erosion. Support to decision makers in improving co-ordination of coastal erosion and surface water flood risk – strengthens emergency planning arrangements.

The FP7 THESEUS project ("Innovative coastal technologies for safer European coasts in a changing climate" - http://www.theseusproject.eu/) developed a systematic approach to delivering both a low-risk coast for human use and healthy habitats for evolving coastal zones subject to multiple change factors. Innovative combined mitigation and

adaptation technologies included ecologically based mitigation measures (such as restoration and/or creation of habitats), hydromorphodynamic techniques (such as wave energy converters, sediment reservoirs, multi-purpose structures and overtop-resistant dikes), actions to reduce the impact on society and economy (such as promotion of risk awareness or spatial planning) and GIS-based software to support defense planning. Eight study sites across Europe were selected, with specific attention Eight study sites across Europe were selected, with specific attention to the most vulnerable coastal environments such as deltas, estuaries and wetlands, where many large cities and industrial areas are located.

Catastrophic events such as the Xynthia event in France (February 2010) highlighted research needs in the prevention and preparedness of such extreme events, which were reflected in two major projects, namely: the FP7 PEARL project ("Preparing for Extreme And Rare events in coastal regions" - http://www.pearl-fp7.eu) developed more sustainable risk management solutions for coastal communities focusing on present and projected extreme hydrometeorological events. Seven case studies from across the EU were designed to develop a holistic risk reduction framework to identify multi-stressor risk assessment, risk cascading processes and strengthen risk governance by enabling an active role for key actors. Development of novel technologies and methods improved the early warning process and its components, building a pan-European knowledge base gathering real case studies and demonstrations of best practice across the EU to support capacity development for the delivery of cost-effective risk-reduction plans. Additionally, the project provided an interface to relevant ongoing tsunami work: it plugged into global databases, early warning systems and processes at WMO, and contributed to community building, development of guidelines and communication. Besides, the FP7 RISC-

KIT ("Resilience-Increasing Strategies for Coasts" - http://www.risckit.eu/np4/ home.html) developed ready-to-use methods, tools and management approaches to reduce risk and increase resilience to low-frequency, high-impact hydrometeorological events. Open-source and free-ware were developed to assess present and future hot spot areas of coastal risk due to multi-hazards, as well as high-resolution Early Warning and Decision Support System (EWS/DSS) for use on these hot spots (with a scale of 10's of km) and web-based management guide offering innovative, cost-effective, ecosystem-based DRR measures. Testing toolkits using data collected on 10 diverse case study sites were deployed along each of Europe's regional seas and one international site.

1.6. Science–policy interfacing

1.6.1. *Linking different actors*

The management of disaster risks such as coastal storms and floods is overseen by a number of international, EU and national policies covering various sectors and operational features such as preparedness, prevention, detection, surveillance, response and recovery. A wide range of research and technological developments, as well as capacity-building and training projects, are striving to support the implementation of these policies. However, the complexity of the policy framework and the wide variety of research, capacity-building and training initiatives often lead to a lack of awareness about policies and project outputs by the users, namely, policymakers, scientists, industry/SMEs and practitioners, e.g. civil protection units, medical emergency services along with police departments. Highly fragmented information often leads to poor awareness of policy requirements by research and industry communities along with poor transfer of research results to policy and stakeholder communities.

1.6.2. *Governance and knowledge transfer*

Several levels of governance need to be considered: (1) a "horizontal" level in the framework of which interactions among research, industry, policymakers and practitioners are established in a coordinated way at different scales, i.e. EU, national and regional. (2) A "vertical" level which establishes operational links between the EU, national and regional levels through appropriate information relays, synergies and demonstration activities.

The different levels are illustrated in Figure 1.2 and deal with, in particular:

1) Horizontally:

– *Science to science:* sharing information and developing interactions among H2020 research projects dealing with coastal risk and floods to develop a critical mass and reduce fragmentation, and bring tools/technologies to the market through links with industrial stakeholders. Projects should, in principle, respond to topics which are generally based on well-defined policy hooks (in this case, environmental and climate policies). Hence, we might expect that projects supporting common policy goals will establish synergies, which is rarely the case without a push from the European Commission owing to various considerations (intellectual property rights in particular). Sharing information and developing interactions on a regular basis should become a common practice.

– *Policy to policy*: policy interactions in the light of implementation needs, and establishing links with EU Member States. While International and EU policies are developed in close consultation between different sectors, in practice, few interactions take place at the implementation level between sectors within the Member States (e.g. climatologists working with hydrologists for policy

implementation-related actions). This is partly due to insufficient sharing of information and joint actions.

– *Science to policy*: formatting/translation of research information in a way which is tailor-made to policymakers and ultimately user's needs, responding to well-specified technical challenges. This is directly linked to the above, with the requirement for the scientific community to format/translate research information in a way which is tailor-made to policy applications, basically responding to well-specified technical challenges.

– *Policy to science*: identification of research needs from policymakers, stakeholders and practitioners on the short- to long term and communication of these needs to be taken into account in research programming, development and implementation. An essential component of the policy to science interaction is the capacity for policymakers to identify research needs on the short to long term and communicate these needs in anticipation to the research community so that programming, research development and implementation can match the policytimeline (e.g. access to the scientific state-of-the-art, short-term research/capacity building, longer term research goals, and pre- and conormative research).

2) Vertically :

– *International/EU to National*: in the research sector, interactions through H2020 consortia; in the policy sector, interactions through Committees representing Member States and stakeholders, working out appropriate relays to national authorities and stakeholders based on well-formatted information. At international/EU level, policies are elaborated by relevant organizations (e.g. Sendai Framework for Action and European Commission for climate /environment-related EU policies). The links to the National level take place through Committees in which Member States are represented. There is a need to ensure that these

Committees are informed on similar grounds about science and policy developments.

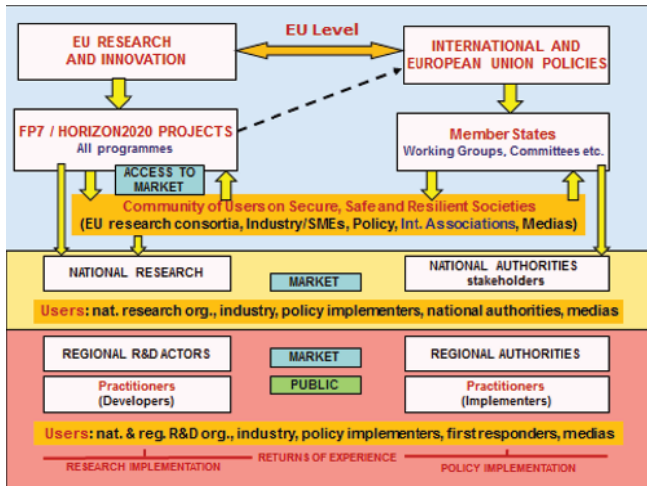

Figure 1.2. *Different levels of governance. For a color version of this figure, see www.iste.co.uk/quevauviller/storms.zip*

– *National to Regional / Local*: information is communicated through interactions with regional research partners and regional authorities as well as practitioner's networks and associations. Once representatives of the Member State's Committee are informed, it is to be expected that appropriate communication with regional / local implementers will then take place under the MS responsibility. This also requires a level of coordination, which depends upon the willingness and capacity of each Member State. This level of interaction is less well defined than the EU level because of different settings within the different Member States.

– *Regional to National / EU*: return of experiences from either practitioners involved in EU-funded projects or practitioners informed via national channels to the EU level.

1.6.3. *Networking needs*

In a world facing a growing risk of hydrometeorological disasters such as coastal storms and floods and the security of citizens – infrastructure and assets have become a high priority in the European Union, in particular for strengthening capacities in disaster risk management and improving resilience related to coastal risks. Indeed, the impact of climate change on natural hazards has seen a rise in the severity and frequency of various natural disasters in Europe and beyond. Meteorological hazards such as extreme weather events, floods and heat waves, as well as forest and wildfires have become recurrent phenomena in the EU. The Xynthia storm of 2010, the major floods in Southern Germany and neighboring regions in 2013, and the deadly heat wave which struck Europe in 2003 are a few examples.

Coastal risks management involves various communities covering research, policy and operational actors (including industry/SMEs, first responders, civil protection units, decision makers, etc.), all of which have specificities but share common features regarding the overall risk management cycle (preparedness/prevention, detection/surveillance and response/recovery) and the need to ensure a proper transfer (and implementation) of research outputs to "users".

This diversity of actors requires that the dissemination and communication of project results be tailor-made to different sectors, while bearing in mind that the common goal is to ensure that "solutions" resulting from research will reach users (often regional implementers, first responders, civil protection units, SMEs, individuals, etc.) in a timely and relevant manner and be translated into "useful & used operational tools", hence contributing also to the European economy through improved competitiveness. The high number of research projects and the lack of "interfacing" mechanism make it difficult to efficiently reach this goal.

1.6.4. *Who are the users of research?*

Fields concerned by coastal risks, including security, safety and resilience for societies are themselves scattered into different disciplines and sectors. In other words, we will distinguish five main categories of actors: (1) policymakers; (2) scientists; (3) industry (including SMEs); (4) training and operational units; and (5) NGOs and general public:

1) Policymakers and stakeholders*:*

– at the international level, UN bodies are closely working with the EU in the field of disaster risk reduction (UN-ISDR), environment protection (UNEP), etc.

– at the EU level, the main policies concerned with coastal risk management cover civil protection, environment and climate action;

– at the Member State's level, Ministries and Agencies in charge of Civil Protection, Environment, Research and Industry, as well as Agencies and Regional Authorities, are concerned;

– often working at the interface between policy and science, various stakeholders are involved in bridging interests of different communities, e.g. consultancy companies;

2) Scientists:

– Coastal risk-related research involves a range of scientific disciplines which have to interact, ensure complementarity and build interdisciplinary networks;

– Different types of scientists are to be considered (universities, research institutes and research units linked to ministries or agencies);

3) Industry (including SMEs):

– Many industry branches and stakeholders are involved in the areas of civil protection, environment and climate.

4) Practitioners:

– First responders, i.e. fire brigades, emergency services, civil protection units, water/flood management, etc., as well as decision makers (at national or regional levels).

– Training centers for first responders and command control centers.

5) NGOs and general public:

– NGOs, Civil Society Organizations, public at large, education (schools) and training.

While some of the above actors in categories 1, 2 and 3 are used to participate in international meetings, this is less frequent for SMEs (in category 3) and even less for actors in categories 4 and 5. New ways must be found to ensure that information may freely circulate "horizontally" as well as "vertically" in order to fertilize all project deliverables while, at the same time, maturing them to the final operational phase (also called "usefulness & use") by end-users, and integrating them into appropriate policy implementation and development.

1.6.5. *Building-up of a "Community of Users"*

The large span of projects leads to a huge dispersion of resources as no mechanism is presently in place to establish a common platform to exchange information of public character, boost awareness, transfer of relevant research projects to relevant users (and to industrial/SMEs share- and stake-holders) and make them "useful and used". In addition, efforts have to be made to better address users' needs which will be reflected into possible inputs to (EU and

national) research programming. The need for a sharing platform led to the idea of developing a Community of Users along the principle shown in Figure 1.3.

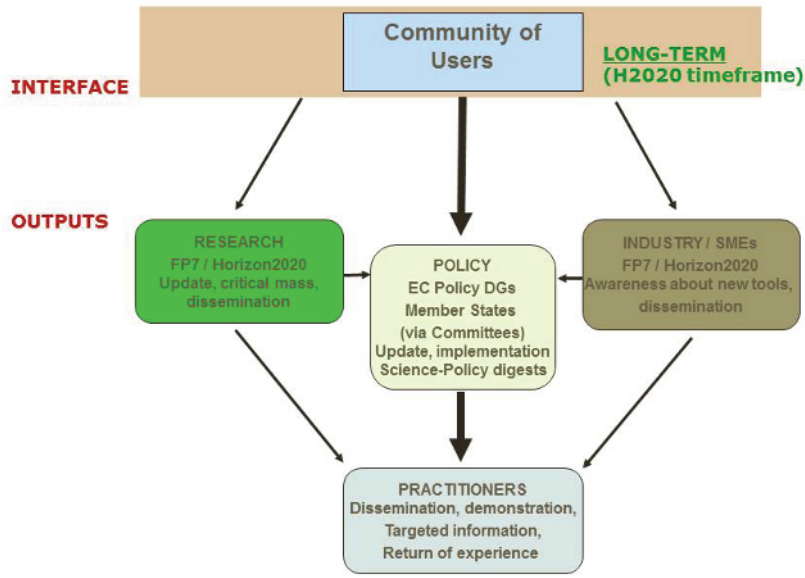

Figure 1.3. *Principles of the Community of Users. For a color version of this figure, see www.iste.co.uk/quevauviller/storms.zip*

The concept of "Community of Users" (CoU) is closely linked to the needs for a better coordination of information exchanges of general nature through a visible platform. An initiative has been launched by DG HOME (DG Migration and Home Affairs) since 2013, the objectives of which is to boost transfer of research outputs to relevant users and facilitate sharing of information among different actors. The objective is to create a mechanism involving different levels (EU, national and regional) by which the different actors, and primarily the "users", will be able to trace back information and experiences issued from research, capacity-building and training projects, giving them the opportunity

to identify and contact the appropriate party at the right time to get the feedback that they need via a CoU-dedicated website. Regular information exchanges and debates orchestrated by the Community of Users will enable us to better channel the information to the "users", which will have a direct effect on research programming, policy implementation and update. It will also have an effect on the involvement of end-users at various levels, e.g. in steering committees of Horizon 2020 projects, consortia and cater links between research projects and capacity-building/ training initiatives, e.g. making links with training programmes and centers, module exercises, etc.

If the Community of Users develops as expected, it has a potential to become a useful, complementary, and supporting group on research-related activities to EU policies, including policies relevant to coastal risks (not duplicating existing advisory groups dealing with policy implementation but rather channeling information about research outputs) in the framework of which the European Commission with the EU Member States (through the policy and programme committees). The EU Agencies, Intergovernmental Agencies, International Organizations and the wide range of sectors concerned (research, industry, practitioners) will cooperate for boosting implementation of research outputs, including their usability for policy implementation in the Member States (through information given to relevant existing committees and advisory groups). This will, in addition, have the capacity of returns of experiences from Industry and practitioners to the EU level, and enable us to identify potential technologies, tools and methods in order to support their access to the market.

The Community of Users, along with a related initiative, namely, the Disaster Risk Management Knowledge Centre (DRMKC) coordinated by the EC Joint Research Centre, will enable us to better visualize/identify research (and on the

long-term capacity-building and education) projects related to different themes relevant to safety, security and resilience. While this network is progressively establishing "horizontal" dialogues and helping interactions among different disciplines and actors, it will not have the capacity to create operational links with users at large without dedicated thematic networks (referred to as "Communities of practice") in Figure 1.4.

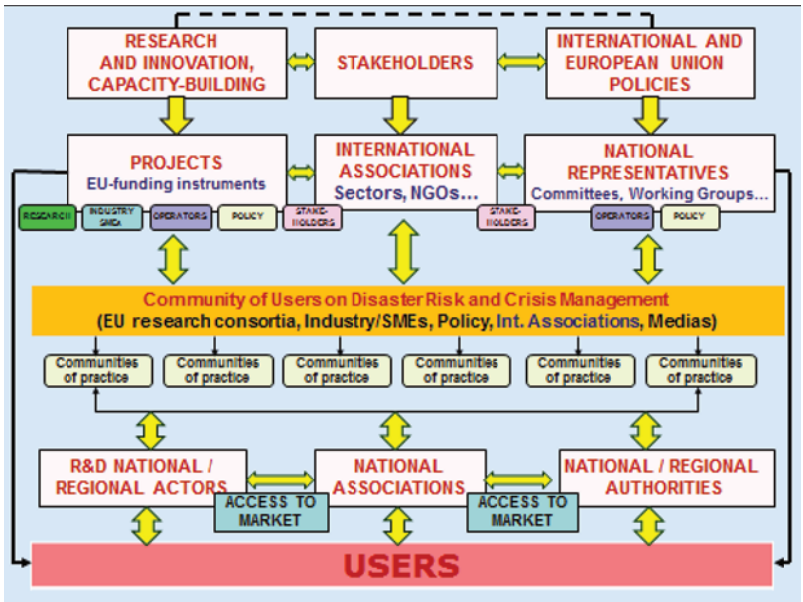

Figure 1.4. *Linking CoU to Communities of practice. For a color version of this figure, see www.iste.co.uk/quevauviller/storms.zip*

This need for "vertical" transfer of information from the EU to the national and the regional levels could be fulfilled by connecting the CoU to appropriate expert networks or communities, either existing or to be developed, which would play the role of knowledge integrating and "translating" bodies at European levels, with the mission – in support and connect with MS authorities – to effectively relay research

outputs (e.g. new tools or technologies, methods, etc.) to appropriate users at national, regional and even local levels. This process of pulling EU research outputs to users, i.e. transforming these outputs into outcome, can only be possible through an effective partnership with users. In other words, if the CoU provides on a regular basis information on new tools/technologies or other research information, different "communities of practice" might format this information to address different categories of users (policymakers, scientists, industry/SMEs, practitioners and civil society) and undertake *ad-hoc* actions to ensure that potentials of EU research developments are known and possibly applied by them. This flow of information would enable that we do not miss opportunities (or duplicate work) and would also create effective bridges among the EU down to the citizen's level with possible feedback received and contributing to further research programming.

In the coastal risk area, the CoU will continue its efforts in identifying relevant projects funded by different (research and capacity-building) programmes with the aims to propose clustering initiatives through platforms of information exchanges. Stakeholders will continue to interact with these programmes to help interfacing with relevant policies. The CoU is naturally not interfering with policy development and implementation, but contacts are readily established with different policy bodies, enabling us to inform users about possible updates and helping research information to be efficiently disseminated to policy actors. The "Community of practice" needs to be activated to relay *ad-hoc* information to users as shown in Figure 1.5.

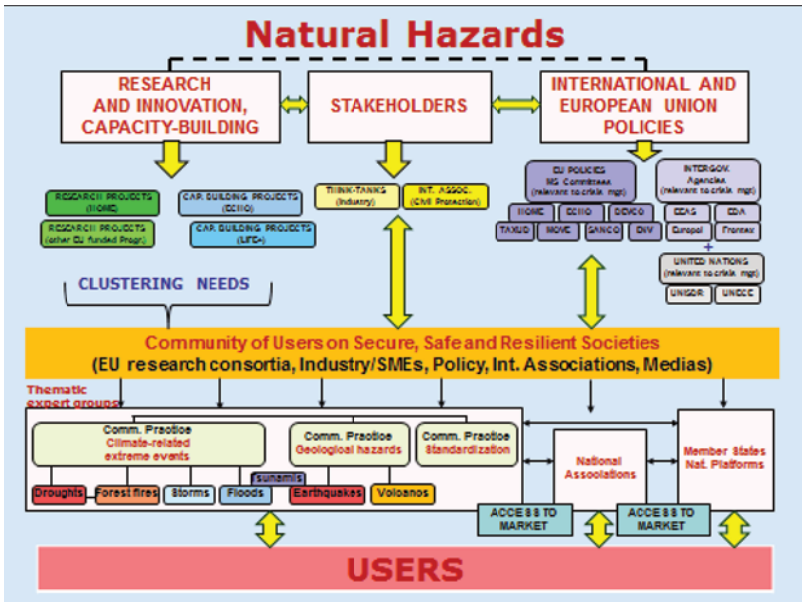

Figure 1.5. *Main actors in the Natural Hazards area. For a color version of this figure, see www.iste.co.uk/quevauviller/storms.zip*

Zooming into the picture (Figure 1.6), would imply that each Community of practice gets a comprehensive overview of leading projects in their area (research, capacity-building and training/education) and help bringing these projects. Interfacing among research and innovation and other actors in the industry and policy areas should be facilitated by stakeholder expert/ working groups with a mediating role, i.e. able to translate/format the information to target specially different users (e.g. specific technology information addressed to industry, support to a specific policy action with reference to the appropriate regulation, etc.). In bridging the different "worlds", there is a greater chance that users will get better, channeled information as the knowledge base would in principle become consolidated and made known to a wide range of different actors.

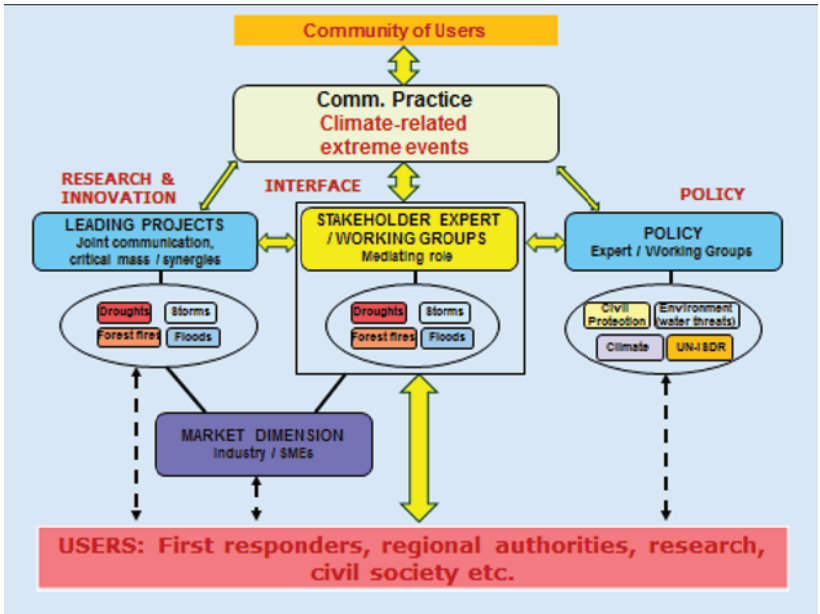

Figure 1.6. *Channeling information in the Natural Hazards area. For a color version of this figure, see www.iste.co.uk/quevauviller/storms.zip*

In conclusion, the Community of Users has the vocation to act as a facilitating platform, creating links and dialogues among different actors/disciplines (the "horizontal level") and among different levels (from EU to local). Based on the present mapping, a similar architecture will be used to develop a website which will facilitate information searches (not repeating what is readily in place but rather providing paths helping users to more easily find information per theme/areas). This mapping will be complemented on a regular basis (annually) for H2020 and other projects, and the CoU will pursue the organization of gathering events to consolidate a culture of exchanges at EU level for the sake of improved safety, security and resilience of our societies.

1.7. Conclusions

Most policies dealing with Disaster Risk and Crisis Management have established operational links with research. While interactions among research and policies are high on the policy agenda, much remains to be done to improve the way information flows from the different communities involved in implementation of both research outputs and policies. This includes capitalizing on past research and enhancing cooperation among EU Member States organizations. The complexity of the security sector arises from the wide variety of actors involved and the lack of coordination mechanism at EU and national level regarding the transfer of information and their actual use by implementers and decision makers. The need for enhanced coordination and information sharing forms the basis of the Community of Users on Safe, Secure and Resilient Societies described in this chapter.

Prior to developing a Community of Users (based on existing communities which are presently fragmented) with the view of improving science–policy–industry–operator's links in the context of Horizon 2020, it was essential to *understand the architecture* of the research framework and how it interacted with various policy technical/scientific challenges. This was the subject of the mapping which should not be regarded as an impact assessment (i.e. no analysis was done about the actual impact and the use of research outputs on policies) but rather as a means to better understand the complex science–policy working environment at EU and national levels and propose a mechanism to *streamline information flows and transfer in the future* [EUR 17]. The analytical value of the document stands for the "matrix" established between research and science, i.e. a factual image of the present situation. For the time being, it does not go as far as analyzing the real outputs of research

regarding policy implementation but complements the work of the Commission's Disaster Risk Management Knowledge Centre (DRMKC), which intends to improve science-based services and analysis, the use and uptake of research and operational knowledge, as well as to advance science and technology in DRM.

What is the way ahead? Several objectives will be pursued, from the short- to the long term, which are described in details in the above referred report [EUR 17]. Besides the technical objectives and the coordination of a better information exchange system, the Community of Users on the long term has the capacity to rise sharing of experiences among different actors involved in disaster risk and crisis management (including coastal risks), with possible initiatives leading to synergies in the EU and beyond.

As a concluding remark, it should be recalled that policy orientations rely on scientific evidence. In this respect, the efficient use of science represents an increasing challenge for the scientific and policy-making community, the private sector, NGOs, citizens' associations and professional organizations. The need to improve the role that science plays in environmental policy-making has been widely debated over the last few years; in particular, the need to ensure better linkages between policy needs and research programmes, with enhanced coordination regarding programme planning, project selection and management, and mechanisms for knowledge transfer to ensure that outputs from research programmes really do contribute to policy development, implementation and review. This issue has been discussed in depth in the water sector at European Union level for more than 5 years, underlining the need to develop a conceptual framework for a science–policy

interface related to water which would gather together various initiatives and knowledge [QUE 10] which is illustrated in Figure 1.7, showing the necessary links between research recommendations or tools and "users" (policymakers, stakeholders and water managers) and the need to ensure a "memory" of scientific information (facilitated by various dedicated websites), demonstration of the applicability of the research and dissemination through appropriate communication and translation of the scientific information. This closes the present chapter in underlining that the bridge between policy and research is non-trivial and deserves more attention from all actors concerned.

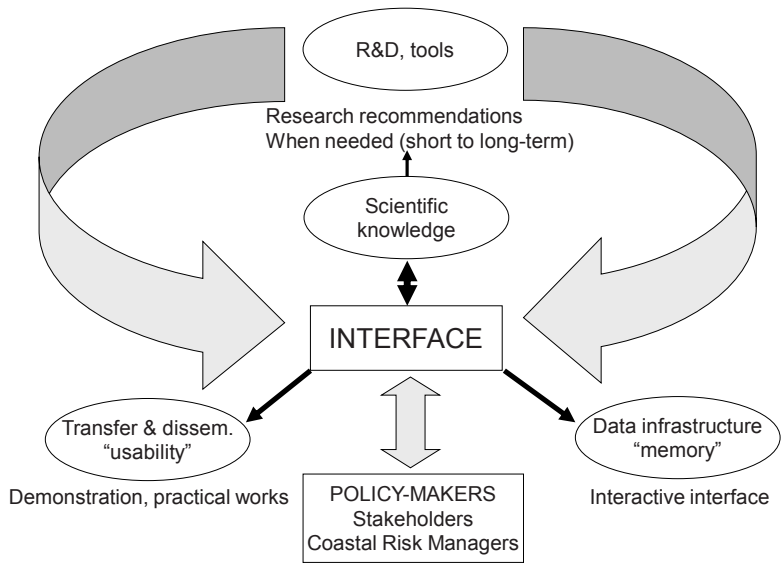

Figure 1.7. *Needs of interface between science and policy (adapted from [QUE 11])*