1 Introduction

Scientific foundation of environmental policies: Where do we stand?

The need to strengthen links among scientific outputs and policy-making activities is subject to on-going debates [1], and specific discussions in the water and marine sectors have examined concrete developments [2]. One of the key conclusions of these discussions among scientists, policy-makers and stakeholders underlined the possibility to develop a conceptual framework for a science-policy interface related to water, which would gather various initiatives and knowledge. The present paper takes over these general conclusions and elaborates on a possible scenario regarding water (including marine) science & policy interface.

1.1 The environmental policy chain related to pollution protection

Key steps of the environmental policy chain related to protection against pollution can be summarised as follows:

- Identify pressures;
- Quantify relationship between pressure and environmental response;
- Quantify relationship between social and economic cost and pressure;
- Identify least cost pathway;
- Define policy instrument;
- Implement the policy instrument and assess response;
- Take appropriate measures (control, remediation);
- Review policy on the basis of scientific/technological progress.

Each link of this chain is based upon a scientific foundation and basic technical knowledge. The reliability of the overall chain will indeed depend upon the effectiveness of the integration of scientific and technological knowledge in a timely fashion at each step of the policy development, implementation and review.

1.2 State of knowledge of 'environmental interfaces' and pollution pathways – Links with policy design

The knowledge of ‘environmental interfaces’, e.g. soil-water interactions, and of pollutant pathways at this interface (e.g. mobility, bioavailability) represents a basic feature for understanding the impacts of anthropogenic pressures on various environmental compartments. It has hence a direct impact on the way policy is designed, developed and implemented. This knowledge should, in principle, be tackled in a 'holistic' fashion. In other words, it is hardly possible to understand the overall impact of a specific pressure on the environment by looking only at one environmental compartment. However, the awareness about the need to undertake integrated scientific, multidisciplinary, studies of the environment is quite new, and it is only recently that progress on environmental interfaces has started to produce concrete results. This sectoral knowledge is also reflected in the way policies have evolved over the last decades: until the end of the 1990’s, environmental policies were developed 'vertically', i.e. per specific areas, even in single fields (e.g. freshwater, drinking water, groundwater, etc.). With the 6th Environment Action Programme (2002–2012) [3], and the development of framework directives (e.g. air, water, waste, and soon soil and marine), there is now a move towards more integrated policies. Steps forward in this direction will only be possible if the scientific knowledge establishing links among different environmental interfaces is well consolidated.
and usable in such a way that it can match legal requirements, thus allowing to move out from the precautionary principle. As an example, there are pathways of pollutants which may lead to either toxicity enhancement or reduction, and the policy response should hence be adapted to these features. The main pathways are summarised in Fig. 1.

The diagram illustrates the complexity of the pollutant pathways, and the need to look at them in a multidisciplinary fashion. The purpose of this paper is not to describe them, which would be far too extensive, but rather to highlight the key issues which have a link to environmental policies as described in section 3.2:

- Interactions among water and solid particles (sediments, suspended matters, soil): most of the environmental pollutants (in particular organic micropollutants) display a high capacity to adsorb on solid particles and accumulate in sediments or soils. Release to water (dissolved phase) is however also occurring in the case of physico-chemical changes (e.g. pH lowering). Infiltration of pollutants (indirect input) may occur from top soils to groundwater through leaching processes.
- Atmosphere-water interface: the accumulation of pollutants in atmospheric particles leads to precipitations which may contain high levels of contaminants, including acids resulting from SO₂, N₂O, and NO₂ anthropogenic emissions. This diffuse pollution pattern has effects on the remobilisation of pollutants adsorbed onto solid particles.
- Sea-land interface: interactions among sea and land environments lead to various pollution pathways, e.g. soil watering and other sources leading to increased levels of pollution in river systems, and transit of pollutants to estuaries (contamination sinks in tidal sediments) and the ocean. Biological effects play a role in re-suspension of contaminated sediments (benthic organisms) which may affect filter-feeding species.
- Surface water-groundwater interface: polluted groundwater (either through direct or indirect introduction of pollutants) may have a direct detrimental impact on the quality of associated surface waters and wetlands. Contrarily to sea-river interfaces, the time of transit may be much longer, in particular for what concerns indirect pollution.

The different pollution pathways depend upon the nature of the pollutants (type and origin of chemical substances) and a high variety of environmental factors such as e.g. the climate, hydrology (water flows and related sedimentation rates), geology, hydromorphology, physico-chemical conditions (e.g. pH, redox potential), biological interactions, etc. In this respect, it is hardly possible to understand a given pathway by looking at a single environmental compartment and through one discipline only.

To date, the knowledge of environmental interfaces is limited by the lack of sufficient multidisciplinary studies. Progress is on-going in the framework of various EU-funded projects (see section 3.1), but the scientific foundation is not considered to be sufficiently developed to be able to effectively assess the effectiveness of environmental policies in a holistic context. This is discussed in section 3.2.

Worth mentioning is 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 such as the European Environment Agency’s State-of-the-Environment programme) and the development of models now provide a much better vision of the problems to be tackled and of the way to approach them. On the medium term (5 years horizon), it will be possible to establish a much better 'holistic' evaluation of environmental interfaces and related pollution pathways. This will obviously have a direct effect on the implementation and review of related EU policies. On the longer term (10–15 years), the increasing number (and quality) of environmental data bases, models, and other monitoring facilities (e.g. GMES) should enable to look at the environment as a single entity instead of series of separate compartments.

2 EU Scientific Framework in Support of Water Policies

2.1 Water policy framework

The 6th Environment Action Programme (6th EAP) [3] defines the environmental policy trends for the period 2002–2012. It strongly affirms that environment policies should be based on the best scientific evidence and also that its priorities need to figure prominently in the Community RTD (Research and Technological Development) programmes.
The complexity of environmental problems that we now face makes the science approach even more necessary – interlinkages and trade-offs between problems are more apparent. Acting on one problem can harm or benefit the solution of other problems. Measures need to be assessed in an integrated fashion to avoid undesired side effects. Significant research efforts have been devoted in recent EU research programmes in support of water policies. Among the strategies defined in the 6th EAP, water is considered as case study in the context of the present paper, namely the Water Framework Directive (WFD) [4] and related water policies.

The WFD establishes environmental objectives of 'good status' for all waters to be reached by the end of 2015, which are based on clear milestones (e.g. characterisation, monitoring, river basin management plan, programme of measures). To support both the policy and technical challenges of this directive and its ambition (concerted management of more than 120 river basin districts at the scale of the EU and associated/candidate countries), Water Directors of the respective countries have decided to launch a Common Implementation Strategy (CIS) in 2001, of which the aim is to develop a common understanding and approaches, elaborate informal technical guidance including best practice examples, share experiences and resources, avoid duplication of efforts, and limit the risk of bad implementation of the directive [5].

The WFD provides a well-established policy basis and a stable platform which enables building up communication and best practice exchanges among different players (policy implementers, technology providers, scientific community, industrial stakeholders, NGOs). As described below, this is reflected in clear improvements within the last 4 years, with plans for developing joint initiatives (involving EC Research and Environment General Directorates, scientific actors and Member States through the WFD-CIS) in 2007–2009 for integrating scientific inputs and progress into the implementation process. These activities will not only support the WFD implementation but also the implementation of other water policies such as the Urban Wastewater Treatment directive (UWTD) [6], the Bathing Water directive (BWD) [7], the Drinking Water directive (DWD) [8], the recently adopted Groundwater Directive [9], as well as policy under development such as the Flood and Priority Substances directives.

Finally, RTD perspectives in the water sector should also be seen in the context of the Millennium goal and take account of the development of the EU Water Initiative (EUWI). Progress updates of these policies are published on a regular basis (twice a year) [10].

### 2.2 Water in the RTD framework and LIFE programmes

#### 2.2.1 The EU RTD framework programme

The Treaty establishing the European Union indicates that Research Framework Programmes have to serve two main strategic objectives. First, it provides a scientific and technological basis for industry and encourages its international competitiveness. And second, it promotes research activities in support of other EU policies. To this end, Framework Programmes are designed to help solving problems and responding 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 research on water since several years through its successive Framework Programmes (FP) for Research and Technological Development (RTD) [11]. 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.

#### 2.2.2 5th framework programme (1998–2002)

Water has been identified as a key action of the 5th Framework Programme (1998–2002), as part of the Environment and Sustainable Development Programme. The Key Action 'Sustainable Management and Quality of Water' has invested more than 150 million € in research projects directly relevant to the Water Framework Directive. To further enhance the impact of EU funded research, projects within the same thematic area were clustered together in order to improve coordination and synergies, promote integration and synthesis of results of policy needs, create platforms/fora for active communication and targeted dissemination of RTD results to key stakeholders and end-users. In this respect, the 5th FP has represented a turning point in water research. In fact emphasis has been given to problem-solving approach, support to relevant EU policies, especially the WFD, and sustainable management of water resources [12]. Examples of topic areas were process-oriented research addressing surface and groundwater hydrological interactions, structure and function of ecosystems dynamics and wetlands, physico-chemical behaviour of various pollutants in the aquatic environment, climate change and extreme events. Attention was also given to environmental quality and monitoring issues, in particular the development of advanced analytical methods for the determination of water quality, waste water treatment and fate of pollutants originating from contaminated industrial areas or waste disposal sites to groundwater.

#### 2.2.3 6th framework programme (2002–2006)

In the 6th Framework Programme (FP6) water research continued to be supported, complementing and expanding research undertaken in FP5 to support EU policies and developing tools for the sustainable water management in the EU. It also intended to support the objectives of the EU Water Initiative and other international activities, i.e. the Millennium Development Goals. The FP6 included two main priorities which integrated research in support of water policies, namely the Priority 6.3 'Global change and ecosystems' and part of the so-called Priority 8 (SSP) 'Scientific Support to Policies'. Topics are mainly implemented with the help of large-scale research projects (Integrated Projects), Networks of Excellence, Specific Targeted Research Projects (STREPS), Coordination Actions (CA) and Specific Support Actions (SSA).

- The Priority 6.3 opened the possibility to fund research projects contributing to medium to long-term policy ob-
jectives. Water research in the context of the Global Change and Ecosystems sub-priority was mainly supported by the ‘Water cycle, including soil-related aspects’ area which put emphasis on hydrology and climate processes, ecological impact of global change, soil functioning and water quality, integrated management strategies and mitigation technologies, and scenarios of water demand and availability.

- The Priority 8 ‘Research for Policy Support’ (SSP) activity has been designed to underpin the formulation and implementation of Community Policies. It hence enabled publication of calls for proposals which accommodated specific research needs identified by the policy DGs. In this respect, a range of topics has been defined, in particular, in support of the WFD implementation.

- Another instrument (not tailor-made to a specific sector) worth to be mentioned is the ERA-NET scheme, which has been set up within the 6th Framework Programme to co-ordinate national and regional publicly funded programmes. Funding bodies like ministries and research councils may submit proposals for the networking of national or regional research programmes or innovation programmes in sectors of their choice. The Commission funds the co-ordination and the Member States finance the research activities. Typically, ERA-NET projects include exchanges of information on programmes and projects, exchanges of best practice, strategic analyses for future joint activities and programmes, joint calls for proposals, etc. This mechanism hence allows for the co-ordination of research programmes with relevance to environmental policies, including the Water Framework Directive, but also on bilateral or international (research) programmes. The ERA-NET scheme represents a very valuable mechanism to regroup national funds at the level of programmes so that larger or more coordinated projects can be funded. Further, it allows increasing the access to scientific expertise available at regional or national level as well as cross border cooperation at the levels of programmes and of projects.

2.2.3 Joint research centre (JRC) – Multi-annual work programme (MAWP)

EC funded research has also been developed through the Joint Research Centre' Multi-Annual Work Programme (MAWP) embedded into FP6. Several key actions of the MAWP are directly relevant to water policies, e.g. actions related to chemicals in the aquatic environment, ecological water quality, marine ecosystems, water quality information system, European Measurement Infrastructure, and policies and human resources for research.

2.2.4 LIFE programme

Finally, besides FP6 funding, the LIFE programme – the Financial Instrument for the Environment – is a EC DG Environment’s financial mechanism specifically aimed at assisting the development of environmental policy through its co-finance of demonstration projects. LIFE has co-funded close to 1200 projects related to water policies since 1992, which were thus potentially in a position to help prepare the ground on location for a subsequent WFD implementation. The rational behind this instrument is simply that innovation, be it highly technical or more like a new approach to an old problem, needs to be demonstrated to persuade other potential users of their value, and to establish that any innovations proposed actually do work in the real world. This funding instrument thus represents in principle a natural continuation of research projects, aiming at demonstrating the applicability of innovative methods, solutions, techniques on real environmental cases.

2.2.5 Orientations of the 7th framework programme (2007–2013)

The Sixth Framework Programme (FP6) has been terminated at the end of 2006, and is now continued by the Seventh Framework Programme (FP7) which began on 1 January 2007 and will run until the end of 2013. While FP6 was the Commission’s response to the requirements of the Lisbon Summit in March 2000 calling for a better use of European research by creating an internal market for science and technology (the European Research area), FP7 is designed to build on the achievements of its predecessor and to move forward in the creation of a European knowledge economy and society. FP7 is to respond to Europe’s employment needs, competitiveness and quality of life.

The Seventh Framework Programme covers priority areas reflecting EU research needs in 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 one of these ten priorities. It focuses on knowledge on the interactions between the biosphere, ecosystems and human activities, and the development of new technologies, tools and services, with emphasis on:

- Improved understanding and prediction of climate, earth and ocean systems changes
- Tools for monitoring, prevention and mitigation of environmental pressures and risks
- Management and conservation of natural resources, etc.

More specifically, the research areas will address pressures on environment and climate, impacts and feedback, environment and health, conservation and sustainable management of natural resources (including groundwater), evolution of marine environments, environmental technologies, understanding and prevention of natural hazards, forecasting methods and assessment tools, and earth observation. The overall Environment (including climate change) theme has a budget of 1890 millions euros for the period 2007–2013 (on a total budget of 50,521 millions Euros).

2.3 Identification of research needs in the water policy sectors

2.3.1 Type of research

It is not always possible to establish a clear cut among ‘basic’ and ‘applied’ research. Also the timing aspect (short-, medium- and long-term) is intimately linked to the way research instruments are being operated. The identification of research needs is of course fed by advances in scientific knowledge, but is also directly influenced by the evolution and requirements of policies. The needs 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 water policy sector, depending on timing considerations:

- **Short-term (~1–2 years):** Needs are basically concerning 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 sorted out in a 6–12 months period). Policy development also requires an efficient and user-friendly access to background scientific information and archives; a typical example are the thematic strategies covered by the 6th EAP. 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, i.e. 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 timely be tackled through JRC action lines (see section 2.2.3) that are identified in their annual work-programme and agreed by DG Environment, as well as through possible national research programmes; successful examples exist in the sector of water policies. In the future, short-term needs could also be partially fulfilled through a coordination of national research calls for proposals (ERA-NET scheme).

- **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 WFD in support of which research activities have been carried out since the time of its adoption (2000), in response to needs linked to e.g. analysis of pressures and impacts, characterisation of water bodies (2004–2005), economic analysis (2005). For the forthcoming milestones, the formulation of medium-term research needs will have to take into account e.g. monitoring (2006), and the preparation phases (2007–2008) of the first river basin management plan to be published in 2009. The SSP mechanism (research in support of policies) within FP6 was well adapted to respond to such identified needs, i.e. a detailed description of research needs by policy-makers and the follow-up of projects in close coordination with the scientific community represent key elements for achieving a successful use and application of research to the policy-making process. RTD projects running over a 2–3 years period may also fulfil 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-years horizon, or the review process of the legislation. In the case of the WFD, long-term research needs may be linked to the development of the programme of measures which has to be operational in 2012. It may also concern the review process of the technical requirements detailed in the relevant annexes of the directive, which should be known at the time of the 2nd River Basin Management Plan in 2015. It is expected that research activities as they are developed under Integrated Projects (funded under FP6 or FP7) may respond to either well-defined milestones of the thematic policies or the review of the legislation.

3 Integration of Scientific Outputs in Water Policy Development

3.1 On-going RTD and demonstration activities

Water pollution pathways can be looked at from different angles (e.g. environmental media and interfaces with water or types of pollution sources). This is illustrated by a wide range of RTD and demonstration projects funded under FP5 and FP6. Let us take few project examples and consider different aims to evaluate the various types of on-going and completed R&D activities:

- **Series of projects looked at pollution issues on the angle of ‘risk assessment’, namely to develop assessment tools (models, measurement protocols, strategies).** Here the research aimed to provide decision-makers with specific tools that could be used for assessing risks linked to specific situations (e.g. contaminated sites, risks to biota from contaminant release). Examples of FP5 ‘risk assessment’ projects were e.g. GRACOS (Groundwater Risk Assessment at Contaminated Sites) and TRACE-Fracture (Towards an improved risk assessment of the contaminant spreading in fractured underground reservoir).

- **Other projects investigated management issues and information tools toward a range of end-users.** Typical examples of such projects were: WELCOME (Water, Environment and Landscape Development of Contaminated Megasites), WATCH (Water Catchment Areas – Tools for Management and control of Hazardous Compounds), EUGRIS (European Sustainable Land and Groundwater Management).

- **Topics of concern are also focusing on remediation, e.g. INCORE (Integrated Concepts for Groundwater Remediation), diffuse pollution, e.g. SOWA (Integrated soil and water protection from diffuse pollution).**

More recently, the need for integrating different disciplines and building up multi-stakeholder consortia have been reflected in the launching of new instruments (large scale projects), e.g. Integrated Projects or Networks of Excellence. One example is the AQUATERRA (FP6) project aiming to develop an integrated modelling of the river-sediment-soil-groundwater system, with the objective to provide the scientific basis for improved river basin management. It is typically this kind of project which might – providing that a proper coordination is ensured among different work packages (in this case nine different tasks) – have a direct support to policy development, implementation and review. Other research projects are tailor-made to policy needs, having been designed by respective policy General-Directorates. In the sector of water policies, typical projects funded under the SSP priority are SWIFT-WFD (Screening Methods for Water Data Information in support of the implementation of the WFD), BRIDGE (Background Criteria for the Identification of Groundwater Thresholds), and REBECCA (links
among ecological and chemical status of surface waters). Finally, activities also concern networking of scientific experts, policy implementers and stakeholders in the framework of coordinated actions (e.g. ERA-NET) or networks of excellence: Examples are ANCORE (Academic network on contaminated land management in Europe), NICOLE (Network for industrially contaminated land in Europe), SENSPOL (Sensors for monitoring water pollution from contaminated land, landfills and sediments), SNOWMAN (Sustainable management of soil and groundwater under the pressure of soil pollution and soil contamination).

3.2 Links with environmental policies
Considering the wide range of RTD and networking projects funded under FP5 or FP6 (searching engine available via CORDIS [13]), the basic question is whether and how these projects are linked/integrated to environmental policies. We may consider the integration from various perspectives as follows:

Links with atmosphere. Diffuse atmospheric pollution sources affect all environmental media (as receptors) which may act both as a sink (atmospheric inputs) or as pollution sources themselves (through volatilisation, evapo-transpiration, etc. processes) – Policy links are related to the CAFE initiative and regulated under the Air Framework Directive [14].

Open water/soil/sediment. Sediment act as sinks for pollutants (adsorption onto particles, sedimentation) and accumulated in river, estuarine and lake environments. Main pollution risks concern possible re-suspension of sediments (e.g. through dredging), contamination of benthic fauna, soil contamination (as a result of flooding of plains, or disposal of dredged sediments onto soils). These interactions are regulated under the Water Framework Directive but also by a range of other directives (e.g. landfill directive [15], environmental impact directive [16]). They are also of concern for the EU Marine strategy [17] and the future Soil Framework Directive [18].

Open water/Groundwater. Interactions among surface and ground waters are mainly regulated under the WFD and the new daughter groundwater directive (in particular through the groundwater chemical status definition which links groundwater quality to surface water status).

Soil/Groundwater. These interactions are certainly the most complex ones with respect to policies. They are covered under the groundwater regulatory framework but also by a range of parent directives such as the Nitrates [19], Pesticides/biocides [20,21], Landfill [15], Sewage Sludge [18], etc. directives, and they will have an obvious link to the future Soil Framework Directive. Other directives regulating point sources of pollution are also directly concerned e.g. the IPPC directive [23], the mining directive [24].

Soil/Plant/Health. Issues of soil/plant/health interactions will be tackled by the Soil Framework Directive [18] but also by e.g. the Pesticides strategy [25].

Environment/Health. Detrimental effects of the environment on health are being discussed in the Communication on Environment & Health [26], which provide a general outline of 'environmental risks' on human health, highlighting the needs for a better integration of environmental pathways.

A better understanding of the above environmental interactions (based on relevant scientific knowledge) might have a direct effect on policy integration. This is discussed in section 5.

3.3 Consultation process (involvement of scientific stakeholders)
With respect to the WFD, the CIS [5] ensures that regular contacts and information exchanges take place among policy implementers, RTD project coordinators and the Commission through specific working groups.

3.4 Successes and drawbacks
3.4.1 Short analysis of the way policy needs were met from FP5 to FP6
The definition of the FP5 work programme roughly coincided with the period of negotiation of the WFD (adopted in December 2000). In this respect, the Key Action ‘Sustainable Management and Quality of Water’ was fully in line with requirements expressed in the legislative text. These considerations were also taken on board when the FP6 work programme has been developed. In practical terms, we may distinguish the following positive points:

- Research needs issued from WFD provisions were appropriately considered in the FP work programmes
- A wide range of projects has been funded, which enabled to generate scientific outputs of direct relevance to water policies in general.
- The launching of a stable communication platform such as the Common Implementation Strategy of the WFD has considerably helped to improve interactions among policy and scientific communities.

The reverse of the medal may be summarised as follows:

- RTD projects were built-up according to clear technical specifications, which could not anticipate the outcome and orientations of political decisions regarding daughter directives (not defined at the starting time of the projects), and of which the modification was not foreseen (in FP5) at least in a flexible way. This has sometimes resulted in results which although had the potential were not being fit for policy development.
- The coordination among different actors has not been sufficient to allow a full integration of scientific inputs from RTD projects into the policy discussions neither to make them know in time to meet policy needs. This was due to a lack of clear ‘science-policy interface’.

3.4.2 Recognition of gaps in knowledge transfer
Interactions among policy and scientific communities vary according to the phases of the projects. To date, these interactions are not coordinated in a systematic way and are rather functioning on ad hoc basis (based on links among 'indi-
viduals' rather than 'institutional' structured links). On the other hand the various policy departments have different formal and informal contact points in the Member States coming from numerous research and 'policy' communities with discrete interests. These communities are often also competing internally also (e.g. competition between the water quality/quantity research community, or between responsible national authorities/local water managers), which creates an obstacle in the pursuit of effective collaboration.

4 Interactions with the Scientific Community
At the start of projects which have been identified as relevant to water policies, there is certainly a need to clarify policy issues by describing the aims, milestones, technical challenges to the RTD project coordinators so that they understand what are the policy expectations 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.

4.1 Synthesis needs
At the end of the projects, the most critical issue is the way the scientific information is 'digested' so that it may efficiently be disseminated 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 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).

4.2 Exchange platforms
As a follow-up of RTD or LIFE projects, useful interactions may occur at the occasion of 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 organise regular joint meetings focusing on specific themes. This is already happening in the WFD sector [12] and should be systematised.

5 Towards a More Integrated Environmental Policy Based on the Science of Environmental Interfaces
5.1 Towards a 'science-policy interface'
As stressed in section 4.2, at the present stage efforts are lacking for presenting results of research and demonstration projects in a form that policy-makers may easily use, e.g. 'science-digested' 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 to integrate 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 WFD implementation [12]. 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 synthesised in a way that can efficiently feed the implementation and further reviews of the 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. development of the daughter directives covered by the WFD, implementation issues, reviewing). This is already happening through regular contacts within Commission services and with 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). This is not yet or rarely the case, but there are increasing examples of RTD projects which include a demonstration phase.

More than dissemination and application, the interface should establish strong links among the different funding mechanisms existing at the EU level and the thematic policies. This should enable to promote pilot projects combining the implementation of results of successfully completed EC-funded RTD or demonstration projects with the implementation of related policies. This would allow forming new and innovative partnerships by combining various EC (RTD, LIFE, COST, Structural and cohesion funds (Interreg projects, agricultural funds, etc.) and regional/national funding mechanisms, and the establishment of a collaborative partnership involving scientists, policy makers, 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, e.g. Fig. 2 shows different catchment-related projects funded by various mechanisms (FP6, LIFE, Interreg, COST, ERA-NET) for which no 'umbrella' coordination has been envisaged so far.

In response to the above considerations, a concept is under development in collaboration among EC DG Environment, DG Research and LIFE, aiming to establish an efficient and sustainable science-policy platform linked to WISE (Water Information System for Europe) [27]. This concept is known after WISE-RTD [28] and is discussed below.
5.2 Science-based development of an integrated environmental policy

In first instance, one may ask the basic question: is our scientific (multi-disciplinary) knowledge sufficient to develop a more integrated policy? The ongoing 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 FP7 could lead to the establishment of an operational science-policy interfacing mechanism at the 2015–2020 horizon.

Noteworthy is the consideration about scientific uncertainty which grows in importance. Such considerations seek to invoke the standard of evidence that ‘guilt’ must be demonstrated 'beyond a reasonable doubt'. However, given the complexity of environmental pollution pathways, this would mean that the reality of environmental 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.

The WFD is a good example of such an evolution tending to better policy integration. This is illustrated in Fig. 3, showing a progressive integration of existing directives to be repealed under the WFD.

In the context of WFD requirements, the following observations can be made:

- Monitoring and data reporting for evaluating the environmental status and trends need to be coordinated at EU level in the framework of a common mechanism. This is the goal of WISE [27,31], which will allow making a considerable step forward at the horizon 2008–2009. Coordinated reporting and data sharing should constitute the core basis for water policy implementation and review within the next decade. In the light of increasing considerations about climate change (and its impact on water management), one may wonder whether this data sharing should not expanded at a global scale in the form of a WISE-global to be closely linked to GMES developments.

- Building-up environmental databases as the one to be developed under the WFD monitoring programmes should enable to test/validate existing models and develop new models able to better evaluate environmental risks linked to pollution pathways, and thus better evaluate the efficiency of policy responses. This is closely linked to the knowledge-based considerations expressed in this paper.

- Risk assessments and programmes of measures need to be coordinated in the light of effective implementation of directives in force (namely all directives listed in Annex VI, part A, of the WFD) [4].

Integration of scientific knowledge and of environmental policies actually goes hand in hand. The basic DPSIR principle is followed in any cases through risk evaluation, status monitoring and evaluation, trend assessment and programmes of measures, and these concern all environmental ‘interfaces’ (Fig. 4).

The consequence of better integration of scientific knowledge and policies might result in a few number of framework legislation on the long term: In the above diagram, specific RTD projects studying ‘environmental interfaces’ are closely interlinked to specific policies. The overall cycle, however, could be conceived in one single environmental circle. In this context, a better – knowledge-based – appraisal of risks in the context of concerted planning (e.g. at river basin level) would facilitate the design of monitoring programmes (avoiding duplication, focusing on specific features) and the elaboration of programmes of measures. The way framework directives are being developed open the door for an increasing integration which should be pursued and linked to a sound and validated scientific foundation.

6 An operational Web Interface: WISE-RTD

6.1 The HarmoniCA initiative

Harmoni-CA is a large scale concerted action supported by the DG-RTD under FP5 [29]. One of the objectives of Harmoni-CA is to create a forum for communication, information exchange and harmonisation of Information Communication & Technology (ICT)-tools for integrated river basin management and the implementation of the WFD.
Harmoni-CA’s role is twofold: a) to facilitate specific activities as identifying and enhancing complementarities between different research projects and disseminating research results, focusing on the project in the EC supported CatchMod modelling cluster and b) to bring together the demand and support for ICT-tools and methodologies for the implementation of the WFD.

Recently, a closer cooperation has been proposed between RTD and those responsible for implementing the WFD [12], in particular the following activities have been proposed and developed from 2004 to 2006:

- Linking WFD requirements and RTD products;
- Building of a web-portal;
- Establishing a close cooperation within Pilot River Basins.

The web-portal primarily aimed to focus on operational managers (people responsible for practical aspects of policy implementation) and research & technology providers. It developed into a wider information platform as described in section 6.2.

6.2 The WISE-RTD webportal

The WISE-RTD has been conceived as a platform for accessing scientific information of potential use to water policy implementation [30]. It will progressively be enlarged to cover specific scientific information for policy officers, RTD managers and scientific stakeholders, providing access to relevant scientific information. The web-portal will be supported by manpower through a Communication Services Centre (CSC) and it can be seen as a first step towards a sustainable communication process. The portal has been made publicly available along the launching of WISE in March 2007 [31], and will continuously develop within the forthcoming years.

In the sketch below (Fig. 5), the water policy process (centre of the figure) is closely linked to a larger circle concerning research and technological developments (FP7 for EU research, ERA-NET for national research), demonstration (LIFE programme, link with Pilot River Basin of the CIS [12,32], possible INTERREG support), interface through a

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**Fig. 4:** Environmental interfaces and related projects & policies

**Fig. 5:** Links between water policies and research & demonstration
This diagram however shows an ideal situation which is far from being operational. To make it workable, a strengthened coordination has to be developed among the responsible services at the horizon of the 7th Framework Programme (Fig. 6).

The goal would be to operate a science-policy interface through 'WISE-RTD' (providing access to RTD information) as displayed above. In this configuration, a first phase would act as a 'steering filter' for RTD and demonstration projects (analysis of relevance to water) – Phase 1 'RESEARCH OUTPUTS' – followed by an EVALUATION (selection of the most relevant projects), a VALIDATION (demonstration of successful RTD) and COMMUNICATION in the form of technical guides translated in the EU languages (addressed to policy managers). It is most likely that only a limited number of projects would be selected until the last step. In other words, there are many projects which may be of high scientific value without necessarily fulfilling concrete policy needs. The evaluation and demonstration steps would then be of critical importance to judge those projects which deserve to be transferred at wide-scale to water managers in the EU and beyond.

7 Conclusions

This paper highlights the needs for integration at various levels for a proper understanding and implementation of water policies, with focus on science-policy integration and interfacing. Difficulties experienced to date stem from the fact that there is no sufficient streamlining of information from e.g. the scientific community to policy decision-makers. In this respect, efforts are ongoing in the framework of various initiatives to examine how an efficient and operational 'science-policy interface' could be developed in support of the implementation of the Water Framework Directive and other water policies. This development is being undertaken in the framework of the Common Implementation Strategy of the WFD [5] and in close cooperation with the Harmoni-CA initiative [29] which has elaborated the WISE-RTD prototype [28] (considered to be one of the elements of the 'science-policy' puzzle).

The ultimate aim is to develop such an interface in a way that it could meet the demand of different levels of users (e.g. policy-makers, industry, etc.) and stakeholders (e.g. the scientific community, academia, etc.), ensuring an efficient dissemination and use of research results. This was the scope of a workshop held in Ghent on 4–5 October 2004 which gathered representatives of the Member States environment ministries and agencies, coordinators of research, development and demonstration projects, European Commission officials, of which the main conclusions were published in the open literature [2,12]. Workshop discussions had clearly identified the 'missing link' corresponding to an operational 'science-policy interface', which would allow results outputs to efficiently flow into the policy-making process as discussed throughout the present chapter.

This interfacing goal is ambitious and involves many different actors, hence its complexity. It should also be seen in a wider framework, in liaison with other parallel activities. One of them concerns coordination of national research programmes (the so-called ERA-NET initiative). A possible framework, linking water policies in a broad sense to the R&D life cycle, should include research development (links to FP7 and national research), demonstration (testing of R&D outputs in the framework of LIFE projects [33] or projects funded with Regional funds, or INTERREG), communication (through the WISE-RTD webportal), and policy review (taking policy-related research needs into account when establishing research priorities). At present, this framework does not yet exist. The challenge over the next few years will be to establish operational links among the different pieces of this puzzle, constituting a general interfacing mechanism within the timeframe of the 7th Framework Programme (2007–2013). A newly started project, named SPI-Water, is specifically looking at such development and concrete outputs are expected from 2008 onward [34].
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