Document for open consultation to water stakeholders
1st phase

Strategic Research Agenda 2009

OFFICIAL STATEMENT FROM THE WATER SUPPLY AND SANITATION TECHNOLOGY PLATFORM TO THE EUROPEAN COMMISSION DIRECTORATE GENERAL RESEARCH AND TECHNOLOGY DEVELOPMENT

A common vision for water innovation

Public consultation on Strategic Research Agenda 2009

All interested stakeholders are invited to submit comments by **Monday 14 December 2009**

to

wsstp@wsstp.eu

The results will be made publicly available on www.wsstp.eu

Please indicate if you do not agree to make your comments publicly available on the internet.

Questions:

(1) Do you agree with the content of the SRA?
(2) Are the main drivers and challenges still relevant?
(3) What could be realistic and meaningful quantitative and qualitative targets for future research and innovation projects for each pilot programme?

TABLE OF CONTENTS

1. PRELIMINARY

The water sector plays a major economic role in European countries, providing close to **600,000 jobs** for more than **70,000 water services operators**. Goldman Sachs has estimated at **463 billion USD** the world's water industry. It is also worth noting the importance of investments in infrastructure assets, with more than 3.5 Mkm of drinking water networks, more than 2.2 Mkm of wastewater networks and almost 70,000 wastewater treatment plants. Investments in the sector represent overall more than **33,000 M€** annually. The turnover for this sector is around **72,000 M€** annually.

Our vision:
The European water sector will be the leading international centre of expertise for providing safe, clean and affordable water services while protecting the environment and managing the water resources for the next generations.

2. THE RESEARCH AND INNOVATION CYCLE FOR THE WATER SECTOR

In the field of water management, boosting research and innovation means to sustain research activities, to identify needs and gaps, to extend bottom-up and market driven innovation by developing a user approach, and to support coordination activities between all these stakeholders and the water research community.
To face the major societal challenges of Europe and to unleash and preserve its competitiveness capacities; the European water sector needs to further support research and develop low carbon technologies and services to provide safe, clean and affordable water services while protecting the environment and managing the water resources for the next generations.
Innovation is key driver to develop a better exploitation of partnership and coordinated actions; a strong argument to confirm the role of a Strategic Research Agenda (SRA) for the water sector and the relevance of the WssTP, the European Technology Platform for Water.
To answer those key challenges, the WssTP has defined a Strategic Research Agenda based on a common vision for water innovation through an open consultation identifying major challenges and strategic concrete steps to face the main issues of the water sector.

The WssTP provides strategic answers for the water research future challenges. From fundamental research to implementation, the WssTP is proactive in identifying future challenges. It has set up 6 pilot programmes to cover all water related issues of our societies.

- Pilot programme 1: Mitigation of water stress in coastal zones.

- Pilot programme 2: Sustainable water management inside and around large urban areas.
- Pilot programme 3: Sustainable water management for agriculture.
- Pilot programme 4: Sustainable water management for industry.
- Pilot programme 5: Reclamation of degraded water zones.
- Pilot programme 6: Proactive and corrective management of extreme hydro-climatic events.

Pilot 1: Mitigation of Water Stress in Coastal Zones
Promoting integrated water resources management to increase the coastal zone areas value chain
With the highest concentration of people, coastal zones represent 61 % of the world's GDP which is heavily depending on water related resources. Addressing pressures is made difficult by the variety of water bodies but also by the large number of stakeholders, policies, legislation and conflicting interests. Forecast scenarios predict further degradation of coastal zones, making it a socially and economically relevant focus in need of specific applied sciences, technologies & policies.

Pilot 2: Sustainable water management in and around large urban areas
Enhancing urban water services through efficient water management
More than 50% of the population lives in urban areas. Urban areas, especially large or densely inhabited ones, raise specific issues with regard to water management. Urban areas require developments to manage efficiently the water services, in a balancing act towards the public health and the aquatic environment while protecting the water resource and reducing the carbon emission of the system.

Pilot 3: Sustainable water management for agriculture
Making the best of innovation for an integrated water management in agriculture
Agriculture is a significant user of water in Europe, accounting for around 24 % of total water use. The challenge of sustainable use of water in agriculture tackled the key issues of irrigation, water reuse, and nutrient pollution but also to balance water use with food production and the preservation of the environment.

Pilot 4: Sustainable water management for industry
Disseminating a sustainable management of water in all industries
The industrial sector is of great economic importance, where water related cost can reach up to 25% of the total production cost. The main challenges are to promote a sustainable use of water in industries processes while bensuring efficient management of other resources required in the production such as raw materials or energy.

Pilot 5: Reclamation of degraded water zones (surface and groundwater)
Stimulating ecological processes and systems for an environmental water management
Numerous rivers such as the Guadalquivir, the Tirjo, the Rhine or the Elbe are subject to water exploitation more than 30%, and 60% of European groundwater bodies are overexploited. To cope with the challenges of degraded zones on both ecological and chemical level calls for development of innovative technologies, among with ecological processes, to solve complex problems in water management.

Pilot 6: Proactive and corrective management of extreme hydro-climatic events
Managing risks and adapt water management to extreme events
In recent years, the average estimated cost of droughts in Europe was 6.2 billion Euro/year, with a high of 8.7 billion in 2003. Costs of flooding due to extreme precipitation and run-off amount to figures in the same order of magnitude. Addressing Climate Change, Hydro-Climatic Events as a consequence of Global warming highlight the need for proactive management not only to manage current risks but to also address anticipated risks in the future.

3. A VISION FOR WATER

Collaboration, Integration, Innovation

In March 2000 the European Council set out the *Lisbon Agenda* for the European Union (EU), which aims to make the EU "*the most dynamic and competitive knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion, and respect for the environment*". The creation of the European Technology Platforms (ETPs) is one concrete measure translated from the goals of the *Lisbon Agenda*.
The Water supply and sanitation Technology Platform (WssTP) is the European Technology Platform for Water. It was initiated by the European Commission in 2004 to stimulate collaborative, innovative, visionary and integrated Research and Technology Development strategy for the European water sector and to meet the objectives of the *Lisbon Agenda*.
The WssTP is federating the R&D efforts of the European water sector that has long been fragmented in order to support the competitiveness of European water technology and services. The core of the WssTP vision is that by 2030 the European water sector will be the leading international centre of expertise for providing safe, clean and affordable water services while protecting the environment and managing the water resources for the next generations.

A Strategic Research Agenda for our future, a common vision for water research
After providing a preliminary vision for water research throughout the Strategic Research Agenda (SRA) in 2006, major European water stakeholders have reviewed this reference document according to the progress of the collaboration within WssTP and recent technique or scientific evolutions. The Strategic Research Agenda describes the research which must be undertaken to realize our vision. The stakeholder-driven approach to developing a research agenda empowers all stakeholders (private and public) to define the future of research, and to share the actual research and implementation activities.

Based on a joint effort
Water and sanitation is a sector where services in Europe are provided by tens of thousands of public and private bodies of all sizes, with numerous organizations involved in research in all aspects of the water cycle. The WssTP is federating the European water sector around a common vision and a common Strategic Research Agenda. More than 450 individuals contributed to the work of the WssTP of more than 25 countries and 150 organisations; 125 individuals directly contributed to the update of this document.
The WssTP aims to create synergies between researchers, water utilities and industries for RTD fostering, and to accelerate the implementation of new methods and technologies. The

SRA may be used as input for the definition of the 7th Framework Programme, but also to facilitate a further coordination of research programmes in and between Member States.

An Integrated collaboration

The distinctive and key innovative feature of WssTP research is that it will not address single issues in isolation, but will adopt a systems approach and develop integrated solutions which address all the major issues and relevant interfaces within the system.

To address these problems an integrated approach based on Integrated Water Resources Management (IWRM) is a key concept to the work of our pilot programmes. This overarching systems approach which considers water supply, sanitation, water use in agriculture and industry and river basin management needs to be embedded into the local framework of laws, regulations, and into practices. To make this leap forward, the WssTP will include research on water technologies in a social and economic context across all water users and their supply chains.

Integrated Water Resources Management

According to the Technical Committee of the Global Water Partnership[1], IWRM is a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. As such, IWRM is a comprehensive, participatory planning and implementation tool for managing and developing water resources in a way that balances social and economic needs, and that ensures the protection of aquatic ecosystems for future generations. Beyond the participatory approach between several water users or industries, IWRM calls for more emphasis on regional or transboundary water supply challenges at the scale of river basins, including socio-economic development and governance perspectives.

Water in Europe

Facing challenges through Research and Innovation

Few facts on water in Europe

The average available renewable freshwater resource per capita among European countries is highly variable ranging from less than 100 m^3/inh.yr in Malta to above 500,000 m^3/inh.yr in Iceland. The European average is about 5,000 m^3/inh yr. A relatively low available renewable freshwater resource (<5,000 m^3/inh.yr) is measured in half of EU countries.

It is estimated that in the south-eastern regions of Europe about 65% of the annual precipitation occurring in the plains is transferred by evapo-transpiration, 10% carried as surface runoff to the sea through rivers, and 25% percolates into the soil and reaches the groundwater.

According to recent reviews, 20 % of European surface waters are seriously threatened, 60 % of its ground waters are overexploited and 50 % of its wetlands have ‘endangered’ status.

[1] Global Water Partnership. Integrated Water Resources Management. TAC Background Papers, no 4, 2000, p. 22.

The Water Framework Directive

In 2000, the European Commission endorsed a directive which set a framework prescribing steps to reach the common goal rather than adopting the more traditional limit value approach, and which rationalised the Community's water legislation by replacing seven of the "first wave" directives: those on surface water and is two related directives on measurement methods and sampling frequencies and exchanges of information on fresh water quality; the fish water, shellfish water, and groundwater directives; and the directive on dangerous substances discharges.

The Water Framework Directive (WFD) commits European Union member states to achieve good qualitative and quantitative status of all water bodies (including marine waters up close to shore) by 2015. It is a framework in the sense that it prescribes steps to reach the common goal based on integrated risk assessment and management rather than adopting the more traditional limit value approach.

The directive defines 'surface water status' as the general expression of the status of a body of surface water, determined by the poorer of its ecological status and its chemical status. Thus, to achieve 'good surface water status' both the ecological status and the chemical status of a surface water body need to be at least 'good', i.e. recovery the pristine conditions defined in absence of anthropogenic influence. Ecological status refers to the quality of the structure and functioning of aquatic ecosystems of the surface waters. The directive requires member states "to encourage the active involvement of interested parties" in the implementation of the directive.

The WFD calls for integrated water resource management at the scale of the river basins. The overall goal of the WFD represents a shift from a paradigm focused on the exclusive uses of water. The goal is to ensure that the water demands of natural systems are environmentally balanced with the agricultural, industrial and domestic needs of societies. In particular, the WFD requires “the promotion of sustainable water use based on a long term protection of available water resources”, controlling the negative environmental impacts that water users can have upon the water cycle. At different steps in the cycle, water will be considered as a valuable finite natural resource while wastewater can be considered as a source of beneficial compounds.

The need to conserve adequate supplies of a resource for which demand is continuously increasing is also one of the drivers behind what is arguably one of the Directive’s most important innovations - the introduction of pricing. Adequate water pricing acts as an incentive for the sustainable use of water resources and thus helps to achieve the environmental objectives under the Directive. Member States will be required to ensure that the price charged to water consumers - such as for the abstraction and distribution of fresh water and the collection and treatment of waste water - reflects the true costs. These costs include in most cases a high percentage of fixed costs due to investment in infrastructure.

Despite the anticipated impacts of climate change on water quantity and quality, adaptation to climate change is not addressed explicitly in the Water Framework Directive.

Greening the European economy with water
In the context of the Water Framework Directive and the mitigation policies against climate change, the European water sector has strong assets to contribute to the European "Green economy", supporting regions and cities in their quest to maintain Europe's global leadership in the field of green technologies.
The financial crisis pushed further the need for cooperation and creating synergies in RTD on green economy to tackle simultaneously environment and sustainable growth, jobs and competitiveness. Innovation should be based on Life Cycle Assessment to develop RTD focusing on eco-innovation and implementation cases that will open new markets.

4. MAJOR CHALLENGES

GLOBAL DRIVERS
Worldwide, the water sector is facing a dramatic evolution because of major 'drivers'. The related challenges, if addressed proactively and responsively, could offer tremendous opportunities.

Water: a necessary but low-added value good
Water is fundamental for life, not only for direct consumption (potable water) but also for sanitary and health requirements, and for the production of food or basic industrial goods and commodities. Even though water is so central and absolutely necessary to the existence of any society, it is a low-added value good with production costs in industrialised countries typically below 1 EUR/m^3 for potable water and below 2 EUR/m^3 for treated wastewater. In developing countries and regions with extreme poverty (i.e. living with less than 1 USD a day) a substantial lower cost is required. The investment and operational costs associated with the collection / distribution and treatment of the municipal drinking water and wastewater need to match with the limited financial window of this low-added value product.

Global trends
Large scale evolutions will have further increasing impacts on the availability of natural resources and basic commodities required for life. Water, the element indivisible to life, will not be an exception, and the water sector will be set under extreme pressures.
These evolutions are (i) demographic growth and urbanisation; (ii) globalisation and wealth growth; (iii) spatial and temporal pressure (coastal cities, tourism); and (iv) climate change. They are already taking places and can be measured and quantified as consequences of the growing industrialisation and the technical progress of the mankind. They are rapid and measurable at the scale of the human being, i.e. there increasing impacts can be perceived from one generation to the other.

Demographic growth and urbanisation
The earth, home of 6.7 billion people in 2010, about 8 billion by 2030 (+80 million per year today).

The total population of the EU 27 countries has augmented from 400 million in 1960 to 497 million in 2007 (Eurostat, 2008a). The raise of the population naturally increased the water requirement over this period and the EU27 population is expected to grow to 521 million by 2035 (Eurostat, 2008b). These trends will put pressure on water resources and management. At the world level, rapidly increasing urbanization is one of the most distinctive changes of the 20th and early 21st centuries. All over the world people are moving away from rural areas towards the cities. In many cases, this migration is triggered by poverty resulting from large scale destruction of natural resources e.g. deforestation, overgrazing and resulting erosion problems. The challenge of urban and peri-urban areas is the unpredictability and the rate of migration, which makes it difficult to plan and ensure appropriate water services. Flexible and innovative solutions are needed to cope with sudden and substantial changes in water demand for people and their associated economic activities in many regions of the world.

The migration also raises issues about safe food supply and its associated water requirements, due both to the concentration and increase of demand, and to the competition for land in peri-urban areas where urbanisation pressure pushes away agriculture, even from areas with high agronomical potential, but also providing opportunities for safe re-use of treated wastewater by peri-urban agriculture or landscape irrigation.

Globalisation and wealth growth

Together with population growth and urbanisation, globalisation and wealth growth is enforcing rapid changes such as industrialisation, extensive agriculture in association with changing food consumption pattern leading to a dramatic increase in high-quality water consumption. The wealth growth of low income countries increases water requirements in consumption habits favouring products and services with higher water footprint (meat-rich diets, more commodities, more packaging, more electricity, water demanding bio-energy etc.).

Frequently, this demand for water cannot be satisfied by the locally available water resources, while the discharge of insufficiently treated wastewater increases costs for downstream users and has detrimental effects on the aquatic systems. The increased water demand and wastewater production leads to issues of water allocation and competition between the water users (domestic, industry, agriculture and environment).

Wealthy consumers in urban areas tend to be more critical and well informed, and expect a safer and higher quality of service. This requires increased security and monitoring as well as emergency systems.

Spatial and temporal pressure (coastal urbanisation, tourism)

In the Mediterranean region, international tourist numbers have risen from 58 million in 1970 to more than 228 million in 2002, with France, Spain and Italy combined about 75 % of the current influx (UNEP, 2005). Up to 80 % of tourist stays in the region are concentrated in the period from May to September when water availability is at a minimum and water stress peaks (EEA). Tourists tend to concentrate punctually in coastal areas which at the same time contains natural systems that provide more than half of the global ecosystem goods (e.g. fish, oil, minerals) and services (e.g. natural protection from storms & tidal waves, recreation), exacerbating the tensions on water demands, allocations and cross-impacts between water users.

Climate change

There is a general consensus on the fact that climate change is happening as a result of anthropogenic greenhouse gas emissions and changes in land use (deforestation, urbanisation…).

Recent observations confirm that the mean temperature in Europe has increased by 1.0 ºC compared with pre-industrial times (the global warming is 0.8 ºC). Projections from several General Circulation Models indicate further temperature increases, between 1.0 – 5.5 ºC in Europe by the end of the century. Changes in precipitation show more spatially variable trends across Europe, but annual precipitation patterns suggest an exacerbated difference between a wetter northern part and a dryer southern part (EEA-JRC-WHO, 2008).

These changes will affect the availability of water, especially in summer, and will increase the areas that suffer from water stress (Mediterranean region and some parts of Central and Eastern Europe) (Alcamo et al., 2007). Apart from impacts in the water quantity and availability (increased frequency and intensity of extreme events, emphasized temporal and spatial rainfall variability…), climate change may worsen the water quality and it can have economic impacts (need for additional investment to adapt infrastructures) and social consequences (conflicts over diminished water resources, migrations, loss of territory…).

There are two approaches to cope with climate change impacts: mitigation and adaptation. While mitigation aims at reducing the causes and the negative impacts, adaptation aims at learning to cope with the changes, by e.g. changing water consumption habits. The water sector needs to address a combination of both strategies (energy efficiency vs. system resilience).

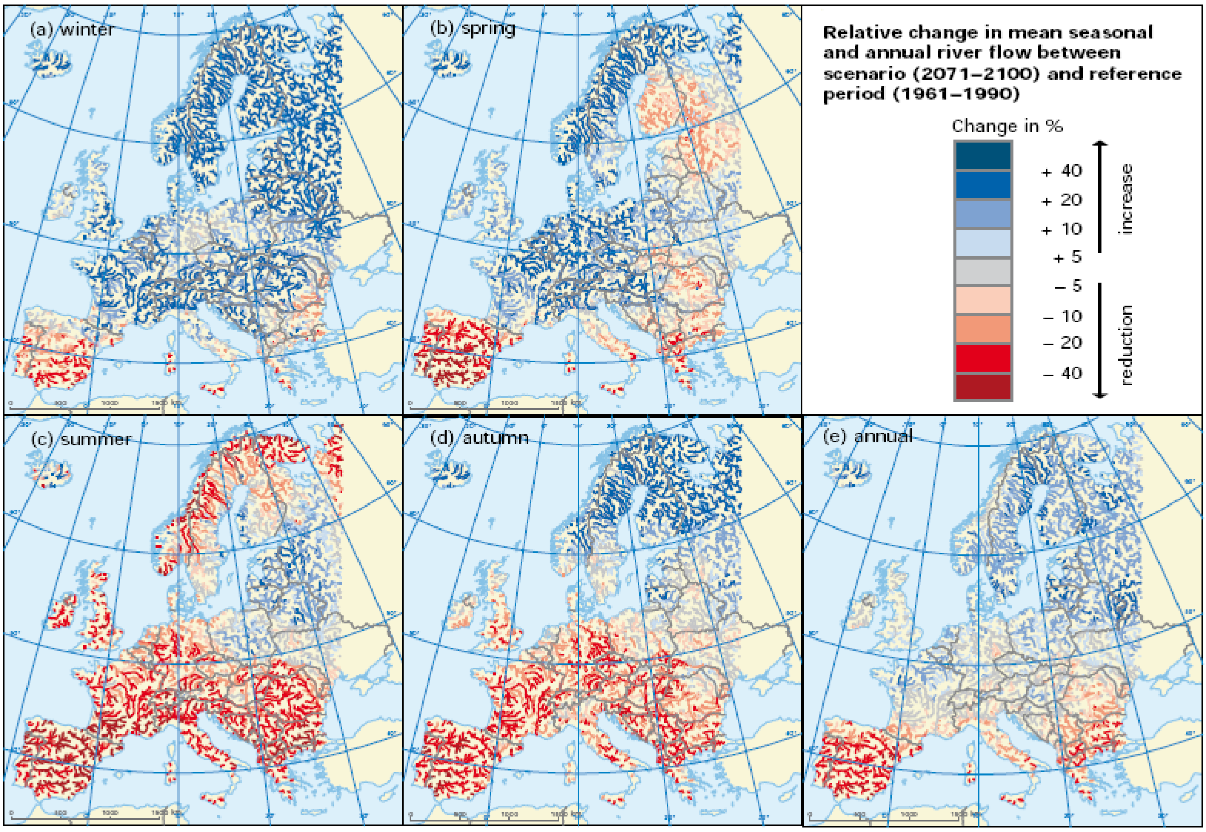

Figure 1: Projected changes in mean seasonal and annual river flow between 2071-2100 and the reference period 1961-1990, simulations with LISFLOOD driven by HIRHAM-HadAM3H based on IPCC SRES A2, Dankers and Feyen, 2008a (EEA-JRC-WHO, 2008, p.94)

MAJOR CHALLENGES

Coping with increasing water stress (quantity & quality)

In the past years, the topic of water scarcity and drought has grown up to the top of the European agenda: in February 2008 the EU Report 'Water Scarcity and Drought' stated that water stress affects structurally 130 million inhabitants (30% of population in Europe) in Southern Europe but also in Northern countries such as Belgium, Denmark, Germany, Hungary and the United Kingdom.

Recent analyses predict that by 2050, 3 billion people will suffer from water scarcity and that worldwide about 200 km^3 storage capacity will be required by 2025. As a consequence, it is expected that water related conflicts should increase worldwide. In March 2008, the EU Report 'Climate change & international security' drew the map of potential threats related to exacerbate situation of water scarcity and drought in numerous regions of the world.

Similarly, the current global trends with seriously impact or endanger the quality of the water bodies, both surface and groundwater, resulting in detrimental effects on the aquatic life and ecosystems, but also on potentially adverse health effects, and the related economic downturns. In Europe and worldwide, efforts will be required to preserve the physical, chemical and ecological status of the water bodies.

Reducing impact of extreme events (droughts and floods)

Simulation scenarios predict that climate change will increase the frequency and amplitude of acute and short term hydro climatic events such as droughts and floods and therefore increase the economical and social consequences of those events.

The consequences of more severe and often floods will be exacerbated in plain and valley areas by intensive land use including uncontrolled urbanisation, but also in coastal low lying areas such as the Netherlands by the risk related with the sea level rise following global warming.

According to the EU Report 'Water Scarcity and Drought', increased drought was observed in the past 30 years, affecting 100 million inhabitants (20% of population) in 4 events since 1989. The report concluded that in the past 30 years, water scarcity and drought had a cost of €100 billion to the European economy (€8.7 billion only for the drought of 2003).

Managing aging or lacking infrastructure

Two trends are confronting with on one hand, aging infrastructures in high revenue countries and lacking infrastructures in low revenue countries.

Urban areas around the world suffer from old and deteriorating water infrastructures that are very vulnerable to failure due to aging, damage from excavations or over-loading. It is a technological and financial challenge to maintain and upgrade it in such a way that quality water can continue to be delivered to all sectors and wastewater can be adequately collected and treated. The International Water Association (IWA) suggests an annual pipeline replacement rate of at least 1.5% in order to stabilise the leakage level in a water distribution system and containing the loss of "non-revenue water". The World Business Council for Sustainable Development estimates that the total costs of replacing aging water supply and sanitation infrastructure in industrial countries may be as high as $200 billion per year.

On the other side, many regions in low income countries of the world, and/or in rural or peri-urban areas, are not equipped today with central water supply and sewer networks. The financial needs to install basic facilities in these regions are high. The historical solutions of central infrastructures, proven in high income countries, may not always be technically appropriate or financially optimised in other circumstances. While existing water reuse options have to be further developed and implemented, the need for smaller scale, adaptable, local infrastructure systems is immense.

Facilitating technology transfer

The water sector is broad, fragmented and diverse. It consists of a number of different stakeholders from public institutions and utilities, private organisations and services, associations, universities and research entities, etc. The variety of actors and interests is a key challenge to build a strong European research for the water sector and to transfer and apply the outcomes of the research to local and regional users. As an ETP, the WssTP is a useful tool to accelerate knowledge and technology transfer, facilitating the coordination and communication efforts; enhancing synergy effects and to mobilizing resources.

As a go-between, the WssTP has built a network of experts to address the full spectrum of research, from basic to applied research through effective demonstration to successful commercialization and will oversee efficient knowledge transfer along the whole knowledge chain, overcoming the traditional fragmentation of the water sector. It supports effective engagement with a range of businesses, regulators and academic institutions, as well as collaboration with public and private entities.

Establishing an "Enabling Framework"

In Europe and in other regions of the world, the smooth and efficient implementation of systemic integrated and site-specific integrated water solutions to solve the major water issues will require the establishment of an appropriate "Enabling Framework".

The two aims are to ensure the proper consideration, understanding and inclusion of social, economic, climatic, environmental, political, legal and regulatory concerns in the decision process used for selecting global and site-specific water solutions and to identify, understand and break the four major barriers for cross cutting issues impeding the deployment of integrated water solutions at the local, regional, national or translational level, namely: compliance with regulations and directives, public and political acceptance, financing of infrastructure and water value pricing.

It is accepted that monetary value assessment allows benefit-cost-analysis for policy guidance and thus ranking of alternative prevention, restoration and mitigation policy options. The total economic value includes the direct use values (irrigation, energy resource, etc.) but also the indirect use values (nutrient retention, storm protection, etc.) and other values (biodiversity, etc.), and may help devising sound water pricing and allocations to achieve efficient and sustainable water resources management.

The establishment of an "Enabling Framework" should include:

- Developing risk assessment and risk mitigation strategies to ensure the optimisation of the solution selection process, the public and political acceptance and the compliance with legal constraints
- Developing harmonised procedure of Decision Support Systems taking into account the specific local social, environmental, economical and political aspects. The harmonisation of procedures will rationalize and facilitate the decision-making process.

- Streamlining education and training process, key to break the public and political acceptance barrier (update water managers and stakeholders in general about best-practices and latest progresses).

The Millennium Development Goals for Sustainable Water Supply and Sanitation Services in Developing Countries

International efforts are required for the regions superposing acutely the challenges faced by the water sector. The United Nations adopted the Millennium Declaration on the 8th of September 2000. For the water sector, the goal 7 targets “environmental sustainability” and especially to “half by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation”. The same goal on water supply and sanitation was agreed by the delegates to the 2002 Johannesburg Summit.

Facts:

• In 2002, an estimated 1.1 billion people lacked access to a safe water supply and 2.4 billion to improved sanitation.

• Africa has 38% of its population unserved by safe water and 40% by sanitation; the figures for Asia are 19% and 52%, and 15% and 22% for Latin America and Caribbean.

• Over the next 25 years, the urban populations of Africa and Asia will almost double; the urban populations of Latin American and the Caribbean will increase by nearly 50%.

• The provision of full water and wastewater connections and primary wastewater treatment to the urban population would entail an annual cost of US$ 17 billion for water and US$32 billion for sanitation. To serve 2 billion more people by 2015 will require connections for more than 350,000 individuals each year.

• The recent Third World Water Forum highlighted the fact that there are a further 3 billion people who only use pit toilets, flush toilets, or sewers without any treatment before discharge to the environment (World Water Forum, Rich Nations Get Wealth by Polluting Poor Nations, 17th March, Kyoto, 2003)

Enabling research and development of technologies that could also be applied to contribute to MDGs inside and outside Europe.

- Research into sustainable application of system solutions in water supply and sanitation that are embedded in the local MDGs context. Make solutions more sustainable in the sense of operational life time, not solutions that are abandoned within a very short time frame and create technology graveyards in MDGs countries.
- Include participatory approaches, bottom up rather than top-down technological solutions. Investigate active learning societies to make solutions and their implementation more sustainable within the political and socio-economic context.
- Research into the small urban water cycle including new concepts as no-mix toilets and re-use of water and human and animal excreta and nutrient recovery for food production. Energy recovery from human and animal waste.
- Adaptation of water supply and sanitation solutions in MDGs areas to be more robust and able to cope with the impacts of climate change e.g. flooding and drought.
- Research into hydro-soil erosion to minimise both its contribution to water pollution and instead have additional positive impacts in terms of water availability.
- Research into alternative and simple water purification technologies that can be used in critical condition in both developing and developed countries inside and outside Europe.

TO CONCRETE STEPS

A consistent and focused approach of the WssTP is to ensure the progress on the SRA and to ensure that the Vision becomes a reality. The success depends on the commitment of stakeholders and their involvement to further collaborate for water research. This report, produced in a consultation with major European water stakeholders is one contribution to set an integrated and concrete vision on water research.

The Strategic Research Agenda of the Water Supply and Sanitation Technology Platform is implemented through Pilot Programmes embracing key challenges from generic research and enabling technology development, prototype development, piloting, demonstration to deployment of cases. Six pilot programmes were defined, each with a different area in focus. They cover a large portion of the spectrum of water problems without aiming at providing the solution to all European water problems.

The implementation of the Strategic Research Agenda will need to further push for implementation cases and concrete demonstration implying to find financial support. The main source of finance will obviously be from industry and research organisation, but this needs to be complemented by a variety of public financing mechanisms at national and European levels. The latter will involve utilising channels such as ERA-Net, COST actions, Life+, Eureka and Framework Programme collaborative projects. Clearly, implementation will build on existing knowledge and ongoing research. To avoid the risk of duplication, it is important to link ongoing activities to the implementation of the Research Areas and activities of the European Commission and national members' states.

5. CONCRETE STEPS

Pilot 1: Mitigation of Water Stress in Coastal Zones

Coastal zones occupy less than 15% of the earth's land surface, yet they accommodate approximately 60% of the world's population, and of the world's total GNP of approximately 44 trillion USD, 61% comes from coastal areas within 100 kilometres of a coastline.

Coastal Zones are where surface water, groundwater, transitional 'brackish' and coastal water interface at scales where changes in the river basin will affect this interfacing and the related biota and human activities. This explains why transitional & coastal water are part of the Water Framework Directive.

It is the area with the greatest variety of water bodies - including temporary water bodies - that play an important role in the water cycle, in the ecosystems (major nursery systems) and in the mitigation of climate change impacts. Groundwater resources are either located in complex hydro geological structures or local & shallow aquifers where water stress and saltwater intrusion often occur.

If Coastal Zones are a buffer against sea & ocean impacts, they also inherit the upstream water inflow and the consequences of the measures taken in the related river basins.

The increasing anthropogenic pressures (augmenting permanent settlers, tourism but also expanding trans-oceanic transport and fast growing aquaculture productions) affect water resources negatively, decrease groundwater recharge and increase surface water run-offs,

floods, saltwater intrusions and the overall degradation of water and water dependent ecosystems more than in any other type of environment.
In 1999 a study by the European Commission highlighted that about half of the population of those Member States with a coastline lives within 50 kilometres of the sea while the coastal zones include the Union's most valuable habitats and that the total ecosystem benefits generated by the EU coastal zones are worth more in economic terms than the national GDP of any of the smaller EU countries. Due to the close link between population development and natural resources, population is expected to increase faster than the overall in an even much narrower band of the coast while the coastal zone contains natural systems that provide more than half of the global ecosystem goods and services.
The coastal zone contains natural systems that provide more than half of the global ecosystem goods (e.g. fish, oil, minerals) and services (e.g. natural protection from storms & tidal waves, recreation).
More and more cities are located along coasts, generating a variety of pressures driven by demand for water, energy, space, sanitation and infrastructure. On the other hand, the OECD recently estimated that with some 3,000 billion US$ of assets at stake in coastal port cities about 5% of global GDP is at stake in context of flooding and storm surges.
Taking into account the present mitigation measures and the global or climate change forecasts, scenarios predict further degradation of coastal zones, making it a socially and economically relevant focus in need of specific research and technology development (RTD) and policies.

Challenges
Addressing water stress by integrated water resources - or cycle - management in coastal zones is made difficult by the number of different water bodies, but also by the large number of stakeholders, policies, legislations and conflicting interests. In spite of legislation and policy implementations since the 1970s (e.g. Bathing Water, Groundwater, Drinking Water, Fish Water & Shellfish Water Directives between 1975-1980), a number of surface water and groundwater bodies will fail to meet the EU Water Framework Directive (WFD 2000/60/EC) objectives by 2015.
Water issues in coastal zones have generated the development of alternative water supplies that raise a number of new issues that also need to be addressed. For example, desalination plants are a fast growing new source of freshwater along the coastlines with specific intake and discharge needs. At the same time, water injection in aquifers for storage, restoring due to impedance of recharge by surface modifications or saltwater intrusion mitigation is still limited. As well, there are still measures that can be taken to reduce the consumption and losses of resources even if it is acknowledged that they will not be sufficient to maintain the economical growth in coastal zones.
The complexity of this environment and thus the level of required integration are definitely higher than for inland waters. At an environmental science level, one cannot dissociate hydrology, biota and the hydrodynamics of sediments. At a political and economical science level, one cannot dissociate water from the socio-economical context, the legislations, regulations and overall governance in coastal zones.

Research and Technology Development Needs
While the focus is on RTD for freshwater resources - supply & sanitation - solutions need to take into account the social and economical impacts of the proposed solutions

demonstrations for the targeted coastal area as a whole, investigating the short term and long term as well as the direct and indirect costs and benefits, by determining cause-effect relationships or increasing resilience of water bodies. Indeed the human activities causes and effects on water are not independent and can only be addressed by an integrated perspective; RTD fostering and implementation in this context requires an adequate participative and legislative framework for integrated and sustainable water cycle management.

The following major RTD needs have been identified to support the implementation of the WFD and Daughter Directives:

- Sufficient fit for purpose data, based on defining common measurements accuracy and precision for coherence of uses. Finer **characterization and monitoring systems** to assess water (mainly groundwater) abstraction and recharge and to better assess the ecological status of surface and groundwater as reported in the current key outcomes of WFD and daughter directives deployment. This is to include developments and proof-of-concept in terms of novel geophysical and hydro geophysical modelling and inversion algorithms.
- Seamless data integration at a systemic level, with propagation and dissemination of results: There is a need for an **enterprise solution web-based information management system,** with an open standard architecture and flexible design, to access new and existing databases to organize data and present the integrated results for technical analysis and report generation (specifically transboundary water bodies).
- There is a need to develop a European **coastal zone freshwater bodies classification and alert system** based on key physical and economical identifiers in terms of land use changes, water inflow changes and increasing groundwater extraction rates for the analysis. This classification is to assist water managers in the selection and implementation of **salt water Intrusion mitigation measures,** to ensure sustainable freshwater resources.
- There is a need to further develop triage tools and methodologies –often regrouped under the term "**scenario-builders**" - taking into accounts the pluri-disciplinary aspects of water in its socio-political and environmental context, either to guide decision makers and water managers or for the analysis of solutions effectiveness, feeding the **Decision Support Systems**, taking into account the impacts, cost and benefits, of possible solutions, integrating various levels of uncertainty and sensitivity.
- There is a need to implement **managed aquifer recharge** field pilots in coastal aquifers to test and validate parameters and indicators fulfilling the needs of water managers and policy makers and define the technical and economical feasibility of this technique based on the key uses such as rehabilitating aquifer recharge, inter-seasonal storage enhancement or saltwater intrusion barriers.
- There is a need to develop Coastal **ecohydrology methodologies** for sustainable water resources management and flexible in-situ bioremediation, to restore and maintain at a catchment scale water circulation, nutrient cycles and energy flows as well as enhancing the carrying capacity of ecosystems against human impacts.

- There is a need to **reassess Mediterranean coast karst groundwater resources** in the light of the Messinian salinity crisis to develop, manage and protect them based on a systemic approach. Indeed, during the past decades, many projects were focused on the karst management and protection in particular KATRIN, COST 65, COST 620, COST 621, MEDITATE. However, none of them attempted to summarize the major points of knowledge, techniques and gaps concerning the karst groundwater resources in all the Mediterranean countries.
- Finally for coastal zones, more and more dependent on tourism, there is a need to find water and wastewater technological solutions to keep their tourism industry competitive in a global economy. In short, coastal zones will try to find a way to minimize the cost that has to be passed to the visitors. This could be achieved for example by the identification of opportunities and development of tools to increase energy efficiency in this highly fluctuating context (seasonal variations), to generate renewable energy within the coastal zone water cycle by innovative integration of technology to allow **energy valuation of waste** (from agriculture, wastewater treatment plants, industry, recreational activities) as the water and energy needs and waste production needs fluctuate similarly.

Implementation Cases

The following implementation cases have been used to contact key local stakeholders, identify the issues, translate them into potential needs and identify the possible solutions and RTD topics.

- Guadiana Estuary and Ria Formosa, Algarve Region, Portugal
- Southern Adriatic Dinaric Coast (South of Slovenia, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, Albania, north west of Greece)
- Adour-Garonne basin & Gironde estuary, France
- Andalucía, Malaga & Almeria, Spain
- Region of Barcelona, Llobregat delta, Spain
- Thessaloniki Chalkidiki Coast, Greece
- Damour region, Lebanon
- Izmit bay, Turkey
- Rivers Rhine, Meuse, Scheldt delta, Netherlands & Belgium
- Syracuse, Italy

With additional supporting cases:

- Plaine du Roussillon, Pyrenees Orientales, France
- Venice lagoon, Italy

Managed Aquifer Recharge

Managed Aquifer Recharge (MAR) comprises a wide variety of systems in which water is intentionally introduced into an aquifer. The objective is i) to store excess water for times of less water availability (especially in arid and semi-arid regions), ii) to introduce an (additional) barrier for purification of water for a specific use, iii) or to reduce the risk of intrusion of impaired water (e.g. in coastal aquifers). In the frame of alternative water resources to balance water supply and demand, MAR can act as a technique which could enable the efficient use of water resources that are currently not captured (e.g. storm water, high flows from springs, flood waters, treated sewage effluent), but also which could protect existing water resources.

Against the background of growing urbanization and industrialization worldwide as well as predicted climatic changes the sustainable use and conservation of groundwater representing 98 % of the world's ice-free freshwater resources is of greatest importance. Over-abstraction of groundwater for drinking water and irrigation has already now resulted in a wide-spread decline in water levels resulting in increased energy consumption for pumping, saltwater intrusions and land subsidence especially in regions vulnerable to water scarcity and drought. Managed aquifer recharge (MAR) is a tool to support natural groundwater replenishment for drinking water, irrigation or industrial use and to achieve the goals of the EU water framework directive by an optimized regulation of the water cycle at basin scale.

Research needs were identified in the field of defining criteria for recharge in terms of minimal water quality requirements for recharge and developing simplified models to allow rapid and easy evaluation of MAR feasibility. This will improve the easy and broad implementation of the MAR technology as a helpful tool for local or regional Integrated Water Resources Management.

Pilot 2: Sustainable Water Management in and around Large Urban Areas

Since 2007, more than 50% of the world population lives in urban or peri-urban areas. Sustainable urbanisation models could be a solution to the environmental challenges of the 21st century.

Background

Approximately 50% of the population of the European Union live within urban areas. These range in size from larger towns with perhaps 50,000 inhabitants to the major conurbations which may be home to many millions. Flexible and innovative solutions are needed to cope with such substantial changes in water demand for people and their associated economic activities.

Urban areas vary greatly, in their relation to water resources and uses. This diversity depends on:

- Climate and topography
- Quantity and quality and seasonal variability of nearby water resources
- Size and population of the area, industries and the pace and history of urban growth
- Characteristics of the different parts of the urban and surrounding areas
- Seasonal variability of population, activities, and water uses

- Economic and social conditions
- Condition and capacity of infrastructure and surface assets

Existing and emerging urban areas therefore raise specific issues in terms of water management.

1. The population density within the area and the variety of water uses mean that there can be chronic, seasonal or permanent imbalance between water demand and availability. This leads to pressure on the environment from water abstraction, from the treatment and discharge of waste water and from the concentration of run-off during rain events.
2. Urban water systems are necessarily complex and concentrated within limited space. This means that complex management tools are necessary to resolve conflicts between water system requirements and more general land management.
3. Protection of the environment, inhabitants and the urban infrastructure from water related risks such as flooding and drinking water pollution require safe, robust and integrated solutions
4. Water and waste treatment processes in urban areas have in the past adopted energy intensive technologies to minimise footprint and reduce costs. Increasingly climate change agreements will require the use of more energy efficient systems.

Urban areas by definition present some unique issues and also others that overlap with rural and coastal areas. These overlap areas differ from country to country and depend on population distribution and the nature of the suburban development.

Challenges

The main and all embracing issue facing urban areas is to reconcile the need to meet an increasing demand and to meet more exacting quality standards in an economic and sustainable manner. The demand is seldom predictable in the medium or long term and operating circumstances are constantly changing.

Much of the existing water related legislation is being incorporated into the Water Framework Directive and its daughter directives. Of particular relevance to Urban Areas are:

- The Groundwater Directive (limiting substances that can be discharged to groundwater)
- The Bio-solids Directive (which encourages re-use whilst strengthening environmental controls)
- The Landfill Directive (which also encourages re-use of bio-solids)
- The Urban Waste Water Treatment Directive (which designates sensitive surface water bodies and means to protect them)
- The Surface Water Abstraction Directive (which regulates the volume of water that can be used
- The Drinking Water Directive (which sets 48 microbiological and chemical parameters to be met throughout the EU)

Within this overall scenario there are numerous more detailed challenges involved in the provision of water services to a modern urban area.

Balancing Supply and Demand

There is a tendency for population to migrate to cities and their suburbs from rural areas, increasing local requirements for domestic water. It will be vital to balance demand and supply of water within the urban area, maintaining a fair balance between the use of water in urban areas and in the surrounding, or downstream areas.

The satisfying of this increase in water demand without major environmental penalty will involve the use of sustainable solutions within a framework of integrated water management. Increasing urbanisation will increase the need to develop sustainable solutions for integrated water management (IWM)

Public Health

In some developed countries this tends to have become forgotten as there are seldom public health problems caused by the public water supply. However it will always be a primary concern for water undertakings. It is important that when responding to the changing requirements of a modern city the integrity of a water supply or sewer system is not compromised. The water quality supplied to customers must always be safeguarded.

Safeguarding the Environment

- Meeting new and existing environmental standards such as those required by the Urban Waste Water Treatment Directive (UWWTD) and the Water Framework Directive through the implementing of new technological developments. This is a weakness as option selection; permitting and implementation to address a problem can take several years. Any change in government or economic circumstances can mean that projects are delayed or equipment are purchased that is inappropriate to current conditions
- The minimisation of the environmental footprint of water operations

Accommodating Extreme Events

The change of weather pattern and more extreme hydro-climatic events presents a major challenge to water services in urban areas.

- Changes will be needed to the water supply system to accommodate the change in seasonal patterns and the increased likelihood of droughts.
- Provision of storm run-off areas will be required in urban developments to reduce the risk of flooding and the inundation of sewer networks and wastewater treatment works.
- Forecasting and decision support systems will be needed both for long term planning but also for short term management of extreme events.

Infrastructure

- The need to manage or renew very old assets, particularly below ground. Replacement of large sewers that can be over 100 years old can cause major disturbance to life in a modern city.

Research and Technology Development Needs

For the various challenges related to water services in urban environment, RTD needs will include:

Balancing Supply and Demand

- Development of water saving concepts and technologies
- Methods of customer education promoting efficient use of water (EUW)
- Advanced metering technologies to promote EUW
- Develop tools to understand, predict and manage demand
- Alternative Water Resources
    - Identification of potential sources
    - Reduction of the environmental impact of desalination plants
    - Development of other advanced technologies to permit the re-use of waste water
    - Treatment systems for rainwater harvesting
- Definition of water quality requirements for various uses
- Determine the impacts of water demand and supply management options

Public Health

- Tool to manage risks at all levels of the water cycle
- Monitoring systems to detect low levels of chemicals and microbiological contamination in river water or distribution systems

Safeguarding the Environment

- Methods to monitor and remove point source and diffuse chemical and biological pollutants
- Develop water and wastewater treatment systems having reduced energy and chemical usage
- Develop better methods and tools to determine environmentally sustainable river flows
- Decision support systems for the implementation of the sustainable management of bio-solids in urban areas
- Develop processes to produce energy and usable products from bio-solids and other residuals

Accommodating Extreme Events

- Modelling tools for integrated risk assessment and management of urban flooding and pollution
- Integrated, quality based storm water management systems

Infrastructure

- The development and introduction of easily accessible below ground pipe channels
- Gain an understanding of scaling, corrosion and bio-fouling and corrosion of below ground assets and develop suitable methods for identification and remediation
- Develop advanced, non-disruptive methods for maintaining and replacing underground assets

- Asset management tools for sustainable maintenance and upgrade programmes and for integrated design of networks and decentralized processes

Enabling Framework
- Identify most appropriate, risk management, IWRM and DSS methods for various water industry applications
- Gain agreement on standardised approach for the above
- Research the relative importance of the barriers to the implementation of integrated water solutions
- Identify the most appropriate knowledge transfer and education methods

Implementation Cases

The following implementation cases have been used to develop an understanding of key issues, contact key local stakeholders, translate them into potential needs and identify long term requirements and Research and Technology Development Topics.

Berlin: Large conurbation characterised via semi closed water cycle through bank filtration and artificial infiltration. Current R&D topics are:
- Impact of global changes on water cycle
- Risk management associated with water resource management (aquatic environment, human health …), in particular with regards to trace organics
- Optimised water services (energy efficiency, asset management and leakage control, alternative sanitation systems etc)

London: Suffers from problems of aging infrastructure because of its early urban development: leakage and quality issues related to the water supply network are coupled with increasing water scarcity from changing rainfall patterns and population pressures in south-east England. It is intended to use London as an example to develop:
- Smart metering to provide real-time data on water consumption and costs for the benefit of customers and operators
- Solutions for demand management to minimise the reliance on expensive technological equipment to satisfy demand.

Madrid: Fast developing city situated in water stressed area with high summer temperatures. The case will be used to develop:
- Integrated resource management techniques
- Demand forecasting and management

Prague: Used as a basis to develop:
- Augmented environmental protection measures in line with EU standards
- Cost effective solutions to upgrading assets

Utrecht: The city requires a new waste water treatment plant and this requirement will be used to facilitate a programme on:
- Integrating a WWTP into a modern urban environment
- Methods to remove priority substances from sewage

‘Sensors and Monitoring’

Real-Time monitoring and control systems have been deployed over the last few decades in water and wastewater plants and big facilities, for real-time optimized operation, alarms management, energy optimisation, quality control, crisis management. But these technologies were neither mature nor cheap enough to be deployed in large quantities in water and wastewater networks. The evolution of electronics, telecommunications and battery technologies is now changing this paradigm. This is a major evolution for water business which has to be handled carefully by water utilities and water companies for the benefit of the final consumers and a better protection of the Environment.

District metering, on-line leak detection, automated meter reading through fixed networks, all those new businesses are not far from being mature and lead the water industry to start evolving from lack of data to what we could call a new “drought of data”. This revolution will not stop and is rapidly moving forward due to new generations of on-line sensors. There is here a real research need for assessing how far micro and nano sensors will really fit the water industry requirements and how easy and economical feasible it is to massively deploy those new sensors in water and wastewater networks and facilities.

Regarding Environmental monitoring the combination of existing and new sensors with satellite-based monitoring systems (GEOSS) should also be investigated, as it will require multi-sources data management and the organisation of seamless data bases.

A new revolution has already started and is leading water utilities and water companies to adapt their practices and organisations to get ready to develop and manage Networks of Sensors for appropriate applications. But, the water industry is not yet ready to deploy those systems, and another research need consists is being able to understand their total environmental and economic cost of ownership (impacts on operational and maintenance business processes and organisations).

Pilot 3: Sustainable water management and agriculture

Agricultural production is inseparably linked to water supply.

Most of European agriculture is directly dependant on rainfall. But 9,8 % of European agricultural land is irrigable and 6,7% are irrigated.

Worldwide, agriculture accounts for two thirds of all water used, mainly for irrigation. In Europe agriculture accounts for 24% of water abstraction, reaching up to 73% in Southern Europe.

The water sector together with the agricultural sector are looking for solutions to achieve a sustainable water management. There is a need for a better understanding of the main issues, challenges, constraints and uses of water in agriculture. It is necessary to develop and implement technologies and methods that will make it possible to secure water supply to agriculture, to increase water use efficiency and to improve water protection. Besides society’s expectation to improve water management agriculture is facing an increasing demand of secure food supply, globalization, price volatility and climate change.

The vision for the agricultural sector is that:

• Agriculture will be able to produce sufficient and safe food and other agro-products at reasonable prices in a sustainable way

• Agriculture will use water more efficiently, and will make better use of non-conventional water resources
• Agriculture will further improve environmental protection while producing food and other commodities
•. Agriculture will increasingly benefit from new water technologies, equipments and facilities

Challenges
The following challenges will be addressed:
1. The implementation of the Water Framework Directive (WFD) will have an impact on water related investments and current management practices in agriculture
2. Increasing water scarcity and drought in many regions of Europe and a rising number of floods and heavy rain events will impact agricultural production
3. Balancing water supply and demand at local level is crucial and needs the collaboration of many stakeholders
4. Climate change is felt through water in agriculture, there is a great need for adaptation to changing climate making use of innovative approaches to reduce vulnerability

Three topics related to water requiring RTD activities are given priority:
- irrigation: technology and irrigation management, improved cropping practices
- water re-use: linking technologies and legal framework, water quality for different agricultural purposes
- nutrients and pesticide management; measures to reduce inputs and to reduce leakage

Research and Technology Development Needs
For the various challenges related to water management in agriculture, RTD needs will include
• Improvement of water use efficiency at different scales (local, regional, farm level). This needs a) the development of new water management tools, such as integrated models and decision support systems and b) the improvement of water productivity while making use of improved irrigation technology and innovative production methods.
• Safe use and reuse of water in agriculture and its long-term impact on the environment. This calls for the design of new technologies and management methods for e.g. 'cascading' systems and safe reuse of treated wastewater.
• Reduction of diffuse pollution caused by agrochemicals, nutrients and manure. This will require the development of cost-effective, easy-to-access and adaptive technologies like precision farming, regulated drainage and an adapted management of buffer strips.

Main recommendations
1. Need for locally adapted solutions linking new or improved technology with appropriate management regarding water quality and quantity
2. Innovative solutions in agricultural water management taking into account the diversity of European agriculture regarding natural conditions, size and farm types
3. Need to adapt existing technologies to agricultural production systems (in many cases developed for industrial purposes) and to give advice concerning their use.

‘Water reuse’

The water sector in Europe, as well as in many other parts of the world, is in a transitional phase with unique opportunities for water reuse to be implemented on a larger scale as a sustainable practice within a framework of integrated water management. Hochstrat et al. (2006) estimated that in the time span between 2000 and 2025, in Europe alone, the direct utilisation of treated municipal wastewater could more than double, growing from 750 million m^3 per year to 1,540-4,000 million m^3 per year.

In general, 'water reuse' is more a question of scale and size of the reuse cycle compared to the water cycle which is impacted by human activities at many points so that pristine water bodies are hardly found in Europe. It addresses key topics as irrigation of agricultural land, urban water, water in industry, groundwater recharge, the use of treated waste water and technologies to provide the quality required for the specific water source and application.

The recent EU projects demonstrated that the reuse of treated wastewater is becoming an issue and a great challenge for the sustainable development in Europe, in particular in the Southern countries and the Mediterranean region. A number of water reuse projects have been documented with well recognised benefits. It was demonstrated that water reuse can be the lowest true cost solution to increasing water availability and to face water scarcity, thus contributing to the objectives of the Water Framework Directive and Millennium Development Goal. Moreover, depending on the application, water reuse can be an efficient local adaptation or mitigation solution to climate change. Nevertheless, several issues, barriers and impediments to the widespread implementation of water reuse were identified, including the lack of public acceptance and adequate pan-European regulation.

Pilot 4: Sustainable water management for industry

In the EU as a whole, energy production accounts for 44% of total water abstraction, primarily serving as cooling water.

Background

Water is of prime importance for the industrial sector as it is used in a variety of ways for transport, cooling and heating, cleaning, washing and also as raw material and product. Major water using and/or discharging industries include pulp and paper industry, textile, leather, oil/gas, chemicals/pharmaceuticals, food, energy, mining and metal. For industries, water is of great economic importance, as water related cost can reach up to 25% of the total production cost. There is a need to develop and implement technologies and methods, in support of the vision that water for the industry is not a consumable or utility anymore, but a highly valuable asset: a vital element used in close conjunction with production processes. The definition and application of water qualities up to their specifications is an important part of this sustainable water use; the focus is not only at the water use between the walls of the factory, but also in relation to other users of the water system, like the municipal and agricultural sectors. Finally the development in industries, using more biomaterials, lead to significant changes, making them more and more water dependant factories.

Challenges
The key European directive relevant to water issues in industry is the IPPC Directive 96/61/EC (1996) which governs how industries must prevent and control emissions of pollutants to the environment. Best Available Techniques (BATs) for industrial wastewater treatment are central in the implementation of the directive.

For facing the increasing water stress and water costs in a sustainable way industry's challenges of today are:

- To define and use water quality fit for use
- To close the water cycle, leading to a **zero discharge system**
- To develop sustainable use of resources (discharge, waste, energy)
- To address the element 'water in industry' as part of the total water system
- To address protection of environment, health and safety

These challenges are closely related to each other. For water reuse and closing the water cycle the water quality demands should be known, water and energy (re)-use are often coupled and environmental, health and safety aspects are part of all the challenges. Therefore an integrated approach is necessary.
The following topics are of particular interest:

- Development of a sustainable water system as part of sustainable production (factory of the future)
- Industry as part of the total water system and far going cooperation with the urban and agricultural sectors
- Besides technological challenges there are other challenges, for example on societal level in relation to acceptance and perception

Research and Technology Development Needs
Closing the water cycle is one of the main research topics of sustainable water use in industries. In the first place, the insight in water quality demands needs to be improved by placing more focus on the production processes. Besides the development of knowledge on water quality demands there is also a need for better control of the water quality with new (on-line) monitoring systems, also in relation with health and safety. Last but not least, new treatment technology is needed making the closure of the water cycle technical feasible. Small scale systems and technologies for the removal of specific substances are still needed.
Also for sustainable use of resources in industrial water systems, resulting in a decreasing water foot-print there is a need for new technologies using less energy, producing less or no waste by recovering raw materials and being able to remove specific substances to apply to legislation as the Water Frame Work Directive.

Implementation cases
Implementation cases defined until now were oriented to specific sectors or more general problems. Many research questions are gathered in the FP7 Integrated Project AquaFit4Use which started in 2008, with a strong focus at water system within wall of the factory, but also with the other following approaches:

- Water system: Integrated agriculture, WWTP, industry
- Closer to the processes

Future implementation cases will be focused on the two approaches:

1. Sustainable water use as part of sustainable production (factory of the future)
2. Industrial water use as integrated part of the local water system

In the first approach there will be more focus at the water using (and producing) processes in the different industries. Close cooperation with other European Technology Platforms is needed.

In the second approach more area oriented cases will be developed also dealing with other issues, like energy reuse, aquifer recharge, and water cascading.

Water & Energy

Important interactions exist between water and energy. Energy is needed for water supply and wastewater treatment and the heating of water in buildings represent at least 75% of the total domestic energy requirement and green gas emissions. In return, water is a crucial component in the production of power (cooling towers, hydropower), and renewable energies are often related to water and or the presence of water bodies with embedded energies (geothermal power, heating pumps, tidal and wave power, osmotic power, etc). In industries the optimisation of the water cycle is very often associated with energy reduction when reusing water with low or high temperatures.

In addition, there is another strong interaction of water and energy with climate change. Indeed, extensive use of fossil energy is one of the main causes of global warming. On the one hand, climate change will impact severely on water management practices, but on the other hand, energy crisis (depletion of fossil energy) and needs for low carbon emission (Post-Kyoto policies) will drive up energy prices and will call for energy efficient water technologies and even perhaps wastewater schemes with neutral or positive energy balance. Also implementation of the Water Framework Directive will require additional treatment measures and existing solutions all require additional energy. In the UK, energy consumption in the water sector has doubled since 1990 as a result of the UWWTD and DWD, further increases are likely, resulting in a “pollution displacement” from water bodies to the atmosphere. Therefore there is an urgent need to conciliate the Water Framework Directive and the European “Energy Package” and to find optimum and low energy measures which will best protect water bodies while minimising the impact on global warming. There are many examples of costly enhancements to wastewater treatment that deliver questionable environmental benefits, inter alia: a spot compliance regime, effluent disinfection, odour control, nitrogen removal and sludge pasteurisation. The materials and chemicals used in water and wastewater treatment will also come under increasing scrutiny because of their carbon footprint. Finally, in order to improve the energy balance of wastewater schemes in industries or municipalities, biogas producing anaerobic and fermentation processes are expected to be more systematically used.

The interaction between water, energy and climate change will also impact current heating practices in households, as 89% of carbon emissions in the municipal water cycle are related to domestic water heating. For example, in regions with hard water, water softening may have an overall positive energy balance, improving the energy transfer for heating in household appliances. Another dimension relates to the production of biodiesels from crops as renewable energy which will increase the agricultural water demand. Biodiesels of 2^{nd} or 3^{rd} generation (with waste biomass or with algae) will be very useful in decoupling the energy production from the water demand, and may as well provide interesting complementarities to sanitation schemes.

Pilot 5: Reclamation of degraded water zones (surface and groundwater)
20 % of European surface waters were seriously threatened, 60 % of its ground waters were overexploited and 50 % of its wetlands had 'endangered' status.

Background
European rivers and lakes are of great importance for our economies and our well-being, but more generally they support crucial ecologies that make up our natural environment. Since the industrial revolution human pressures have increased with rapid economic growth, urbanisation and uncontrolled exploitation of our water systems. Rivers have been dammed, lakes have been used as dump sites, and coastal waters have been used as seemingly unlimited sinks for the effluents of our cities. As a consequence many of our waters have been degraded.
Since the introduction of the Urban Wastewater Treatment Directive much has been done to reverse this situation. At the launch of the Water Framework Directive (WFD) 20 % of European surface waters were seriously threatened, 60 % of its ground waters were overexploited and 50 % of its wetlands had 'endangered' status. Today all European countries are working to find the methods and the means to implement the WFD and recover the original ecological status of all European water bodies.
In particular the situation is serious in the Member States in Eastern Europe, mainly due to lack of treatment, over-exploitation, lack of environmental legislation and/or lack of enforcement of the legislation in the past. These countries expect rapid economic growth and it is imperative that this growth is matched by appropriate environmental planning. Some areas in Western Europe have similar needs as they transform from traditional manufacturing industries to more service based societies with greater emphasis on human well-being as a key factor for future economic development.

Challenges
Although many policies have been developed and implemented for preventing impacts on water in the last 2 decades, integrative responses need to be designed and policies have to come to more efficient synergies to address the complexity and variety of challenges that threat water. Among others, the following issues are still yet underestimated or not sufficiently addressed in all EU countries to assure safe and well managed water resources for the next decades:

- **Landfills**: Numerous landfills are abandoned and/or do not comply with state of the art technical specifications. They represent a clear threat for groundwater and surface water quality.
- **Brownfields**: Former industrial areas located in urban and suburban areas. They represent a challenge for urban planners (integrate them in urban development plans) and a potential threat for human health and the environment (potential source of contamination due to former industrial activity).
- **Urban environments**: Technology challenge for enabling water supply (Infrastructures for water treatment and water supply) – Need to implement mitigation strategies, water recycling. High water consumption, Water contamination through human activities (industrial, domestic, recreational etc.)
- **Mining areas**: Potential sources of water contamination. Necessity for rehabilitation strategies and technologies.

- **Agriculture**: Transversal issue Planning Need of implementation of mitigation and adaptation strategies of agricultural impacts. High water consumption, modification of natural balance, perturbation of aquatic ecosystems, diffuse contamination, development of remediation technologies and adaptation strategies.
- **Adaptation strategies to climate change:** Planning the creation of "potpolders" as buffer zones for floods. Adaptation strategies to climate change in tune with reclamation strategies. For example phyto-remediation. (CO_2 capture)
- **Mitigation strategies for climate change**: Mitigation strategies for CC have transversal effects. Thinking about sustainable (low CO_2 emission, renewable energy consumption, self sustaining techniques) remediation technologies for degraded water zones.
- **Health related contaminants as consequence of population growth – and accelerated urban concentrations:** Need of technology R&D for tackling water contamination (improve/adapt existing infrastructure to address this issue). Technologies for contaminated areas' remediation, Passive and active technologies.
- **Runoff resulting from soil sealing through urbanisation:** Need to implement mitigation strategies. Transversal issue – Land planning policy. Reduced water infiltration in addition to high groundwater consumption results in highly modified groundwater bodies (scarcity) and rapidly changing river flows (floods) and mobilisation of contaminants from point sources – Need to implement mitigation strategies.
- **Planning harmonization:** Transversal issue. As a mean to mitigate pressures on the environment and adapt political models to global change (Governance, infrastructures and technology issues). As a frame for managing degraded zones – take advantage of intelligent and sustainable land planning for integrating degraded zone reclamation, e.g. recreational areas demand or economic development in urban environment situated in "brownfields" are an opportunity for addressing degraded zone reclamation together with urban planning and land-use management

Research and Technology Development Needs

Development of techniques:

- Survey the state of degraded water sources systems.
- Derive the cause-effect relationships that have led to the degraded state.
- Generate information that can support transparent decision making between all stakeholders.
- Plan scenarios for system restoration, covering physical, ecological, social and economic benefits and costs.
- Develop appropriate treatment technologies to ensure that discharges to the environment can reliably meet the required standards.
- Mitigate specific adverse impacts.

Development of optimal strategies and Decision Support Systems

- Provide 'lessons-learned' and 'best practice' guidelines for possible application in similar cases in Europe and outside Europe.
- Guide optimal investment strategies and/or optimal allocation of water resources.

Development of integrated forecasting and Early Warning Systems

- Use real-time data, integrating hydrological parameters, pollution loads, temperature, water quality (chemical, microbiological etc.).
- Develop contingency plans for various stakeholders.
- Monitor progress in implementation on a wide variety of parameters.
- Monitor compliance with regulations, including EU directives.

Implementation cases

The implementation cases will address following overarching issues:

- The requirement for cross border co-operation between countries and all involved parties.
- Ensuring the active participation of all stakeholders, including NGOs and local communities, in water management activities.
- Balancing the interests of the environment with the interests of those who depend on it.

Ecohydrology – *enhancing the capacity of natural systems*

In the context of the European Water Framework Directive (WFD) and related directives, river basin management districts call for integrated solutions to achieve and maintain for sustained use the ecological and chemical status of water bodies. This represents a shift from a paradigm focused exclusively on the uses of water.

Ecohydrology is a scientific concept applied where problem solving needs to consider elements of the following disciplines:

- Hydrology, that studies the occurrence, distribution and movement of all waters on the earth, both in time and space, their biological, chemical and physical properties, their reaction with their environment including their relation to living beings;
- Ecology, the interdisciplinary study of the interactions between organisms and their environment;
- The combined application of both, taking into account both scientific and engineering aspects for an integrated and sustainable management of water.

The solutions combine the hydrodynamic processes as well as the hydrochemical and hydrobiological processes, and the functioning of the ecosystems to reach both the sustainable use of water resources and the protection of the aquatic ecosystems.

Ecohydrology adds to the WFD perspective since it considers:

- Groundwater-surface water interactions which are important for supporting ecological processes and habitat requirements of aquatic and wetland ecosystems.
- The role biota and ecological processes can play in the improvement of water quality and the sustainability of the water resources.

Moreover, synergistic effects of various measures from upstream land management to downstream flow regulation stabilise and improve the quality of water resources.

Controlling the interactions between biota and water is particularly relevant to the support of health of rivers, estuaries, lagoons or coastal waters. The interactions between groundwater and surface water can maintain rivers base flows, wetlands and habitats, or stimulate the capacities of the unsaturated zone. The capacity of ecosystems can maintain, restore or enhance water and sediment quality affected by, for example, pollution, eutrophication, toxic blooms, or invasive species, ultimately providing a sustainable solution for human needs.

Ecohydrological applications can be considered as complementary solutions to treat wastewater effluents, control nutrient cycles or mitigate the contamination of water bodies by flood or storm water.

Research and technology development projects propose the identification of independent criteria to enable the assessment of sites in need of ecohydrological solutions and the development of cost effective monitoring and modeling tools for the application of natural solutions encompassing the entire value chain.

Pilot 6: Proactive and reactive management of extreme hydro-climatic events

In summer 2007 Spain suffered from severe drought while UK was facing major floods.

Background

Recent events such as the summer floods in the UK of summer 2007 and the severe drought in eastern Spain during the same period continue to provide clear evidence of the need for a proactive integrated management of **extreme hydro-climatic events**. That Europe is both exposed and vulnerable to these types of hazard is widely recognized and water-related disasters must be addressed across Europe (Figures 2).

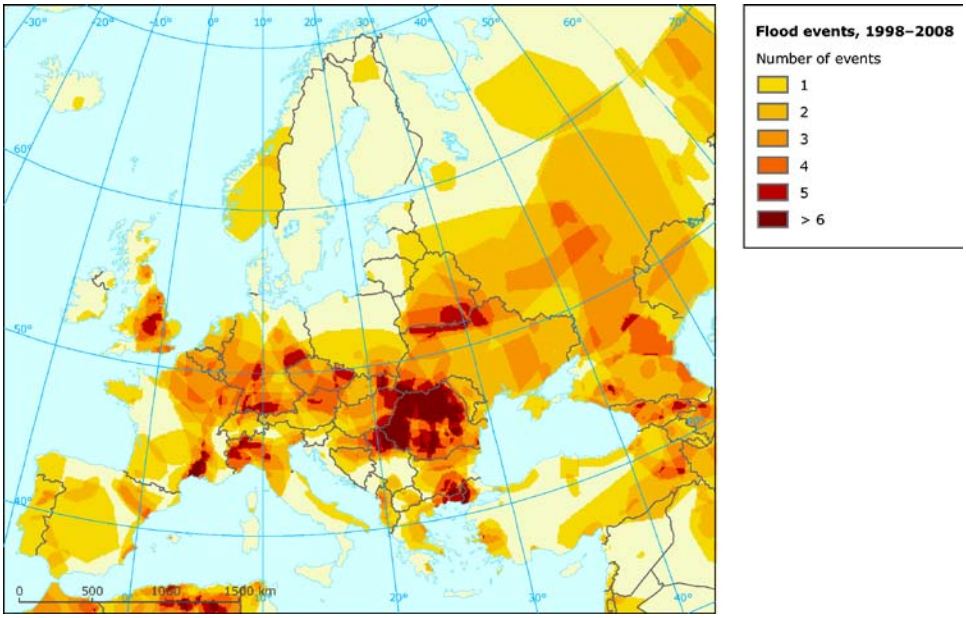

Figure 2: Occurrence of flood events in Europe 1998–2008
from the EEA web site http://www.eea.europa.eu Copyright EEA, Copenhagen, 2008.

Climate change in Europe is expected to magnify regional differences in Europe's water resources. The most vulnerable industries, settlements and societies **are generally those in**

coastal and river flood plains and those in areas prone to **extreme weather events**, especially where rapid urbanisation is occurring. Proactive management to cope with extremes is needed not only to better manage current risks but to also address future risks.

Floods and droughts cannot be prevented but their socio-economic impacts can be reduced by short-term mitigation, preparedness and long-term planning.

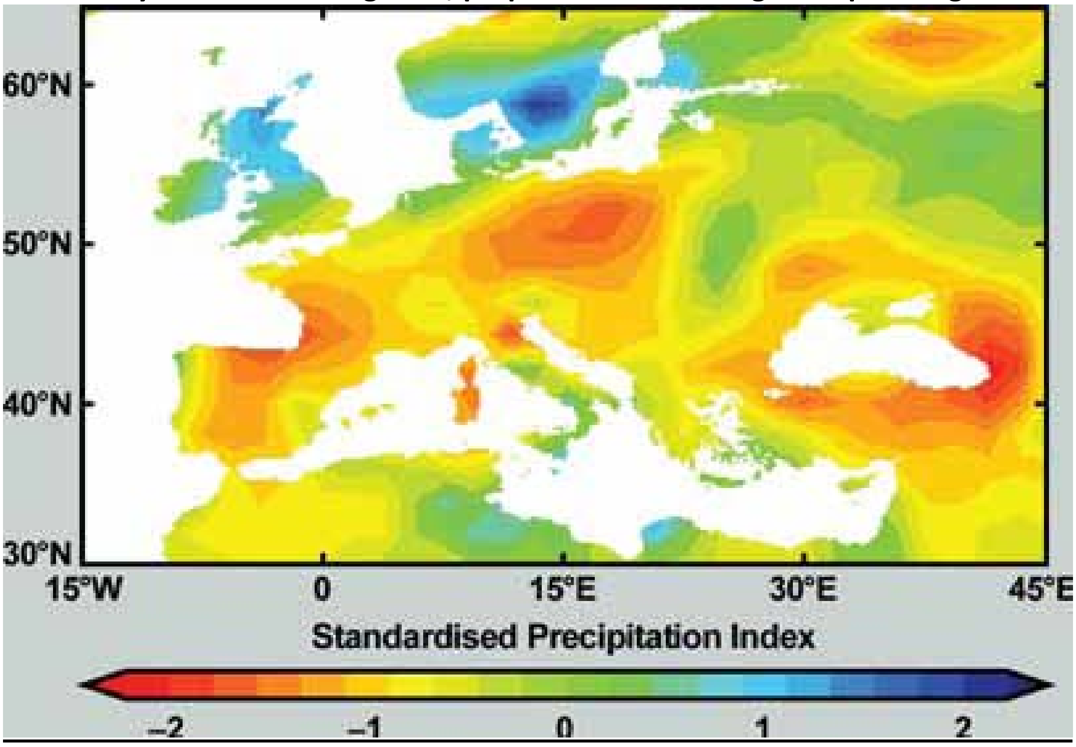

Figure 3: The extent and severity of the 2003 drought across Europe.
From EURAQUA, Towards a European Drought Policy, 2004

Challenges

The management for hydro-climatic extremes must address a number of challenges;

- Hydrological response is highly variable reflecting the wide variety within and between catchments depending on land cover, topography, geology, soil type, vegetation, etc.
- Hydro-climatic extremes include flash floods, landslides, river, groundwater and coastal flooding, landslides, hydrological and climatic droughts, forest fires, destruction or modification of habitats, etc.
- Hydrological extremes impact many sectors and interests, including cities, agriculture, land-use planning, floodplain management, water resources and water quality in the surface and subsurface, ecological status, fisheries, tourism, public health.
- Hydro-climatic extreme events can have catastrophic impacts, are highly visible and often costly events.
- Droughts and large-scale floods occur across large regions including several countries and responsibility for managing floods may reside at different levels in different countries, from national organisations, regional authorities to local municipalities and city councils.

- The meteorological community and the hydrological community need to be brought together to both predict and manage hydro-climatic extremes.
- Addressing short term forecasting and operational water management together with the expected impact of climate change.
- Addressing the problems of predicting hydro-climatic extremes and managing their impacts over time scales that typically range from hourly and daily to seasonal, decadal and greater and spatial scales from global to regional to catchment scales.

Research and Technology Development Needs

For forecasting extremes

- Seasonal forecasting
- Drought forecasting and monitoring
- Combined forecasting of water resources and water demands
- Forecasting using uncertainty estimation and data assimilation of traditional & new measuring techniques

For long term planning/management of extremes

- Quantifying combined hydro-meteorological uncertainty in climate change impact assessment, climate proofing and adaptation
- Optimisation of water uses and saving and the management of multiple water users
- Exploiting new remote sensing (satellite, doppler radar, wireless sensor and other measurement) for forecasting and monitoring
- Integrated modelling across surface water and groundwater, coastal and fluvial systems, hydrological and meteorology, water and sediment transport
- Risk-based decision-making and planning tools including socio-economy, effective communication and conflict resolution

For future drought and flood management

- Improved climate models for long duration, extensive droughts and high intensity localized rainfall events
- Multiple hazard management – heat waves, droughts, water pollution, landslides, flash floods, ice floods, coastal floods, etc.
- Changes in extreme distributions (flood & droughts) under climate change and land-use change addressing the complex relation between climate mean values predicted by climate models and hydrological extremes

Implementation Cases

The three following Implementation Cases are exemplary of typical issues.

Upper & Middle Odra

The Odra River basin is subject both to frequent and often catastrophic fluvial flooding and to hydrological droughts governed by its location and continental climate. It is a transboundary river with headwaters in the Czech Republic, flowing through Poland and along the border between Poland and Germany into the Baltic. Flash flooding occurs in the southern mountainous tributaries in the Czech Republic. Key management issues include water supply, flood management, short-term and long-term forecasting, reservoir and structure operation, and river ice formation.

Upper Guadiana Basin, Spain

Located in the centre of Spain, the Upper Guadiana Basin can be considered as a prototype of semi-arid Mediterranean catchment. The intensive water abstraction for agricultural purposes from aquifers in the basin and the importance of the associated wetlands and natural reserves are currently critical water management issues. The alternation of dry and wet periods is a characteristic of the climate of the Upper Guadiana with extreme droughts, both in intensity and length, being of special interest. However climate change is expected to alter this pattern, with longer drought periods and more intense and extreme precipitation.

The Thames River Basin, UK

The Thames flows through London and therefore it is important to understand the impacts of extremes on critical infrastructure. The long discharge record provides clear evidence of climatic variations in the flood flows during the 20th century. At the same time it is subject to water stress and both extremes are expected to be exacerbated by development pressure and climate change.

Climate Change

Climate change can exacerbate the increasing drought risk in some parts of Central and Eastern Europe and especially in the Mediterranean region. Economic loss due to 2003 drought was €11,6 billion in twenty European countries (EC, 2007). Even though it is not possible to achieve a 100% reliable system, there are effective measures that can be implemented to reduce vulnerability to water scarcity in those regions.

Floods are one of the most important hazards in Europe regarding both economic and life loss. In 2002, the direct costs of flooding amounted to €13 billion (EC, 2007) and it has been proved that the annual number of reported floods and damages in Europe increased during 1972-2002 period (Guha-Sapir et al., 2004). Climate change, combined with land use changes, is very likely to raise the frequency of heavy rainfall events, increasing the risk in areas that already were vulnerable to floods. Thus, it is very important to carry out strategies to improve flood protection and risk management.

The foreseen climate change impacts that will affect extreme events are:

- Drier and hotter summers that will increase frequency and duration of droughts
- The increasing in the number and intensity of extreme precipitation events that will increase the risk of floods and worsen water quality, due to an increase in the load of pollutants washed from soils
- Increased rainfall intensities that can lead to more soil erosion and, as a consequence of it, this can cause a decreasing in reservoirs' storage capacity. More intense precipitations will also produce more overflows in the sewer systems.

Main R & D needs related to hydro-climatic extremes and climate change that have been identified are:

- Early warning systems: forecasting is mostly oriented to floods but may be developed also to predict drought periods. More work is needed to improve the spatial precision and increase the lead-times (time to react) of these systems in order to facilitate public preparedness.
- Climate models at regional or local scale: current global climate models cannot capture the full range of scales that take part in the modelling process of the climatic phenomena and then, improved downscaling techniques are needed (considering smaller scales, micro-topography, and additional features as land-use and vegetation covers).
- Evaluation of uncertainty: projections of climate change are subject to uncertainties and they are larger when referred to predict precipitation extremes. Longer series of data and probabilistic predictions are required to evaluate the increasing trend in the frequency and intensity of storms.
- Land management practices: flood plain restoration and river banks stabilisation can be a sustainable solution to increase protection against floods. These practices include: widen floodplains to detain more water, replacement of crop farming in risk zones for grassland field to reduce economic loss and hold back water, etc.
- Asset's resettlement: measures like removing or protecting assets from high risk flooding areas must be further studied through work with satellite imaging for example. Cost-benefit analyses may be carried out to assess costs of resettlement in front of those for protection measures and thus, take decisions from the results.

- Risk information availability: mapping of risks is already required by the Floods Directive by the end of 2015. Methodologies to take into account impacts of climate change need to be developed and implemented.

Thank you for comments and collaboration

You are invited to submit comments by Monday 14 December 2009 to wsstp@wsstp.eu

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