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International Workshop

Climate Change Impacts and Adaptation:

Reducing Water-related Risks in Europe

6 – 7 July 2010

Scientific and policy report

STUDIES AND REPORTS

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Brussels, 6 – 7 July 2010

Scientific and policy report

edited by

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FOREWORD

It is a pleasure for us to introduce the proceedings of the International Workshop on Climate Change Impacts and Adaptation: Reducing Water-related Risks in Europe, which was held in Brussels on 6 and 7 July 2010. This is the second event where the European Commission Research Directorate-General and the United Nations International Strategy for Disaster Reduction (UNISDR) have joint forces in support of a better feed-in and accessibility of scientific knowledge to decision-makers within the EU and international context on disaster risk reduction. While the first workshop held in October 2010 had natural hazards and disaster risk in general as a theme, this event focused on climate change impacts and water-related risks in Europe.

Climate change impacts on the hydrological cycle display different patterns, for example effects on atmospheric water vapour content and changes of precipitation patterns. These have been linked to warming observed over several decades. More specifically, higher water temperatures and changes in extremes, including floods and droughts, are projected to affect water quality and exacerbate many forms of water pollution. This will lead to possible negative impacts on ecosystems and human health, as well as on water system reliability and operating costs. In addition, sea-level rise is expected to expand areas of salinated groundwater and estuaries, resulting in a decrease of freshwater availability for people and ecosystems in coastal areas. Besides this, changes in water quantity and quality due to climate change are expected to affect food availability, water access and utilisation, especially in arid and semi-arid areas, as well as the operation of water infrastructure (e.g. hydropower, flood defences, irrigation systems).

In addition, impacts on the overall hydro-cycle (in particular extreme events) are raising concerns abut the possible implications for security. For example, decreasing access to water resources and other related factors could be a cause or a multiplier of tensions within and between countries. Security threats resulting from climate change have hence to be closely looked at in the context of social, economic institutional vulnerabilities or resilience and other factors that influence local, national and international relations between countries.

Actions to adapt to climate change at global and EU scales are embedded in European Union policies as well as in international frameworks. The Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters (HFA) is the key instrument and global blueprint for implementing disaster risk reduction. Its overarching goal is to build the resilience of nations and communities to disasters by achieving substantive reduction of disaster losses by 2015. This comprehensive framework provides clear guidance on how to reduce disaster risks, including those of climate-related nature and provides directions on enhancing resilience to disasters through political, technical, social, development and humanitarian processes.

Similar actions are highlighted in the integrated energy and climate change policy adopted by the EC in December 2008 as well as in the White Paper "Adapting to Climate Change: Towards a European Framework for Action" released in April 2009. Furthermore, the adoption of the EU's communications "EU Strategy for Supporting Disaster Risk Reduction in Developing Countries" and "A Community Approach on the Prevention of Natural and Man-made Disasters" indicate the need to reduce vulnerability to disasters including water-related risks. Climate change impacts on the water cycle as well as on the reliability of current water management systems are also specifically tackled the Water Framework Directive and parent legislation such as the Flood Directive. This framework is complemented by drought action programmes, which are also taking climate change components into account.
Scientific outputs are highly valuable for international policies and debates, in particular through inputs to IPCC Assessment and Special Reports, UNFCCC documents as well as to the Global Assessment Reports on Disaster Risk Reduction. More specifically, the European Commission is funding research through its Framework Programme for Research and Technological Development. In this context, projects of the on-going 7th Framework Programme (FP7, 2007-2013) contribute considerably to gathering knowledge relevant to climate change adaptation and disaster risk reduction. In this context, we would like to recall that FP7 is open to participation of all countries of the world, with a total of 39 contributing states.

The event leading to these proceedings was quite unique in that it brought scientists and policy-makers together to discuss various aspects of climate change impacts on water-related hazards. The workshop gathered representatives of on-going FP6 and FP7 projects, related EU-funded projects, IPCC authors, Hyogo Framework for Action Focal

Points, National Platform Coordinators and other ISDR system partners as well as representatives of several European Commission Policy Directorates to exchange practices, common knowledge and research programme outcomes. The results of the brainstorming sessions held the day before the workshop were summarised in thematic presentations tailor-made to ensure a better communication of scientific progress and perspectives to the policy-makers present at the meeting. These were followed by presentations by Policy EC Directorate Generals and National Platforms for Disaster Risk Reduction and engaged debates with the audience on how to link policy developments and research needs.

Knowledge needs to progress further in the understanding of the climate system, the evaluation of the impacts of climate change and on the identification and assessment of mitigation and adaptation options through risk reduction activities. This endeavor strongly relies on effective partnerships among research organizations and policymakers from the EU and international partners, including cooperation on adaptation with the most vulnerable developing countries. Worldwide action is needed, and we have to carefully design the strategy research and technologies are and will be developing at a global scale. Disaster risk reduction needs to be regarded as a triple win at all levels: implementing disaster risk reduction policies and programmes can limit the impacts of climate-related hazards, directly support adaptation to climate change, and help to alleviate poverty.

One important key to boost communication and exchanges among the scientific and policy communities, as well as societal partners, would be the development of a better science-policy interface – improving the interfacing is a main priority of us in collaboration with other European and international institutions. Ways forward were also discussed at this workshop, highlighting the growing awareness and need for optimising operational science-policy mechanisms.

The EC Directorate-General for Research – Environment Programme and the UNISDR would like to thank all participants for their valuable contributions.

Elisabeth Lipiatou
European Commission
DG Research

Paola Albrito
United Nations
International Strategy
for Disaster Reduction

Introduction and objectives

International Workshop

Climate Change Impacts and Adaptation: Reducing Water-related Risks in Europe

***Venue* – University Club Foundation, rue d'Egmont 11, 1000 Brussels**

www.fondationuniversitaire.be

This workshop was organised with the aim to boost synergies among research consortia and provide an exchange platform for the scientific and policy communities in the area of climate change impacts and adaptation to hydrometeorological risks.

The first part of the event consisted in a scientific brainstorming organised by the European Commission, Directorate-General for Research, which constitutes the first part of this report. It aimed particularly to gather representatives of on-going FP6 and FP7 projects, as well as of related EU-funded projects, IPCC authors, Hyogo Framework for Action Focal Points, National Platforms coordinators and other ISDR system partners to discuss the state of knowledge, identify research perspectives and needs, and best ways to communicate key findings to policy-makers and stakeholders. Linked to this goal, the publication of a special issue on an international scientific journal is under way, which will include key findings of RTD projects of interest to IPCC authors and ISDR system partners (publication planned by Spring 2011).

The second part of the report deals with an international science-policy workshop, which was jointly organized by the EC DG Research and the UNISDR Europe Regional office. This event was built on the outcomes of the EC DG Research-UNISDR October 2009 workshop "Dialogue Among Scientific Community and Policy Stakeholders on Disaster Risk Reduction". The meeting intended to continue reinforcing the exchanges among the scientific and policy community that in Europe deals with the issue of adaptation to climate change and reducing the risks posed by natural hazards, in particular, water-related risks. The event aimed at providing practical examples of how research can contribute to guide policy makers in investment decisions towards disaster risk reduction in order to implement the climate change adaptation agenda. The workshop also addressed how the policy makers access the information produced by research projects, specifically those supported by the EC (under the funding windows of FP6 and FP7).

Scientific gathering event

Climate Impact Research and Response Coordination for a Larger Europe: CIRCLE-2 ERA-Net

Markus Leitner[1*], Tiago Capela Lourenço[2]

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As a precursor, CIRCLE ERA-Net (Climate Impact Research Coordination for a Larger Europe) was a European Commission (EC) Framework Programme 6 (FP6) funded project under the European Research Area (ERA) Networks scheme. Its success is now being followed by CIRCLE-2 (Climate Impact Research and Response Coordination for a Larger Europe) a European Commission (EC) Framework Programme 7 (FP7) funded project. CIRCLE initiated in 2005 as a Coordination Action (CA) until 2009 and its second phase CIRCLE-2 (2010-2014) currently involves 20 partner and 14 contributing partner institutions from 24 different European countries. Key national research funding and managing institutions across Europe are represented in the CIRCLE-2 consortium either directly or through their national/regional research programmes on Climate Change Impacts, Vulnerability and Adaptation (CCIVA).

The main objective of CIRCLE-2 is to step up coordination of research activities carried out at national/regional level in the EU Member and Associated States by (i) establishing a research funding network, (ii) supporting and enhancing collaboration efforts between national research programmes on CCIVA promoting the alignment among their CCIVA research agendas, (iii) designing and funding joint initiatives and joint calls for research projects and (iv) sharing the knowledge learnt to support the EC and all CIRCLE-2 member countries to adopt appropriate adaptation strategies, action plans and measures. By the setting up of different sub-groups based on their geo-climatic or socio-economic circumstances (e.g. Mediterranean, Nordic, Central and Eastern European States, Mountainous areas) CIRCLE establish a strong and close network that enables the alignment of national CCIVA research agendas and their funding budgets. Other different sub-groups of partners and contributing partners are being created based on common topics (e.g. extreme events, deltas, water and health).

Through a multi-level assessment of CCIVA research needs, CIRCLE provided the framework for the programme, design and launch of joint calls for research projects. Three of such transnational joint calls where issued for the Mediterranean (2007-2010), the Nordic (2007-2009) and Mountainous areas (2009 – 2010). Alongside with its focus on the research management of transnational CCIVA science, CIRCLE has developed efforts to support the European adaptation and response processes by aggregating and making available national/regional information on CCIAV research programmes, projects and their results. CIRCLE-2 will move further and create a science policy interface for transnational collaboration and activities. By matching its knowledge base with the EC and its Member and Associated States' research agendas, CIRCLE-2 will set in place an integrated structure to consider and support European CCIVA research needs and to contribute towards the development of a truly multidisciplinary ERA on Climate Change.

Brainstorming of RTD projects – Session A: Water Cycle & Ecosystems

WATCH (Water and Global Change): Our current knowledge of the terrestrial Global Water Cycle

Richard J Harding,

Centre for Ecology and Hydrology, Wallingford, OX10 9LG, United Kingdom

The Global Water Cycle is an integral part of the Earth System. It plays a central role in global atmospheric circulations, controlling the global energy cycle (through latent heat) as well as the carbon, nutrient and sediment cycles. Globally, fresh water resources far exceed human requirements. However, by the end of the 21st century, these requirements begin to approach the total available water. Regionally water demand – for agriculture, and domestic and industrial use – already exceeds supply. This will certainly get worse with increasing population and societies' changing water demands, a situation exacerbated by the need to maintain river flows for ecosystem and human services.

Increasing CO_2 levels and temperature are intensifying the global hydrological cycle, with an overall net increase of rainfall, runoff and evapotranspiration, and will increasingly do so. Regionally there will be winners and losers. Although the predictions of future rainfall are fairly uncertain, there are indications, for example, that the Mediterranean region will see reductions of rainfall and some equatorial regions, such as India and the Sahel, will see increases. The seasonality will change, causing new, and sometimes unexpected, vulnerabilities. Changes in the hydrological cycle induced by increasing greenhouse gas levels may affect society more than any other changes linked to increasing greenhouse gases, e.g. with regard to flood and drought risks, storm frequency, rising sea levels, and changing water availability and water quality.

Feedbacks between the climate and hydrology will occur. The snow/climate feedback is well known and described. However, feedbacks between CO_2 increases and vegetation, soil moisture, groundwater recharge and climate are less well understood and are not well described in most climate and hydrological models. Conversion of land to agriculture not only impacts on the evaporation and water flow generating processes but may also influence the spatio-temporal distribution of rainfall and evaporative demand also affecting non-agricultural land. Agriculture (and urban development) has increased substantially in the past century and will continue to develop in the 21st century. Therefore any assessment of the world's water resources must take into account both the direct and indirect influences of land use changes.

There are thus many uncertainties in our understanding of the current global water cycle and how it will develop in the future. The EU funded WATCH project aims to provide a more consistent analysis of components of the terrestrial water cycle for the 20th and 21st centuries. The project is producing consolidated data sets to drive a range of global hydrological models, providing new tools (for example to bias correct existing climate model outputs) and new analyses of global and regional water resources, floods and droughts.

All large- scale hydrological models need extensive gridded input data to provide precipitation and driving variables for evaporation and snowmelt estimates (in addition to e.g. land cover and data on water use). Within the WATCH project (http://www.eu-watch.org) a comprehensive assessment of components of the water cycle, incl. large-scale hydrological extremes for 20th and 21st C are being made using hydrological and land surface models. A new global sub-daily meteorological forcing data has recently been produced (i.e. WATCH Forcing Data, WFD) for use with land surface and hydrological models. The data are derived from ERA-40 reanalysis corrected using CRU (monthly corrected temperature, diurnal temperature range, cloud-cover and wet days http://www.cru.uea.ac.uk/cru/data/) and GPCC (monthly precipitation totals, http://disc.sci.gsfc.nasa.gov/precipitation/) monthly observations combined with new corrections for varying atmospheric aerosol-loading and separate precipitation gauge corrections for rainfall and snowfall. These data are for the ERA40 time period (1958-2001). The data set has been further extrapolated to the whole of 20th C using the 20th century CRU monthly data and re-sampled ERA-40 to provide typical within month distributions (Weedon et al., submitted, this volume). For selected river basins in Europe hydrological drought derived from simulated time series using either local forcing data or WFD are more less similar showing the potential of these large-scale forcing datasets. This 20th Century data set will be supplemented with a number of bias corrected global data sets derived from three climate models for the 21st century.

Eleven land surface models and global hydrological models from Europe, USA and Japan are currently participating in a model intercomparison project (WaterMIP). The objective of WaterMIP is to estimate current and potential future global water resources based on common forcing data and a standardized simulation protocol (www.eu-watch.org/watermip). The models show a significant spread of the partitioning of precipitation into snowfall and rainfall, and of the partitioning of precipitation into evaporation and runoff. Simulated global evaporation over land show a large range, from 415 to 586 mm year^{-1} (61 to 86 10^3 km^3), and the simulated runoff ranges from 290 to 457 mm year^{-1} (43 to 67 10^3 km^3), with the global mean model simulated runoff fraction (i.e. runoff coefficient) ranging from 0.33 to 0.52.

A number of important challenges remain to improve our understanding of the future of the global water cycle, we need:

- increased international efforts to maintain the existing river flow measurement networks and to enable the free flow of data to the international community,
- an improved global analysis of groundwater resource and changes,
- a better understanding of regional and global patterns of evaporation (and its components),
- a better understanding of land-surface/climate feedbacks to better assess the impacts of future land cover changes on our climate
- a better global analysis of extremes (floods and droughts) for the 20th and 21st centuries
- to include relevant human influence on the hydrological cycle within Earth System Models
- higher resolution predictions from global (and regional) climate models to better represent local feedbacks and orographic effects
- to use multi-model ensembles for impact studies to better represent uncertainty in our prediction.

Brainstorming of RTD projects – Session A: Water Cycle & Ecosystems

CIRCE project: climate change and impact research in the Mediterranean

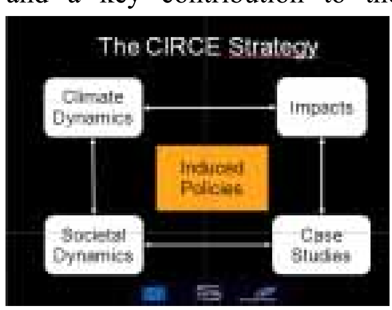
Ana Iglesias
Universidad Politecnica de Madrid, Spain

The CIRCE project

CIRCE is coordinated by the Istituto Nazionale di Geofisca e Vulcanologia, Italy, started on 1st April 2007 and will ends on 31st March 2011.

- CIRCE involves 64 partners from Europe, Middle East and North Africa and from the natural science and social sciences communities, working together to evaluate for the first time the **best strategies of adaptation to the climate change in the Mediterranean region**.
- **Beyond research.** In CIRCE, the role of public engagement will be fundamental, especially at the local level.
- **Case studies** and specific participative methods will be designed to achieve this result.
- Exploiting several research skills in **different disciplines**: radiative fluxes, water cycle, cloudiness, aerosol and extreme events, impacts on agriculture, ecosystems, forest, air quality and human health. A special emphasis on economics and social aspects (tourism, energy markets and local migration).

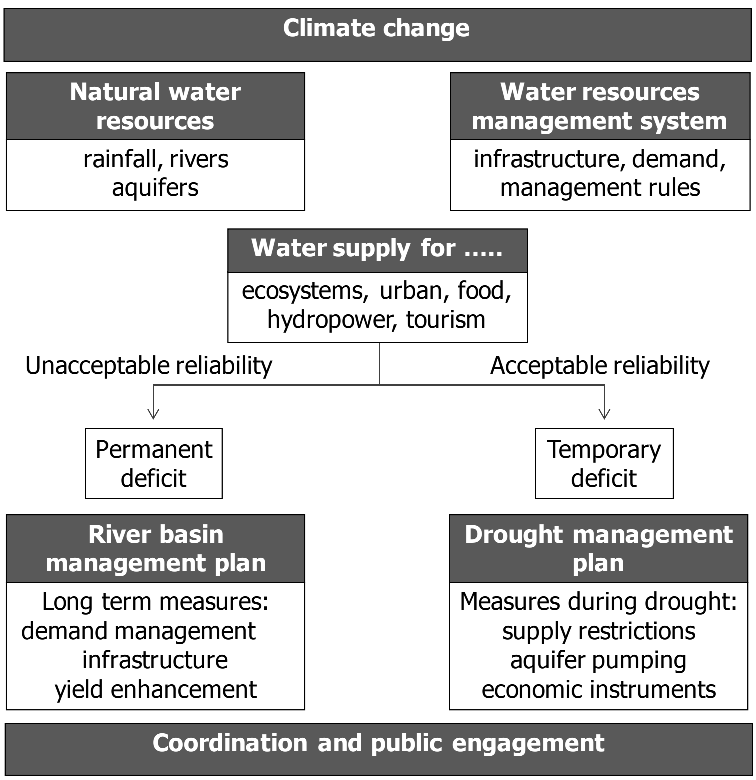
The output of CIRCE will be presented in the first **Regional Assessment of Climate Change in the Mediterranean area** (RACCM), a book series with five volumes, to be published in March 2011. This will be a powerful contribution to the definition and evaluation of adaptation strategies and a key contribution to the UNISDR and IPCC.



Scientific outputs related to water

CIRCE is developing for the first time an assessment of the climate change impacts on water resources and water policy in the Mediterranean area, involving physical scientists and social scientists. The main results of the water component of CIRCE are:

- Projections of rainfall and temperature changes and variability in the Mediterranean region
- Projections of changes in runoff and aquifer physical impacts of climate change in the Mediterranean area;
- Evaluation of change in the water resources management system
- Changes in society and the economy resulting impact on water demand
- Identification of adaptation strategies in collaboration with regional stakeholders: definition of long term measures to be included in river basin plans; definition of measures to be included in drought management plans under climate change



Key research outcomes of CIRCE related to water risks in the Mediterranean under climate change

- Research Line 2 of CIRCE considers the interaction between the Mediterranean region and the global climate system. Deliverable D.2.2.2 Simulating codes and infrastructure of three Mediterranean Simulators, for instance, develops climate evolution scenarios which provide important findings for the WFD such as water flux due to river runoff.
- Research Line 5 analyses the natural water cycle and links to the management and policy included in Research Line 12. WP5.3 Variations in the terrestrial component of water cycle and specifically, deliverable D5.3.8 Impacts of climate change on surface water and groundwater in the Mediterranean environment. Deliverable D5.2.1 Current climate trends in Mediterranean precipitation according to controlled RCM sensitivity evaluations, global modelling and reanalysis data. The results are central for the WFD.
- The CIRCE deliverables D6.5.2 Database for the estimation of future impacts of weather and climate extremes and CIRCE D10.4.4 Computation of drought occurrence for all regional climatic simulations of CIRCE' will contribute to making available information on the likelihood and severity of extreme events. This will allow for consideration of factors related to weather and climate extremes relevant to the WFD in the review and update of river basin management planning.
- CIRCE deliverable D7.4.4 Green and blue water availabilities and crop water productivities (virtual water contents) as well as non-conventional water options per country under climate change' can also feed into the review of the WFD scheduled for before 2015 and provide information on likely agricultural water use, which in the Mediterranean, in some cases can represent over 80% of the total renewable water use per year of countries or areas.
- Through CIRCE's RL 12 and, more specifically WP12.3, a climate policy index (CPI) and water model have been developed in order to bridge the gap between impact assessment and policy formulation for the Mediterranean region. These tools help diagnose water management

capacity and can be of great use for the design of a regional river basin management system. Finally, the water model aids in the identification of vulnerable areas in need of management improvements.

- CIRCE deliverable D13.5.3 Adaptation strategies for the Mediterranean region can feed into the general policy process of the review of the WFD and any related legislation, programmes or initiatives that are discussed for the Mediterranean region,

Perspectives and policy focus related to water

The projections for future climate and socioeconomic scenarios developed by CIRCE are a contribution for evaluating the water supply and demand in the Mediterranean under climate change and therefore inform current and future water management plans and policies. This is especially relevant to the next periodical update of management by river basin and the regional focus. Additionally, CIRCE's ability to predict and quantify the physical impacts of climate change will help in the development of the Water Framework's coordinated approach, to inform the IPCC and to be included as strategy for drought and food mitigation for the UNISDR.
The 6-year River Basin management cycle requires continued updating and in the next cycle the introduction of climate change is essential. CIRCE has produced a suite of outcomes that will inform this process and permit climate change impact assessment in the water sector. These assessments facilitate water policy which can have a direct impact on development efforts.

Main recommendations related to water

- Recognise the importance of including climate change projections and impacts on River basin management plans.
- Increase the awareness of characterisation, likelihood, severity and spatial extend of drought and floods in the Mediterranean.
- Propose adaptation options to climate change to ensure sustainability of measures and programs.
- Develop a model that guides policy on measures that increases adaptive capacity.
- Facilitate the inclusion of stakeholder dialogue and policy innovation.

Brainstorming of RTD projects – Session A: Water Cycle & Ecosystems

HighNoon: adaptation to changing water resources availability in northern India with Himalayan glacier retreat and changing monsoon

Eddy Moors

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Climate change is expected to have a profound impact on the availability of water in the Ganga Basin. The combined changes in glacier melt and monsoon precipitation will affect the total amount of water available. However, the magnitude of these changes is highly uncertain. The increase in greenhouse gases is also likely to lead to the intensification of the water cycle, causing an increase in extremes events, especially in droughts.

Monsoon-snow interaction affecting water resources

Rivers draining from Himalayan headwater basins, in which precipitation is enhanced orographically, deliver large quantities of runoff to tributaries of the major rivers of the Indo-Gangetic plain. Strong regional climatic variation along the Himalayan arc leads to increasing impact on runoff of monsoonal precipitation from west to east. Relationships between climate and runoff, which vary also with percentage basin glacierisation, prove difficult to assess in the Himalaya, as a result of scarcity of available data, particularly in the upper Ganga basin in the central Himalaya. Attempts to model runoff responses to climatic warming are limited by lack of field measurements, but summer precipitation in the Indian and Nepal Himalaya appears to stave off reduction of meltwater discharge with glacier decline in the central and eastern Himalaya by comparison with the drier Karakoram in the west (Rees & Collins 2006). Available datasets are examined with a view to assessing variations in seasonal distribution and annual total runoff from basins with differing proportions of glacier cover located in areas with varying degrees of monsoonal influence distributed along the Himalayan arc. In the Karakoram, in headwater tributaries of the Indus, runoff increases from April to annual maxima in July or August, and the strength of correlation between runoff and April/May through September/October air temperatures increases with increasing glacierisation. In the central and eastern Himalaya, in tributaries of the Ganga, runoff rises from April to a June peak, before being reduced as occurrence of summer snowfall raises albedo and cloud cover reduces energy availability for melt. From August discharge increases again to a late summer high, before declining as radiation decreases. Correlation between runoff and annual and summer precipitation totals show limited variation with percentage glacierisation. Ice melt is subdued during the longer monsoon, and the extent to which runoff from summer rain compensates for loss of melt declines where basin ice-cover is larger. Downstream influence of melt water runoff on annual total discharge extends further where summer rainfall amounts are not great. In monsoonal areas, snow and icemelt influences from headwaters extend downstream in spring and autumn before and after the incidence of summer precipitation. Records of river flow are generally short making estimation of the deglaciation discharge dividend problematic.

Adaptation strategies

Being largely an agrarian society, India is vulnerable to adverse impacts of contemporary and long-term changes in climate. India's agriculture mainly depends on the strength of the monsoon as water availability is the most critical component for the agriculture sector. Floods as well as droughts afflict agriculture in the Ganga basin. Flood impact is exacerbated by high vulnerability of the population as the region has high level of poverty, poor access to education and health care.

Vulnerability can be reduced through adaptation in biophysical and/or social/human systems (Adger et al., 2007). The challenge remains to use up to date knowledge on system dynamics and to define adaptation strategies, which are location specific, accepted by stakeholder at all relevant levels and which integrate effectively the various sectors such as energy, agriculture and health.

From coping to adaptation

Adaptation strategies are more than a collection of measures and above all need to be tailor-made to local circumstances in order to address site-specific vulnerabilities. In the EU project HighNoon (see www.eu-highnoon.org) possible adaptation measures for the Ganga basin are currently under investigation. The project includes three case study sites to represent upstream, midstream and downstream parts of the Ganga basin, allowing horizontal comparison between vulnerabilities and possible adaptation strategies.

The aim is to get from individual measures to coherent strategies and feasible action plans. In the three case studies of HighNoon, stakeholders at different levels, from farmer to state government, are involved. Integration between sectors is most prominent in the upstream case study, around the Tehri dam, where hydropower, agriculture and water supply for Delhi compete for available water.

Local communities try to cope with climate variability based on past exposure and experience in managing climate extremes. Some of the coping strategies employed by communities are to migrate to nearby urban centres for labour (mainly unskilled), selling of personal assets during stress periods, and taking formal or informal credits (Kelkar and Bhadwal 2007). Other often-mentioned local coping strategies, to deal with known and observed climate risks are the use of short duration or traditional crop varieties (Attri and Rathore 2003). However, these local coping practices may not be sufficient to reduce the risk of increased climate variability and climate change appreciably. And most of the above mentioned coping strategies are reactive instead of proactive.

More proactive approaches are needed as being an important feature of adaptive capacity, together with the capacity for individuals to learn and adapt their behaviour (Pahl-Wostl, 2007). Some examples are:

- Promoting agricultural practices more adaptive to climate variability, for example cultivation of short cycle crops, promotion of drought resistant crop varieties and use of appropriate rice cultivars;
- Involving local organizations such as Panchayati Raj Institutions (PRIs) and Self Help Groups (SHGs) to build capacities to deal with climate variability and take informed decisions to address the same.

In designing adaptation strategies it is important to recognize and promote people's knowledge and skills on coping strategies; pay attention to local agro-climatic and socio-political realities; and promote people's institutions and self-help approaches. Hence preparing for climate change is not something that individuals can do alone. It is a shared responsibility that requires action at different levels and in different sectors, with partnerships across the community so that households, community groups, businesses and governments can make necessary changes effectively and efficiently.

Current gaps in adaptation strategy development

Although in recent years the Government of India has been spending about 2% of GDP to address climate change adaptation, there is still a need further to strengthen this effort. In India there has been a focus on involvement of stakeholders in implementing various projects, for example in watershed management and participatory irrigation management (TERI 2009). There is limited access for stakeholders to up to date information. Predicting and analyzing climate change is still mainly the domain of scientists, whose insight has not always reached the local levels. Hence, there are needs to strengthen structures for participation and widen the knowledge base of stakeholders so that their effective participation can be ensured.

Policy view and research strategies

In order to combat impacts of climate change, the Prime Minister of India's Council on Climate Change released a National Action Plan on Climate Change (NAPCC) in 2008. At the core of the NAPCC is water, with Missions for Water, for Sustaining the Himalayan Ecosystem, and for Sustainable Agriculture as well as for strategic knowledge of climate change. To ensure success of the NAPCC, inter-disciplinary research is needed that cuts across the various missions with increased international collaboration.

Many open research questions need to be addressed:

Complex interaction between snow/glacial melt and monsoon requires better representation in models. High resolution observed and model simulated data are needed to provide basic information on variability of rainfall, snow and temperatures over Himalaya topography. Area/mass relationships are not well-known for Himalayan glaciers, giving uncertainty as to how glacier runoff will respond to climate change. In the data-sparse headwaters of the Ganga, remote sensing and ground based data collection will help improve understanding.

High resolution regional climate models are needed, coupled with hydrological models, to translate climate change scenarios into impacts on seasonal and overall water resources availability. These must be combined with modelling human demand for water resources.

The relative contribution to total discharge of snow and glacier ice melt decreases downstream along the Ganga, as monsoon precipitation increases. Impacts of climate change will therefore vary down the basin. Finding the right adaptation options at the right times for various places will indeed be challenging: what kinds of policy measures to regulate demand and allocation of water are necessary successfully to adapt to climate change?

Projects such as HighNoon that aim at a transdisciplinary approach – combining tacit knowledge with scientific discovery - may well prove to be best suited for seeking sustainable strategies for adaptations in water utilisation as climate changes. The way forward must be to provide water resources policy makers not only more insight concerning expected changes in future climate and water availability but also with suitable adaptation strategies actually to be used to combat adverse impacts of climate change.

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Brainstorming of RTD projects – Session A: Water Cycle & Ecosystems

The ACQWA Project: Investigating the vulnerability of water resources to climatic change in mountain regions

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As the evidence for human induced climate change becomes clearer, so too does the realization that its effects will have impacts on socio-economic systems and terrestrial ecosystems. Some regions are more vulnerable than others, both to expected physical changes and to the consequences they will have for ways of life. Mountains are recognized as particularly sensitive physical environments with populations whose histories and current social positions often strain their capacity to accommodate intense and rapid changes to their resource base. The ACQWA Project (**A**ssessing **C**hanges in the **Q**uantity and quality of **WA**ter in vulnerable mountain regions) of the 7th Framework Programme of the EU thus aims to assess the impacts of a changing climate, focusing on the quantity and quality of water originating in mountain regions, particularly where snow- and ice melt represent a large, sometimes the largest, streamflow component.

An increasing number of observations related to glacier retreats, permafrost reduction and snowfall decrease have been observed in many mountains, suggesting that climate modifications may seriously affect streamflow regimes, in turn threatening the availability of water resources, increasing the downstream landslide and flood risk, impacting hydropower generation, agriculture, forestry, tourism and water-dependent ecosystems. As a consequence, socio-economic structures of populations living downstream will be also impacted, calling for better preparedness in developed countries and strategies to avoid the exacerbation of the already conflict-prone situation in many countries, like those in Central Asia and South America.

The goal of the project is to use advanced modelling techniques to quantify the influence of climatic change on the major determinants of river discharge at various time and space scales, and analyse their impact on society and economy, also accounting for feedback mechanisms. The focus is be on continuous transient scenarios from the

1960s up to 2050. In comparison to many existing studies, the limitation of the modelling horizon to mid of the 21st century allows to develop more realistic assessment of the progressive impact on the social, economical and political systems, which we expect to evolve typically in an adaptive mode on shorter time scales than the centennial ones, eventually shifting to new equilibria when forced abruptly. Environmental and socio-economic responses to changes in hydrological regimes are being analyzed in terms of hazards, aquatic ecosystems, hydropower, tourism, agriculture, and the health implications of changing water quality. Attention is also devoted to the interactions between land use/land cover changes, and changing or conflicting water resource demands.

Integration of the information from all these sectors and the impacts on economies will feed into a quantitative model of water use incorporating supply and demand. Supply is conceived as having physical inputs (from the regional climate models) as well as societal inputs based on property, price, and regulatory factors. Demand reflects population evolution, price, and economic activity. The resulting integrated model will enable the construction of scenarios and allow the evaluation of various policy options for adaptation and mitigation, both within the EU and in other mountain regions where opportunities and stresses will arise as water resources change.

Project website: www.acqwa.ch

Brainstorming of RTD projects – Session A: Water Cycle & Ecosystems

GENESIS, Groundwater and dependent ecosystems: New Scientific and Technical Basis for Assessing Climate Change and Land-use Impacts on Groundwater Systems

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Groundwater resources are facing increasing pressure from consumptive uses (irrigation, water supply, industry) and contamination by diffuse loading (e.g. agriculture) and point sources (e.g. industry). This cause major threat and risks to our most valuable water resource and on ecosystems dependent on groundwater. New information is need on how to better protect groundwaters and groundwater dependent ecosystems (GDE) from intensive land-use and climate change. The impacts of land-use changes and climate changes are difficult to separate as they partly result in similar changes in the ecosystems affected. The effects are highly interwoven and complex. The EU groundwater directive (GWD) and the water framework directive (WFD) provide means to protect groundwater (GW) aquifers from pollution and deterioration. At present, the maximum limits for groundwater pollutant concentrations have been set for nitrate and various pesticides. Also, water of sufficient quality and quantity should be provided to ecosystems dependent on groundwater. The European aquifers differ by their geology, climate, and threats to aquifers. This must be considered when general guidelines for management of these systems are developed. GENESIS research project will give input to the planned update of the directive and future groundwater management. The work focuses on various aspects of groundwaters in a multidisciplinary way. Key issues studies include groundwater flow characterization, hydrogeology and hydrology; leaching of nitrates and pesticides in various climatic conditions; groundwater dependent ecosystems, their hydrology and biodiversity; modeling methods for simulation of climate and land-use; and groundwater management including various methods related to hydroeconomic management, social impacts and legal issues.

Brainstorming of RTD projects – Session A: Water Cycle & Ecosystems

GRAPHIC (Groundwater Resources Assessment under the Pressures of Humanity and Climate Change)

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UNESCO, International Hydrological Programme

GRAPHIC Vision

GRAPHIC promotes and advances sustainable groundwater management in the face of climate change and linked human impacts.

GRAPHIC Mission

GRAPHIC provides a platform for exchange of information through case studies, thematic working groups, research, and communication. GRAPHIC serves the global community through providing scientifically-based recommendations that are policy relevant. GRAPHIC uses regional and global networks to improve capacity to manage groundwater resources.

GRAPHIC – An Introduction

Groundwater is a valuable natural resource providing a primary source of water for agriculture, domestic, and industrial uses in many countries. The use of groundwater has particular importance to the availability of many potable-water supplies because groundwater has a capacity to balance large swings in precipitation and associated increased demands during drought and for surface-water resources close to the limits of sustainability. However, global groundwater resources may be threatened by human activities and the uncertain consequences of climate change. Recent research has documented the effects of direct human activities, such as groundwater mining and contamination, on groundwater resources. The effects of climate change, whether caused by human activities or natural variability, on surface-water resources and associated ecosystems have been evaluated. However, little is known about how subsurface waters in the vadose zone and groundwater might respond to climate change and affect the current availability and future sustainability of groundwater resources. Thus, there are urgent and ongoing needs to address the expected coupled effects of human activities and climate change on global groundwater resources. To address these concerns regarding groundwater, UNESCO-

IHP initiated the GRAPHIC (Groundwater Resources Assessment under the Pressures of Humanity and Climate Change) project.

Aims/Rationale of GRAPHIC

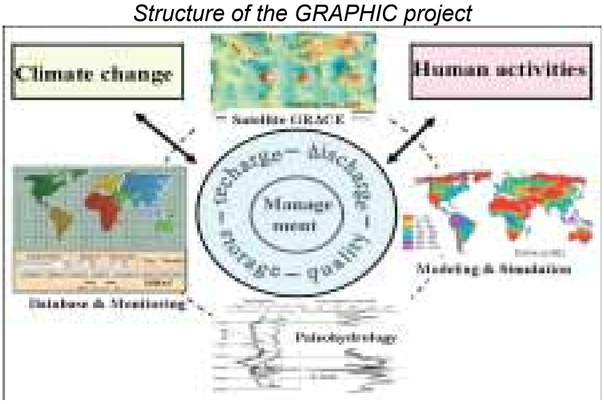
1. State the problem. What is the problem?
2. How to investigate this problem? Apply scientific methods. Identify relevant indicators of change (climatic and human impacts).
3. Mitigation and adaptation. Suggest some mitigation/proposals based on scientific evidence that will be relevant for policy.
4. Communication strategy (to policy makers). Stake-holder engagement, to improve upon the message.

Structure of GRAPHIC

The GRAPHIC project was designed with the understanding that groundwater resources can have nonlinear responses to atmospheric conditions associated with climate change and/or terrestrial-surface conditions associated with human activities. Thus, groundwater assessments under the coupled pressures of human activities and climate change and variability involve exploration of complex-system interactions. GRAPHIC incorporates a multidisciplinary scientific approach as the most rigorous platform to address such complexity. Furthermore, the GRAPHIC project extends investigations beyond physical, chemical, and biological interactions to include human systems of resource management and governmental policies. The structure of the GRAPHIC project has been divided into Subjects, Methods, and Regions.

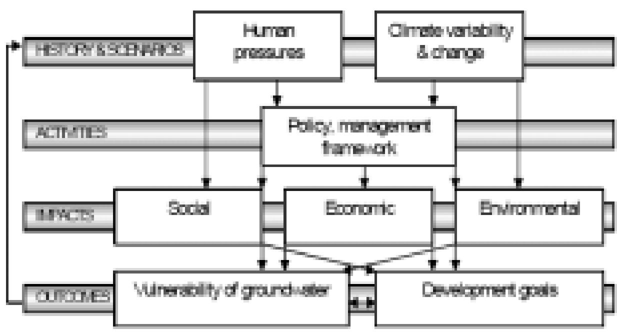
(A) **Subjects**; thematic, cross-region issues (1: Recharge, 2: Discharge, 3: Storage, 4: Quality, 5: Management)
(B) **Methods;** methodological approaches (1: Database and Monitoring, 2: Satelite GRACE, 3: Modeling and Simulation, 4: Paleohydrology), and
(C) **Regions;** representative geographical areas, where pilot studies will be made. (1: North and South America, 2: Europe and Russia, 3: Asia and Oceania, 4:Africa).

Structure of the GRAPHIC project



Targets and plans of the project

The **GRAPHIC** project has identified the following problems and research needs related to groundwater **recharge** and **discharge**: 1) spatial and temporal scaling issues; 2) quantitative plant physiology and succession for environmental stress responses; 3) hydrological boundary conditions affecting recharge and discharge; 4) feedbacks associated with societal adjustments in land/water resource management; and 5) coupled atmospheric – hydrologic - oceanographic processes. Nutrient and material transports through groundwater recharge and discharge are the keys for groundwater **quality.** Reduction of available groundwater storage due to contamination and ecological impacts are keys of the GRAPHIC, as well as groundwater **storage** change due to vigorous human activities. Systematic analysis of stakeholders and groundwater-related policies is a crucial part of GRAPHIC. Groundwater **management** is typically characterized by a many objectives, impacts, policies, and stakeholders, and of variables that are known with a low or very low level of accuracy. Those variables are strongly interconnected, and belong traditionally to different scientific disciplines. The ***basin-scale pilot studies*** will be made in each region by the subject experts and local scientists. We will operate "intercomparisons" using four methods to evaluate each subject intensively.



Management framework of the GRAPHIC project

Expected products of the project

The project will not only provide a better understanding of the functioning and change of groundwater resources under the pressures of humanity and climate changes, but also address scenarios and future developments for regional scales to the global groundwater assessment and synthesis effort. Products will include: (1) Database of the magnitude of changes in groundwater resources, (2) Methodology for evaluating groundwater resources due to climate change and human impacts; (3) Regional synthesis for evaluation in the global network; (4) Protocols for integrated assessment, modeling and forecasting for dissemination in training workshops.

Selected GRAPHIC case studies

1. Recharge Modeling for Climate Change Studies: Advances and Challenges, the Abbotsford aquifer, Grand Forks valley and the south Okanagan valley, Diana Allen, Department of Earth Sciences, Simon Fraser University, Burnaby, BC (Canada)
2. Case studies in Latin America and Caribbean: Brazil, Henrique Chaves, University of Brasilia and Argentina, Litoral Area, Ofelia Tuchjneider, Universidad de Litoral.
3. Current GRAPHIC-related research activities in the humid tropics of East Africa, Richard Taylor, University College London UK, (Uganda)
4. Impacts of Climate Change on Coastal Groundwater Resources in The Netherlands, Gualbert Oude Essink, TNO (The Netherlands)
5. Interrelation between the sea and groundwater in Israel – past, present and future, Yoseph Yechieli, Geological Survey of Israel
6. Evaluating human activities and climatic effects on ground water in the High Plains Aquifer, USA, Jason Gurdak, U.S. Geological Survey, Denver, CO (USA)
7. Climatic and Human Influences on Groundwater in Low Atolls, Ian white (Pacific)
8. Human Impacts on urban subsurface environment in the Tokyo Metropolitan Area Basin, Makoto Taniguchi, RIHN Institute, (Japan)
9. Climate change impacts in groundwater resources in a Mediterranean island, Mallorca, Lucila Candela, UPC, (Spain)

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Brainstorming of RTD projects – Session A: Water Cycle & Ecosystems

Adaptive strategies to mitigate the impacts of climate change on European freshwater ecosystems (REFRESH)

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REFRESH is a collaborative large-scale integrating project under the FP7 theme 6: Environment (including Climate Change). The project was launched on February 1st 2010 and has a duration of four years. The consortium lead by Dr. Martin Kernan (PI) and Prof. Rick Battarbee consists of 25 partners from Europe, Canada, and Australia. The focus of the project is on three principal climate-related and interacting pressures: increasing temperature, changes in water levels and flow regimes, and excess nutrients, primarily with respect to lowland rivers, lakes and wetlands because these often pose the most difficult problems in meeting both the requirements of the WFD and Habitats Directive.

REFRESH will advance fundamental and applied science in 5 key areas: (1) understanding how the functioning of freshwater ecosystems is affected by climate change, (2) new indicators of functional response and tools for assessing vulnerability, (3) modelling ecological processes, (4) integrated modelling, and (5) adaptive management. The project considers how freshwater ecosystems in Europe will change over the next fifty years and it uses a combination of novel experiments and modelling to generate the understanding and tools needed to implement an adaptive management strategy.

The project has the following specific objectives:

- to generate scenarios and storylines for future climate, land-use/land management, nutrient loading and water resource demand relevant to the future management of freshwater ecosystems;
- to review and assess measures that can be taken to mitigate the effects of temperature, changing hydrology (and salinity) and increased nutrient and organic matter loading expected under different future scenarios;
- to understand the processes that govern the relationship between temperature, hydrology (and salinity) and nutrient/organic matter loading and the structure, function and biodiversity of freshwater ecosystems;
- to develop methods for identifying thresholds and reference conditions for systems facing climate change;
- to develop new indicator systems and vulnerability assessment methods for systems facing climate change;

- to assess how climate change will alter species distribution patterns, especially those prioritised in the HD, at the European scale;
- to develop and demonstrate effective methodologies to assess the cost-effectiveness of alternative adaptation/mitigation strategies in freshwaters;
- to develop and improve the performance of integrated catchment models for simulating the ecological response of freshwater ecosystems to climate, land-use/management and pollution change;
- to use the models to explore the ecological and cost-effectiveness of alternative adaptation, mitigation and restoration strategies at the catchment scale to ensure long-term sustainable management; and
- to engage with stakeholders to develop scenarios and storylines and explore barriers to the implementation of adaptation and mitigation strategies at national and catchment scales.

REFRESH will review and develop realistic scenarios for future climate change, land-use/land management change, nitrogen deposition and water abstraction/water resource change and combine the scenarios to generate a range of storylines for use throughout the project. The project focuses on problems of increasing water temperature, changing hydrology and interactions between climate change and the behaviour of nutrients and organic matter as the principal climate-related threats to freshwater ecosystems. The aim is to improve the resistance and resilience of freshwater ecosystems to the adverse impacts of climate change by restoring ecosystem quality, as required by the WFD, by managing habitats sustainably for priority species, as required by the HD, and by improving the connectivity of rivers, lakes and wetlands within catchments to enable effective migration and dispersal of aquatic plants and animals to take place. Specific adaptation strategies addressed in the project include:

(i) management of riparian areas to control water temperature by the establishment of woody riparian vegetation along streams and rivers;

(ii) management of catchment hydrology to maintain flow in streams, water-level in lakes and regular flooding in wetlands;

(iii) re-creation of riparian floodplains to buffer against extreme precipitation events and changes in hydrodynamics, and to reduce nutrient flows and humic substances to water bodies;

(iv) management of catchment land-use to reduce diffuse nutrient loading and soil erosion;

(v) management of water abstraction from, and effluent discharge to, surface waters.

A series of carefully designed, co-ordinated field experiments is carried out in a north-south gradient of climate conditions across Europe. For rivers the emphasis will be on the impact of changing temperatures and low and variable flows under different nutrient conditions. For riparian wetlands the experiments are designed to study the processes involved in changing temperatures, changing flooding regimes, reducing nutrient loading on established wetlands and the creation of new wetlands. For lakes the experimental focus will be on lake-level fluctuations and on ecosystem functioning especially with respect to carbon, nitrogen, phosphorus, oxygen and salinity dynamics.

A critical concern in the management of freshwater ecosystems is the attempt to prevent water bodies from crossing key thresholds, where systems may change abruptly and involve a switch to regimes that are difficult to restore. REFRESH will identify thresholds in structure, function and biodiversity for the effects of temperature, low flows (rivers), low water levels (lakes, including impacts on salinity), changes in flooding regimes (riparian wetlands) and changes in nutrient and organic matter loads (all) and develop vulnerability indicators for these effects. Building on the results from Euro-LIMPACS, the project will examine how the concept of a dynamic reference state can be built into WFD and HD methodologies. The ultimate objective of REFRESH is to develop parsimonious integrated models that can generate robust simulations of future water quantity, quality and ecology at the catchment scale at which adaptive measures will be most effective. In REFRESH our intention is to develop a generic approach to integrated catchment modelling that brings together both the ecological and economic dimensions of the project and to demonstrate the use of the approach at a series of catchments distributed across Europe, that represent the different climatic settings. Engaging stakeholders in a dialogue to identify problems, design solutions and address barriers to their uptake will assist with the implementation of the WFD and HD and build adaptive capacity.

Brainstorming of RTD projects – Session A: Water Cycle & Ecosystems

Integrating wetlands in river basin management: key for adaptation to climate change – the WETwin project

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The 7FP funded WETwin project, currently at mid-term, aims to enhance the role of wetlands in basin scale integrated water resources management (IWRM), with the aim of improving community service functions while conserving good ecological status. Wetlands are insufficiently addressed in current river basin management plans. WETwin is expected to generate site-specific knowledge, models, and strategies for supporting the management of the study wetlands. WETwin will support wetland management on global scale as well, by means of its generic *guideline*. Trainings for partners and stakeholders contribute to capacity building in non-EU countries. Stakeholder platforms and twining cooperation established within WETwin support integrated and participatory wetland management both on local and global scales.

For this purpose WETwin has developed a decision-support framework based on three existing methodologies: 1) Ramsar Critical Path approach; 2) EU Water Framework Directive (WFD); 3) UNESCO spiral process for Integrated Water Resources Management. The WETwin framework consists of the integration of adaptive planning cycles at wetland and river basin levels. Integration means interaction and exchange of information among agencies in charge of the two management processes. An actual merge or transfer of responsibilities is not envisaged, since wetlands remain to have their own dynamics, need to be managed at a different scale and have different challenges. The WETwin framework however aims to improve the performance of management agencies and enhance the coordination between concerned institutions

Wetlands are particularly vulnerable to climate change. Management solutions therefore are developed by taking into account global change scenarios derived from IPCC-SRES and the Millennium Assessment. These scenarios are downscaled to a regional and local level with the involvement of local experts. In response to different scenarios we assess possible management options for each case study and use these to build the decision space. While trade-offs exist between multiple ecosystem services, compromise management solutions are identified in the decision space using Multi Criteria Decision Aid (MCDA). Model-based evaluation of alternative management solutions is a key step in MCDA.

A message from WETwin with respect to address climate change, is that wetlands can be considered as 'natural water infrastructure'. Wetlands can be both a measure to improve flood buffering and a key element for nature restoration or conservation. The integration of wetland management into river basin management can thus create 'win-win' situations. Measures for wetland restoration are as well measure for adaptation to climate change. Following recommendations can be given:

- Wetlands cannot be the sole responsibility of nature agencies
- Cooperative governance across sectors & scales needed
- Wetlands to be recognized as essential element of river basin management
- Water resources planning and allocation has to ensure delivery of sufficient water quantity & quality to maintain wetlands in the basin

Brainstorming of RTD projects – Session A: Water Cycle & Ecosystems

SCENES: exploring the European water futures

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SCENES is a four year European research project developing and analysing a set of comprehensive scenarios of Europe's freshwater futures up to 2025 and 2050. The project has started in 2006 and is currently in the final phase of scenario development. SCENES is covering all of "Greater" Europe reaching to the Caucasus and Ural Mountains, and including the Mediterranean rim countries of North Africa and the near East (further referred to as pan-Europe). These scenarios will provide a reference point for long-term strategic planning of water resource management, alert policymakers and stakeholders about emerging problems, and allow river basin managers to test regional and local water plans against uncertainties and surprises, which are inherently imbedded in a long-term strategic planning process. The SCENES project will deliver *combined qualitative and quantitative* scenarios. Within SCENES, scenarios are understood as descriptions of possible futures that reflect different perspectives on past, present and future developments. The qualitative scenarios (storylines) provide an internally consistent picture of how water resources in pan- Europe may develop. The quantitative scenarios, produced by state-of-the art models, complement the storylines by providing numerical information. Each scenario has its specific consequences for the state of the future pan-European waters and the functioning of its services.

SCENARIO DEVELOPMENT

The Storyline and Simulation (SAS) is a widely used approach for scenario developed (Cumming et al. 2005; Alcamo et al. 2005). This approach is adopted by the SCENES-project to develop pan-European water scenarios. In SCENES, however, the SAS approach is adapted by including scenario enrichment steps through integration of different levels of scale, back casting activities and an indicator based assessment of the storylines.

Important steps of the SAS approach include the establishment of a scenario panel and scenario team and the construction of storylines that are quantified and revised in an iterative procedure. The *scenario team* is a group experts responsible for the coordination of the scenario development process and quantification of the driving forces and pressures on the water resources. The *scenario panel* is a core group of key stakeholders that are responsible for the actual development of storylines. In SCENES, scenario panels are formed at the pan-European level and for all nine pilot areas within four regions (Mediterranean, Baltic, Lower Danube and Dnepr-Don). The Pan-European Panel (PEP) is responsible for the storylines development at Pan-European level. Input from regional panels is a part of the enrichment process. Within SCENES the iterative scenario development process consists of 3 cycles of storyline development and quantification of storylines. Currently, the project is in the final cycle and the key messages presented in this paper are based on the second cycle (PEP2).

To compute the impact of climate change and other important driving forces on future water resources the water model WaterGAP (Water – Global Assessment and Prognosis) is applied (Döll et al. 2003). WaterGAP consists of two main components: a Global Hydrology Model to simulate the terrestrial water cycle and a Global Water Use Model (Flörke & Alcamo 2005) to estimate water withdrawals and water consumption of the domestic, thermal electricity production, manufacturing, and agricultural sectors. In SCENES, WaterGAP was developed to compute both water availability and water uses on a 5 by 5 arc minutes grid (longitude and latitude; 6 x 9 km in Europe), covering whole Europe.
To describe, evaluate and assess the consequences of changes in water resources a core set of 30 impact indicators has been developed. Within SCENES, we distinguish two types of impact indicators (see Figure 1):

- generic impact indicators: indicators that are addressing the hydrological changes in freshwater availability and quality in terms of too much (flood events), too little (drought events, water stress) or too dirty (water pollution).
- impact indicators for water system services: indicators that are addressing the environmental, ecological and socio-economical consequences of changes in the state of fresh water resources on water system services: Water for Food, Water for Nature, Water for People and Water for Industry and Energy.

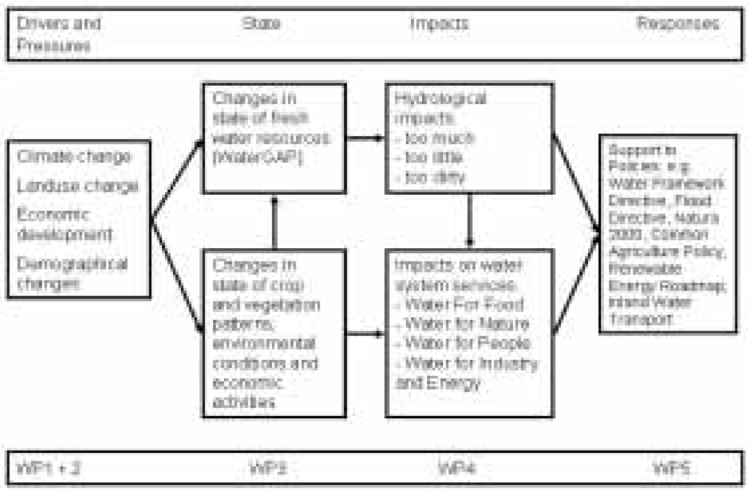

Figure 1: the structure of the SCENES Project within DPSIR context.

WATER SCENARIOS

Four scenarios have been developed in the form of narrative, qualitative stories:

- Sustainability Eventually
- Policy Rules
- Fortress Europe
- Economy First

The four scenarios mainly focus on addressing the prospects for water use in the most important economic sectors in Europe and the future of the European Water Framework Directive. In addition, the focus of the storyline is on potential conflicts, trade-offs and the complementary between the society oriented and the nature-oriented water system services. Each narrative storyline describes three periods: the beginning (2008-2015), the middle period (2015-2030) and the final period (2025-2050). For the quantification of effects countries are divided into water poor countries (southern and parts of central Europe) and water rich (western, eastern and northern Europe).

As climate scenario development is not part of SCENES, climate scenarios were selected from existing data outside the project. Instead of making ensemble runs, which is often done to deal with uncertainty, the variability concerning both temperature and precipitation was investigated within SCENES by selecting different combinations of emission scenarios (IPCC 2007) and Global Circulation Models (GCM). In PEP2, for each SCENES storyline the scenario team selected a climate scenario (combination of emission scenario with the results of one of the GCM's) that would best fit with the various storylines (see table 1). The following climate model and emission scenario combinations were selected:

- The IPSL-CM4 model from the Institute Pierre Simon Laplace, France (IPCM4-A2) representing an A2 scenario. This scenario indicates high temperature increase and low precipitation increase or decrease in Europe.
- The MICRO3.2 model from the Centre for Climate System Research, University of Tokyo, Japan (MIMR-A2) representing an A2 scenario. In accordance with the IPCM4 model, the MIMR model projects a high temperature increase over Europe, but in combination with a high precipitation increase or low decrease.
- The ECHAM5/MPI-OM model from the Max-Planck Institute for Meteorology, Germany (MPEH5-B1) representing a B1 scenario. In contrast to the A2 scenario, the B1 scenario predicts a small temperature increase and an average precipitation change.

Table 1. SCENES storylines and associated climate scenarios

storyline	**climate scenario**
Sustainability Eventually	A2 – IPCM4
Policy First	B1 – MPEH5
Fortress Europe	A2 - MIMR
Economy First	A2 - MIMR

In the final phase of the scenario development every storyline will be combined with two climate scenarios: A2 – IPCM4 and A2 - MIMR

KEY MESSAGES

Based on analysis of the PEP2 scenarios we have identified the following key messages:

- Climate change has a significant impact on the water availability in pan-Europe, however both direction and change depends on the climate scenario selected.
- All climate scenarios indicate a significant decline in average water availability in Mediterranean region: in summer period, the decline in water availability is over 30%.
- The average water availability in winter period is likely to increase, especially in Nordic countries and central Europe.
- Extreme discharge level may become more frequent and intense in parts of the Mediterranean region, central Europe and Scandinavia.
- Low flow conditions will be more frequent and intense in Turkey, Iberian peninsula, France and UK.

- Innovations in water technology can compensate climate change impacts on agriculture, nevertheless irrigation water stress will increase in Mediterranean region and Black Sea region.
- For agriculture, socio-economic drives, technological development and agricultural policies are more important than climate change as a factor influencing irrigation water withdrawals and water stress.
- Domestic water scarcity is not likely to be a major problem, when water saving technologies are implemented.
- Vast majority of freshwater ecosystems in Europe will experience significant ecological changes as alterations in flow regime will not meet the hydrological requirements to support good ecological status.
- Future water temperature in lakes will affect fish populations and communities in many European river catchments.
- Cooling water capacity in rivers will decline and restrain electricity generation by thermal power plants in large parts of Europe.
- All scenarios show that many rivers and lakes in western and central Europe will remain suffering from high nutrient levels resulting in a decline of biodiversity and a moderate or poor ecological status.
- In future, harmful algal blooms will seriously jeopardizes bathing water quality in large parts of Europe in all scenarios.

PERSPECTIVES

The SCENES project will deliver a framework for scenario development, including consolidated conceptual models to develop consistent storylines through participatory processes, methodologies to generate data on the future of driving forces and pressures to the availability and quality of water resources, a modelling framework to quantify future changes in water quantity and water quality at Pan-European scale and a core set of impact indicators to evaluate and assess the ecological, environmental and socio-economic impacts on water system services. Water scenarios are a powerful tool to increase awareness of future water issues. However, to cope with the rapidly changing world, water outlooks should be updated frequently. Therefore, we recommend launching an on-going stakeholder driven water scenario development process, to establish a European water scenario team to facilitate the scenario development process. In the next outlook on European water futures in Europe special attention is asked for environmental flow requirements, climate adaptation strategies and water quality issues.

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Brainstorming of RTD projects – Session B: Water, security and resources incl. drought

CLIWASEC – A cluster of FP7 research projects on climate change, water and security in Southern Europe and neighbouring regions

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Background

The Mediterranean and neighbouring countries are already experiencing a broad range of natural and man-made threats to water security. According to climate projections, these regions are at risk for an even pronounced susceptibility to changes in the hydrological budget and extremes. These changes are expected to have strong impacts on the management of water resources as well as on key strategic sectors of regional economies and their macroeconomic implications. Such manifold developments bare a strong capacity to exacerbate tensions, and even intra- and inter-state conflict among the social, political, ecological and economic actors. It is nowadays widely agreed that effective adaptation and prevention measures need multi-disciplinary preparation, analysis, action and promotion of collaborative strategies.

The European Commission actively tries to prepare Europe and its neighbouring countries for the climate induced ecological and socio-economic changes that lie ahead. A major contribution in this direction has been granted by the formulation of related priority research topics in the Seventh Framework Program for Research and Technological Development (FP7). More specifically, in order to better assess the manifold consequences and uncertainties in climate impact on man-environment systems, a coordinated topic has been programmed between Theme 6 ('Environment (incl. climate change)') and Theme 8 ('Socio-Economic Sciences and Humanities') in the 3rd FP7 call for proposals (2009). **CLICO** (SSH2009.4.2.1) with **WASSERMed** (ENV2009.1.1.5.2) and **CLIMB** (ENV2009.1.1.5.2), all started in early 2010, have established a research cluster for scientific synergy and improved policy outreach. The cluster comprises a critical mass of scientists from 44 partners (29 institutions from the EU, 5 institutions from S&T countries and 10 international institutions) with an EC contribution of more then 9 M€.

The Study Areas

The analysis of climate change impacts on available water resources and security is targeted on Southern Europe and neighboring regions. The case studies, selected according to project specific criteria, are complementary in either scope, region or scale.

WASSERMed: Syros Island (GR), Merguellil (TN), Sardinia (IT), Jordan River (JO), Nile (EG)

CLICO: Cyprus, Andalusia-Morocco biosphere, Sarno (IT), Niger, Alexandria (EG), Sudan, Seyhan (TR), Jordan River, Sinai Desert (EG), Nile (ET), Ebro (ES)

CLIMB: Noce (IT), Rio Mannu (Sardinia, IT), Thau (FR), Chiba (TN), Izmit Bay (TR), Gaza (Palest. Adm.), Nile Delta (EG)

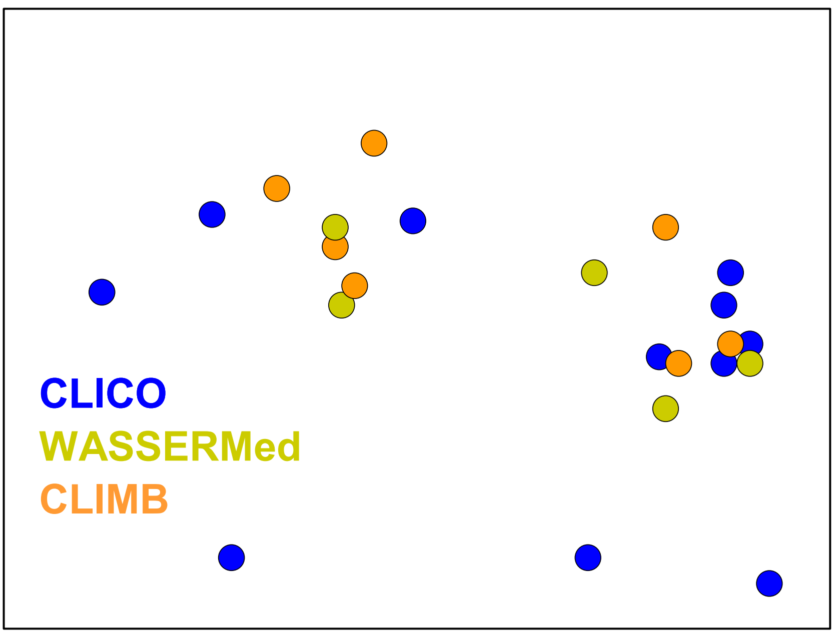

Fig. 1: Location of Study Areas within the cluster projects

WASSERMed

Water Availability and Security in Southern Europe and the Mediterranean

The WASSERMed project analyses, in a multi-disciplinary frame, ongoing and future climate induced changes in hydrological budgets and extremes in southern Europe, North Africa and the Middle East. This will include the assessment of changes in mean flows, frequency and magnitude of extreme precipitation, surface run-off, ground water balance, as well as social and economic factors.

A climatic and hydrological component directly addresses the reduction of uncertainty and quantification of risk. This component will provide an interface to other climatologic projects and models, producing climate change scenarios for the Mediterranean and Southern Europe. These will serve as baselines for impact assessment analysis, in three dimensions that will provide the data for the analysis of risk to security: the case studies, the strategic sectors, and the macro-economic effects. WASSERMed addresses macroeconomic and sectoral consequences of water scarcity, in particular through investigation of virtual water trade.

CLICO

Climate Change, Hydro-conflicts and Human Security

The CLICO project will mobilize 14 research teams from Europe, North Africa, Sahel and the Middle East and will bring together for the first time leading researchers in water resource, vulnerability, and peace and security studies. A large dataset – the first of its kind – of hydro-conflicts in the region will be regressed against climatic, hydrological and socio-economic variables. Natural and social scientists will work together in a trans-disciplinary fashion.

Much of the debate on climate change and hydrological impact focuses on national security and the potential for armed conflict. CLICO complements this with attention to the regional and local scales and with a concern for the impacts of climate change on vulnerable livelihoods. CLICO takes a critical look at the sources of vulnerabilities that undermine human security and the governance arrangements necessary to enhance adaptation. It will map existing policies at the national and international level and envisage a better overarching framework with improved links between existing policies.

CLIMB

Climate Induced Changes on the Hydrology of Mediterranean Basins – Reducing Uncertainty and Quantifying Risk

CLIMB analyzes ongoing and future climate induced changes in hydrological budgets and extremes across the Mediterranean and neighboring regions. The work plan is targeted to selected river or aquifer catchments, where a combination of novel field monitoring and remote sensing concepts, data assimilation,

integrated hydrologic modeling and socioeconomic factor analyses is employed to reduce existing uncertainties in climate change impact analysis.
Advanced climate scenario analysis will be employed and available ensembles of regional climate model simulations will be audited and downscaled. This process provides the drivers for an ensemble of hydrological models with different degrees of complexity in terms of process description and level of integration. The results of hydrological modeling and socio-economic factor analysis will enable the development of a GIS-based Vulnerability and Risk Assessment Tool, serving as a platform for dissemination of project results, including communication and planning for local and regional stakeholders.

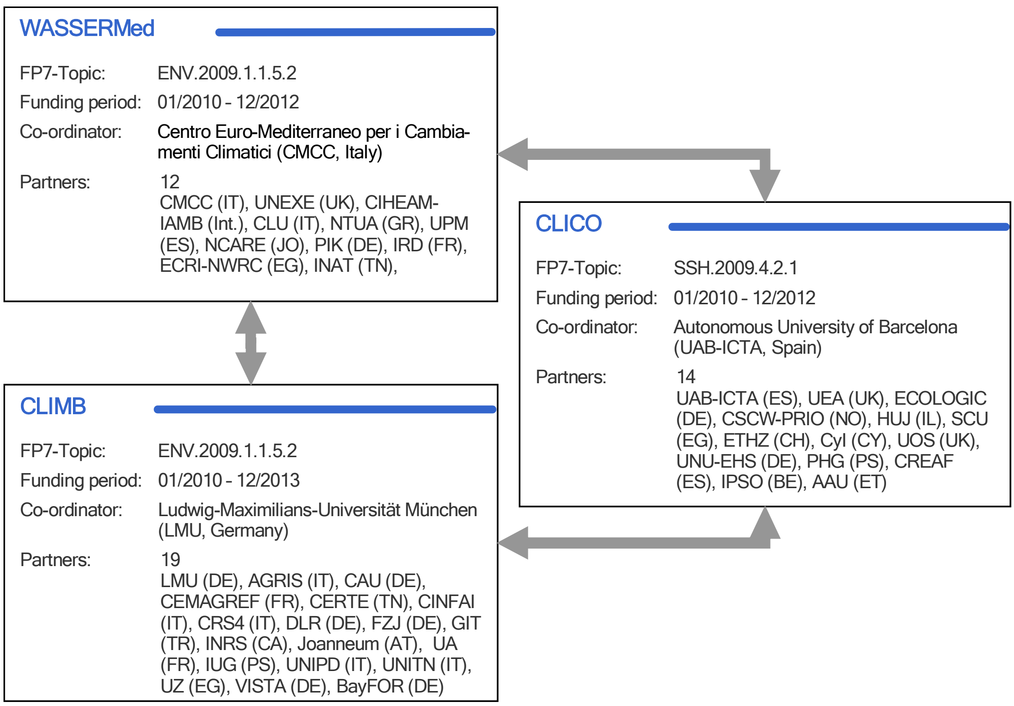

Fig. 2: The research cluster WASSERMed – CLICO – CLIMB on climate change impacts on water and security

Commitment and perspectives of the cluster

The three projects have installed a con-joint Work Package to identify and foster scientific synergies and to establish a more focused and efficient policy outreach strategy. Major building blocks of this collaboration include scientific exchange and review, the organization of joint annual general assemblies, a dissemination plan for presenting the results of the three projects in the scientific literature and the setting up a cluster project web-portal (www.cliwasec.eu), which will also host and advertise further related projects.

Policy briefs of the projects findings will be prepared and posted on the cluster website on an event basis. To initiate and maintain a sound and successful dissemination process, regional, national and international stakeholders and policy bodies are invited to express their research needs and recommendations.

Linking the cluster to EC's thematic priorities in climate change and water research

The joint activities of the cluster are well in line with the related thematic priorities of EC. The impact of climate change on water resources are raising concerns over the possible implications for security. Decreasing access to water resources and other related factors could be a cause or a 'multiplier' of tensions within and between countries. Whether security threat arise from climate impacts '-or options for cooperation evolve- does not depend only on the severity of the impacts themselves, but on social, economic institutional vulnerabilities or resilience and other factors that influence local, national and international relations.

Actions to combat climate change at global and EU scales are embedded into European Union policies, namely through the integrated energy and climate change policy adopted in December 2008, which includes ambitious emission reduction targets for 2020. Specific considerations about climate change impacts on the water cycle as well as on the reliability of current water management systems are also tackled by EU policies, namely through the Water Framework Directive 2000/60/EC, which provide ambitious environmental targets with due considerations of climate change adaptation needs in the context of river basin management planning. This framework is complemented by parent legislation, such as the Flood Directive 2007/60/EC and drought action programmes, which are also considering climate change components.

Research on climate change is closely linked to policy developments at EU level, as highlighted in the White Paper on adaptation to climate change. In addition, research is needed to clarify the relations between climate change impacts and security also considering the policy attention to them, including in the 2008 paper of the EU High Representative and the European Commission dedicated climate and international security
http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressdata/EN/reports/99387.pdf

Scientific outputs are also contributing to international policies and debates, in particular through inputs to IPCC assessment reports and UNFCCC documents. More specifically, the European Commission is funding research through its Framework Programme for Research and Technological Development. In this context, projects of the on-going 7th Framework Programme (2007-2013) or FP7 largely contribute to gathering knowledge relevant to climate change adaptation.

Brainstorming of RTD projects – Session B: Water, security and resources incl. drought

The project CapHaz-Net: Social capacity building in the field of natural hazards and the role of risk communication

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Unlike in developing countries, social capacity building in the field of natural hazard has so far been widely neglected in Europe. Instead, much money and energy has been invested in expensive infrastructure efforts that might no longer be sufficient in the future. In the last years, the social dimensions of risks and natural hazards have been increasingly addressed by social science research. The project CapHaz-Net, a coordinated action within the 7th EU framework program, has the overarching goal to document the state-of-the art of social science research. It aims at promoting a more integrated perspective by establishing a framework on social capacity building in the field of natural hazards for a European context. This will be achieved by bringing together different disciplinary perspectives, and by enhancing and fostering communication between researchers, policy makers and practitioners from across Europe.

CapHaz-Net focuses on synthesising and integrating knowledge and perspectives from five main themes that are central for developing social capacities for natural hazards: risk perception, social vulnerability, risk communication, risk education and risk governance. In a first phase, key studies are documented within each of these topics, achieved through literature review work and thematic meetings. In the second phase, the results are scaled down to particular regional contexts and evaluated with respect to local experiences and existing practices, which is achieved through three regional hazard workshops. During the final phase, the network will integrate findings and develop recommendations on the specific steps that should be taken to improve social capacity building in European societies' facing natural hazards. The project concludes with guidance for future research.

A year after the outset of the project, CapHaz-Net is entering the second project phase in which the review of the main themes is essentially completed and to be synthesised. The present paper presents some first reflections on the process of social capacity building and will in particular focus on the role of risk communication in this process.

Social capacities refer to the context-related abilities of an individual, a social group, an organisation or a community to decide and to behave successfully in a certain situation in order to anticipate, respond to, cope with, recover from and adapt to the negative impacts of an external stressor (e.g. a hazardous event) as well as to employ the necessary resources. These abilities and resources include knowledge capacities, attitudinal/motivational capacities, network/organisational capacities, psychological capacities as well as operational/procedural capacities. 'Social capacity building' is a normative concept that describes the process of rediscovering, enhancing and developing the previously mentioned resources and abilities. It is not understood as a short-term linear process but rather as a long-term, iterative and mutual learning process which is based on the cooperation and interaction of a variety of actors including individuals, organizations, communities and institutions. This implies also that those considered as 'lacking' a certain capacity should not only be involved (and have the capacities) in defining their own 'deficit' but also in defining the aims and purposes of the capacity building effort.

To understand the process of social capacity building, it is necessary to know what the deficits with respect to social capacities are, what actions should be taken to remedy these deficits and as to whether these actions are successful. For instance, to increase people's knowledge and awareness of risks and their perception of their own vulnerability risk communication and education are commonly considered adequate actions. Whether these actions are effective and lead to an enhanced societal resilience towards natural hazards, however, depends on the risk governance structures they are embedded in.

Fig. 1: Elements involved in social capacity building for natural hazards according to CapHaz-Net

There is widely shared consensus that risk communication is a key factor for building social capacity in the field of natural hazards. Risk communication, however, is a very complex and multifaceted process that is hard to grasp. At a very general level, risk communication can be defined as exchange of risk-related information between decision-makers, experts, stakeholders and the affected public. The reality is usually more complex with risk communication occurring between different spatial scales, a multiple actors, for varying purposes and through manifold tools and channels. This complexity is what makes communication research and evaluations particularly challenging.

So far, relatively little empirical knowledge is available on the effects of risk communication in terms of capacity building, and the bulk of relevant literature refers to technological risks or health risks. Empirical findings on the effects of one-way risk communication suggest that while such communication efforts often are successful in raising risk awareness and in increasing risk-related knowledge, their effects on people' risk preparedness and emergency behaviour are very limited. Two-way risk communication, however, appears to enhance trust in authorities and the mutual understanding between experts and local stakeholders which provide a valuable basis for more effective one-way risk communication. Thus, combining one-way and two-way risk communication seems to be the most promising strategy.

Our exploratory inventory of innovative risk communication practices in the field of natural hazards reveals that one-way risk communication between decision-makers, stakeholders and the concerned public still represents the mainstream practice in a number of European countries. Two-way risk communications were almost exclusively found for floods, but not for alpine hazards or heat-related hazards. Furthermore, only few risk communication practices in the field of natural hazards explicitly aim at improving the relationships and mutual understanding between relevant actors. Findings also stress that good practice criteria differ depending on the phase within the risk management cycle and the actual purposes of communication.
More systematic research on the effects of risk communication and risk education is needed to better understand how they can best contribute to building the social capacities that are needed to be better prepared for, to better cope with and to recover from natural hazards in Europe.

Brainstorming of RTD projects – Session B: Water, security and resources incl. drought

FREEMAN – Flood Resilience Enhancement and Management: a pilot study in Flanders, Germany and Italy

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Soresma, Belgium

The objective of the FREEMAN project, funded under the CRUE ERA-NET 2nd Common Call, is to assist efforts in improving the resilience of communities in flood prone areas. The projects aims to find indicators and drivers that can increase the overall level of resilience. In doing so, FREEMAN will be able to provide guidance on the integration of flood resilience into operational Flood Risk Management – and provide practical policy recommendations to aid the implementation of the EU Flood risk Directive (FRD).

Former Flood Risk Management focused solely on the technical, so called structural, flood measures (protection). These measures include the raising and strengthening of levees or dikes and creating dams. The general idea seemed to be that when good Flood Risk Management (FRM) measures were taken no flooding could occur, and there would be no need for preparation. Within this view, existing structures were made more resistant against floods (Vis *et al.*, 2003). These were measures aimed at preventing floods and protecting inhabitants to withstand floods. Although safety levels in most flood prone areas have gone up due to these technical measures, the effect of a possible flood have become worse (Klein *et al.*, 2003).

The FREEMAN project focuses on finding ways to minimize the possible impact of a flood by taking non-structural measures . One of the ways in which potential damage can be minimized is by decreasing the level of vulnerability and increasing the level of resilience. Although this might sound straightforward, it is more complicated than it seems at first sight.

The project is aiming to find **indicators** that can help enhancing the level of resilience. Indicators identify measures that can or could be taken into account when you are dealing with flood risks. (Lankao & Tribbia, 2009; Bharwani *et al.*, 2008; Kasperson & Dow, 2005; Klein *et al.*, 2003). According to FREEMAN resilience consists of several main underlying principles: “risk perception and communication”, “flood modelling tools” and “institutional organization". First, before any discussion on indicators can be held a clear definition of resilience should be defined.

Within the study of the human dimensions of floods, the concepts of vulnerability (V), adaptive capacity (AC)and resilience (R) are increasingly important. The three concepts (VAR concepts) each have a rich history and their origins do not necessarily lay within the same research domain. With the years, a plurality of definitions were defined, not only with different foci but also different meanings across disciplines. Today, this plurality is a hindrance to understand and communicate the concepts. The concepts cannot be viewed as unique individual concepts, as they are interlinked within a non-trivial way. However, it is necessary to find an operational definition to be able to bring the concept of resilience into practice.

In FREEMAN the choice has been made to view resilience as adaptive capacity. We view resilience as the ability to cope and respond before, during and after a hazard occurs. Resilience is about returning to the original state or beyond. Our approach is shown in the figure below:

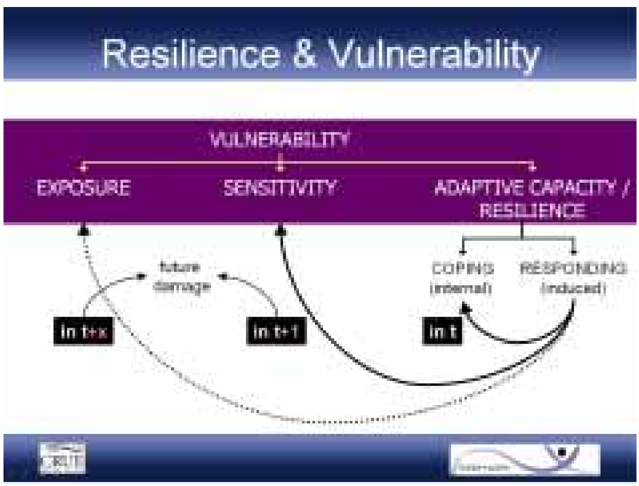

Figure 1. Resilience according to FREEMAN.

Resilience is considered as an ongoing dynamic process, which will not only return to its equilibrium (resistance or persistence) but will gradually increase and thereby bringing its equilibrium to a higher level.

Indicators provide a means of measuring resilience and vulnerability. Within Freeman, indicators (drivers) will be selected that will have a positive effect (pressure) on the level of flood resilience (state) therefore diminishing the vulnerability to an adversary (impact) and increasing adaptive capacity (response) (using the DPSIR-model). Indicators can be identified in several fields of expertise and across several levels.

In FREEMAN we discern four levels of resilience:

- Individual: meaning the individual person.
- Community: meaning a municipality, or system acting as a community (serving the same goals and objectives).
- Sub-national: this can be water basins, regions, provinces etc. This depends on the governmental structure of a country.
- National: meaning the national government or national based institutions and organisations.

Freeman focuses on social resilience and institutional resilience, Within Freeman, it is considered that economic resilience is a part of social resilience (Bharwani *et al.* ,2008).

Freeman operates using three distinct work packages, each with their own focus.. The titles of the work packages are self explanatory.

Figure 2. The FREEMAN workpackages

In order to be able to compare the different case studies a Case Study Report (CSR) will be filled out by all partners. The CSR consists of a list of predetermined questions covering all work packages and all defined indicators. It will measure each characteristic using several indicators. To be able to quantify the outcomes a grading system will be set up. This means that an answer found to a question will be awarded a certain score.

This would than contribute to the overview of the characteristic. The amount of "points" or arms of the diagram change according to the number of indicators used on an characteristic. This could result in an overview like the example below – given for the work package of Flood Risk Management.

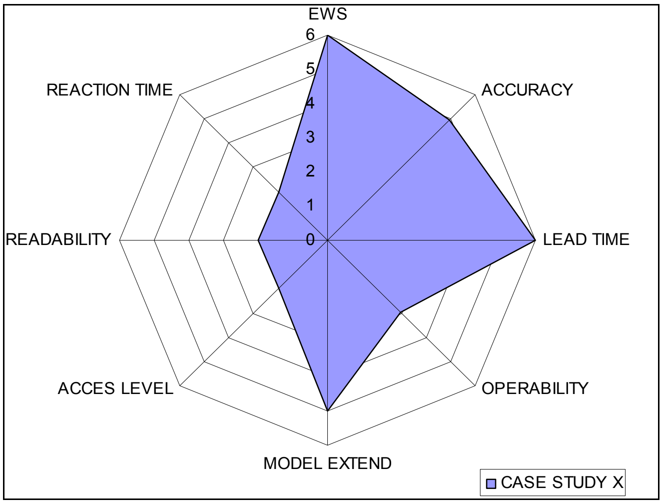

Figure 3. A star diagram for WP3.

In the end, the collected Case Study Reports will give a state of the art overview on the level of operational resilience in the chosen case study areas.

In FRM resilience can be seen as a key concept. FREEMAN aims to find useful measures to enhance FRM – and make the community more resilient.

Brainstorming of RTD projects – Session B: Water, security and resources incl. drought

XEROCHORE – An Exercise to Assess Research Needs and Policy Choices in Areas of Drought

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XEROCHORE:

FP7 Funding Scheme: Support Action
Project duration: 24 months (01 May 2008 – 30 April 2010)

Core Group

- Fondazione Eni Enrico Mattei (FEEM, coordinator), Italy
- Wageningen Universiteit (WU), the Netherlands
- Water Management Center GbR (WMC), Germany
- Universitetet i Oslo (UiO), Norway
- Ministero dell'Ambiente, della Tutela del Territorio e del Mare (MATTM), Italy
- Ministerio de Medio Ambiente (MMA), Spain
- Natural Environment Research Council (NERC), United Kingdom
- National Technical University of Athens (NTUA), Greece
- DG Joint Research Centre, European Commission (JRC), Italy
- Centre National du Machinisme Agricole, du Genie Rural, des eaux et des Forets (CEMAGREF0, France
- The International Union for Conservation of Nature and Natural Resources (IUCN), Switzerland.

Background

Droughts are generated by climate variability. They should not be confused with aridity (permanent dry climate) or water scarcity (water demand larger than availability). Prolonged dry and hot weather resulting in less than normal natural water availability has always been a challenging issue in most parts of Europe. Climate change will likely enhance the scale, frequency and severity of droughts throughout Europe. Droughts have a wide range of impacts (Fig. 1). They affect environment (e.g. water quality, aquatic ecosystems, wetlands, forest fires), economy (e.g. agriculture, forestry, energy sector, waterborne transport, water supply and tourism) and society (e.g. health, poverty). These impacts will likely worsen with the predicted climate change and the increasing population and societies' rising water demands, a situation exacerbated by the need to maintain groundwater storage and river flows for ecological and human services. This emerging situation requires development of adequate drought management plans (DMPs) at different scales (river basin, national and pan-European). It should be supported by a targeted drought policy that is well integrated in the EU Water Framework Directive (WFD) and other policies (e.g. Common Agricultural Policy CAP).

Objectives

The XEROCHORE objectives were:

- to synthesize knowledge on past, current and future drought events, which includes physical causes and the spatio-temporal characteristics of droughts, human influences and that also considers climate change trends and impacts;
- to compile a roadmap that provides a vision on research needs and steps forward towards supporting the implementation of drought management plans within the WFD development as a result of a European drought policy;
- to provide information on possible impacts of droughts and guidance for stakeholders in the area of planning, implementation and scenarios;
- to further extend and develop the network of drought experts (EU and overseas) established as part of the European Drought Centre (EDC) to assess the international (inside and outside of Europe) state of the art in research related to droughts, addressing the natural/physical system, economic, social and environmental aspects, and policy development;
- to initiate a long lasting platform beyond this project through the network (i.e. extended EDC) that communicates drought related research and policy making within the research community, water managers, policy makers and the wider public.

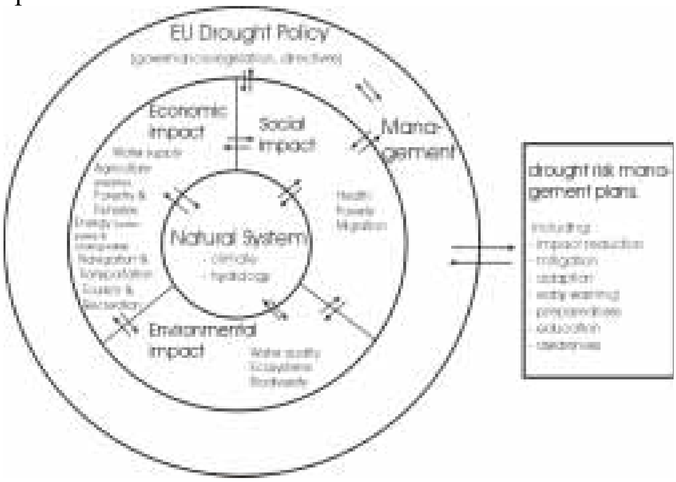

Figure 1 Integration of relevant aspects towards a future EU Drought Policy.

Approach

XEROCHORE involved 11 Core Partners and more than 85 Network Partners whose input was valuable for reaching project's objectives. The project organized three large-scale international events to exchange views and share experiences with Network Partners. These include:

1. Workshop on "Drought & Natural Systems (Climate & Hydrology)", 15-17 June 2009, Noordwijkerhout, the Netherlands;
2. Workshop on "Socio-economic and environmental impacts of droughts", 5-7 October 2009, Venice, Italy;
3. Conference on "Supporting Drought Policies in Europe", 23-24 February 2010, Brussels, Belgium.

The Core Group identified and invited drought experts for each of the two workshops (65-80 experts). In the first workshop the focus was on climate and hydrology and accordingly most experts were from these disciplines. However, experts on the other drought aspects (impacts, drought management and policy) also participated to keep the integrated focus. A similar approach was applied to the second workshop that focused on drought impacts (socio-economic, environment). The design of the workshops (introductionary presentations, key notes, parallel breakout groups, plenary roundtable discussion, synthesis) triggered optimally sharing of experiences. The concluding drought conference presented the broad spread of drought aspects with emphasis on drought management and policy.

Additionally, a Science-Policy event was organized in Brussels (22 February 2010) to brief key experts and policy makers about the results of the project and to exchange views. The event was strongly supported by a member of the European Parliament and attended by staff members of the DG Environment, European Environmental Agency, several river basin authorities, and the Water Directors' expert group on Water Scarcity and Drought.

Science Policy Briefs

Important outcomes of the XEROCHORE project are the Science-Policy Briefs (SPBs, Fig. 2), which are an innovative way to bridge the gap between science and policy. The SPBs link major drought issues to the Water Framework Directive 2000/60/EC and assess research needs and policy choices in the area of drought. They provide a review of the state-of-the-art and identify research gaps in the natural system, impact assessment, policy-making and integrated water resources management with assessment of the possible socio-economic and environmental impacts of droughts and give guidance on appropriate management responses.

Figure 2 Example of the head of a Science Policy Brief.

XEROCHORE has produced the following SPBs referring to specific WFD articles:

- Characterisation of water bodies and of the analysis of pressures and impacts (Art. 5)
- Monitoring of surface water and groundwater status and of protected areas (Art. 8 - relevant also for Art. 1)
- Recovery of costs for water services (Art. 9)
- Implementing a programme of measures (Art. 11, including Annex VI part b)
- River basin management plans (Art.13)

Each SPB addresses: (i) policy focus, (ii) purpose, (iii) policy milestones and relevant XEROCHORE key outputs, (iv) limitations identified by XEROCHORE, and (v) main recommendations.

Other deliverables

Other major outcomes from the XEROCHORE project are the guidance documents on: (i) the natural/physical system, (ii) economic and social impacts, (iii) environmental impacts, and (iv) drought management and policy options (Fig. 3). The comprehensive documents include thorough literature reviews and the outcome of the roundtable discussions with the Network Partners. They provide for each of the fields the state-of-the art and research gaps.

Fig 3. XEROCHORE's Guidance Documents

The Guidance Document on the Natural System explores hydroclimatic aspects of drought, propagation of meteorological droughts into hydrological droughts, land-atmosphere feedbacks; integrated drought assessment framework (atmosphere and land) and drought monitoring (incl. early warning) and forecasting. The review of Drought Impacts and Water Demand/Supply Management Options synthesizes knowledge on economic, social and environmental impacts of droughts. The Guidance Document reviews recent drought cases, methodologies used for the impact estimation; practical issues making the assessment difficult; and research gaps to which future research should be directed. A wide range of water demand- and supply management (WDM and WSD) instruments have been reviewed and experiences from their application synthesised. The review of Drought Policies and Management provides an overview of the European and international policies and management efforts addressing droughts.

Network of international drought experts

XEROCHORE has further extended the network of drought experts (EU and overseas) established as part of the European Drought Centre (EDC). The number of members of the EDC has almost tripled to about 250 drought experts during the lifetime of XEROCHORE. About 30% of the members are from overseas[1]. The extended EDC is expected to be a long lasting platform of drought experts after the finalization of the XEROCHORE project.

Websites

- Xerochore: http://www.feem-project.net/xerochore/
- European Drought Centre: http://www.geo.uio.no/edc/
- European Drought Observatory: http://edo.jrc.ec.europa.eu

[1] D6.4. Drought Network to be integrated in the existing and then extended European Drought Centre, including also drought experts from outside EU

Brainstorming of RTD projects – Session B: Water, security and resources incl. drought

The SCARCE Consolider project on Iberian river basins

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1. Introduction

Water resources in Spain are subjected to rising pressures, related to the socioeconomic activities of an increasing human population, expressed by accelerated land use changes, and the specific climate characteristic of Mediterranean countries. The main panels on climate change [1] predict a future scenario of increasing frequency of floods and extended droughts in the Iberian Peninsula, mostly in the Mediterranean basin. This will certainly add to the currently existing problems, and will probably affect the available water resources, their quality, the functioning of associated ecosystems, especially rivers and their aquifers, and the ecosystem services they provide.

Water has been a major driver of socio-economic development in the entire Mediterranean basin, mainly because of its temporal variability, that has been exacerbated by changes in hydrological response of drainage basins and by recent climate change [1]. In particular, Mediterranean streams are undergoing severe alterations in the flow regime because of a decrease in the number of precipitation days, and an increase in days with heavy rains [2, 3]. The imbalance between the available water resources during extended droughts and the increasing anthropogenic water demand results in major ecological and economical problems. In consequence, water availability has become a major issue for all governments in Mediterranean regions. However, the consequences of global change will not only be on water availability but also on water quality and ecosystem services.

2. Goals

In such context, SCARCE is a project that aims to describe and predict the relevance of global change impacts on water availability, water quality and ecosystem services in Mediterranean river basins of the Iberian Peninsula, as well as their impacts on the human society and economy. Hence, the project has assembled a multidisciplinary team of leading scientists in the fields of hydrology, geomorphology, chemistry, ecology, ecotoxicology, economy, engineering and modelling, in an unknown effort in the CONSOLIDER framework. The project also considers the active involvement of Water Authorities and other relevant agents as stakeholders.

SCARCE has two complementary objectives. The first and largest tackles basic research questions and will define the long-term patterns and the mechanisms that operate in the hydrology, water quality, habitat dynamics, and ecosystem structure and function of Mediterranean basins. The second objective is related to the effects of climate and human footprint (taken both as key elements of global change) that provide on the ecosystem services, rivers and streams, as well as the urgent need to implement and eventually refine the water management policies demanded by the EU Water Framework Directive. Therefore, the project emphasizes linking basic research and management practices in a single framework. The project has the external support of several Water Authorities and stakeholders.

3. Study approach

SCARCE will apply a multidisciplinary cross-scale approximation, with data mining and field based research in four representative basins in Spain: Llobregat, Ebro, Júcar and Guadalquivir. The selected basins cover a substantial area of the Mediterranean Spain, as well as a rich set of socioecological conditions: forested mountainous areas, highly populated basins, agricultural areas, and industrial clusters based on groundwater resources.

- The Llobregat receives extensive urban and industrial waste water discharges that can not be diluted by its natural flow; this river experiences periodic floods and droughts which lead to frequent morphological variations in the river bed; waters have high concentration of pesticides, surfactants, pharmaceuticals and estrogenic compounds, with important effects on the biological communities.

- The Ebro is largely regulated by dams and canals, which have altered its hydrological and sedimentary regime. Abstraction of ground and surface water, irrigation and industrial activities have also deteriorated soil and water quality, where pollution is relevant.

- The Júcar basin has regulated surface water resources, though groundwater use is very intense. It is affected by water scarcity, salinisation and agricultural and urban pollution.

- The Guadalquivir river basin is impacted by reservoirs and dams and its regime is rather artificial. The lower part of the river (including the estuary) has a high ecological value, but has been subjected to relevant transformations, and suffers from metal inputs and other pollution issues.

The basic research element will be the kilometre-scale river reach, including the river channel, the alluvial plain and associated groundwater, as well as the dams that disrupt river continuity. At this scale, we will evaluate the impacts of global change on several processes affecting freshwater ecosystem services (e.g. nutrient processing and contaminant retention, sediment transport, community assembling, and habitat integrity). Results will be upscaled from the targeted river basins to the whole Mediterranean region in Spain.

SCARCE is structured across a series of Horizontal and Thematic Work packages that coordinate the various scientific goals, as well as their interactions. These WPs will deal with data collection (WP1), hydrology (WP2), sediment transport and river channel morphology (WP3), chemical and biological quality (WP4), ecosystem processes (WP5), modelling (WP6), socioeconomic scenarios (WP7), ecosystem services (WP8), river management (WP9) and coordination (WP10).

2. References

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Brainstorming of RTD projects – Session B: Water, security and resources incl. drought

RESPONSES – European responses to climate change: deep emissions reductions and mainstreaming of mitigation and adaptation

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EU action on climate change is now focused on accelerating mitigation efforts, while seeking to reduce risks associated with climate change impacts. To achieve the multiple goals of cutting greenhouse gas emissions, reducing vulnerability to climate impacts, and building mitigative and adaptive capacities, climate action needs to be mainstreamed across all EU policy sectors. As the scale of European policy grows, mitigation and adaptation need increasingly to be integrated. These policies have strong international dimensions. The RESPONSES project addresses EU policy challenges by: developing new global low emissions scenarios, placing EU efforts in a global context; building an approach for assessing EU policies against mitigation and adaptation objectives and for developing alternative policy options; applying this framework in five EU policy sectors (water and agriculture, biodiversity, regional development/infrastructure, health and energy), linked by a set of cross-sectoral integrative activities; and synthesizing the results to new policy strategies. The main outputs of the project will be: a set of global low emission scenarios, differentiated by key countries; options and strategies for integrating mitigation and resilience to climate impacts into EU policies; a validated strategic climate assessment approach. The RESPONSES consortium brings together seven leading European research institutes working on climate change scenarios, modelling, analysis and policy, combining the necessary disciplinary and sectoral expertise. Chinese, Indian and US partners and associates will also participate in the project. The consortium builds on partners' experience in other EU and national projects, including the ADAM project, and will foster close relationships with policymakers. Research outputs will be of direct relevance to the IPCC and to post-2012 international negotiations, as well as supporting implementation of the EU White Paper on Adaptation.

Brainstorming of RTD projects – Session C: Extreme floods

ConHaz – Costs of Natural Hazards

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Cost assessments of damages of natural hazards supply crucial information to policy development in the fields of natural hazard management and adaptation planning to climate change. There exists significant diversity in methodological approaches and terminology in cost assessments of different natural hazards and in different impacted sectors. ConHaz provides insight into cost assessment methods, which is needed for an integrated planning and overall budgeting, and to prioritise policies. To strengthen the role of cost assessments in natural hazard management and adaptation planning, existing approaches and best practices as well as knowledge gaps are identified. ConHaz has three key objectives. The first objective is to compile state-of-the-art methods and terminology as used in European case studies, taking a comprehensive perspective on the costs of natural that includes droughts, floods, storms, and alpine hazards. ConHaz also considers various impacted economic sectors such as housing, industry and transport, and non-economic sectors such as health and nature. It will consider single and multi-hazards, leading to direct, indirect and intangible costs. ConHaz moreover looks at costs and benefits of risk-prevention and emergency response policies. The second objective of ConHaz is to evaluate the compiled methods. The analysis addresses theoretical issues, such as the principal assumptions that underlie economic valuation of damage types, as well as practical issues, such as the qualifications needed for data collection and quality assurance. ConHaz also looks at the reliability of the end result by considering the accuracy of cost predictions and best-practice-methods of validation. A central issue of the evaluation is to compare available methods with end-user needs. The third objective of ConHaz is to synthesize the results and give recommendations according to current best practice as well as to resulting research needs.

Brainstorming of RTD projects – Session C: Extreme floods

IMPRINTS. IMproving Preparedness and Risk management for flash floods and debris flow events

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Summarized goals and objectives

The aim of IMPRINTS is to contribute to the reduction of loss of life and economic damage through the improvement of the preparedness and the operational risk management of Flash Flood and Debris Flow (from now on FF/DF) generating events, as well as to contribute to sustainable development through reducing damages to the environment. To achieve this ultimate objective, the project is oriented to produce methods and tools to be used by practitioners of the emergency agencies and utility companies responsible for the management of FF/DF risks and associated effects. Impacts of future changes, including climatic, land use and socioeconomic changes will be also analysed, in order to provide guidelines for mitigation and adaptation measures.

Specifically, the consortium will develop three methodologies of different complexities to provide FF/DF forecasting and warnings: (i) an early warning FF/DF system based on simplified calculations, (ii) an integrated probabilistic forecasting FF/DF system, and (iii) a probabilistic rule-based forecasting system adapted to the operational use by practitioners. These systems will be tested on five selected flash flood prone areas, two located in mountainous catchments in the Alps, and three in Mediterranean catchments.

The IMPRINTS practitioner partners, risk management authorities and utility company managers in duty of emergency management in these areas, will supervise these tests. The development of such systems will be carried out using and capitalising on the results of the previous and ongoing research on FF/DF forecasting and warning systems, in which several of the partners have already played a prominent role. The project aims to fill the gap between what we know and can be done and what is available in operational centres

One major result of the project will be a prototype of the operational platform including the tools and methodologies developed under the project. This prototype will be designed under the premise of its ultimate commercialisation and use worldwide.

The webpage of the project is www.imprints-fp7.eu.

Key achievements and messages

The project is close to his midterm and the results coming from the first workpackages are envisaged.

Main research topics:

The expected progress in science, requirements and developments of the tool to be delivered by the project are organised around the following main objectives:

Advances in Rainfall Forecasting:

Methods and algorithms to increase anticipation in rainfall forecast, using radar-based extrapolation techniques (short leadtime), analog methods or improvements in blending Numerical Weather models and radar forecasts.
Introduction of orographic forcing into radar-based forecasting techniques, extension of the Ensemble Prediction System concept from NWP models to radar rainfall nowcasting, as well as the development of techniques for merging short-term NWP and radar-based forecast ensembles.

Developing probabilistic FF/DF Early Warning Systems :

Develop a system to provide guidance for an early detection and warning of phenomena potentially giving rise to FF/DF events without performing advanced hydrological computations. It will be based on the identification of potential high-risk areas using GIS information (including socio-economical characteristics) and the space-time properties of the forecast rainfall. It will be considered as the most straightforward and readily implementable FF/DF forecasting system to be developed during the project. The main objective is to set-up a FF/DF guidance system for leadtimes less than 6 hours (using high temporal and spatial resolution rainfields coming from radar) and complementary, FF risk guidance system for leadtimes around 3 days (adapting current EFAS to a 1 km2 resolution in FF prone basins). Additionally, the introduction of probabilistic risk warnings is a research key point for this FF risk guidance system in order to provide better information for the decision-making process.

Advances and integration of Probabilistic Hydrologic Forecasting

Develop a system able to produce probabilistic FF/DF forecasts employing the ensembles of rainfall estimates and forecasts generated in the project, which represent the uncertainties associated with the rainfall inputs. A crucial point to deal with is the challenge of providing the probabilistic forecasts in such a manner that they can really assist and be useful to risk managers in their real-time decision making duties. Different models will be integrated in one platform to introduce uncertainty in the flood forecasts. Moreover, hydrological models are able to take into account different sources of uncertainty. In addition, new data assimilation techniques are been developed in order to improve hydrologic forecasts with the real-time observed data.

Developing a Rule-based Probabilistic FF & DF Forecasting System:

Develop an automatic expert system able to provide a tool to associate the FF/DF triggering factors (rainfall, terrain properties, natural and anthropogenic debris availability, antecedent conditions) and socio-economical characteristics with potential consequences and impacts. Such rules will be established on the basis of highly-detailed simulations of FF/DF generating processes at the hillslope scale, using models already developed by the partners in previous projects. The simulation analysis will cover the entire parameter space of the triggering factors and will allow the identification of probabilistic links between the input variables and the ultimate impacts. These rules will be implemented in a fuzzy logic framework able to provide instantaneous probabilistic predictions of the effects of a given space-time rainfall forecast ensemble.

Assessing the Impact of Future Changes:

Analyze the impact of plausible future changes (climatic, land use, socio-economic and other hazards, such as forest fires) that can occur in the test-bed areas and may affect their hydrological response, in particular with respect to FF/DF generating events. Available scenarios characterizing the relevant changes in these areas will be translated into the input variables of the rule-based forecasting system developed and the resulting consequences will be analyzed to provide guidelines for mitigation and adaptation to impacts of climate and other future changes.

Providing Tools for Practitioners:

Build a prototype of the operational FF/DF forecasting platform, including the tools and methodologies developed in the previous activities.
The aim of this Task is to development of a prototype of the operational FF & DF forecasting platform. The prototype will implement available data, tools and methodologies developed in the previous activities, as well as an integrated visualization interface. The requirements from the practitioners will be a main feature in the design process (especially regarding the visualization interface), in order to obtain prototype outputs and products adapted to operational needs. A total of 6 modules or tools are expected in the prototype, covering the previous research advancements:

1. Radar ensemble nowcasting
2. Merging (radar + NWP) ensemble forecasting

3. Areas of high FF & DF potential risk
4. Probabilistic FF & DF early warning system
5. Hydrological probabilistic FF forecasting system
6. Rule-based probabilistic FF & DF forecasting system

Every module will include the available data and algorithms for the selected test-basin.

Verification on the Test-Beds:

The practitioner partners of IMPRINTS, namely the risk management authorities and the utility company managers in charge of emergency management in these areas, will test the developed FF/DF forecasting platform on 6 selected flash flood prone areas (2 located in mountainous catchments in the Alps, and 4 in Mediterranean catchments). They will also use the results to provide a direct input to the implementation of the upcoming Flood Risk Management Directive.

Results that can be used by policy makers

The practitioner partners of IMPRINTS will use the results of the project and the experiences obtained during the testing experiments to provide a direct input to the policy makers involved in the implementation of the Flood Risk Management Directive.
Four local workshops on the use of the developed risk management tools in the test-bed areas and the implementation of the EU Flood Risk Management Directive are planned in four different European countries to arise awareness and preparedness of the stakeholders and the general public in the test-bed areas. They will be aimed at a broader audience, including technical agents from the emergency agencies and town councils as well as interested public. The first local Workshop has been already organized in Barcelona (Spain) on 17th June 2010 under the tile "International workshop on EU Flood directive implementation in Mediterranean zone: Tools and challenges for efficient risk management". A total of 145 participants, which discussed the strategies for the FD implementation at different levels (from international to local) in a poster session and a round table, made the workshop an absolute success.

Results of relevance for users, practitioners and managers

A main result of IMPRINTS will be the prototype of the operational platform including the tools and methodologies developed under the project to assist risk managers in emergency events. Six European Test beds will be used to provide a unique experience on the use of the advanced systems produced by IMPRINTS. Once verified and tested, this prototype will be prepared for

commercialisation so potential users, practitioners and managers around Europe will be able to get support to install the IMPRINTS platform in their own river basins.
Finally, An International Conference will close the project, in which the success stories about the application of the results of the project will be the crucial point.

Key material/deliverables
Besides the scientific papers and reports (Deliverables), an educational documentary video about the risk of FF/DF will be produced. It will be oriented to broader audiences (adapted to be distributed in local TVs and High Schools), and will present the forecasting and warning systems to potential end-users and public (stakeholders, householders....) and to provide guidance rules to act in case of such events. The first video was produced and presented in the first IMPRINTS Workshop in Barcelona. The title of the video is "Flash Floods and Debris Flows Risk Management. Part 1 - Living with the Risk" (in English, Spanish and Catalan).

Additionally, four local workshops on the use of the developed risk management tools in the test-bed areas and the implementation of the EU Flood Risk Management Directive will be organized in four different European countries. They will be aimed at a broader audience, including technical agents from the emergency agencies and town councils as well as interested public.

Brainstorming of RTD projects – Session C: Extreme floods

FLASH - Observations, Analysis and Modeling of Lightning Activity in Thunderstorms, for use in Short Term Forecasting of Flash Floods

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Coordinator: Prof. Colin Price (Tel Aviv University, Israel)
Partners: Prof. Yoav Yair (The Open University of Israel)
Dr. Alberto Mugnai (CNR-ISAC, Italy)
Dr. Kostas Lagouvardos (National Observatory of Athens, Greece)
Prof. Maria-Carmen Llasat (University of Barcelona, Spain)
Dr. Silas Michaelides (Cyprus Meteorological Service, Cyprus)

Website: www.flashproject.org

Introduction

Thunderstorms can be very destructive as a result of intense rainfall that occurs over short periods of time, often resulting in flash floods. While many developed countries have weather radar networks to track storms and precipitation, the majority of the world is not covered by radar observations. In addition, radar coverage is usually sparse and inadequate in mountainous regions such as most coastal regions of the Mediterranean basin that are prone to flash floods. Infrared (IR) measurements from geostationary (GEO) satellites enable the following of storm development at the relevant space and time scales, but have limited applicability for quantitative precipitation measurement. Alternatively, microwave (MW) observations from low Earth orbiting (LEO) satellites provide more direct and reliable measurements of precipitation and cloud internal structure, but do not properly address the fundamental space-time scales of precipitation and storm evolution.

Since thunderstorms usually develop within 1-2 hours, there is a need to use data having high temporal resolution and to develop methodologies to monitor intense rainfall continuously, especially in regions not covered by radar networks. Unlike radar observations of thunderstorms, lightning observations of storms can be carried out from thousands of kilometers away due to the propagation of low frequency electromagnetic waves emitted from lightning discharges. Therefore, lightning observations provide a possibility of monitoring regional thunderstorm activity continuously in remote regions of the Mediterranean and Europe. Lightning activity also defines the convective core of thunderstorms where rainfall is normally the heaviest.

In order to use lightning as a proxy for convective rainfall, one first needs to investigate the relationship between these physical parameters. The correlation between the temporal evolution of lightning and rain in thunderstorms, and the similarity in their spatial distribution is supported by many studies performed in different geographical locations. In the vast majority of the studied thunderstorms an increase in rain generally corresponds with an increase in lightning activity. Furthermore, spatially cloud-to-ground (CG) flashes are generally found to occur close to the heaviest precipitation. However, many studies reveal a time lag of a few minutes between lightning and rain initiation, or between the peak flash rate and the maximum rain rate.

Our primary scientific objective was to provide improved forecasts for flash floods in the Mediterranean region using lightning data as a key parameter. We started by studying 23 past flash flood events in the Mediterranean region using archived lightning data sets, precipitation data sets, and numerical models. Simultaneously, we used lightning data in conjunction with available IR/MW observations from GEO/LEO satellites to improve cloud characterization, convection detection and rainfall retrieval (i.e., location, amount and timing). Lightning data over the Mediterranean was used to develop algorithms to supply short term (3-hour) warnings of the risk of flash floods. In addition, these same lightning data were assimilated into mesoscale meteorological models to improve the mid-term (1-2 days) forecast of flash floods in the Mediterranean.

In addition to the precipitation forecasts, we used hydrological models to estimate the surface flooding resulting from intense rainfall in different regions of the Mediterranean. The hydrological models were used to simulate past flash flood events, with the intention of eventually linking hydrology models with atmospheric forecasts to allow for better flash flood forecasting.

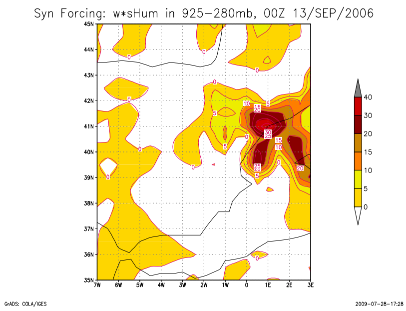
In addition to the high frequency of flash floods produced in Mediterranean countries, these floods occur in regions with a great vulnerability due to the high concentration of population and infrastructure. Although it is still not clear if the number of floods in the Mediterranean region have changed in recent years, there exists complete agreement between the scientific and technical community that the damages produced by floods, and the social impact is rapidly rising.

Major FLASH accomplishments

1) *New synoptic meteorological indices for flash flood prediction*

Two new synoptic meteorological indices were developed for the specific purposes of forecasting flash floods in the Mediterranean region. Normally the

K-index is used to forecast the potential of thunderstorms activity, based on either observed or forecast synoptic parameters. However, the K-index does not always work well in the Mediterranean since often the boundary layer is very humid in the summer months, but this is capped by a large scale inversion that prevents the development of convection.



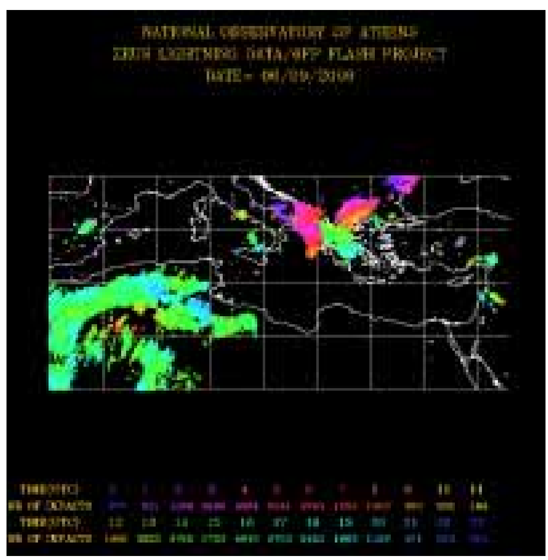
DRI Index for Flash Flood in Barcelona

As a result, the modified K-index (MKI) was developed that takes into account the mid-level relative humidity as well. The second synoptic index is related to the potential for producing heavy rain, called the Rain Dynamic Index (RDI), and consists of the vertical integration of the updraft velocity and the precipitable water, between 925 and 300 hPa. Both these indices were checked against the 23 case studies analysed, and they both show significant improvement in the skill of forecasting regions prone to flash floods.

2) *New lightning product for the Mediterranean*

The ZEUS lightning detection network (operated by the National Observatory of Athens) was used in the FLASH project for all studies of flash floods.

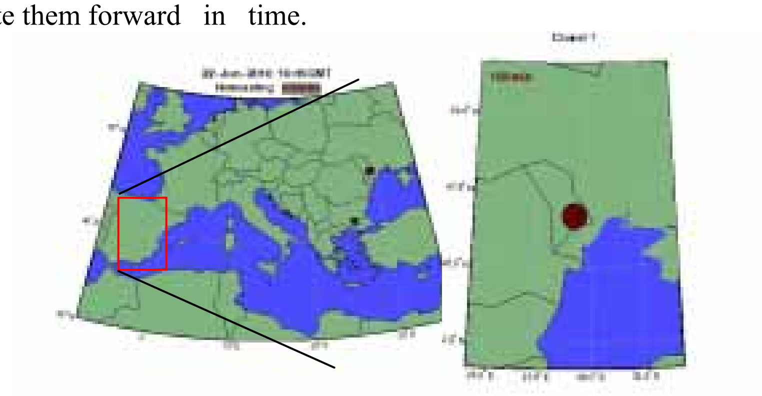
A real time product has been produced that is available on-line at the project website, updated every hour. The lightning activity is colour-coded according to hour of the day, and the accumulated lightning during the day is presented, in order to following the propagation of the thunderstorms across the Mediterranean region. These lightning data are used below in the nowcasting algorithm to give short-term forecasts of thunderstorm activity. These data are freely available in graphic form to the public and end users.



Lightning activity on 6 Sept 2009

3) *New Lightning Potential Index (LPI) for numerical models*
A new algorithm for predicting the likelihood of lightning activity in meso-meteorological models was developed. This Lightning Potential Index (LPI) takes into account the microphysical parameters simulated in the model. Using the amount of ice crystals, graupel particles, mass flux, etc. the LPI predicts the likelihood of electrification in the simulated thunderstorms, the initial step before lightning occurs. During the simulations of the 23 case studies, we found that the LPI generally reproduced the location and timing of the electrical activity in the observed storms. This new LPI is now being implemented by other research groups interested in forecasting lightning activity in their models.

4) *New "Nowcasting" product*
Using the ZEUS lightning data together with the WDSS-II software for nowcasting, we have developed a real time product for short term warnings of intense thunderstorms across Europe and the Mediterranean. The product uses the raw lightning data every 15 minutes to cluster the flashes into storms, and then to propagate them forward in time.

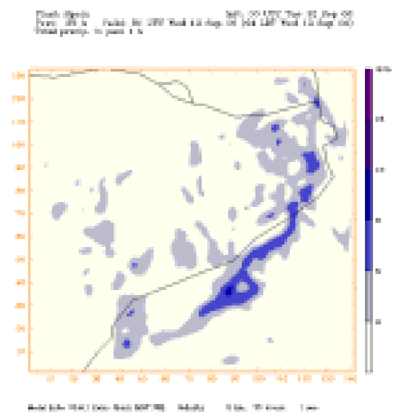


Nowcast of thunderstorm activity for 22/6/10

The nowcasting system is continuously updated every 15 minutes to improve/update the nowcast. This product is based only on lightning data, since these are the only uniform real time data available across Europe and the Mediterranean from a single observation system.

5) *Improved forecasts of heavy precipitation*
Using high spatial resolution mesoscale meteorological models we started investigating the possibility to improve 24 forecasts of rainfall by assimilating lightning data into the model's initial conditions. All models have to be initialised using observations, and lightning is generally not used for this initialization. However, lightning observations in real time can help determine whether thunderstorms should (or should not) be present at time t and location x in the model domain. If lightning is observed, the lightning observations can be

used to correct the model if no convection is present in the model. On the other hand, if the model indicates convection with no lightning observations in reality, the convection in the model can be switched off or diminished. Such a procedure has shown positive results, improving the 24 hour forecasts of heavy precipitation. Lightning data assimilation into weather models may result in significant improvements in forecasting heavy rainfall in the future.



Forecast of Heavy Rainfall associated with flash flood in Barcelona

6) *Website for educational outreach on societal impacts of flash floods*

We have developed a separate website specifically for dealing with social impacts and educational outreach http://gama.am.ub.es/flash. This site explains many concepts such as floods, flash floods, thunderstorms, risks, prevention, and a library of documents that can be used by end users and stakeholders.

Brainstorming of RTD projects – Session C: Extreme floods

Collaborative research on flood resilience in urban areas (CORFU)

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Introduction

Collaborative research on flood resilience in urban areas (CORFU) is an interdisciplinary international consortium that looks at advanced and novel strategies for improved flood management in cities. CORFU (www.corfu-fp7.eu) started in April 2010. The differences in urban flooding problems in Asia and in Europe range from infrastructure age, levels of economic development, social systems and decision making processes, to prevailing drainage methods, seasonality of rainfall and climate change trends. CORFU vision is that this project will use these differences to create synergies that will bring new quality to flood management strategies globally. Through a four-year collaborative research programme involving leading European and Asian institutions in this subject, the latest technological advances will be cross-fertilised with traditional and emerging approaches to living with floods.

Objectives

The overall aim of CORFU is to enable European and Asian partners to learn from each other through joint investigation, development, implementation and dissemination of short to medium term strategies that will enable more scientifically sound management of the consequences of urban flooding in the future. Flood impacts in urban areas – potential deaths, damage to infrastructure and health problems in the first place and consequent effects on individuals and on communities – and possible responses will be assessed by envisaging different scenarios of relevant drivers: urban development, socio-economic trends and climate changes. The cost-effectiveness of resilience measures and integrative and adaptable flood management plans for these scenarios will be quantified. Planned research is structured in *seven Work Packages (WPs),* which are further split into a number of tasks that are strongly interrelated. The concept and the overall scientific and technical objectives of the WPs can be summarised as follows.

WP0 considers *synergies and governance.* The objective is to establish and maintain links with recently completed and ongoing major national and EU research projects related to urban flooding, with the view of enabling smooth acceptance and further enhancement of methodologies developed in these projects, aiming at a better use of resources and avoiding duplication of work. Links with major urban flooding related research programmes outside EU will also be established and maintained, in order to enable identification of synergies, enhance mutual support and consider the potential for joint dissemination of projects' results through multiparty workshops and conferences. The ultimate aim of WP0 is to build up relationships with Member States at EU level through the CIS Flood Working Group, and with national and regional decision-makers in Asian countries and elsewhere.

WP1 (led by Hamburg University of Technology) looks at *drivers* that impact on urban flooding. The objective is to determine the interactions between economic and urban growth, societal trends and the urban structure, which will serve as the basis for the development of a DPSIR (drivers-pressures-state-impact-response) logical framework. The analysis will be completed in conjunction with IPCC-based projections of climate change, economic, health and social development, aiming at identifying the future policy areas where the responses to the drivers and pressures can be most effective. This will be achieved through developing a fundamental understanding of how human capacity and action can shape the future dealing with urban flooding by identifying the future mechanisms through which feedback to drivers/pressures can be achieved and delivered to stakeholders. WP1 will consider all relevant drivers – economic, social, land use/planning, soil sealing limitation strategies and mitigating practices and climate trends.

WP2 (led by DHI – Water & Environment) assesses and enhances methodologies and tools for off-line and real-time *flood hazard assessment based on urban flood modelling*. Missing elements in existing models for *system analysis* will be developed in order to identify consistent procedures for calibration of urban flood models at different scales, having in mind the envisaged technological advances – wider availability of weather radars and on-line rain gauges, increase in computer speed and possibilities for coupling of runoff-sewer-river hydrologic and hydraulic models. The ultimate objective is to develop generic tools for urban flood mitigation plans and test real time urban flood forecast systems, including real time data assimilation and including uncertainty estimates. WP2 will enable evaluation of future impacts of urban growth and climate change on flood probability through scenario studies. That way the strategies for urban flood management will be developed analysing the dynamics of urban flood risks and the boundaries in knowledge and practice in urban flood modelling will be taken forward.

WP3 (led by University of Exeter) will improve, extend and integrate methods for flood *impact assessment*. The objective is to develop a comprehensive and flexible framework that will amalgamate different methodologies for evaluation of *all* types of damage. Assessment of health problems will be taken to a higher level by a combination of hydraulic modelling of floods and quantitative microbial risk assessment. Interrelationships between risk perception, level of preparedness and actual responses will be studied, distinguishing between impacts on individual and on communities. WP3 will enable better assessment of vulnerability to urban flooding at different spatial and temporal scales, aiming at quantification of the efficiency of adaptive management strategies related to changes in drivers in alternative scenarios context and of the cost-effectiveness of resilient measures. Thus, WP3 will include a wide range of possible impacts and interactions of different drivers.

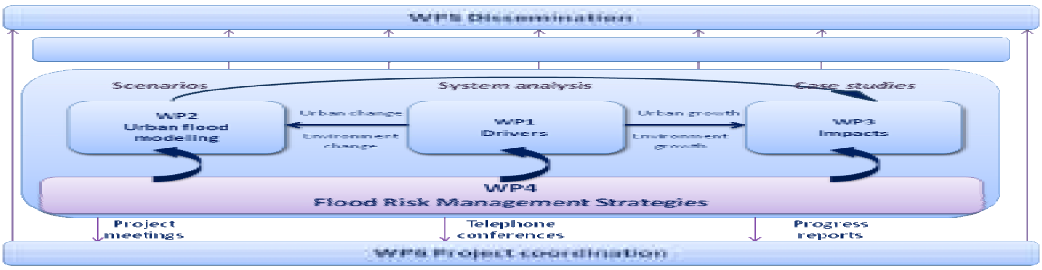

Figure 1: Dependencies between CORFU components

WP4 (led by University of Nice-Sophia Antipolis) will assess and enhance existing *flood risk management strategies* related to planning and prevention for the minimisation of flood risk, management during flood events including early warning systems, emergency protocols and crisis management and measures to be taken after a flood event, including evaluation of damages, recovery measures and the procedures that allow learning from experience. This approach guarantees comprehensive coverage of the whole flood management cycle. WP4 will develop new *strategic flood risk assessment strategies* by building on the outputs from the first three WPs (Fig. 1). A general strategic scheme for urban planning will be developed and tested, such that flood resilience is defined and implemented according to the situation of any city. The ultimate objective will be to formulate good practices and good standards that can be implemented nationally in partner countries. As a result, WP4 will develop efficient medium- to long-term strategies and provide adequate measures for improved flood management at relevant levels.

WP5 will *disseminate new approaches* and support exploitation of opportunities at local, national and international levels. The aim is to engender a 'flood resilience' culture through awareness rising of proposed strategies and comprehensive adoption of CORFU tools. This will be accomplished through engaging policy makers, especially in the CORFU study areas, to share best practice in flood resilient design and planning enabling policy decision making to be positively influenced by new urban flood risk management principles.

WP6 (led by University of Exeter) will *co-ordinate the project* within a robust organisational framework that supports collaboration, oversees science and society issues, promotes gender equality, ensures the financial viability of the entire project and ensures good internal and external communication, in compliance with FP7 guidelines and principles.

Case studies

The research involves a number of case studies in Europe and Asia through which the new strategies will be investigated and enhanced. Comparisons will be made by implementation of new approaches in cities in different socio-economic systems and different climate zones. Particular attention has been paid to the careful identification of case studies such that they (as a set) satisfy a range of criteria:

- major large urban centre with history of flooding,
- specific flooding problems that are not common,
- flooding problems linked to different causes and interactions at different scales,
- local flood management systems with different levels of sophistication in place,
- team members are involved in developing local flood management strategies,
- rich databases with rainfall patterns, urban surfaces and drainage systems exist,
- verified hydrologic and hydraulic models exist and are accessible,
- possibilities for engagement of stakeholders and their interest are present.

As a result of this process, the following cities were originally selected at the time of proposal writing: Barcelona in Spain, Beijing in China, Dhaka in Bangladesh, Hamburg in Germany, Mumbai in India, Nice in France. In addition, three more case studies in Asia will be studied: Taipei, Seoul and Songdo. Each of these cities has been working for many years with urban flood modelling and has extensive experience in urban flood management. Hence, the CORFU project partners have considered flooding issues and current management strategies and identified available datasets in the above cities. This choice will enable testing of the new methodologies comprehensively and their dissemination among local institutional entities, technical people and citizens, and beyond.

Principles

The CORFU research programme has been developed based on the following principles:

1. *Interdisciplinarity:* The research will involve a broad range of disciplines relevant to dealing with urban flooding, such as hydrology and hydraulics, urban planning, economic and social sciences, technology and management, and this is clearly reflected in the composition of research team.

2. *Reliance on real-world examples:* The methodologies that are being developed will have generic components, but they will be tested and implemented in a series of case studies, i.e. the team will strongly rely on real-world data on infrastructure, meteorological inputs, population and economic parameters.
3. *Emphasis on 'responding', including adaptation and resilience measures.* The first two elements of FP7 Environment research ('understanding' and 'assessing impact' in particular) will be part of the programme, though mainly in order to enable more sound focus on the third one – 'responding'.
4. *Building on the CORFU team experience as well as on general scientific and technological progress in the field.* The methodologies and tools developed by the CORFU team will be implemented and further developed, with adequate consideration and inclusion of recent advances made by other research teams.
5. *Collaboration between the EU and Asia.* The intention is to make scientific progress by cross-fertilising the latest technological advances with traditional and emerging approaches to living with floods, including those based on involving socio-economic aspects, which will be driven by interactions between the EU and Asian partners.

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Brainstorming of RTD projects – Session C: Extreme floods

Urban Flood

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Outline of the UrbanFlood project

Reducing water related risk from Climate Change can be undertaken in a number of ways, with climate change being an important consideration in the preparation of the flood risk management plans required by the European Floods Directive. UrbanFlood (www.urbanflood.eu) is developing technology to help emergency management of flood conditions that become more severe in most scenarios of climate change.

The focus of UrbanFlood research is on the use of sensors within flood embankments to support asset management (i.e. the routine operation and management of flood embankments), online early warning systems and real time emergency management. By using sensors within flood embankments, knowledge can be gained on the performance state of the embankments in real time. Without such sensors, assessment of embankment performance is typically through periodic visual inspection or costly, slow and intrusive site investigations. Neither visual nor intrusive site inspections offer a fast, cost effective means for the assessment of flood embankment performance in real time during a flood event. Reliable real time monitoring will facilitate precautionary emergency evacuation during an event if the embankment is shown to be suffering distress as well an enabling better targetting of maintenance operations under normal flow conditions.

The UrbanFlood project is funded from the ICT-2009.6.4 programme which has a core focus upon the development and use of ICT for climate change adaptation. The project started in November 2009 and runs for a period of 3 years. The project integrates expertise (6 different partners from 4 different countries) from both the ICT and flood risk management sectors. However, the concepts under development here also provide a generic early warning system (EWS) structure that could be used for monitoring a range of structures in response to different natural hazards such as landslides, fire etc..
The goal of the UrbanFlood project is to develop and apply (at three pilot locations) a working flood risk EWS that uses sensor technology embedded in

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flood embankments, linked via Internet technology with online user interfaces as well as a multi user, multi-touch table system for information access and control during an emergency situation. Examples of the touch table system will be demonstrated at each pilot location (London, Amsterdam, St Petersburg). More specifically, the UrbanFlood project has five key objectives:

- **Objective 1**: To identify potential functionality, user requirements and user scenarios for such early warning systems (EWS) through consultation with researchers and end users within the field of flood risk management
- **Objective 2**: To install, operate and maintain sensor networks at sites in London, Amsterdam, St Petersburg and a field laboratory to allow development and evaluation of the EWS. The EWS will include internet based analysis modules that will learn to detect potentially harmful scenarios.
- **Objective 3**: Create specific decision support, computational and visualisation services for the embankment EWS. Create a virtual dike with data generators for system testing, flood mitigation planning and training purposes.
- **Objective 4**: Create an internet based, common information space (CIS) that interfaces, amongst others, with the sensor network, the monitor system computing facilities, the decision support systems, command and control centres and public information systems.
- **Objective 5**: To test the UrbanFlood, Internet based EWS in the context of existing EWS of leading stakeholders.

As well as improving the resilience of flood risk management operations to climate change, UrbanFlood also contributes knowledge and techniques which support the development of a Community framework on disaster prevention within the EU[3].

Scientific development and expected outputs from UrbanFlood

UrbanFlood is structured according to seven work packages, with WP1 addressing project management. Work packages 2-7 are summarised below:

WP2: Stakeholder Analysis
- Describing the current state of the art
- Consultation to establish demand, concerns and user requirements from stakeholders
- Development of UrbanFlood EWS requirements (as an internal project development specification)

[3] See Conclusions of 2979th JUSTICE and HOME AFFAIRS Council meeting, Brussels, 30 November 2009

- Development of evaluation criteria for impact analysis

WP3: Design and Implementation of the Sensor Network
- Review and design of sensor networks (Identification of required parameter measurement, selection of hardware, positioning linked to embankment performance etc.)
- Selection of pilot sites; installation and operation of sensor network at pilot sites
- Development of a monitoring system to access data
- Signal processing and interpretation – analysis of data, including filtration of background noise, periodic noise (e.g. passing ships) and identification of performance trends
- Extraction of key performance parameters for use in visual displays (online and multi-touch tables)

WP4: Modelling, Simulation, Visualisation and Decision Support
- Identification of data flow and analysis methods (i.e. processes from measured data through failure modes, potential breach growth, inundation prediction and flood risk prediction)
- Identification and adaptation of models to link sensor data through to the EWS
- Development of a virtual dike model for system testing and training
- Development of visualisation software (user interface) for website and multi touch table access
- Development of decision support system linking the UrbanFlood EWS to DSS concepts as outlined in the FP6 FLOODsite Integrated Project

WP5: Common Information Space
Create the common information space technologies of the EWS, including:
- Design of structure for information flow (e.g. access and storage of data) and scheduling of ICT resources

WP6: Service Platform Development
- Development of plug in technologies for use in CIS
- Design and creation of EWS hosting platform
- Development of Internet DSS viewer and user and developer GUIs

WP7: Dissemination and Exploitation
- Establish and undertake dissemination, exploitation and standardisation activities
- Undertake a usability evaluation and impact analysis
- Establish Advisory board and support recommendations
- Support participation with the Dutch Ijkdijk programme

Conclusions and research needs

Research conclusions

With the project barely 6 months into a 3 year programme, the research programme is in the early stages of implementation. However, initial reviews and stakeholder consultation are complete and confirm:

(i) Stakeholder interest in the use of modern technology in this way

(ii) That whilst much of the technology exists, it has not been applied in practice for a flood risk EWS

(iii) The provision of recommended design and operational features, enhancing the project development specification

Prototype software for the various components of the system is now under development and specific pilot site locations and installation details are evolving ready for preliminary sensor system installation later this year (2010).

A prototype version of the multi-touch table to support emergency management is under development and will be provided as a means for showing how the EWS works at public locations near to each pilot site (e.g. Thames Barrier visitor centre in London). The touch table uses concepts similar to that seen in products such as the iPad where touch screens allow simultaneous use of multiple applications to access and use different data sources, in this case to facilitate emergency management activities.

An initial challenge for the project team has been to establish strong and integrated team working between experts drawn from very different scientific communities (i.e. meshing complex ICT technologies with detailed flood risk management concepts and practice).

Open questions for further research

One of the main objectives of UrbanFlood is to show that the combination of hardware and software technologies can be used to significantly support and advance flood risk management practice through routine asset management, early warning and flood event management. This is consistent with UN-ISDR objectives (www.unisdr.org/ppew/ppew-index.htm). It will be important to show how the UrbanFlood EWS can mesh with existing practice and flood risk DSS.

Some of the key questions that need to be addressed within and beyond UrbanFlood include:

- How accurate are sensor systems within a sensor based EWS?
- How to deal with uncertainty in relation to end user needs within EWS based upon sensor systems
- How to ensure high system reliability and security, particularly during extreme events, to avoid false alarms and missed events

- How to provide multiple means for verification of flood risk scenarios when they develop
- How to develop a system that is economic for use at both small and larger scales, suitable for new build installation as well as retrofitting
- How to maximise interaction, communication and hence acceptance with the public through sharing access to online data and systems. Greater public awareness of the EWS and how it works will help to ensure more effective risk management (i.e. evacuation) during an event

Some of the longer term issues related to the implementation of sensor based EWS on a larger scale include:

- Implementation at a larger, say catchment scale brings significant added potential in terms of opportunities to better manage flood risk and emergency events, but also brings challenges in terms of economic large scale installation and maintenance, operation and integration across multiple organisations, management of very large data volumes in real time etc.
- Larger scale implementation also raises the opportunity of meshing into emergency planning / simulation models, such as the Life Safety Model (FLOODsite – www.floodsite.net) which allows simulation of potential inundation, damage, loss of life and specific evacuation processes. This would significantly increase the information available to the emergency management team during an event.
- Implementation on a wider European or international scale raises the question of standards for hardware and operation
- The UrbanFlood EWS framework also offers a generic solution for EWS potentially addressing a range of different natural hazards, rather than just flood risk. This would require integration of different sensor types, and dealing with issues of sensor dispersion, data type and volume and speeds of analysis for effective warning

Addressing many of the concerns or areas of uncertainty listed above will help to support uptake of such EWS as part of policy for dealing with flood risk. European or wider international collaboration on larger, catchment scale system validation is likely to offer the best means for addressing the various issues identified here.

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Brainstorming of RTD projects – Session C: Extreme floods

Theseus

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Motivations

Coastal areas are vital economic hubs already threatened by many coastal problems including erosion, flood risk and long term habitat deterioration. As economies continue to develop, the asset base at risk will grow, while accelerating climate change will increase the likelihood of damaging extreme events, as well as accelerate habitat decline. Existing coastal management and defence approaches are not well tuned to these challenges and required a multidisciplinary framework and an international dimension.

The project at a glance

The large integrated project “Innovative coastal technologies for safer European coasts in a changing climate”, THESEUS, is funded by the European Commission within FP 7 Environment (6.530.000 €). The project started on Dec.1st, 2009 and will work for four years.

The legend, the project

The project acronym remembers the ancient Greek legend of Theseus and the Minotaur, the monster who lived in the labyrinth of Cnosso (Crete) and pretended annual human sacrifices. Theseus entered the labyrinth, defeated the Minotaur and finally safely walked out from the labyrinth thanks to the help of Ariadne and her ball of string. In this project, the Minotaur is synonym for storms, erosion and flooding risk. The changing climate, environment, economy and society form a dynamic labyrinth in which the Minotaur is moving. Ariadne’s ball of string represents the different mitigation technologies. To defeat the Minotaur and find his way out of the labyrinth, THESEUS has to integrate these technologies into an adequate defence strategy.

Aims

THESEUS will examine the application of innovative combined coastal mitigation and adaptation technologies generally aiming at delivering a safe (or low-risk) coast for human use/development and healthy coastal habitats as sea levels rise and climate changes and the European economy continues to grow. The primary objective is to provide an integrated methodology for planning sustainable defence strategies for the management of coastal erosion and flooding which addresses technical, social, economic and environmental aspects.

Baselines

Natural processes ignore administrative boundaries and borders. In this context learning from partner countries through co-operation is important in order to develop a sound and integrated approach to management. There have been many initiatives promoted by the EU related to exchanging knowledge and showing best practices in the last decades about coastal risks and coastal defences. THESEUS will start from these initiatives deriving experience and results, specifically:

- methodologies for risk assessment (Eurosion, SURVAS, DINAS-COAST, FLOODsite, SafeCoast)
- design techniques of hard defences and methodologies for beach nourishment and dredging operations (ComCoast, DELOS, CLASH, BRANCH, FLOODsite, SafeCoast, EroGrass, CONSCIENCE)
- design techniques of wave energy converters, for the first time proposed for integration into coastal protection schemes (CORES)
- knowledge of ecological effects of rocky structures (DELOS) and nourishment/dredging operations (BEACHMED-e)
- knowledge of ecological vulnerability and recovery to coastal floods in the choice of managed realignment (ComCoast, BRANCH, SafeCoast)
- methodologies for increasing socio-economic resilience to floods (FLOODsite)
- integrated approaches in beach defence management (DELOS, SPICOSA)
- multidisciplinary software for coastal risk assessment (DINAS-COAST)

Consortium

The project consortium consists of 31 partners, of which 25 are from 12 Member States and the others are from China, Mexico, USA, Ukraine, Russia, Taiwan.

THESEUS partners come from all over Europe since coastal erosion and flooding are wide-spread across the EU, with different characteristics and impact depending on the environmental and socio-economic conditions. Moreover, the expected worsening of climate change (and thus increasing severity and frequencies of storm surges and coastal floods) differs across the EU. As a consequence, but also to enhance the dissemination of the concepts and frameworks developed in THESEUS, EU member states from far South (Greece) to far North (Latvia) and far West (Spain) to far East (Bulgaria) are involved.

The consortium comprises partners with different expertise and backgrounds:

- coastal and civil engineering;
- ecology;
- social sciences and economics;
- meteorology and climate change;
- computer science and GIS.

Science-policy interaction
The work under the THESEUS project is aimed at contributing directly towards practical defence planning to provide protection to inhabitants, infrastructures and economic activities. Whilst some aspects of the work (i.e. the analysis and development of innovative technologies) will necessitate academic research, each component of the work will ultimately contribute towards development and implementation of improved flood risk management and mitigation.

Study sites
To aid this process, eight study sites have been selected within European large urban and/or industrial areas, estuaries and deltas. Other motivations are their specific erosion and flood risk management challenges, their high vulnerability to erosion and flooding, their meaning from a European point of view as well as the availability of data and opportunity to link directly into existing 'local' management teams. In this way, THESEUS gains immediate access to established groups of stakeholders who will be motivated to participate in the demonstration of the project deliverables.

Specific objectives of the inclusion of these study sites in the project are:

- to focus research on solving problems in a manner suitable for immediate use in coastal risk management;
- to provide real sites with specific problems against which tools, techniques and decision support systems may be tested and validated;
- to provide feedback into the research and development process from coastal stakeholders;
- to ensure that THESEUS deliverables are of real value, practicable and usable.

The study studies from West to East are: Santander spit, Atlantic Ocean, Santander, ES; Gironde estuary, Bordeaux, FR; Plymouth Sound to Exe Estuary, English channel, Plymouth - Teignmouth - Exeter, UK; Scheldt estuary, Antwerp, NL-BE; Elbe estuary, North Sea, Hamburg, DE; Po delta plain and adjoining coast, Mediterranean Sea, Venice, IT; Vistola flood plain, Baltic Sea, Gdànsk, PL; Varna spit, Black Sea, BG. The sites are characterised by:

- a variety of environments (estuary, delta, coastal lagoon, protected or unprotected beach);
- different wave climate conditions and sea level rise expectations (Atlantic Ocean, North Sea, English Channel, Baltic Sea, Mediterranean Sea, Black Sea);
- different social and economic conditions (urbanised and industrial areas).

The analysis of these sites can benefit from data collection performed during previous EC projects (DELOS, COASTView, FLOODsite, SPICOSA, ASTRA, SESAME) so that the application of new technologies in these sites will complete and upgrade the work started thanks to other EC funds.

Advisory Board and End users

As regards interaction with stakeholders and dissemination, THESEUS project already involves

- 53 end users from 16 countries
- 12 members from 11 countries selected for their specific knowledge and/or reputation of their institution and/or high management level.

Among THESEUS partners, it is worth to note that there are 6 coordinators of national networks and 3 Theme responsible within the EC funded ENCORA Coordinated Action: the inclusion of these already well established networks will guarantee a perfect link to stakeholders, SMEs and in general end users and coastal community.

Technologies

While in the media and the public mind, coastal floods and erosion are often seen as unnatural and nonallowable, they are natural occurrences, and no amount of investment can reduce risks to zero -- an acceptable level of residual risk must always be defined. While new defence technologies have the potential to reduce costs and risks and increase our portfolio of management tools, we do not see technical solutions alone as the answer. Rather the need is to integrate the best of technical measures in a strategic policy context which also considers the environmental, social and economic issues raised in any coastal area. It is in this spirit that THESEUS will advance the state-of-the-art in applying innovative technologies to reduce risks on coasts.

Within coastal engineering, THESEUS will examine how to reduce incident wave energy on the shores with innovative structures such as wave energy converters, multi-purpose structures such as artificial reefs and improvements of existing defences such as overtopping resistant dikes. THESEUS will also address the issue of coastline stabilization and of the volumes of sand needed for beach maintenance. Plans of dredging and nourishment operations, management of borrow areas, reactivation of the littoral drift, estimation of plume dispersion will also be analysed.

Within ecological science, THESEUS will examine the extent to which natural biogenic habitats offer coastal protections and the extent to which such protection can be enhanced (salt marshes, dunes) and managed. THESEUS will also provide an in depth knowledge of the environment vulnerability to sea water inundation that is essential to proceed with no-defend options (inundation in controlled areas), since it will allow us to identify the habitats that should be protected and those habitats where little or nothing should be done. Evaluation of natural habitat management will be considered alongside the ecological effects that coastal engineering intervention will have on marine habitats, providing guidelines and best practices for minimizing their impact through a proper design.

Within THESEUS social science and economics will address the challenges of transforming the concept of resilience into a portfolio of tested operational innovative tools for policy and management purposes of coastal flooding risks. THESEUS will produce ground tested guidelines for innovative coastal risk governance in terms of insurance schemes, land use planning, private sector strategies, post crisis management, knowledge mobilization and crisis planning protocols.

Expected outcomes

THESEUS will integrate scientific outcomes into design guidelines for defence design and in the integrated THESEUS software tool for coastal risk assessment and management.

The methodologies and tools to be developed within THESEUS will contribute to improve the knowledge of the performance and design of innovative coastal defence technologies, to promote coastal flooding resilience, to implement an integrated protocol for coastal risk management.

The societal impact of THESEUS will be felt in many sectors, including the coastal environmental authorities and consultancy organisations advising the management of the coastal area and its living resources; local political, regulatory and enforcement authorities; civil engineering, ecology, socio-economic and psychology communities.

Brainstorming of RTD projects – Session C: Extreme floods

FLOODprobe - Technologies for improved safety of the built environment in relation to flood events

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Introduction

Floods are considered the major natural hazard in the EU in terms of risk to people and assets. Currently, more than 40 bn € per year are spent on flood mitigation and recovery (incl. compensation of flood damage) in the EU. More than 75 % of the damage caused by floods is occurring in urban areas (COST22, 2008). About 3 billion € per year are spent on large scale flood defence structures alone. Climate change and concentration of population and assets in urban areas are main trends likely to affect these numbers in the near future. Global warming is expected to lead to more severe storm and rainfall events as well as to increasing river discharges and sea level rise. This means that flood risk is likely to increase significantly. Furthermore, 80 % of the population will live in urban areas by 2020 and the economic values in these areas are constantly growing. That means that flood risk in urban areas will increase disproportionately: flood damage figures could rise to 100 bn € per year by the end of the century (European Environment Agency, 2008).

The problem owners of the issues addressed above are the public authorities responsible for flood protection and water management as well as other asset managers. They need to be able to assess the expected risk reduction of both, upgrading of flood defences for improved protection for prevention of floods, and increased flood-resilience of the protected assets, in order to act appropriately.

The principal aim of FloodProBE is to provide cost-effective means for flood risk reduction in urban areas. To this end, FloodProBE will develop technologies, methods, concepts and tools for enhanced assessment and adaption of urban systems related to floods.

Project objectives

The specific project objectives are:

1. To improve methods for assessing the vulnerability of the urban environment related to floods, especially by extending conventional

methods with the ability to assess indirect impacts of damage to networks and assets with a high value density.

2. To improve the understanding and assessment of urban flood defence performance, in order to develop suitable protection measures and to increase the cost-effectiveness of future investments.
3. To develop and test construction technologies and concepts to improve the performance of existing and new flood defences and for flood-proofing of the urban environment.
4. To integrate the knowledge developed in the project on assessment of vulnerability of urban areas and flood defences as well as the newly developed construction technologies and concepts to support holistic flood risk management strategies. That implies that optimal solutions require a joint consideration of flood defences and adaptation of the protected assets.
5. To contribute to harmonisation of guidance in flood risk assessment and flood management in the urban context, and thereby support the implementation of the EU Flood Directive**.**

The methods and technologies to be developed comprise:

- assessment methodologies and tools
- guidance
- construction technologies and concepts for flood protection
- decision support systems / methods

By integrating the knowledge developed in the project in existing flood risk management strategies, the end-users, mainly the responsible public authorities and asset managers, are enabled to manage flood risk using more holistic approaches.

Vulnerability of urban systems

Urban systems contain assets of high value and complex and interdependent infrastructure networks (i.e. power supplies, communications, water, transport etc.). The infrastructure networks are critical for the continuity of economic activities as well as for the people's basic living needs. Their availability is also required for fast and effective recovery after flood disasters. The severity of flood damage therefore largely depends on the degree that both high value assets and critical urban infrastructure are affected, either directly or indirectly.

Current flood risk management and research mainly use the susceptibility and value of the protected assets (expected damage to buildings and inventory) to assess their vulnerability, i.e. the potential direct damage. Improving the assessment of potential indirect damage to the entire urban system caused by flood-induced failure of particular important components is of great value. It allows decision-makers to focus their investments on such “risk hotspots”, i.e. particularly vulnerable elements of the urban system. This will considerably increase the cost-effectiveness of their investments.

- FloodProBE will further develop the state-of-the art vulnerability analysis methods on a more detailed urban level to identify, assess and rank the most vulnerable assets and elements. FloodProBE will especially advance the knowledge on the susceptibility of (types of) buildings by developing more detailed assessment methods. These will include the pathways on building level (how does flood loading, thus water, lead to damage) and the building functions that are affected. The results of this activity will particularly enable the development of flood-proofing concepts and technologies for increasing building flood resilience, thus decrease their susceptibility to flood loading and / or increase the capacity to recover from flood damage. This is particularly relevant for critical buildings, i.e. those that need to remain operational during flood events: hospitals, fire stations, water supply and treatment works, and energy generating stations. Floodprobe will furthermore refine existing damage models, by research on the expected repair of damaged assets, particularly buildings with public, commercial and industrial use with high concentration of persons and values.
- For the purpose of improved vulnerability assessment, FloodProBE will also develop methods and tools for assessing the indirect damage to the urban system by failure of infrastructure networks. Latter activities include network reliability and failure mode and effect analysis (FMEA), focussed on (indirect) damage expected from floods. The outcomes of such analysis might lead to significantly different conclusions regarding protection measures compared to decisions based on the expected direct damage only.

FloodProBE is expected to contribute significantly to taking away pressure from urban areas caused by these autonomous developments. The focus of the developments is on the main contributors to direct and indirect potential flood damage, the infrastructure networks and high-density value assets. Especially long disruptions of public services, like critical infrastructure networks, cause major (indirect) damage after flood disasters. FloodProBE will provide means for identification, assessment and protection of these assets.

Reliability of urban flood defences

Improved identification and upgrading of weak links in flood defence systems will increase the cost-effectiveness of flood protection investments significantly. There is a need for improved understanding and clear guidance on assessing

erosion processes, internal and surface erosion and erosion around transitions of soft to hard structures. These failure modes have proven to be particularly problematic for urban flood defences (USACE, 2007). This requires attention for the application of suitable detection, prevention and repair technologies.
The main uncertainties determining the reliability of urban flood defences are related to the underground and the soil involved as construction material. Conventional exploration techniques for assessing geotechnical properties assess the local properties quite accurately, however, the properties over larger volumes are rather diverse and in between measured points they have to be interpreted or interpolated, introducing large uncertainties. Lately, the use of geophysical methods and Remote Sensing is becoming popular for assessing larger volumes, even though with less accuracy. There are quite different national approaches to the application of these techniques. Furthermore, classical and innovative methods generate different types of data. These are currently not yet satisfactorily combined in assessment methods and tools, but used separately or implicitly combined by engineering judgement.

- FloodProBE will build upon the state-of-the-art to advance the fundamental knowledge on soil erosion along structures and at structure transitions. This new knowledge will be used to extend or introduce new failure mode descriptions for the risk analysis of urban flood defences in particular. FloodProBE will also work on a new and practical method for measuring soil erodibility in the field. FloodProBE will also deliver new or extended guidance on taking decisions on design, repair and upgrading of urban flood defences, in particular the design of transitions between embankments and structures.
- FloodProBE will deliver new or extended guidance by best practices on efficient acquisition and usage of distributed data for reliability assessment of urban flood assessment thus also contributing to harmonisation. Developing methods and tools for combination of data from different sources (site investigation, geology, remote sensing, geophysical techniques) will lead to effective and complementary use of existing data and knowledge.
- FloodProBE will deliver new or extended guidance for diagnosis of urban flood embankment performance, especially on determination of weak spots.

The impact will be contribution to structured approaches and formalized procedures to combine data from different information sources for the purpose of reliability assessment. The outcomes will lead towards European harmonisation of guidance for a larger community of potential users. This will help to create uniformity in the risk assessments within the EU Flood Directive.

Construction technologies and concepts for flood protection and flood proofing of buildings

Flood defence improvement and repair techniques need to meet the special requirements in urban areas. These concern especially space limitations, visual and functional integration in the environment and minimizing disruptions caused by carrying out the works. Conventional techniques like sheet piles or grouting are currently used in practice for prevention, retrofit and repair technologies related to geotechnical failure mechanisms. An innovative biotechnical concept using bacteria and nutrients to modify ground strength or permeability is being developed, with significant potential for failure prevention, retrofit and repair of flood defences.

The ongoing growth of cities is reflected in a trend towards higher density urban areas. Various functions such as flood defence, housing, transport compete for space. The essential idea is to combine flood defence functionality with other functions in a new type of flood defence system and thereby making better use of the available space.

- In FloodProBE, the application of the biotechnological methods (BioGrout technology) will be developed and tested for the prevention, retrofit and repair of geotechnical failure mechanisms in flood defences. The main characteristics in comparison to conventional flood defence improvement technologies are: (a) it is a non-destructive retrofit technology, (b) it causes less disruption of urban activities, does not require any additional space to be occupied by the flood defence and does not change the visual appearance of the structure and (c) it repairs flaws or improves weak spots without creating new weak elements (e.g. transitions with hard structures).
- FloodProBE will further develop the state-of-the art design concepts for multifunctional flood defences. By developing construction concepts that integrate other commercial or industrial functions in flood defences, the investments in flood protection can be made more cost-effective.
- FloodProBE will develop technologies, concepts, guidance and a road map for the flood proofing of vulnerable critical assets (risk hot spots). Examples of hot spot buildings are: high density buildings, high-rise buildings and buildings that contain network infrastructure or are hubs for public services. Protection and adaptation (pro and/or reactive retrofitting) of such buildings will decrease their susceptibility to floods. FloodProBE will also elaborate the promising concept of integrated vertical evacuation and shelter functions in utility and high-rise buildings, in order to provide alternatives to horizontal evacuation strategies.

Urban flood risk management decision support

Modern urban flood risk management in developed countries requires Decision Support Systems (DSS). These are often based on source-pathway-receptor concepts . The source is the representation of the hazard, whilst the pathways commonly represent the flood defence system and the receptor is the representation of the values at stake, including economic and societal value as well as human beings at risk (Samuels et al, 2008).
FloodProBE focuses on urban flood risk identification and assessment and on offering cost-effective solutions for the most important risk contributors, such as assets of high vulnerability like critical infrastructure networks and weak links in flood defence systems. The project develops solutions trough easily accessible technologies, concepts, methods and tools, for practical application by public authorities, asset managers and their consultants.

- Several of the developments in FloodProBE represent improvements in form of extensions or additions to existing modules in such DSS. FloodProBE will elaborate the results of its activities in form of modules or methods that can be integrated in the different national DSS for flood risk management. New insights, methods and tools will be integrated in existing DSS and tested at pilot locations to illustrate the impact of the newly developed knowledge and technologies.
- Furthermore, the newly developed knowledge in FloodProBE will lead to amendments of existing and the creation of new guidance documents on vulnerability assessment, flood defence assessment and protection and flood-proofing measures. This will contribute to harmonisation of approaches and guidance throughout Europe and form an essential contribution to the implementation of the EU Flood Directive.

Application will enable the problem-owners to increase the effectiveness of their investments in flood protection and flood-proofing, by identification and targeted improvement of "risk hotspots", as well as by utilisation of the newly developed cost-effective technologies and concepts. The final impact is a significant saving on the costs of flood damage and protection in Europe.
The developed solutions will be generic and applicable in urban areas across the EU and worldwide.

Towards flood-resilient urban environments

Uncertainties about climate change scenarios and autonomous economic and social developments make it difficult to determine optimal strategies for urban flood risk management. It is likely that a combination of flood prevention and flood resilience is a robust strategy. Making urban environments more flood resilient means, amongst other aspects, to make it less susceptible to flooding

and to increase its recovery capacity after flood damage has occurred. FloodProBE will develop new assessment capabilities for the vulnerability of the urban environment and the reliability of flood defences such that they can be integrated easily in the existing flood risk management decision support that is done mainly on national or regional level.
The contributions to harmonisation in guidance clearly supports a European instead of national or regional approach and supports the implementation of the EU Flood Directive. In order to achieve the expected impact described above, the FloodProBE consortium recognizes the need for effective stakeholder involvement in order to develop solutions that meet the end-users needs and that can be applied in practice. Learning, testing and demonstrating through pilot sites strengthens the link between research and practice. The associate program also ensures stakeholder participation to obtain relevant and practicable results in terms of guidance and enhanced decision support tools.

WEBSITE: www.floodprobe.eu

Brainstorming of RTD projects – Session C: Extreme floods

Smart Resilience Technology, Systems and Tools- SMARTeST: Technologies for improved safety of the built environment in relation to flood events

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The project, involving 10 European research institutes, will develop flood resilience systems. It will seek to develop innovative and smart technology and products and to introduce new systems. The emphasis is on cost effective solutions to flood resilient systems in the urban environment.

Background

Climate change and rapid urbanisation will result in increasing flood problems in urban environments through this century. The Foresight Future Flooding project identified potential increases in flood risk by the 2080s of up to 20 times the current risk for the UK as a whole (expressed in economic impacts), unless current policies and investment levels are changed. According to EU policy (EC 2003, EC 2007/60) flood risk management is the appropriate strategy to cope with this increasing flood risk rather than traditional flood defence strategies which try to reduce the flood risk through blocking the pathway using dikes and walls. Flood risk management deals with the flood problem in a more holistic way adapting all components of flood risk. In this context the flood resilience strategy gains great importance as it seeks to reduce the exposure and vulnerability of the receptors which are the population, the built environment and the urban infrastructure. Resilience measures not only consist of individual technical solutions but they need to be integrated to a 'safety chain' which requires the development of resilience systems and tools (see Figure 1) (picks up the intentions of the call ENV.2009.3.1.5.1). They should facilitate their implementation into practice by improving the decision making and acceptance of communities at risk.

Flood Resilient Technologies (FRe) are already established (traditional measures), but many are emergent as they are at their inception or not applied yet. Knowledge and understanding needs to be improved to establish and adapt them in a way that they suit the dynamics of the urban environment. As a consequence of the paradigm shift of the EU water policy (Directive 2007/60/EC, EC 2003) from defence to living with flood, the industry and research has already reacted by developing products, and materials for buildings to enhance their resistance against flood water. The range of vendors offering flood products is already extensive with multiple solutions to adapt buildings for flood (dry-proofing technology) or to adapt their materials and interior to the probability of flooding. Research organisations and authorities reacted on this development by releasing guidelines for their application.

FReM	Type of measure	NS Responses	object
Techniques	Wet-proofing	Traditional	Built environment
	Dry-proofing	Emergent	
	Floatable buildings	Emergent	
	Transportable pumps	Traditional	
	Flow resistant objects of infrastructure	Emergent	Infrastructure
	Water proof sewers, electrical and telecommunication lines.	Traditional	
	Runoff Conveying streets, parks, corridors	Emergent	
System	Flood proof building	Emergent	Adaptation of flood prone area
	Exceeding water conveyance system		
	Flood compartment systems		
	Flood proof infrastructure system		
Tools	Flood proof seal	Emergent	Capacity building & Decision Making
	Building codes		
	Financial incentives		
	Insurance service		
	Reserve funds	Emergent	
	Evacuation and rescue plans		
	Decision support tools		
	Learning tools for capacity building		

Figure B1.1: Flood Resilience Measures (FReM) for urban environment

However, private stakeholders and professionals seldom make use of these new opportunities for the following reasons:

- Insufficient transparency of the performance of the products
- Uncertainty of their efficiency
- Complex technical solutions may not be easily integrated into decision making processes
- Uncertainty how to best utilise and weight flood risk data within decision making
- Inefficient information dissemination according to the great variety of stakeholders

- Insufficient appreciation of the variety of stakeholders concerns
- No coherent information about the new technologies
- Insufficient capacity of stakeholders
- Uncoordinated activities and responsibilities of stakeholders.

Aim and objectives

The aim of SMARTeST is to improve the *Road to Market* of innovative Flood Resilient (FRe) technology by reducing deficiencies and obstacles in the implementation of Flood Resilience Measures, facilitating the design of more holistic flood defence systems and supporting the implementation of the new EU flood risk management policy of "Living with Floods". New technology, systems and tools will be developed. Guidelines for validating their performance will be established and applied in experimental studies to determine the reliability of today's Flood Resilience products.

This will be accomplished through the following specific **objectives**:

- Development and enhancement of innovative technology for the protection of buildings and urban infrastructure from flood:
  - to evaluate the reliability and efficiency of FRe-measures
  - to provide cost effective solutions for existing and new structures within the context of safety standards (building regulations) in national countries
- Development and testing of 'smart' flood resilience technology that progresses technology and test methods beyond the current state of the art, including:
  - Innovative products that can respond and react to flood incidents with minimal human intervention are the prime technological development that will be investigated.
  - Products for resilience of urban infrastructure, focussing on transportation, bridges and dams.
  - Technology to adapt streets, parks and corridors for conveyance of excedance storm water.
- Testing systematically the performance of FRe-products with experimental facilities in hydraulic laboratories of some involved partners and derivation of guidelines for the validation of FRe-technologies and systems.
- Analyse and assess different systems of flood resilience in urban environments corresponding to different flood types (pluvial, torrential, fluvial and estuarial).
- Exploring through review of literature and interview in representative cities of Europe the societal and administrative barriers and implications to implement flood resilience measures at buildings and infrastructure

- Develop new integrative flood resilience systems as a 'safety chain', and develop strategies for integration in existing flood defence systems and urban development.
- Development of guidance and best practice examples for public and professional stakeholders to raise their knowledge, stimulate and guide the implementation of FRe-technology and systems.
- Disseminate the research results at local, national and international level to maximise the impact from the findings.

Strategy and methodology

The project strategy uses the work package system to address the technology, systems and implementation for flood resilient technology. The three main strands of the research will be brought together through an integration work package. The strategy also involves a significant amount of dissemination activity in order to make an impact. Dissemination activities will be varied to reach a variety of stakeholders and to make an impact from the research results.

Impacts and scientific output

This project will act as a springboard to the use of the next generation of FRe-technology. Such technology may be based on so called smart systems that incorporate sensor technology, automatic control, innovative materials and high levels of performance. This innovation will improve the effectiveness especially in the case of pluvial and flash floods where extreme short response time requires automatic deployment of FRe-systems. Through involvement of commercial enterprises and service providers it is believed that the research outcomes of this project will be directly applied by the FRe industry and will especially trigger the development of new markets for the protection of urban infrastructure.

The project will result in the development of guidance documents for validating the performance of FRe technology and in experimental studies the reliability of today's Flood Resilience products.

The project has the potential to make a significant beneficial contribution to flood risk management in Europe and will foster the development of more holistic flood defence systems which will lead in the end to flood resilient cities. The project will substantially reduce the damage, the costs and the health impacts associated with flood hazards.

The selected case studies (Manchester, Hamburg, Dresden, Paris, Valencia, Rotterdam, Athens and in Cyprus) cover various regions of Europe and the coastal regions of the Mediterranean and North Sea. The case studies will be used as instruments for research into systems and the implementation of flood resilient technology.

The scientific outputs are as follows:

- Draft European Standard (technology)
- Model of FRe systems and a research report on systems design options
- A damage model for the simulation of FRe construction, technology and system
- A decision support tool for professional stakeholders in flood resilience technology
- A guideline for the implementation of flood resilience construction, technology and system by stakeholders
- Workshops at local level in case study areas to define requirements for FRe systems
- National workshops for local contact and language dissemination
- International conference
- International publication – research report – draft version
- Policy brief on environmental impact of the research.

National Support Groups and the Application and Implementation Group
National Support Groups (NSGs) will be formed in each country. These groups will be composed of representatives of national governments, local government, environment agencies, industry and local flood forums. The intention of the NSG will be to provide support to the project from each country and to represent the interests of the country and industry in the research. The NSGs will effectively have a role to help to steer and advise the project team. In return the NSG members will have access to the research results at an early stage, in advance of the publication of the findings. In addition, members will have access at reduced rates to dissemination events that will be organised in the UK and on an international basis. The UK NSG represents a substantial opportunity to network with key stakeholders in the field of flood management through regular meetings of the group and virtual networking through a project web site.

The Application and Implementation Group (AIG - external experts to the project) will be composed of a group of 12 experts that will be chosen by the project management group. The members of the Application and Implementation Group will have a heavy industry focus and be central to the use of the technology (manufacturers, standards makers, suppliers, designers, water and sewage/drainage utility companies and contractors).

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HYDRATE: Hydro-meteorological data resources and technologies for effective flash flood forecasting

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Instrument: STREP FP6
Total Cost: 3.422.059,97 €
EC Contribution: 2.350.000,00 €
Duration: 36 months, extended to 45 months
Start Date: 1/09/2006
Consortium: 17 partners from 12 countries
Project Coordinator: Marco Borga, University of Padova (Italy)
Project Web Site: www.hydrate.tesaf.unipd.it
Key Words: flash flood; hydrometeorology; flood forecasting; flood risk.

- **The Problem:** Issue being investigated

Flash floods are localized flood events that occur in catchments up to few hundred square kilometres, with response times of a few hours or less. In the last decades, Europe experienced several catastrophic flash floods, which are among the deadliest weather-related natural hazards. Flash flood risk management requires specific and appropriate technologies and procedures; among these, flood forecasting and warning represent one of the main options. Flash flood events, however, are difficult to monitor because they develop at space and time scales that conventional measurement networks of rain and river discharges are not able to sample effectively. *Observational uncertainties and associated current poor knowledge of the hydro-meteorological processes leading to flash floods hamper advances on the development of appropriate flash flood risk management methodologies.*

- **The Project Objectives**

Better understanding of stream and landscape response to flash flood-generating storms is critical to improve effectiveness of flash flood risk management, including flood forecasts and warning. However, flash floods are locally rare and poorly-observed events. This call for the organization and analysis of the existing patrimony of data concerning past European flash flood events and for the development and harmonization of an innovative European observational strategy focused on flash floods. Therefore, the overarching objective of the project is to improve the scientific basis of flash flood risk management, through:

- analysis of past flash flood events at the European scale;

- advancing and harmonising across Europe a common flash flood observation strategy;
- developing and validating a coherent set of technologies and tools for effective flash flood risk management, including early warning systems.

- **The Methodology**

The methodology is developed around three main themes:

Collation of data and analysis of past major flash flood events. This provides a coherent presentation of European flash flood events, with homogenous coverage of meteorological and hydrological characteristics, and damages. The analysis provides improved understanding of inherent space-time scales, storm structure, and hydrological/hydraulic causative processes.

Development of a flash flood focused observation strategy. This is centered on the development of a network of Hydrometeorological Observatories, and includes i) the development of innovative observation techniques for a better characterization of flash flood events; ii) the development of a common methodology for post event field investigation.

Development of methodologies and tools for effective early warning systems for flash floods, with specific focus on ungauged basins. This includes i) linking local threshold-based models to the larger-scale hydrologic explicit soil moisture accounting models used operationally by the river forecast centres; ii) developing regionalization procedures for flash flood forecasting in ungauged basins; iii) examination of the social response to flash floods.

- **Project Results** (outcome and who can benefit from the results)

There are three main results from the project:

The flash flood focused observation strategy.

This includes two specific steps:

i) procedures for radar rainfall estimation at the ground during extreme rainfall;
ii) guidance and software for more effective execution of post-event field campaign.

Procedures for radar rainfall estimation at the ground during extreme rainfall: HYDRATE developed a set of re-analysis of weather radar observations available for the event, with the goal of reducing biases and local errors that continue to plague operational real-time radar products. The procedures benefit from data collected with bucket surveys of rain gauges and analysis of echo return from ground clutters to adjust for errors due wavelength attenuation.

The set of homogeneous procedures were tested over different weather radar systems from different European countries.

Guidance and software for more effective execution of post-event field campaign: Traces left by water and sediments during the flood provide an opportunity for developing spatially detailed post-event surveys of flash flood response along the stream network. Indirect methods such as slope-area, contracted opening, flow-over-dam, or flow-through-culvert are often used for this purpose. HYDRATE developed a set of integrated procedures, including guidance and software, for the effective execution of post-flood surveys, which incorporate: peak flood estimation at multiple site in the impacted area; eyewitness account collection; data integration through distributed hydrological modelling.

The freely accessible European flash flood data center. This includes development of methodologies for organising data from already established hydro-meteorological observatories, and from complementary information gathered following a flash-flood. The data have been organised according to i) primary data, and ii) high resolution data for specific exceptional flash flood events.

Flash flood primary data: Primary data are represented by: occurrence date; catchment area; peak discharge. Flash flood data from seven hydrometeorological regions in Europe have been collated. The resulting data base is provided at http://www.Hydrate.tesaf.unipd.it/ (HYDRATE flash flood data center). The examination of flash flood regimes across Europe shows that space and time scales of flash floods change systematically when moving from Continental to Mediterranean regions, while seasonality shifts accordingly from summer to autumn months. This has several hydrological implications, which need to be considered, for example, when examining potential effects of land use (urbanisation, deforestation, afforestation) and climate change on flash flood occurrence.

High resolution data from a set of extreme flash floods: Data from 25 high-intensity events occurred in Europe in the period from 1994 to 2008 have been collected (including radar rainfall observations, peak discharges, data consistency check). The analysis of these events led to three important observations: i) runoff ratio from these events is generally low, with a mean value of 0.35, which shows the influence of the hydrological processes in the triggering of flash floods; ii) the runoff ratio is significantly influenced by antecedent wetness conditions; iii) for most of the events, the flood response time is less than 6 hours, which therefore represent a physical constraint to the event-risk management strategies.

The integrated methodology for flash flood risk management in ungauged basins. This integrates tools for i) improved analysis of regional flash floods severity; ii) radar-based precipitation nowcasting and radar-data assimilation for precipitation forecasting, iii) hydro-meteorological models for early identification of areas susceptible to flash flood, iv) analysis of the social response to flash floods.

Improved analysis of regional flash floods severity: HYDRATE developed a set of methodologies for using major flash flood events occurred at ungauged catchments to reduce the uncertainties in estimating regional flood quantiles. The method is based on standard regionalization methods assuming that the flood peak distribution rescaled by a site-dependent index flood is uniform within a homogeneous region. The methodology has been applied successfully at several site in Europe subject to different flash flood conditions.

Radar-based precipitation nowcasting and radar-data assimilation for precipitation forecasting: HYDRATE developed a set of procedures for the assimilation of radar rainfall observations into Numerical Weather Prediction (NWP) models for the forecasting of flash flood triggering precipitation. The methodology has been developed and tested under quasi-operational conditions. The impact of the radar data in the assimilation cycle of the NWP model is very significant, in that the main individual organized convective systems were successfully introduced into the model state, both in terms of timing and localization. This led to strongly improved flash flood forecasts in the area impacted by the event.

Hydro-meteorological models for early identification of areas susceptible to flash flood: HYDRATE developed and tested an approach for the early identification of areas susceptible to flash floods which may be used without calibration data, hence applicable to ungauged basins. The approach is based on the use of the Flash Flood Guidance (FFG) method and a method of model-based threshold runoff computation to improve the accuracy of flash flood forecasts at ungauged locations. The HYDRATE approach requires running the hydrological model to derive flood frequencies at the outlet of the ungauged basin under consideration, and then to derive the threshold runoff from these model-based discharges. The approach provides a pragmatic method to characterize flood severity at ungauged locations. The work examined the potential of this method to account for the hydrologic model uncertainty and for biases originated by lack of model calibration on local conditions. The methodology has been applied successfully under operational conditions in several areas of the Hydro-meteorological Observatories.

Analysis of the social response to flash floods: HYDRATE analysed how the improved methodologies for early flash flood warning can meet the requirements of the population at risk. HYDRSATE introduced a broad characterization of the event management activities into three types according to their main objective (information, organisation and protection) and according to the scale of human organisation dynamics (individuals, communities and institutions). The analysis coupled analysis of the geophysical and social aspects and led to conclusion about i) the characterisation of the social responses according to watershed scale and to the information available, and to ii) the appropriateness of the existing surveillance and forecasting tools to support the event management activities.

The outcomes from the project will benefit two different communities:

- professional communities and users involved in the assessment and management of flood risk and in the flood forecasting area,
- the academic and applied research community, for which many issues related to flash flood are challenging.

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FRMRC – Flood Risk Management Research Consortium

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Outline of FRMRC Phase 1 project

In 2004, the UK the Engineering and Physical Sciences Research Council (EPSRC), in collaboration with the Defra and Environment Agency Joint R&D programme on Flood and Coastal Defence, NERC, the Scottish Executive and UKWIR, agreed to fund an interdisciplinary research consortium investigating the prediction and management of flood risk. The concept behind this innovative joint funding arrangement was that it allowed the Consortium to combine the strengths of fundamental and near-market researchers and research philosophies in a truly multi-disciplinary programme. The Consortium research team engaged over 29 Post Doctoral Research Associates alongside Postgraduate Research Students and an extensive group of academic and industrial researchers. The intention of the Consortium was to derive added value from such an integrated approach in a manner similar to EU FP6 Integrated Projects. The objective was to increase the understanding of flooding by generating new and original science, which then supports improved flood risk management. The research portfolio for the Consortium was formulated to address key issues in flood science and engineering, while being consistent with the agreed objectives of the principal funders. The portfolio of research included:

- The short-term delivery of tools and techniques to support more accurate flood forecasting and warning, improvements to flood management infrastructure and reduction of flood risk to people, property and the environment;
- The establishment of a programme of high quality science to enhance the understanding of floods and to reduce flood risk through the development of sustainable flood management strategies.

The work of the Consortium, and its outputs, has been displayed on the Consortium website where the user-focussed reports include:

- Exploitation of new data types to create digital surface models for inundation modelling

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- Integrated surface and sub-surface interactive flooding and inundation model
- Updating algorithms in flood forecasting
- Flood risk management policy issues
- Accounting for sediment in rivers
- Improved approaches to condition assessment: performance-based visual inspection of flood defence assets
- The influence of desiccation fine fissuring on the stability of flood embankments
- A user guide to the risk and uncertainty decision tree wiki site

Some of these research outputs have already passed in to use in practice within the Environment Agency. At the close of the first Phase of FRMRC in 2008 the project publications included 81 Journal papers, 114 conference papers, 5 book chapters and 32 project reports. In addition 12 PhD students had submitted theses successfully on their research in the project. Subsequently these numbers have increased.

Scientific development and expected outputs of FRMRC Phase 2

The second phase the FRMRC started on completion of the work of FRMRC 1 so that there has been no break in the momentum of the research. Additional funders have agreed to contribute to the project through EPSRC including the Office of Public Works of the Republic of Ireland. The work programme has been renewed to address priority issues agreed with the funders and not covered in the first phase. The research is organised into 5 “Super” work packages and there are cross-project activities on integration and dissemination of knowledge.

SuperWP1: Inundation Modelling - Catchment Flooding

- Hydrodynamic modelling to support enhanced flood risk estimation
- Inundation modelling to support uncertainty analysis
- Rapid flood spreading methods
- Implementing a next generation decision support framework for strategic planning
- Demonstrating strategic flood management of catchment systems
- Demonstrating strategic flood management of estuary systems
- The development of codes of practice for risk and uncertainty estimation in different areas of flood risk management

SuperWP2: Inundation Modelling - Coastal Flooding

- Coastal flood risk modelling
- The extension of uncertainty estimation methods to coastal and estuarine systems
- Tidal surge forecasting

SuperWP3: Urban Flood Modelling
- Quantifying contaminant connectivity across the rural-urban interface and its impact on human health
- Methodologies for improved urban flood risk assessment
- Quantitative precipitation estimation during extreme storms
- Short term forecasting of storm events over urban areas under extreme conditions
- Real-time forecasting of pluvial flooding
- On-line sewer flow and quality utilising predictive modelling
- Improved understanding of the performance of local controls linking the above and below ground components of urban flood flows

SuperWP4: Infrastructure Management
- Predicting and managing flood risks associated with debris at structures
- Performance based inspection of flood defence infrastructure integrating visual inspection and quantitative survey measurements
- Broad scale integration of coastal flood and erosion risk models
- Breach size – rapid methods of assessment
- Next generation tools to support robust and sustainable asset management

SuperWP5: Land Use Management
- Source-pathway-receptor modelling for flood impact of upland land use and management change
- Source-pathway-receptor modelling of sediment yields and downstream morphological responses to changes in climate and land use: upland catchments
- Wetland land use management
- Source-pathway-receptor modelling of sediment yields and downstream morphological responses to changes in climate and lane use: lowland catchments

Conclusions and further research needs

Research conclusions

This section illustrates some of the research conclusions of FRMRC but the project has produced substantially more advances than it is possible to describe below.

The research in FRMRC Phase 1 produced two apparently conflicting results on the effects of land-use and land management on floods. These are important in the context of the European Floods Directive which advocates land management and catchment water retention as a flood risk management measure.
- The research has established a link between land use and land management in upland areas and the hydrological response both in terms of water and

sediment runoff. This link has been shown through field-scale observation which has yielded data for models construction and validation at small scale.
- The research failed to show any linkage at the large scale between land use change and flood hydrological response in a lowland area through scenario testing in a distributed catchment model.

The research developed a visual inspection methodology for condition of flood defence infrastructure which relates systematically visual signs of distress and deterioration of the various components of flood defence infrastructure to its likelihood of premature failure in a flood. This research has already been taken into UK practice and informs assessments both of
- the current level of real flood risk in an area given the condition of the defences and
- how the maintenance and renewal expenditure can be directed to achieve the best effect.

Thus this research contributes knowledge for all three actions of the European Floods Directive – preliminary flood risk assessment, flood risk mapping and the preparation of flood risk management plans.

A full probabilistic analysis of flood risk requires many realisations of flood conditions that may be experienced in events of many difference magnitudes and states of performance of the flood defence infrastructure. To support this FRMRC has been researching new inundation modelling methods which have sufficient accuracy of the main risk parameters (e.g. flood extent and depth) at a fine scale over large areas but which run with substantially reduced resources compared with full hydrodynamic simulation. These methods can be set in a Monte-Carlo sampling framework to provide information at local, regional or national scale for policy and strategy assessment. The work involved close collaboration with the FP6 Integrated Project FLOODsite and have been demonstrated in practice in the appraisal future flood risk management strategies for London in collaboration with the Environment Agency.

The research on real time flood forecasting has focused on the development of new multi-parameter weather radars for rainfall measurement, the use of artificial intelligence, real-time updating of model parameters, estimation of uncertainty in model forecasts and its propagation through complex modelling systems. Some of the results of the research are already being implemented for operational flood forecasting in England and Wales.

Another aspect of the research investigated how river sediment dynamics and morphological changes affect flooding, habitat, and risks to the environmental and public health. Initial work assembled the “Sediment Tool Box” of approaches to account for sediment at broad scale in integrated flood risk management. The research also tracked through field measurements the cycling of contaminated sediments from former mine working in the headwaters of a major rivers downstream through erosion, transport and deposition of the flood plain over decadal time scales. The science in this part of FRMRC has important policy application in the national regulation and remediation of contaminated flood plains, the linkages between the Floods Directive and the WFD in terms of hydromorphology and potentially the future European Soils Directive currently under negotiation.

FRMRC includes research on simulation of floods through urban areas including the interaction between surface and sub-surface flows and examining the impact of urban flooding on human health. The research in Phase 1 was undertaken in the context of several practical applications to real cases in collaboration with local authorities. It also produced practical guidance on the application of existing modelling methods to complex urban floodplains. There are good links in Phase 2 between the research in FRMRC and the FP7 project CORFU, which is coordinated at University of Exeter one of the partners in FRMRC.

The first phase of FRMRC included an important component of social science research; the understanding of risk requires an appreciation of the effects of flooding on society and reactions to it. The research showed that the adoption of policy change often occurs after a major flood but in the context of scientific advance. In terms of risk communication the insurance sector was more open to acknowledging and owning the uncertainties embedded in estimation of risk than the public sector responsible for planning and warning. The research found that having different forms of maps and modelling and updated maps available was confusing for the public and sometimes caused difficulties in communications with professional partners. The research also revealed that stakeholders and the community have a good awareness and understanding of flooding issues in their local area, especially if they have had experience of its effects. A key finding was that traditional consultation procedures have been aimed at gaining agreement and acceptance of plans or proposals and not necessarily designed to either maximise response or gather local knowledge. These conclusions should be considered in the preparation of the maps and plans required for the implementation of the European Floods Directive.

Open questions for further research

The implementation of measures and instruments for flood risk management requires cooperation, communication and understanding across several professions and more generally with the public. Moreover, the context in which flood risk management takes place is not static; there are changes in the physical flood risk system itself as well as in the external drivers (such as climate and demography), autonomous technological and social change and direct policy responses. Important research questions remain across the range of physical and social sciences involved in flood risk. Amongst these are:

- Quantifying uncertainty within assessments of flood risk, particularly in response to climate and social change
- How knowledge of the character and magnitude of uncertainty on current and future risk can be communicated better to professionals and the public to inform flood risk management policies, decisions and actions
- Appraisal methods to incorporate and value adaptability and flexibility of flood risk management measures to inform and optimise flood risk management policies, decisions and actions
- The contribution of land use and management activities to flood risk management objectives at different spatial and temporal scales and their effectiveness in different severity of events
- Techniques for improving flow velocity estimates as well as depth in rapid flood modelling used in probabilistic assessment of risk
- Methods to include a comprehensive and multi-factorial view of risk in flood risk assessment at all scales incorporating loss-of-life, indirect and intangible damages as well as those easily monetised
- Short-term precipitation forecasting and flash and pluvial flood warning in urban areas at the sub-kilometre spatial scale
- The interaction of objects of anthropogenic origin with floods, flood management infrastructure and the consequent enhancement of risk, including vehicles, domestic refuse and large-size objects of domestic and non-domestic sources
- The effects of ageing of flood defence infrastructure on failure probability

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Brainstorming of RTD projects – Session C: Extreme floods

EQUIP –End-to-end Quantification of Uncertainty for Impacts Prediction

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Outline project description

Overview of project and its objectives

EQUIP brings together the UK climate modelling, statistical modelling, and impacts communities to work closely together for the first time on quantifying uncertainty and developing risk-based prediction for decision making. Through quantifying uncertainty more systematically across climate and impacts, and through working with users, EQUIP will lead to improved utility from ensemble climate simulation and climate science. The EQUIP partners will illustrate the cascade of uncertainty from climate to impacts by conducting integrated analyses of a range of sectors, principally crops, marine ecosystems, water management and heat related mortality due to heat waves and droughts.

This is significantly different from tagging impacts models onto climate models, since it implies analysis of sources of uncertainty and use of the resulting information to find better ways of quantifying uncertainty in predictions of climate impacts for decision makers. The project will result in advances in methodology that will enable more systematic quantification of uncertainty and hence more confident statements about climate, climate change, and its impacts.

The principal time-frame for the impact predictions considered in EQUIP are those relevant to decision-making in practice within the next generation; thus EQUIP specifically covers methods of quantifying uncertainty at the decadal time-scale of prediction. The research includes assessment of the information content of climate model projections, combination of climate models and data-driven models to support decisions, and evaluation of the quality of climate and impacts predictions.

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Although the project science will be mainly undertaken within the UK academic sector, EQUIP will ensure practical relevance and utility of the science through substantial interaction with other organisations and stakeholders from development NGOs to the insurance sector and policy makers.

The Consortium

The project team which is funded by the British Natural Environment Research Council (NERC) includes researchers from the universities of Leeds, Exeter, Edinburgh, Newcastle, Liverpool, Reading, the London School of Economics and the Plymouth Marine Laboratory. Additional project partners include the UK Met Office, the British Environment Agency and the aid charity CAFOD. The research on the project commenced in January 2010 and the research team will receive a total grant funding of approximately €1.7 Million from the *Living with Environmental Change* programme of NERC. The project has established an external advisory group to provide independent review and advice to the research team on the progress and management of the research; the advisory group includes membership from the research community and potential users of the science from the UK and internationally. The EQUIP team has established collaboration with several UK and international initiatives including: IPCC AR5 WG1 and WG2, the UK Climate Impact Programme (UKCIP), the UK Government Foresight Programme, the NERC project AEROS (AErosol model RObustness and Sensitivity study for improved climate and air quality prediction), the FP7 project MEECE (Marine Ecosystem Evolution in a Changing Environment) and Climate Change, Agriculture and Food Security, an international World-Bank funded project.

Scientific development and expected outputs

The EQUIP project will produce the following outcomes by meeting its seven objectives.

1. Develop new ways to increase and assess the utility of climate prediction for decision makers.

Climate change prediction is an extrapolatory problem and consequently we have no observations with which to verify or confirm a forecasting system. Nevertheless there are a number of avenues to pursue to assess the strengths and weaknesses of different approaches and to build necessary, if not sufficient, conditions for utility, through which we might gain greater confidence in statements about future climate and its impacts. This work will build on experience and expertise in the field of non-linear dynamics, and will study questions of how observations of the past might be best used to provide one of these necessary but not sufficient conditions.

2. Improve current approaches to quantifying uncertainty in predictions of climate impacts.

This will be achieved through application to the climate-and-impacts system of the methods commonly used to quantify uncertainty in climate prediction (e.g. ensemble weighting, Bayesian analysis). This relatively simple transfer of methods will improve impacts projections through improved use of both climate ensembles and observations of impacts variables. Specific issues addressed include the development of appropriate weights for ensemble impacts prediction: does weighting on impacts skill improve the quality of projections over weights based on climate? This implies effective combination of observations of climate and its impacts with models. Further improvements in methodology are likely to be made through the increased understanding of the cascade of uncertainty associated with objective 5 below.

3. Construct comparable sets of risk-based climate and impacts predictions.

These predictions will be based upon the new approaches and systems developed in the project. They will include an assessment of the relationship between predictability and spatial scale (i.e. reliability of regional vs. continental scale predictions). This will produce new sets of predictions, based on existing climate simulations, which will inform both Working Group 1 and Working Group 2 of the IPCC AR5. The predictions will also be made available to the wider scientific community for academic use.

4. Develop a framework for evaluating the performance of climate and impacts predictions.

There are two reasons for evaluating climate and impacts predictions in the project: to inform assessments of the trustworthiness and value of future predictions by quantifying the performance of climate prediction systems when applied to historical prediction problems; and to inform the use of predictions for making decisions and for improving prediction systems by furthering our understanding of sources of uncertainty. Unlike weather forecasts, the performance of historical climate predictions may be an unreliable guide to future performance because the climate system is evolving into previously unrecorded states. Additional obstacles include the small numbers of climate predictions and commensurate observations that are available for evaluation, and how to account for the effects on performance of past evolution of the climate system. In meeting this objective, therefore, we shall develop the new tools that are required for evaluating the climate and impacts predictions produced in the project. This will transfer ideas from weather forecast verification to create a new framework for evaluating climate predictions and will highlight new research directions in both fields. Quantitative measures of the quality of climate and impacts predictions will be produced and will inform assessments of the skill of future forecasts.

5. Further understanding of the cascade of uncertainty from climate to impacts and its relationship to model error and climate predictability.

The climate and impacts communities will be brought together in analysing the interaction between climate and impacts uncertainty. Uncertainty in climate simulation, model error and the predictability of climate have implications for the predictability of climate impacts. Furthermore, non-linearities in the response of impacts variables (e.g. crop failure resulting from a few days of elevated temperature during flowering) necessitate understanding of a broad range of non-climatic uncertainties (e.g. when the crop flowers, the likelihood of high temperatures during this period and the impact of those temperatures). By increasing our understanding of this cascade of uncertainty, the situations in which climate models can produce useful information, and those in which they cannot, will be identified. Thus the situations in which uncertainty prevents skilful forecasts of climate impacts will be identified. The research will provide new knowledge of these interactions for the examples of crop production, marine ecosystems and European heat-waves and droughts.

6. Interact with users to inform developments and to guide the use of climate and impacts predictions.

The project will promote the use of risk-based prediction systems among stakeholders and will help the research community to understand better the requirements of decision makers. A range of users, from the insurance sector to the development NGOs, have expressed a strong interest in this project. Through early engagement and continual involvement with the project, these users will be enabled to understand and use better climate information. The interactions with the user community will provide the scientists in EQUIP to have a greater understanding of the needs of these users. Opportunities for establishing long-term collaborative partnerships between researchers and users will be created.

7. Grow the community of scientists and users who collaborate to quantify uncertainty in climate and impacts predictions.

This project brings together the UK climate modelling, statistical modelling, and impacts communities to work closely together for the first time on quantifying uncertainty and developing risk-based prediction for decision making. Internal and external collaboration are an integral part of the project, with our activities disseminated through a web site and a conference at the end of the project. The project will build a coherent community with long-term interests in furthering research leadership in the field and the EQUIP cohort of postdoctoral researchers will work closely together to gain valuable cross-disciplinary experience that will build capacity in this area.

Conclusions and further research needs

The project research team began work in earnest in January 2010 and so there are no firm conclusions yet from the work. The project team organised the first stakeholder workshop in April 2010 and has also been establishing the requirements of the methodological and sector research teams for access to existing GCM outputs and requirements for new GCM simulations. The project team intend to make a substantial contribution to the scientific literature available on uncertainty in impact prediction in time for its inclusion in the preparation of the fifth assessment report (AR5) on the IPCC.

An important research gap in the context of the International Workshop on *Adapting to Climate Change: Reducing Water-related Risks in Europe* is that EQUIP has no specific activity on the extreme rainfall and flooding. This topic, though of great practical interest, was considered to require more resource that was possible from the project funding available. Greater research issues were seen in quantifying the scenarios and uncertainty for short-term precipitation extremes rather than in the longer term hydrological extremes which lead to drought. Extension of the work and trialling approaches for extreme floods and important and valuable step for research funders to consider.

Project Contact

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EU/UNISDR International Workshop

SUMMARY

International Workshop Climate Change Impacts and Adaptation: Reducing Water-Related Risks in Europe

Introduction

The international workshop "Climate Change Impacts and Adaptation: Reducing Water-related Risks in Europe" was jointly organised by the European Commission Directorate General for Research and the United Nations International Strategy for Disaster Reduction (UNISDR) in Brussels on 6-7 July 2010. Bringing scientists and policymakers together, the workshop gathered more than 80 participants from EU-funded projects of the 6th and 7th Framework Programme (FP6, FP7), IPCC authors, Hyogo Framework for Action Focal Points, National Platform Coordinators and other ISDR system partners as well as representatives of several policy EC directorates.

This event is the second of its kind where the European Commission and the UNISDR joined forces in support of a better feed-in and accessibility of scientific knowledge to the society and to decision-makers in the context of disaster risk reduction. While the workshop held last October focused on natural hazards and disaster risk in general, the present event's theme was on climate change impacts and water-related risks in Europe.

Background

Research and policy consider climate change impacts on the hydrological cycle from different viewpoints. Understanding of processes and research on disaster risk reduction as a mean to adapt and mitigate climate change is of key importance to directly support policy development towards risk reduction and implementation. Hydro-meteorological extremes, such as floods, droughts, storm surges etc., are prone to lead to possible negative impacts on ecosystems and human health, as well as on water system reliability and operating costs. Besides this, changes in water quantity and quality due to climate change are expected to affect food availability, water access and utilisation, especially in arid and semi-arid areas, as well as the operation of water infrastructure (e.g. hydropower, flood defences, irrigation systems). In addition, impacts on the overall hydro-cycle (in particular extreme events) are raising concerns abut the possible implications for security. For example, decreasing access to water resources and other related factors could be a cause or a multiplier of tensions within and between countries. Security threats resulting from climate change have hence to be closely looked at in the context of social, economic institutional vulnerabilities or resilience and other factors that influence local, national and international relations between countries.

Actions to adapt to climate change at global and EU scales are embedded in European Union policies as well as in international frameworks. At the international level, the Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters (HFA) is the key instrument and global blueprint for implementing disaster risk reduction. Its overarching goal is to build the resilience of nations and communities to disasters by achieving substantive reduction of disaster losses by 2015. This comprehensive framework provides clear guidance on how to reduce disaster risks, including those of climate-related nature and provides directions on enhancing resilience to disasters through political, technical, social, development and humanitarian processes.

Similar actions are highlighted in the White Paper “Adapting to Climate Change: Towards a European Framework for Action” released by the EC in April 2009. Furthermore, the adoption of the EU’s communications “EU Strategy for Supporting Disaster Risk Reduction in Developing Countries” and “A Community Approach on the Prevention of Natural and Man-made Disasters” indicate the need to reduce vulnerability to disasters including water-related risks.

Specific considerations about climate change impacts on the water cycle as well as on the reliability of current water management systems are also tackled by the Water Framework Directive and parent legislation such as the Flood Directive. This framework is complemented by drought action programmes, which also consider climate change components. Disaster risk reduction needs to be regarded as a triple win at all levels: implementing disaster risk reduction policies and programmes can limit the impacts of climate-related hazards, directly support adaptation to climate change, and help to alleviate poverty.

Goal and objectives

The goal of this event was to exchange practices, common knowledge and research programme outcomes on issues related to climate change impacts on water-related hazards.

The three main objectives were:

1. To discuss the state of knowledge, identify research perspectives and needs, and best ways to communicate key findings to policy-makers and other stakeholders (e.g. local authorities, civil protection units etc.);

2. To formulate recommendations on how to ensure smooth communication on policy developments from various perspectives (research, climate, regional policy, disaster risk reduction policies) between policy-maker and research communities;

3. To promote the integration of key scientific findings into European national and EU policies targeting adaptation and risk reduction in water-related hazards as well as contributing to the 5th IPCC Assessment Report.

Content summary

Brainstorming sessions gathered some 30 projects which were summarised in thematic presentations designed to ensure a better communication of scientific progress and perspectives to the policy-makers present at the meeting. These were followed by presentations by the European Commission and National Platforms for Disaster Risk Reduction and engaged debates with the audience on how to link policy developments and research needs.

The European Commission and UNISDR are at the forefront of efforts to provide guidance on reducing the impacts of extreme events due to climate change and water-related disasters. However, effective policy actions will only be possible if they are based on sound and solid science. Knowledge needs to progress further in the understanding of the climate system, the evaluation of the impacts of climate change and on the identification and assessment of mitigation and adaptation options through risk reduction activities. This endeavour strongly relies on effective partnerships among research organisations and policymakers.

One important component to boost communication and exchanges among the scientific and policy communities, as well as to societal partners, passes through a better science-policy interface. This aspect has been discussed in depth at the workshop, using FP6 and FP7 projects as examples for guiding the debate. While science-policy interfacing difficulties are generally understood, operational solutions are not yet in place to improve links among the two communities. The workshop provided some recommendations in this respect, namely:

- Interdisciplinary / multidisciplinary Research and Technological Development (RTD) projects on disaster risk reduction need to be emphasized. . Natural scientists, social science and policy teams should be encouraged to collaborate to improve the knowledge base on vulnerabilities and impacts as well as the transfer of policy-relevant results. This can be helped by involving relevant users, such as disaster risk management actors, civil society organisations and other relevant stakeholders;

- There is a need to create operational, effective and sustainable platforms aiming at optimising the way research will be used at the international, EU, national, regional or local level. National Platforms for Disaster Risk Reduction may provide mechanisms to respond to these needs. In order to reduce societal vulnerability in an appropriate way, relevant platforms ought to be run in a truly multi-stakeholder fashion and reach out to their constituencies – an important one being the scientific community. Local level entities such as River Basin Districts linked to the Water Framework Directive (WFD) should be used to complement national initiatives;

- Effective transfer should also be investigated in the light of previous achievements, e.g. reference test sites or case studies from RTD or other projects (e.g. LIFE+, INTERREG, UNESCO etc.). "Success stories" or "diagnostics" carried out at different scales could be identified, building up cooperation links among different initiatives;

- The dissemination of science information to different stakeholders (from the international down to the regional levels) should be improved. In this regard, recent examples of "Science-Policy Briefs" starting from policy questions and providing scientific insights have been well received by EU Member States environment agencies. More could be done on the development of guidance documents (translated into different languages) describing research outputs in a practical way. However, while the EU and international organisations may act as facilitators, it remains within the remits of national authorities to take over the relay of the information and its use at the most appropriate scale;

- A better coordination in information sharing is highly desirable. The use and linkages of existing portals on disaster risk reduction reaching from science to local practice should be maximised. Websites/tools such as www.preventionweb.net hosted by UNISDR could be further utilised as knowledge hubs for both scientific and policy communities as well as to societal actors;

Conclusions

In the light of the above, the European Commission DG Research and UNISDR will continue their engagement and collaboration to advance on the science-policy-society dialogue on disaster risk reduction issues. The collaboration will include the organization of future similar events as well as exploring possibilities of using existing networks such as the European Forum for Disaster Risk Reduction to strengthen exchanges between policy makers and researchers; Key scientific findings presented at the workshop will be presented in a special issue of the *Environment Science & Policy* international journal. This publication will be made known to IPCC authors, European National Platform coordinators and HFA Focal Points and ISDR system partners.

EU/UNISDR Workshop – Opening Session

Climate Change Predictions, including Extreme hydrometeorological events

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"It is very likely that hot extremes, heat waves and heavy precipitation events will continue to become more frequent". This is a conclusion common to all IPCC Assessment Reports. However, "although the ability of Atmosphere-Ocean General Circulation Models (AOGCMs) to simulate extreme events, especially hot and cold spells, has improved, the frequency and amount of precipitation falling in intense events are underestimated" (AR4, 2007). It is likely that the latter situation will continue for a long time, that is, unless the meteorological basis of current Climate Models becomes able to simulate some specific local-to-regional processes including land-atmospheric-oceanic feedbacks. The observed anomalies and other effects of these processes are, in fact, addressed in the AR4, and some were already addressed in TAR (2001) as information resulting from EC research filtered into the system. In this context, this work reviews some of the processes that should be considered to improve AOGCMs, with reference to specific quotes and comments in the AR4.

Information gathered during various European Commission research projects in the areas of Atmospheric Chemistry and Desertification, i.e., 37 projects from 1974 to 1994, alerted of a loss of summer storms around the Western Mediterranean Basin. This issue was again addressed in 1995 by re-analysing the meso-meteorological information obtained in nine of the EC projects (Annex) and disaggregating the precipitation components for one of the experimental areas used in the projects (Valencia, eastern Spain). The analysis shows that there are three sources of rain in this region, viz: Atlantic Fronts (<20% of total precipitation), Summer Storms (11% to 16% of total precipitation), and Mediterranean Cyclogenesis (>65% of total precipitation). These precipitation components originate from totally different weather patterns. Moreover, the correlation of the Atlantic fronts with the NAO (North Atlantic Oscillation) is negative (–) while the correlation with Mediterranean Cyclogenesis is positive (+).

This situation regarding precipitation components appears to be the norm, rather than the exception, in the Mediterranean and probably in other subtropical areas of the world, which include a very important part of the Global

Climate System Furthermore, in the Mediterranean basin the contribution from Atlantic depressions has been decreasing for the last 50 years, summer storms over the mountains surrounding the Mediterranean have nearly disappeared in the last 30 years, while extreme precipitation events associated with Mediterranean Cyclogenesis are rapidly increasing and becoming more torrential in nature. This is an important point to emphasise, since current Coupled AOGC Models are unable to distinguish between precipitation components in these latitudes. Finally, EC project results show that both summer storms and intense precipitation events due to Mediterranean Cyclogenesis appear to be governed by land-use-atmospheric-oceanic feedbacks.

For example, summer storms form (or used to form) in the afternoon over the mountains surrounding the western Mediterranean basin at 60 to 80(+) km from the sea, as the final stage in a coastal wind system that develops during the daytime and combines the sea breeze and the up-slope winds, henceforth called the **combined breeze**. In this system the sea breeze develops at mid-morning and progresses inland by incorporating, one after another, the up-slope wind cells formed earlier that day. At the leading edge of this combined breeze the air is injected vertically upwards into the return flows aloft, which move seaward and sink over the sea, forming a **"closed"** vertical circulation loop. Storms develop when the Convective Condensation Level (CCL) of the incoming air mass is low enough for deep (moist) convection to be triggered at the leading edge of the combined breeze. If storms do develop, the air mass becomes mixed all the way up to the tropopause, and the closed-loop coastal wind system becomes **"OPEN"**. That is, the system behaves like a small monsoon.

The formation of storms, however, requires the addition of water (evaporated from the surface) to counterbalance the heating that the air mass sustains as it moves inland along the surface, i.e., to bring its CCL below the height of injection into the return flows aloft. Otherwise, its CCL keeps on rising, and a ***"first critical threshold"*** (or tipping point) is crossed when the **CCL becomes higher than the injection height over the mountain tops**. Under these conditions the coastal circulations will stay **"CLOSED"**. That is, storms will not develop, and the return flows aloft will continue moving seaward during the entire day, forming layers that contain the non-precipitated water vapour and the pollutants carried by the combined breeze, and piling them up to 4500(+) m over the Western Mediterranean Basin.

To simulate these processes, e.g., the development of the sea breeze, mesoscale meteorological models require the use of grids smaller than 10 km x10 km. And even when using smaller grids (i.e., 5 km x 5 km), and vertical resolutions at the limit of numerical instability (e.g., 36 m), current models are not able to reproduce the structures documented experimentally over the western Mediterranean. This can be considered relevant as AR4 Section *8.2.2.2 Horizontal and Vertical Resolution*, states that "Changes around continental margins are very important for regional climate change".

Moreover, if the closed-loop conditions develop in other coastal areas of the Western Mediterranean, they can become self-organised during the day to originate a meso-α scale circulation extending to the whole Basin. These "closed loop" conditions have been documented to last from 3 to 9 consecutive days, and recur several times a month, i.e., for a total of 12 to 24 days per month, from late spring to late summer (May-September). During these periods, from $\approx$ 1/4 to 1/2 of the depth of the layers accumulated over the sea on the previous days is recirculated vertically over the basin each day. And because no storms develop, and there is no precipitation inland, these conditions can be considered part of a ***first feedback loop*** that tips the local climate towards increased drought inland.

The self-organisation of the local circulations from the meso-γ scale (to 20 km), through the meso-β scale (to 200 km), into a full-fledged meso-α scale (to 2000 km) circulation during the day can be considered a perfect example of atmospheric properties and processes spilling up and down the meteorological scales, and typical of sub-tropical latitudes. It also means that when storms do not develop, the surface boundary layer becomes folded on top of itself, i.e., after being injected upwards via the leading edge of the combined breezes. Moreover, the observed temperature and humidity profiles over the sea are the result of the systematic folding of the surface boundary layers over themselves during several consecutive days, and other effects too complex to discuss here. This also means that the observed humidity profile is not the result of direct evaporation over the sea, but rather of the displacement of the moist marine air mass towards the coasts, where it becomes heated, and picks up extra moisture, before being injected upwards over the mountains surrounding the sea and, finally, returning aloft and accumulating in layers over the sea.

The self-organisation of the coastal circulation around large enclosed (Mediterranean) or semi-enclosed (e.g., Sea of Japan) seas could also underscore two other aspects mentioned in AR4 when referring to Continental edge effects and lapse rates (*8.6.3.1 Water Vapour and Lapse Rate)*. It stated that "In the planetary boundary layer, humidity is controlled by strong coupling with the surface, and a broad scale quasi-unchanged RH response is uncontroversial". The <u>uncontroversial</u> part of this statement could be <u>just plain false</u>, and it may be the most widely extended fallacy regarding the Atmosphere-Land connection in Climate Change Models. That is, for any region outside flat terrains in the mid latitudes. It is false because when Continental Edges wrap around a large interior sea like the Mediterranean, or around a large semi-enclosed sea, like the sea of Japan, the Continental Edge effects unite to create their own large meso-meteorological circulation. This circulation can dominate the weather patterns in those regions for months. And the effects become particularly important if the Continental Edges are backed by complex coastal terrains, that is, coasts backed by high mountains up to 80(+) km from the sea.

The resulting vertical recirculations could also explain the observed temperature lapse rates including the effects of temperature increases in the airmasses returning aloft (e.g, increases from 13K to 19K documented in the Mediterranean), and the increased water content (i.e., perturbed RH) resulting from evaporation along their land path (but not enough to trigger storms, as mentioned above). These temperature and moisture profiles can be considered "anomalous" with respect to models (currently dominated by advection), which cannot simulate the systematic folding of the boundary layer on top of itself for several consecutive days, and the accumulation of atmospheric properties over the (large interior) sea.

Current numerical simulation models, even when using 2km x2km grids, cannot capture all the details of the observed processes; e.g., they cannot reproduce either the vertical recirculations or the layering over the sea. Nevertheless, the outcome of these processes, i.e., the development of an accumulation mode for water vapour (and pollutants) over the sea, has been validated with water column data from NASA-MODIS since 2000. MODIS data show that there is an intense and prolonged accumulation mode over the Western Basin and the Black Sea in summer, and two weaker accumulation modes over the Eastern Basin in spring and autumn.

These vertical recirculation-accumulation modes make the weather and climate in the Mediterranean Basin, and other semi-enclosed Seas in the subtropical latitudes, very **different** from the mid latitudes. Thus, in contrast with regions dominated by advection, in the Western Mediterranean Basin, water vapour and pollutants can accumulate in layers piled-up to 4500(+) m over the sea, for extended periods during the summer. And, without requiring the high evaporation rates of more tropical latitudes, the above-described mechanisms are able in just a few days to generate a very large, deep and polluted air mass that increases both in moisture content and in potential instability with each passing day.

At the end of each accumulation period (i.e., every few days) the moist and polluted air masses are vented out of the area and can contribute to intense precipitation events and summer floods in Central and Eastern Europe. Moreover, during the vertical recirculations, the greenhouse effect of the water vapour, photo-oxidants (ozone) and aerosols accumulated in layers over the sea enhances the heating of sea surface water during the summer. This propitiates a ***second feedback loop*** where Mediterranean Cyclogenesis fed by a warm(er) sea contributes to an increase in torrential rains and floods in Mediterranean coastal areas from autumn to spring (i.e., effects delayed by a few months with respect to the closing of the first loop).

A ***"second critical threshold"*** can then be crossed in the second feedback loop during intense Mediterranean Cyclogenesis events, if and when torrential rains trigger flash floods, and even mud flows, increasing erosion over the drier and vegetation-deprived mountain slopes already affected by the first feedback loop. This can result in massive soil losses and further reinforcement and propagation of the effects (desertification, drought) caused by the first feedback loop, etc. Available evidence not only indicates that these processes and feedbacks have been operating in the Mediterranean for a long time, but also suggests that fundamental changes, and long-term perturbations to the European water-cycle (extended droughts and intense floods), are taking place right now.

This analysis further suggests that: up to 75% (or more) of the precipitation in southern Europe, i.e., from Summer storms and Mediterranean Cyclogenesis, originates from water that first evaporates and then precipitates, i.e., **it is recirculated**, within the major Mediterranean drainage basin (i.e., all the areas south and east of the European Continental Divide including the Mediterranean and Black Seas). Moreover, on the Mediterranean side of this Divide, rain of Atlantic origin contributes less than ≈ 20% of the total (probably even less than that in Greece), in stark contrast with the Atlantic side of the European Divide where ≈ 80% or more of the precipitation is from water evaporated over the Atlantic.

Finally, land-use appears to play a key role in the loss of summer storms, the shift to more frequent vertical recirculation periods, and the amount of water recirculated within the basin. These findings and the questions they raise are critical for the European Mediterranean Divide:

(a) Drought and torrential rains in areas around enclosed seas in the subtropical latitudes (e.g. Mediterranean, Sea of Japan, South China Sea?) are the result of the same concatenated meteorological processes involving Atmosphere-land-oceanic feedbaks.

(b) The same processes can lead to intense precipitation events and summer floods in other parts of Europe (i.e., points along the European Continental Divide, or within the Mediterranean Catchment side of the Divide). That is, the local-to-regional perturbations can propagate their effects to the Global Climate System.

(c) The basic atmosphere-land-ocean exchange governing these processes are not (and probably can not be included) in current Atmosphere-

Ocean General Circulation Models (AOGCMs).

(d) Thus, the feedback processes in the hydrological cycle, which govern the partitioning and the recycling of the precipitation, and the development of extreme hydro-meteorological events cannot be simulated in the AOGC Models used to assess extreme events in the sub-tropical latitudes.

This situation now presents the research community with very important challenges to improve Atmosphere-Land-Oceanic parametrisations in Atmosphere-Ocean General Circulation Models.

EU/UNISDR Workshop – Opening Session

Managing water-related hazards in London

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In the last decade, London has experienced floods that have damaged homes and infrastructure, a heatwave that killed 600 Londoners and a drought that lead to the construction of a desalination plant. Climate change is expected to increase the frequency and intensity of these existing risks, which unless London adapts, will increasingly affect the prosperity of London, the quality of life of Londoners and ultimately London's reputation as a leading 'world city'.

The Mayor of London is developing a climate change adaptation strategy for the city (http://www.london.gov.uk/climatechange/sites/climatechange/staticdocs/Climiate_change_adaptation.pdf). The Strategy takes a risk-based approach that:

A) Assesses how London is vulnerable to weather-related risks today
B) Uses climate projections to understand how climate change accentuates existing risks, or creates new risks or opportunities in the future
C) Identifies and test risks management options
D) Provides a framework to identify where the Mayor is best placed to act, or encourage and support other stakeholders who could also act
E) Identifies where further work is required to understand the climatic changes and the impacts.

The south-east of England is predicted to experience warmer, wetter winters and hotter, drier summers. Extreme weather, including heatwaves, heavy rainfall events and tidal surges are predicted to become more frequent and more intense. In fact, what is considered an 'extreme' event today, such as the August 2003 heatwave, is expected to become the average by the middle of the century, and a new intensity will define the 2050's heatwave. Sea levels are expected to rise throughout the century, probably by about 1 metre by the end of the century. These changes will mean that London will experience an increasing risk of floods, droughts and heatwaves.

London is vulnerable to flooding from 3 key sources: 'tidal' flooding when tidal surges combine with high tides and onshore winds, 'fluvial' flooding from the freshwater rivers in London and 'surface water' flooding, when heavy rainfall overcomes the drainage system. The city is protected from flooding by a series of flood defences and the drainage system. Fifteen percent of London's area lies on the former floodplains of London's rivers. The standard of protection provided by the flood defences and the area they protect can be mapped and the assets that lie on the protected flood plains plotted. An analysis of 'who and what' is at flood risk today, shows that a significant proportion of London's critical infrastructure lies in areas of flood risk and in addition that some of the poorest Londoners also live in areas of tidal flood risk. This underlines that much of the infrastructure Londoners would rely on in case of a flood is at risk and that the most vulnerable part of the population also live in areas at risk.

The Greater London Authority has been working with partners to determine London's future 'flood gap', using climate projections to understand how much more rainfall is projected to fall in the future and to then compare the different measures to manage it. This comparison will be used to develop 'adaptation pathways', where different combinations of options, from green infrastructure to heavy engineering, are tested to develop a flexible roadmap to resilience through the century.
(http://ukclimateprojections.defra.gov.uk/content/view/919/500/)

Eighty percent of London's water comes from the River Thames and River Lea and twenty percent from the confined chalk aquifer under London. The Thames Basin is the largest river basin in the southeast of England. As such, it offers a more dependable supply of water during droughts than other catchments in the Southeast, as it is able to collect more water.

Despite this, the UK Environment Agency has classified the whole of the southeast of the England as 'severely water stressed'. This means that the amount of water abstracted to meet demands today is causing actual damage to the environment. Under the EU Water Framework Directive (WFD), water companies must contribute to improving the quality of water bodies, which will in effect limit the abstraction from some watercourses, meaning that water supply may fall as unmanaged demand is likely to increase. The Environment Agency is currently assessing what level of 'sustainability reductions' will be required to meet the WFD requirements.
(http://ec.europa.eu/environment/water/water-framework/info/intro_en.htm)

The Greater London Authority has been working with the Environment Agency to look at how to balance London's water supply in the face of increasing demand and declining supplies. The aim is to improve the water efficiency of London's existing stock of 3 million homes to provide water for the future growing population – referred to as 'water neutrality'. In principle this means no net increase in demand despite a growth in the number of Londoners. To deliver these water savings, the GLA is working with the 33 London Boroughs, the 4 water companies and the energy companies on a programme to retrofit water and energy efficiency measures into Londoners' homes at no cost to the householder. The aim is retrofit up to 1.2 million homes by 2015. The ultimate vision is to expand 'water neutrality' to 'water security' where sufficient savings are made to provide a buffer against the impact of climate change on water supplies (including the sustainability reductions referred to above).

In developing the London Climate Change Adaptation Strategy, the following lessons have been learnt:

1) Climate models are tools not answers. In order to be able to use climate projections, stakeholders need to be able to define the vulnerabilities of their system/s and understand what happens when these are exceeded.
2) Adaptation is hindered because we struggle to value social and environmental externalities. This inability to monetise means that standard cost-benefit analyses tend to promote heavy based engineering responses that can be 'accurately' costed.
3) The need to identify flexible 'adaptation pathways' for each risk, recognising that our responses to changing risks must be dynamic
4) You cannot protect all of the people all of the time. Some risks will always exceed our ability to manage them, the key is to identify the vulnerable and the critical and use that knowledge to build adaptive capacity.

EU/UNISDR Workshop – Opening Session

Climate-related hazards and the need to take risk reduction measures: three case studies

Demetrio Innocenti

United Nations International Strategy for Disaster Risk Reduction (UNISDR)

The last decade has seen a massive production of scientific knowledge on the impact of climate change on livelihoods and the environment. In particular, the relationship between climate change and climate-related hazards has been investigated through the creation of climate models operating at different scales (from global to local) and the development of databases for the analysis of climate and hazards data.

Globally there has been an effort to craft a stronger evidence-based body of knowledge which could allow scientifically sound inferences on the links between the changes in global average temperatures and the frequency and severity of climate-related hazards.
The Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report makes specific reference[6] on the impact of climate change on hazards and extreme events. It highlights that *it is very likely* that hot extremes, heat waves and heavy rainfall will continue to become more frequent and erratic with more precipitation at higher latitudes and less in most subtropical areas. The consequences will be a stronger impact of hazards such as flashfloods, floods and seasonal droughts. In addition, the IPCC reports stress that it is also likely that tropical cyclones will become more intense due to the effects of climate change.

In the scenarios depicted by the IPCC, adaptation measures to climate change have a crucial role to preserve sustainable livelihoods and ecosystems both in the developed and developing countries. In this context, investing in Disaster Risk Reduction (DRR) is a crucial political priority and a mean to achieve concrete results in the context of adaptation to a changing climate.

UNISDR along with its ISDR partners (international and regional organizations, national governmental institutions and organizations, NGOs and academia) is

[6] IPCC Fourth Assessment Report, Working Group I, Summary for Policymakers: ttp://195.70.10.65/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf.

promoting Disaster Risk Reduction and the global, regional and national through the implementation of the Hyogo Framework for Action(HFA)[7], which represents the main international agreed policy framework guiding nations and communities in building their resilience to natural hazards.

The HFA recognizes the responsibility of national governments in creating a conducive environment for DRR policies, programmes and investment, nevertheless it also recognizes the crucial role of communities in translating DRR (and climate adaptation) measures into practice.

Since the adoption of the HFA in 2005, UNISDR and its partners have developed several knowledge products in DRR and climate adaptation, these include publications, media and awareness material[8].

Among the awareness products developed, in 2009, two countries **Colombia** and **Vietnam** and one city, **London**, shared their experiences in climate change adaptation through a video supported by UNISDR.

The video discussed the following key elements of the adaptation process:

- The need, in the first place, to understand vulnerabilities and the underlying risk factors for nations and communities.
- Example of practical actions in reducing climate-related disaster risks
- The technical, financial and political challenges in advocating for investments in DRR
- How to deal with uncertainty posed by climate change and the need to invest in climate-risk models
- The ground rule for successful disaster risk reduction projects: involving the communities in planning and developing their own adaptation and DRR strategies
- The need to increase information and good practice sharing in adaptation and risk reduction at the national, regional and global level. This is considered one of the most useful mean to increase the effectiveness and efficiency of adaptation and DRR policies and programmes.

The three case studies showed similarities in the importance they confer to invest in quantitative assessment of the impact of disasters. They identified the

[7] The Hyogo Framework for Action (HFA) is a comprehensive, action-oriented response to the growing impacts of disasters on individuals, communities and national development. The HFA was adopted by 168 governments at the World Conference on Disaster Reduction, held in Kobe, Japan, in January 2005.
[8] UNISDR and ISDR partners material can be found and downloaded on the internet at www.unisdr.org and www.preventionweb.net.

need for tools that can enhance the capabilities of risk models to depict a multiple scenarios in which the with/without DRR investments options are taken into consideration. As well, they identified the necessity of applying a multi-disciplinary approach for climate risk assessments methodologies.

Other elements that emerged, especially in Colombia and Vietnam, is the need to build adaptation strategies on local knowledge. Especially in rural areas, farmers have traditional knowledge on how to cope with climate risks. However, the transmission of this knowledge to the younger generations is threatened by the lack of income opportunities in rural areas. Rural youth migrations to urban areas and the growth of informal settlements also increase urban disaster risks.

The three case studies highlight that there is evidence that a proactive approach to DRR pays off in the future. However, the London case study points out the political challenges of promoting investments in DRR: it is difficult to convince policy makers (who have a short term mandate) to invest limited resources in long term disaster prevention measures.

Interestingly, though with the specific differences in undertaking DRR actions, Colombia, Vietnam and London city, agreed that taking risk reduction measures is "*unavoidable*" in the perspective of a changing climate. The three cases also emphasized the crucial link between research and governance of climate risks. The development of more accurate risk models, especially at the local level, will allow to better deal with the uncertainty posed by climate change and will allow policy and decision makers to take well informed decision on the investments needed for reducing risks.
As a result effective dialogue between climate scientists and policy makers become of decisive importance to address DRR in a changing climate. The HFA promotes the establishment of the National Platforms for DRR, as a multi-stakeholder national mechanism which coordinates and advocate at different levels DRR national programmes. Therefore, National Platforms have a crucial role in sustaining the dialogue between the scientific community and the policy makers. At the regional and international level, organizations such as the European Commission and UNISDR are of critical importance to support the dialogue between the two communities.

EU/UNISDR Workshop – Session 2- Research in support of policy

Outline of FP7 research on climate change & water-related disasters

Philippe Quevauviller

European Commission, DG Research

Climate change impacts on the hydrological cycle (e.g. effects on atmospheric water vapour content, changes of precipitation patterns) have been linked to observed warming over several decades. Higher water temperatures and changes in extremes, including floods and droughts, are projected to affect water quality and exacerbate many forms of water pollution with possible negative impacts on ecosystems and human health, as well as water system reliability and operating costs. In addition, sea-level rise is projected to extend areas of salinisation of groundwater and estuaries, resulting in a decrease of freshwater availability for humans and ecosystems in coastal areas. Besides this, changes in water quantity and quality due to climate change are expected to affect food availability, water access and utilisation, especially in arid and semi-arid areas, as well as the operation of water infrastructure (e.g. hydropower, flood defences, irrigation systems).

Research related to climate change and water is needed to improve understanding and modelling of climate changes related to the hydrological cycles at scales that are relevant to decision-making (possibly linked to policy). At present, scientific information about water-related impacts of climate change is not sufficient, especially with respect to water quality, aquatic ecosystems and groundwater, including their socio-economic dimensions. Research into climate-change impacts on the water cycle and related extreme events (in particular floods and droughts) will help improving the understanding and assessment 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.

In this respect, the European Commission is funding research through its Framework Programme for Research and Technological Development, e.g. projects of the 6th Framework Programme (2002-2006) [in particular, projects funded under the 'Global Change and Ecosystems' sub-priority] and of the on-going 7th Framework Programme (2007-2013) or FP7 [in particular, projects funded under the ‘Environment (including climate change)’ theme] largely contribute to gathering knowledge relevant to climate change adaptation in the context of the WFD river-basin management planning. Research areas covered by the FP7 Environment theme are summarised in Figure 1; they are exemplified by projects described below (the list is obviously far from being exhaustive).

Research into Climate Change Scenarios

Research on climate change scenarios and predictions has been ongoing and expanding in the last few decades. For example, the PRUDENCE (Prediction of Regional scenarios and Uncertainties for Defining European Climate change risks and Effects) project (2001-2004) has provided a series of high-resolution climate change scenarios for 2071-2100, including an analysis of the variability and level of confidence in these scenarios as a function of uncertainties in model formulation, natural/internal climate variability and alternative scenarios of future atmospheric composition. A continuation of this research line is illustrated by the ENSEMBLES (based on predictions of climate changes and their impacts) project (2004-2009), which integrates climate change impact studies into an ensemble prediction system, quantifies the uncertainty in long-term predictions of climate change and provides a reliable quantitative risk assessment of long-term climate change and its impacts. It includes the production of Regional Climate Scenarios for Impact Assessments and the formulation of very high resolution Regional Climate Model Ensembles for Europe.

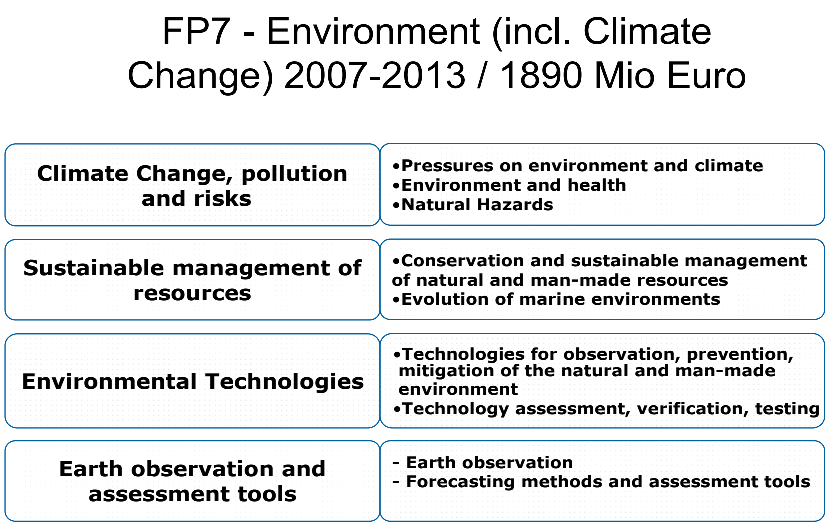

Figure 1 – The research areas of the FP7 Environment Theme

Research into Climate Change Impacts on the Water Environment and Cycle
Research to understand and quantify the impact of climate change on freshwater ecosystems at the catchment scale has been active through the EURO-LIMPACS (European project to evaluate impacts of global change on freshwater ecosystems) project, which examined climate change interactions with other key drivers and pressures related to aquatic systems at multiple time scales. Specific research on climate change impacts on the global water cycle is carried out under the WATCH (global change and water) project, which unites different expertises (hydrologists, climatologists, 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. The project is developing a number of global and regional datasets to facilitate the assessment of changes in the water cycle, including case studies in river basins located in the EU. WATCH aims to increase our understanding of drought and large-scale flood development for the past and future climates through studies at different scales (global, regional, river basin). Five test basins within Europe are being used to translate water resources applications from the global water cycle system to river basins.

The assessment of climate change impacts on water resources is also being studied in focused aquatic environment, e.g. the Mediterranean area through the CIRCE (climate change and impact research: the Mediterranean environment) project. In particular, research is carried out to investigate how strongly climate variations induce significant changes in the hydrological cycle, e.g. increasing atmospheric water vapour, changing precipitation patterns and intensity, and changes in soil moisture and runoff. The project collects data from observations to quantify those changes and to develop a regional climate model able to analyse the conditions in the Mediterranean area. The final goal of this project is to produce an assessment (RACCM – Regional Assessment of Climate Change in Mediterranean) to be used to deepen the understanding of the impact of climate change in the Mediterranean region and to suggest potential adaptation measures.

A more focused research is reflected by the on-going ACQWA (Assessing Climate change impacts on the Quantity and quality of Water) project, which investigates the consequences of climate change in mountain regions where snow and ice is currently an important part of the hydrological cycle. Numerical models are used to predict shifts in water amount by 2050, and how these changes will impact upon socio-economic sectors such as energy, tourism and agriculture. A related project (also dealing with climate change impacts on glaciers) has been launched in 2009: the HighNoon (adaptation to changing water resources availability in Northern India with respect to Himalayan glacier retreat and changing monsoon pattern) project will assess the impact of Himalayan glacier retreat, explore possible changes of the Indian summer monsoon on water resources in Northern India and recommend appropriate and efficient response strategies for adapting to hydrological extreme events such as floods and droughts. This project illustrates international cooperation efforts in climate change research which are also illustrated by other projects, e.g. a recently launched cluster on 'Climate change impacts on water and security' which builds up cooperation among EU countries and neighbouring Mediterranean countries.

Research into Mitigation / Adaptation Options and Costs

Mitigation / adaptation options to respond to climate change conditions have been developed, tested and evaluated within the AquaStress (mitigation of water stress through new approaches to integrating management, technical, economic and institutional instruments) integrated project, leading to the definition of mitigation options exploiting new interfaces between technologies and social approaches, as well as economical and institutional settings. Adaptation and mitigation strategies in support of European Climate Policy have also been investigated within the framework of the ADAM (assessing adaptation and mitigation policies) project, which developed long-term policy options / scenarios that could contribute to the EU's 2°C target and targets for adaptation. The project made significant contributions to climate change policy developments through regular policy briefs, highlighting that Green House Gas emissions could be technically reduced in Europe by up to 80% by 2050. This obviously is only indirectly linked to river basin management developments but nevertheless it has consequences for the way integrated water resource management will have to evolve over the forthcoming decades.

Increasing uncertainties due to the accelerating pace and greater dimension of changes (e.g. climatic and demographic changes) and their impact on water resource management have been investigated by the NeWater (adaptive integrated water resources management) integrated project. The project studied challenges such as climate change, flood-plain management and endangered ecosystems to move from the current regimes of river basin water management to more adaptive regimes in the future. Seven river basins (Amudarya, Elbe, Guadiana, Nile, Orange, Rhine and Tisza) were selected as case study areas to establish the link between practical activities and advances in thematic research and tool development. The project has developed a book on ‘Climate Change Adaptation in the Water Sector’ and synthesis products which are of direct interest to policy implementation and development, including databases, guidelines on uncertainty in adaptive management, etc. which are available on the project webpage. Besides the development of mitigation/adaptation strategies, an important element is the economic valuation of identified measures. In this respect, research has contributed to develop scenarios and quantify environmental and resource costs and benefits linked to adaptation to climate change e.g. through the recently launched ClimateCost (full costs of climate change) project. Finally, specific inputs for the identification of gaps that would have possible effects on the WFD implementation in combating climate impacts on water are being studied by the ClimateWater (bridging the gaps between adaptation strategies of climate change impacts and European water policies) project, which will identify adaptation strategies that were developed in Europe and globally for dealing with climate change impacts on water resources and aquatic ecosystems (preventing, eliminating, combating, mitigating).

Research on Droughts and Water Scarcity

Specific research needs on droughts have been addressed by the XEROCHORE (an exercise to assess research needs and policy choices in areas of drought) Support Action which established the state of the art of drought-related national and regional policies and plans and laid down a roadmap that identifies research gaps on various drought aspects (climate, hydrology, impacts, management, policy) and steps to be taken in order to fill them. This is strengthened by links established with relevant Research and Technological Development (RTD) projects which include drought components, e.g. WATCH, CIRCE, as well as the recently launched MIRAGE (Mediterranean intermittent river management) project on Intermittent River Management.

Research on Floods

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 FLOODsite (integrated flood risk analysis and management methodologies) Integrated Project. The project was interdisciplinary, integrating expertise from across the environmental and social sciences, as well as technology, spatial planning and management. The project has developed robust methods of flood risk assessment and management and decision support systems which have been largely tested in pilot sites. Regular contacts with the European Working Group on Floods of the WFD Common Implementation Strategy have enabled the policy community to be informed about progress on flood risk management. More than 100 research reports are available for public download on the project website.

Flash flood events and predictive scenarios have been studied by the FLASH (observations, analysis and modelling of lightning activity in thunderstorms, for use in short-term forecasting of flash floods) project on the basis of the collection and analysis of lightning data and precipitation observations. Research is continuing on how to reduce loss of life and economic damage through the improvement of the preparedness and the operational risk management for flash floods and debris flow-generating events as currently undertaken by the IMPRINTS (improving preparedness and risk management for flash floods and debris flow events) project. Finally, the recently launched project CORFU (collaborative research on flood resilience in urban areas) will look at advanced and novel strategies and provide adequate measures for improved flood management in cities, focusing on Europe-Asia cooperation. The differences in urban flooding problems in Asia and in Europe range from levels of economic development, infrastructure age, social systems and decision-making processes, to prevailing drainage methods, seasonality of rainfall patterns and climate change trends. The project will use these differences to create synergies that will bring new quality to flood management strategies globally.

EU/UNISDR Workshop – Session 2- Research in support of policy

Policies to reduce climate and natural disaster water-related risks

Kreso Pandzic

Meteorological and Hydrological Service, Croatia

A short review of water-related risk reduction policies in Croatia and South-Eastern Europe (SEE) is presented. The results of two sub-regional projects are described: the first "SEE Disaster Risk Mitigation and Adaptation Programme" of the World Bank, WMO and UNISDR from 2007 and the second "Regional Programme on Disaster Risk Reduction in SEE" of EC DG Enlargement, WMO and UNDP from 2009. In both case the results are satisfactory.

The first project consists of two components.

Component a: *Strengthening of Hydrometeorological Services in South Eastern Europe.* Target Countries are: Albania, Bosnia and Herzegovina, Croatia, Montenegro, FYR Macedonia, Moldova and Serbia.

Component b: *Development and upgrading of hydrometeorological information & flood warning/forecasting system in the Sava River Basin.* Target Countries are: Albania, Bosnia and Herzegovina, Croatia, Montenegro, Serbia and Slovenia.

The second project consists of two activities.

Activity 1: "Building Capacity in Disaster Risk Reduction through Regional Cooperation and Collaboration in South East Europe" –UNDP.

Activity 2: "Regional Cooperation in South Eastern Europe for meteorological, hydrological and climate data management and exchange to support Disaster Risk Reduction" – WMO.
Target countries: Albania, Bosnia and Herzegovina, Croatia, The former Yugoslav Republic of Macedonia, Montenegro, Serbia, Kosovo (as defined by UNSCR 1244) and Turkey.

Part of the second project, which is devoted to the natural disaster risk reduction is considered and represented in a form recomendations for the Croatian

Government e.g. "to enhance technical and human resources of Meteorological and Hydrological Service in operational monitoring, warning, forecasting and mapping of hydrological and meteorological hazards" and "to further strengthen operational cooperation of the National Protection and Rescue Directorate and the Meteorological and Hydrological Service through joint training and improvements to the standard operating procedures across agencies linked to the different threat levels and lessons learnt from each disaster event".

Water balance component analysis has been represented too in order to be stressed climate change issue in both Croatia and SEE.

EU/UNISDR Workshop – Session 2- Research in support of policy

Research needs for water policies

Peter Gammeltoft

European Commission, DG Environment

In April 2009 the European Commission presented a White Paper on adapting to climate change which highlights the need "to promote strategies which **increase the resilience to climate change** of health, property and the productive functions of land, **inter alia by improving the management of water resources and ecosystems.**“ The accompanying Impact assessment describes the potential for ecosystem-based adaptation approaches and the need to properly assess the environmental impact of adaptation measures and policies.

As part of the actions included in the White Paper, Water Directors of EU Member States adopted in December 2009 a Guidance document on adaptation to climate change in water management to ensure that the River Basin Management Plans (RBMP) are climate-proofed.

As a next step, the Commission will present by 2012 a 'Blueprint to Safeguard European Waters', which, together with the analysis of all plans for 110 river basin districts, will perform a review of the Strategy for Water Scarcity and Droughts and of the vulnerability of water and environmental resources to climate change and man-made pressures.

- It will be based on an assessment of vulnerability of water resources and of adaptation measures at EU level, performed using a combination of quantitative modelling and stakeholder discussion.
- Particular attention will be paid to the role of policies and measures to boost ecosystem storage capacity for water in Europe.
- It will include recommendations for ensuring that climate change is taken into account in the implementation of the Floods Directive.
- It will assess the need for further measures to enhance water efficiency in agriculture, households and buildings.

Scientific knowledge will facilitate the implementation of an integrated management approach for water resources, and help making it more resilient to climate change and other man-made pressures. Interaction with policy making should happen not only at EU level to support a strategic vision for EU Water policy, but also at river basin level, for the next generations of RBMP.

Against that background, research needs are focused on :

- Supporting a proper integration of land-use management and ecosystem services in water policy, by coupling biophysical and socio-economic assessment tools, and exploring knowledge gaps in the relationships between systems.
- Contributing to a robust policy making, through a better understanding and explanation of the different levels and sources of uncertainties, and a better dissemination of research outcomes.

EU/UNISDR Workshop – Session 2- Research in support of policy

Research & Development fostered by the Loire River Basin Authority

Jean-Claude Eude

Loire River Basin Authority, France

The Loire River is the longest river in mainland France (more than 1000 km). As a matter of fact, its river basin area drains a fifth of the country. Concerning **the Loire River Basin Authority**, one should be aware that it is a public institution gathering regional and local authorities: 7 Regions, 16 "Départements", 18 cities… It is usually described as a tool for subsidiarity at river basin level, with a focus on economies of scale. Its interventions range from hydraulic matters (flood prevention, water resource management) to territorial development. Not to mention the support granted to research, development and innovation projects. Besides, the Loire River Basin Authority owns and operates the Villerest and Naussac dams (www.eptb-loire.fr).

i) In more strategic terms, the Loire River Basin Authority contributes to **the Loire River interregional programme**, known as "Plan Loire grandeur nature".

To make it short, this plan was decided by the French government in 1994, after fierce ecological conflicts concerning the construction of dams. Initially a top-down approach, this Plan has become, 15 years later, an interesting example of stakeholders' involvement, opening the way to a "peaceful" (not to say "smooth") integrated management of the Loire river basin.

From 2007 to 2013, this Plan can rely on two interregional legal and financial instruments: As regards the national framework, a State/Water Agency/Regions/Loire River Basin Authority contract; As regards the European framework, an EU Operational Programme with ERDF funding. The global budget for the 2007-2013 period amounts to 400 M€.

In the framework of this Plan, the key fields of action are the following: Prevention and management of flood risks / Reinforcement of dikes, levees and spillways / Management of water resources / Enhancement of the Loire Valley natural and cultural heritage / Development of research and data exchange.

ii) In this respect, the **stress** is **put on the strengthening of already strong links between the scientific community, policy makers, practitioners and other stakeholders** confronted to the current challenges related to climate change and the implementation of the EU flood risk management directive.

In order to improve the running of a multidisciplinary interregional network, we benefit from the advices of the Loire River Scientific Council. Set up in 2007, it advises the monitoring and management committees on the implementation of actions decided, in particular under the Research/Data/Information section. It has already formulated more than 60 opinions, on all issues falling under the programmes and projects related to research, technological development and innovation.

At the same time, we ensure the pooling of the partners' specific skills, through the development of an integrated interregional Research/Data and Information platform. This means regular meetings, 3 times a year – Participation being open to all potentially-interested organisations and work carried out in full transparency. Usually two meetings take place in different places on the river basin and a third one in Brussels (in order to foster the exchange of information at European level). In this context, we also welcome foreign delegations.

In addition, we organize an annual meeting of the Loire scientific community and river managers. The purpose of this meeting is to share results, experiences and best practices, also to make the Loire a European benchmark for river basin management. The 2010 meeting will take place in Nantes, on October the fourteenth. It will be dedicated to "*Flood crisis management*".

The promotion of success-stories in the field of research and development also plays a crucial role. This explains why financial support is granted to outstanding research projects. Relevant detailed information being available on line on our collaborative Intranet/Internet exchange platform (www.plan-loire.fr), I will simply indicate: First, that research teams come from all over the river basin and other places in France or even Europe; Second, that we support different types of research projects: Visiting professors, Doctoral and post-doctoral works, R&D projects…

iii) At this point, allow me to draw your attention to **the Loire river basin initiative as regards adaptation to the impacts of climate change**, the central concern being the reduction of vulnerability to floods and drought. As indicated, a major call for research projects was launched in 2008, dedicated to the understanding of human and environmental vulnerabilities in light of the effects of climate change.

Prior to this call, 3 actions had been undertaken: An inventory of the knowledge of the climate change impacts, and adaptation measures already taken at the river basin level ; A prospective hearing on what is at stake for the years to come ; A technical meeting dedicated to the definition of scenarios with climate and modelling specialists.

Building upon the results of these preliminary actions, the call for research projects was launched in June 2008 and selected projects started in 2009. One could say that through this process, our objective was to pave the way to “no regret” adaptation strategies aiming at increasing the resilience of the Loire river basin.

Both the ICC-HYDROQUAL project and the EV2B project constitute important contributions in this respect. The main purpose of the ICC-HYDROQUAL project is to “investigate” climate change impacts on water resources in the Loire river basin, but it is not limited to hydrological modelling. It also aims at evaluating the impacts on two related environmental aspects: The thermic regime and the biogeochemical quality of water streams. The purpose of the EV2B project is to “anticipate” impacts of climate change on hydrological regimes: how vulnerable are biodiversity and urban floodplain areas along the Loire River?

Of course, other related research projects are also being conducted, with more specific focus, for example on the issue of flood prevention. The METHODOLOIRE project aims at developing a methodology facilitating the evaluation of the economic damages linked to flood. The MADIS project promotes a methodology for cross-sectoral analysis and decision making, with particular attention to flood risk management plans on one hand, land use and urban planning on the other hand. The ACCELL project deals with spatial temporal assessment of accessibility to localized stakes in a flooding situation.

At this point, I would like to stress the fact that stakeholders’ involvement developed for years in the Loire river basin is probably an advantage to tackle climate change problems. Besides, the already existing structured dialogue between the science community and river managers play a decisive role: It deeply contributes to the integration of scientific findings in the Loire river basin interregional policies

iv) As regards flood risks, a crucial issue for the river basin, we have already noticed major changes in the scope of intervention: Growing attention paid to long-term drivers such as climate change, revealing the river basin vulnerability to flood risks; Increased importance attached to the prevention of flood risks, with more and more people looking further than just flood protection; Transition from a purely hydraulic focus (hydraulic engineering works) to reducing vulnerability to flooding, in particular for businesses and housing.

It is a well known fact that a major flooding of the Loire River or its tributaries constitutes a great risk which would cause considerable disturbance and damage. In very practical terms, one of the main issues at stake is our collective capacity to safeguard more or less 20000 companies' vital interests against flooding.

In order to do so, we have designed and are currently implementing an **"integrated" interregional action plan for reducing Loire basin businesses' vulnerability to flooding**. To make it simple, we have to create a favourable environment for deploying the initiative (surveys, information campaigns, awareness-raising, training schemes, involvement of elected persons, networking, etc.), to establish a significant number of individual vulnerability diagnostics (objective for 2013: 3000 companies having carried out an assessment of their vulnerability and taken actions to reduce it) and to complete effective, priority measures to reduce vulnerability (on a voluntary basis, by companies, industries and business areas).

The figures indicating the amount of local co financing already secured and progress rapidly made, reveal that the integration of scientific findings in the river basin interregional policies has deeply contributed to the success of this process. As a matter of fact, all this has been made possible because of the coincidence between: A focussed strategy (in line with the EU orientations); A relevant territory (the river basin); An efficient support secured for 7 years (national contract and European programme). All this has been facilitated by a multipartner interregional governance at the scale of the river basin.

To conclude this brief presentation, allow me to draw your attention to the results of the 2009 OECD case study, dedicated to the Loire river basin flood vulnerability reduction strategy, together with the means and tools to implement it.

See you soon in France, along the Loire River!

EU/UNISDR Workshop – Session 2- Research in support of policy

The French National Platform

Jean-Baptiste Migraine

DRR French National Platform

History
The French National Platform succeeded the French Government Committee for IDNDR (1990-2000), and has been active since its inception in fostering cooperation for DRR activities in France and Europe.

Structure
The French Platform is a partnership between public authorities, agencies, and civil society DRR stakeholders at national and local levels. It is led by the Ministry for Ecology and Sustainable Development (MEEDDM), in charge of DRR policies, with the support of AFPCN, acting as the executive (technical) secretariat of the platform. It works under the aegis of the COPRNM, the advisory body to the Minister on DRR matters, gathering the main stakeholders in this domain.

The functions of the National Platform for Disaster Risk Reduction are performed under the direct supervision of the director general of DRR in MEEDDM, Mr Laurent Michel, assisted by the HFA focal point, Mr François Gérard, and by high level staff of the Ministry. Activities are carried out in association with AFPCN.

Established in 2001, AFPCN, has set up a Scientific Council. It works closely with the European Commission. In 2007, it started, on behalf of the French national platform, a European Network of National Platforms (ENNP), a co-operative structure with Germany, Czech Republic and Poland (cf http://www.ennp.eu), working now within the framework of the European Forum for Disaster Risk Reduction (EFDRR) established in 2009.

Budget
The MEEDDM supports the running costs of the platform; the budget for specific activities is financed by small subsidies from other Ministries (Interior etc) and by contributions from AFPCN members, including through pro bono work.

Aims

The National Platform helps shaping public policies on DRR. It develops advices and recommendations involving public authorities, research community and civil society on major issues related to disaster risks and is currently concentrating its activities in the following areas:

- National strategy for flood risk management;
- Prevention of seismic risks;
- Strategic approach to international activities of DRR;
- Evaluation of the effectiveness of local risk prevention planning;
- DRR and global change adaptation;
- Linking prevention and emergency response stakeholders;
- Vigilance and early warning systems;
- Networks' vulnerability and resilience;
- Education and public awareness.

Activities

The COPRNM holds 3 plenary sessions per year since Sept 2009. Working groups are active all through the year.

Activities carried out by AFPCN (since 2001: workshops, working groups, seminars, exhibitions, etc.) are listed in http://www.afpcn.org/Calendrier.htm and http://www.ennp.eu/Calendar.htm.

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EU/UNISDR Workshop – Session 3- Science and policy in climate change adaptation, DRR and water policies

Using research findings in disaster risk reduction policies

Branko Dervodel

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Slovenia lies at the junction of the Alps, the Pannonian Plain, the Dinaric-Karst area and the Mediterranean. Because of its geographical position and diverse landscape, Slovenia is threatened by numerous natural disasters, such as earthquakes, floods, fires, landslides, hail, storms, sleet, frost and draught. Urbanisation and rapidly increasing levels of industrial activities and traffic have also brought on new threats of man-made disasters, such as accidents involving dangerous substances. Contemporary and historical experience has shown that appropriate attention must be given to unexpected population migrations and terrorism. Slovenia has therefore developed a comprehensive system of protection against natural and other disasters.

However, the challenges faced today are becoming more and more complex and inter-related, and require greater cooperation nationally and also on the international level. The risk of disasters is becoming a global problem to mankind. It is particularly linked with increased interaction between hydro meteorological, geological and other natural science phenomena and spatial, sociological, economic and environmental vulnerabilities. Thus, in planning protection against natural and other disasters in Slovenia, special emphasis is placed on inter-ministerial coordination and the integration of science and capability development achievements into disaster reduction and disaster preparedness, as well as into procedures for efficient disaster response.

The aim of research and development projects is to transfer knowledge, technologies and experience from research institutions to practice in order to reduce disasters or mitigate their consequences in a cost-effective manner. Since 1992, the Administration of the Republic of Slovenia for Civil Protection and Disaster Relief (ACPDR) has (co)financed more than 120 development and research projects on protection against natural and other disasters and 20 projects on fire protection. Additionally, it has participated in 18 different EU projects. ACPDR uses results of research projects and case studies in its daily work: in organizing and planning protection, rescue and relief operations, in work processes, in preparing the regulations and revisions of risk assessments, etc.

One of the most important elements of research work is the planning phase, in which the aims of research have to be properly identified to allow the use of research findings in practice. Based on our experience, this can only be successfully implemented if the **end users** (in our case these are often rescue and relief forces, NGOs, etc) **cooperate** with governmental agencies and research institutions already **in the development of the project idea**. Secondly, the promotion of research and development has to have a **legal and political imperative**, with legislation providing a framework for its growth. Thirdly, since disaster risk reduction is inter-ministerial in its nature, cooperation among different stakeholders is necessary. In Slovenia, funds for research and development projects are provided through **national programmes** and not by individual ministries which proved as a good practice in reaching consensus among different stakeholders. Finally, it is also important to assure the **continuation of research**, since one project usually cannot solve all the dilemmas or can even raise new questions.

In line with the legislation, future ACPDR plans for the development and research area in the medium-term period until 2015 are to further systematically implement research and development tasks and projects with the emphasis on the applicability of results regarding support to medium-term priority programmes, and to intensify cooperation in EU projects.

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Improving Science Policy Links For River Basin Management By Crossing Boundaries

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1 Introduction

River basins, that describe the whole soil-sediment- groundwater-surface water system, are complex systems: the relations between the different composing parts are manifold, (highly) dynamical and therefore difficult to know and full of surprises. The ambition to even enlarge this system to the social-ecological system brings about that we are dealing with dynamic, adaptive, complex systems with different kinds of responses and time-place relationships (Folke, 2006). What does this mean for the connection between science and policy in river basin management?

2 The role of science in complex policy problems

In policy analysis a classification of four different types of problems is quite common (Dunn, 1994; Hisschemöller and Hoppe, 2001) that is based on two dimensions: consensus about policy values (objectives and/or underlying values and norms) and consensus (or certainty) about the knowledge base

	Consensus on values or goals	
Certainty on knowledge base or consensus on means	High	Low
High	Well structured problem	Badly structured problem
Low	Moderately structured problem	Unstructured problem

Table 1 Four types of policy problems (after: Hisschemöller and Hoppe, 2001)

When consensus exists about values and about the knowledge base to be used, this is called a well structured problem. Well structured problems are policy problems that are not so much debated and contested. There is consensus among all actors about the goals and objectives of the policy. In reality this doesn't happen that often. In many policy problems values are at stake even when at first glance this is not so visible. When values are at stake and there is no consensus on the knowledge to be used to solve the problem, the problem is called unstructured. Climate change is an example of an unstructured policy problem. A lot of policy problems fall in the categories in which there is debate on the values or goals to be reached. So the unstructured, badly structured and moderately structured types of problems are relevant for river basin management. The type of policy problem shapes the role of science and the use of knowledge. Stakeholder participation, as to articulate their values, is necessary to handle these problems. The relationships between scientific information, policy formulation and implementation and stakeholder participation are context-specific and dynamic. What these processes have in common, though, is that they look at the connection of scientific information and policy making as an intertwined process in which scientists, stakeholders and policy makers are interacting to deal with the policy problem, and that the process of asking questions and giving answers is a highly collaborative process in which the distinction between the different groups are not that much important. This process of collaborative knowledge production is especially suited to deal with complex unstructured problems.

3. Collaborative knowledge production

The Utilization of Knowledge School (Weiss, 1977; Caplan, 1979) studies the inadequate connectivity between science and policy communities from the viewpoint that each community has different sets of rules, habits, languages and standards. Most policy activities are characterized through the existence of diverging communities of scientists, policy makers, and stakeholders, which indicates boundaries between these communities.Boundary spanning refers to the activities that are undertaken to cross boundaries. Leifer and Delbecq (1978: 40-41) identify boundary spanners as "people who operate at the periphery or boundary of an organization, performing organizational relevant tasks, relating the organization with elements outside it". Knowledge boundaries can be bridged through the collaborative generation, integration, and application of so-called boundary objects. Star and Griesemer (1989: 393) define boundary objects as "tangible artefacts or object-like forms of communication that inhabit several intersecting social worlds and satisfy the information requirements of each of them". These boundaries objects are generated, integrated, and applied by professionals working on either side of the identified community boundaries and can have the shape of a paper, a model, a map, etc. We argue that collaborative production of knowledge to inform policy making should integrate

three perspectives on boundary spanning, that is boundary spanning people, boundary objects and boundary spanning processes (Duijn et al., 2008). Boundary spanning processes deliver the context, time and place to create boundary objects and allow boundary spanning people to intermediate between the involved communities. Well designed boundary spanning processes help to cross the boundaries, facilitate collaborative knowledge production and generate meaningful results for the involved policy makers, scientists and stakeholders. Inspired by the concept of boundary spanning, there are three conditions that should be met for a productive connection between science and policy:
1. Joint production of documents, models, etc. (‘boundary objects’)
2. People who can combine different fields of knowledge and can attach to different communities (‘boundary spanners’)
3. Legitimate and transparent processes to guide boundary spanning activities

4 Connecting science and policy in river basin management

Boundaries between the science and policy communities hamper the communication and explain why science and policy don’t go well along, according to the boundary spanning theory. At first sight this sounds satisfactory, but if we look deeper we see more boundaries than only the one between the science and policy communities.

There are (roughly) four communities involved: scientists, stakeholders, policy makers, and politicians. The latter is often forgotten, and mixed up with the policy makers, but they represent a complete different group that has other tasks. If we look still deeper into these communities we see that each community consists of several sub-communities. The scientists are divided in disciplines, politicians are divided according to their political party or beliefs, policy makers according to their specific tasks (most of the time related to a certain law) and stakeholders according to their interests. So boundaries between the communities are multiple. To keep it simple we only look here to the boundaries between the science and the policy makers communities. Then there are three types of boundaries to cross:

1. the science-science boundary: the boundaries between the different scientific disciplines, that are hard to cross as they use different concepts and vocabulary;
2. the policy-policy boundary: the boundaries between the different involved policy domains. In the case of risk based water management it involves spatial planning, land use, soil policy, fresh water and groundwater management etc.;
3. the science-policy boundary: the challenge for the involved scientific disciplines is to come up with meaningful results for the policy domains;

5 Capacity building to foster boundary spanning activities

We speak of individual capacity when actors individually have gained the attitude, the knowledge, and skills to cooperate with others and can perform boundary spanning activities without 'outside help'. What kind of knowledge and skills are needed by the professionals for a better connection between science and policy?

The professionals who take part in the interaction process should have some knowledge about the main concepts and main dynamics on the other side of the boundary, for instance on how they are being judged in their own organisation. They should have an open and creative mind, as the ability to "think with the other side" is of utmost importance to cross boundaries. Furthermore, they should have a cooperative attitude, as in the boundary spanning processes cooperation is needed to produce knowledge together.

In science policy interfacing processes, ideally some people are present that can act as boundary spanners. They should know both "worlds" very well, for instance because they had jobs in both communities. These people are highly valuable for the process as they can intermediate between both worlds and understand both sides very well.

The people who design the science policy processes and/or facilitate them should be professionals with an education or training in mediation or process management.

Organisations can offer people training for the skills needed in boundary spanning activities for instance training in cooperation, listening etc. They also can offer internships to exchange people for a certain period from science organisations to policy organisations and vice versa. Furthermore, organisations who want to facilitate boundary spanning should facilitate learning processes and should keep the intern boundaries as transparent as possible.

6 Conclusions

In this paper we made clear that river basin management is a highly complex issue. Different scientific disciplines, and different policy domains are involved in river basin management, which makes the 'science-policy landscape' fragmented. There are many boundaries between the involved scientific disciplines and involved policies.

Different types of knowledge should be used to link science to policy: procedural knowledge (what laws are applicable?, what is the formal timing?), local knowledge of the people who live in a certain area and have specific knowledge about it and scientific knowledge.

Crossing knowledge boundaries created through specialization of both science and policy, is one of the great challenges in science policy interface processes. Scientists, stakeholders and policy makers should work together in collaborative knowledge production processes to connect science and policy in river basin management. Collaborative knowledge production is easier when both communities use similar language and mental concepts and have to share joint objectives.

Crossing the borders between science and policy must be actively pursued. Sharing the responsibility for collaborative production of (policy oriented) knowledge and its application is not a given. There are too many reasons for professionals on either side of the boundary, whether between scientific disciplines or between science and policy, to remain in their quarters and avoid direct interaction with each other.

Complex research projects that are aimed at bridging disciplines or the science policy gap benefit from the involvement of professionals who's main, and perhaps only, role is to design, organize and implement the crossing of boundaries between scientific disciplines and between science and policy. The competence for crossing knowledge boundaries between science disciplines and between scientists and policy professionals is a specific professional domain.

Skills that are needed by the scientists and policy makers to facilitate the crossing of boundaries are cooperation, listening, asking open questions, etc. These skills can be trained. Furthermore, organisations can facilitate the razing of boundaries by offering internships and exchanging people. In this way people can gain knowledge from "both worlds", which helps them to understand each other better.

As the dynamics between policy making and science are very different, it is hard to bring these two worlds together. With patience and dedication it can be done, though. There are many practical examples that prove this.

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Agenda

International Workshop
Climate Change Impacts and Adaptation: Reducing Water-Related Risks in Europe

Scientific Brainstorming[9]

Restricted to Project Representatives

08:30 Registration

09:00-09:10 **Welcome by Commission** *by Denis Peter and Philippe Quevauviller*
Aim of the workshop – Expected outputs

09:10-09:15 **Quick snapshot about literature review** *by Rasmus Thogersen*

09:15-09:25 **The CLIWASEC (Climate-Water-Security) Webportal** *by Ralf Ludwig*

09:25-09:40 **CIRCLE-2** *by Carin Nilsson and Markus Leitner*

09:45-12:30 Splitting in different sessions

A- Water cycle & ecosystems **Meeting room A**	**B- Water, security and resources, incl. drought** **Meeting room B**	**C- Extreme floods** **Meeting room Jean Willems**
Chair- Martin Beniston (CH) **Co-Chair**- Ana Iglesias (ES)	**Chair**- Ralf Ludwig (DE) **Co-Chair**- Dyonisis Assimacopoulos (GR)	**Chair**- Marco Borga (IT) **Co-Chair**- Paul Samuels (UK)
9:45-10:00 WATCH *by Richard Harding (UK)* 10:00-10:15 CIRCE *by Ana Iglesias (ES)* 10:15-10:30 HighNoon *by Eddy Moors (NL)* 10:30-10:45 ACQWA *by Martin Beniston (CH)* 10:45-11:00 GENESIS *by Bjorn Kløve (NO)*	9:45-10:15 Climate-Water-Security Cluster *by Ralf Ludwig (DE), Roberto Roson (IT) and Joern Birkmann (DE)* 10:15-10:30 CapHazNet *by Mattias Buchecker (CH)* 10:30-10:45 FREEMAN *by Irene Van der Craats (BE)* 10:45-11:00 UNEP activities by *Brendan Bromwich*	9:45-10:00 ConHaz *by Laurens Bouwer (NL)* 10:00-10:15 IMPRINTS *by David Velasco (ES)* 10:15-10:30 FLASH *by Colin Price (IL)* 10:30-10:45 CORFU *by Slobodan Djordjevic (UK)* 10:45-11:00 UrbanFlood *by Mark Morris (UK)*
Break	Break	Break
11:15-11:30 GRAPHIC *by Jose-Luis Martin (Unesco)* 11:30-11:45 REFRESH *by Peeter Noges (EE)* 11:45-12:00 MIRAGE *by Jochen Froebrich (NL)* 12:00-12:15 WETWin *by Jan Cools (BE)* 12:15-12:30 SCENES *by Harm Duel (NL)*	11:15-11:30 XEROCHORE by *Henny van Lanen (NL)* 11:30-11:45 SCARCE *by Damia Barceló (ES)* 11:45-12:00 RESPONSES by *Laurens Bouwer (NL)*	11:15-11:30 THESEUS *by Robert Nicholls (UK)* 11:30-11:45 FLOODprobe *by Derk van Ree (NL)* 11:45-12:00 SMARTEST by *Stephen Garvin (UK)* 12:00-12:15 HYDRATE *by Marco Borga (IT)* 12:15-12:30 FRMRC and EQUIP *by Paul Samuels (UK*

[9] Organised with the participation of the AQCWA, CLIMB, CORFU, IMPRINTS and WATCH projects

International Workshop
Climate Change Impacts and Adaptation: Reducing Water-Related Risks in Europe

Day 1
Tuesday, July 06, 2010

Session 1 – Reducing risks: the need of adapting to climate change
***Chair**:* Elisabeth Lipiatou, *EC DG Research* and Paola Albrito, *UNISDR*

14:00-14:20	**Opening** European Commission United Nations International Strategy for Disaster Strategy
14:20-14:40	**Climate Change Predictions, including Extreme hydrometeorogical Events** Millán Millán, Fundación CEAM, *Spain*
14:40-15:00	**Climate Change Scenarios and socio-economic implications** Richard Harding, CEH, *United Kingdom*
15:00-15:10	**The impact of water-related hazard: the case of London** Alex Nickson, Greater London Authority, *United Kingdom*
15:10-15:30	Break
15:30-15:45	**Water related hazards and the needs to take risk reduction measures** Demetrio Innocenti, *UNISDR*
15:45-16:45	**Roundtable discussion – Questions & answers** Chair: Marta Moren Abat, *Spanish Water Director* (10 minutes introduction)
16:45-17:00	**Conclusions of the session by the Chair Persons**

International Workshop Climate Change Impacts and Adaptation: Reducing Water-Related Risks in Europe

Day 2
Wednesday, July 07, 2010

Session 2 – Research in support of policy

***Chair**:* Demetrio Innocenti, *UNISDR* and Denis Peter, *DG Research*

09:00-9:10	**Outline of FP7 research on climate change & water-related disasters** Philippe Quevauviller, *European Commission*, DG Research
09:10-9:25	**Policies to reduce climate and natural disaster water-related risks** Kreso Pandzic, National Platform for DRR (Met and Hydrological Service), *Croatia*
09:25-9:40	**Research needs for water policies with focus on ecosystem services and multifunctional land-use management measures** Peter Gammeltoft, European Commission, DG Environment
09:40-10:00	**Research on water cycle & ecosystems (thematic presentation)** Martin Beniston, University of Geneva, *Switzerland*
10:00-10:30	**Panel discussion with the speakers** (moderated by the Chair)
10:30 10:50	Break
10:50-11:05	**EU disaster policy** Thomas De Lannoy, *European Commission*, DG Humanitarian Aid (ECHO)
11:05-11:20	**Climate-related water disasters in the IPCC context** Eddy Moors, University of Wageningen, *The Netherlands*
11:20-11:35	**Disaster risk reduction as an opportunity to advance climate change adaptation** Andrew Maskrey, *UNISDR*
11:35-11:55	**Research on Extreme Floods (thematic presentation)** Marco Borga, University of Padova, *Italy*
11:55-12:30	**Panel discussion with the speakers** (moderated by the Chair)

International Workshop
Climate Change Impacts and Adaptation: Reducing Water-Related Risks in Europe

Day 2, ctd
Wednesday, July 07, 2010

Session 2 – Research in support of policy, ctd
Chair: Denis Peter, *DG Research* and Demetrio Innocenti, *UNISDR*

13:30-13:45	**Disaster Risk reduction and the contribution to the Climate Change Policy agenda** Pande Lazarevski, European Forum for DRR
13:45-14:05	**Research on Water, Security & resources, including drought (thematic presentation)** Ralf Ludwig, Ludwig-Maximilians-Universität München, *Germany*
14:05-14:30	**Panel discussion with the speakers** (moderated by the Chair)
14:30-14:45	**Research & Development fostered by the Loire River Basin Authority:** **focus on strengthening of existing networks, reducing habitat vulnerability and ensuring continuity of business activity in case of crisis** Jean-Claude Eude, Loire Basin Public Institution, *France* Jean- Baptiste Migraine, French National Platform and a European Network of National Platforms
14:45-15:15	**Questions & answers**
15:15-15:45	Break

International Workshop
Climate Change Impacts and Adaptation: Reducing Water-Related Risks in Europe

Day 2, ctd
Wednesday, July 07, 2010

Session 3 – Science and Policy in climate change adaptation, DRR and water policies

***Chair**:* Philippe Quevauviller, *DG Research* and Andrew Maskrey, *UNISDR*

15:45-16:00 **Using research findings in disaster risk reduction policies**
Branko Dervodel, Admin. Civil Protection and Disaster Relief, *Slovenia*

16:00-16:15 **Science-Policy links – Environmental policy perspectives**
Nicholas Banfield, *European Commission*, DG Environment

16:15-16:30 **Science-Policy links – 'Breaking the walls': Research perspectives**
Adriaan Slob, TNO, *The Netherlands*

16:30-17:15 **Open questions and debate on cooperation with global and regional platforms for DRR and research prioritisation needs**
Panel: Elisabeth Lipiatou (EC DG Research), Susanne Michaelis (NATO), Paola Albrito (UNISDR), Ian Clark (EC DG Humanitarian Aid) and Nicholas Banfield (EC DG Environment)

17:15-17:30 **Conclusions and closure** by European Commission en

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Brussels, 6-7 July 2010

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This is the second event where the European Commission Research Directorate-General and the United Nations International Strategy for Disaster Reduction (UNISDR) have joint forces in support of a better feed-in and accessibility of scientific knowledge to decision-makers within the EU and international context on disaster risk reduction. The event leading to these proceedings was quite unique in that it brought scientists and policy-makers together to discuss various aspects of climate change impacts on water-related hazards. The workshop gathered representatives of on-going FP6 and FP7 projects, related EU-funded projects, IPCC authors, Hyogo Framework for Action Focal Points, National Platform Coordinators and other ISDR system partners as well as representatives of several European Commission Policy Directorates to exchange practices, common knowledge and research programme outcomes. The proceedings include abstracts of projects presented at the workshop as well as concluding recommendations on the way forward.

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