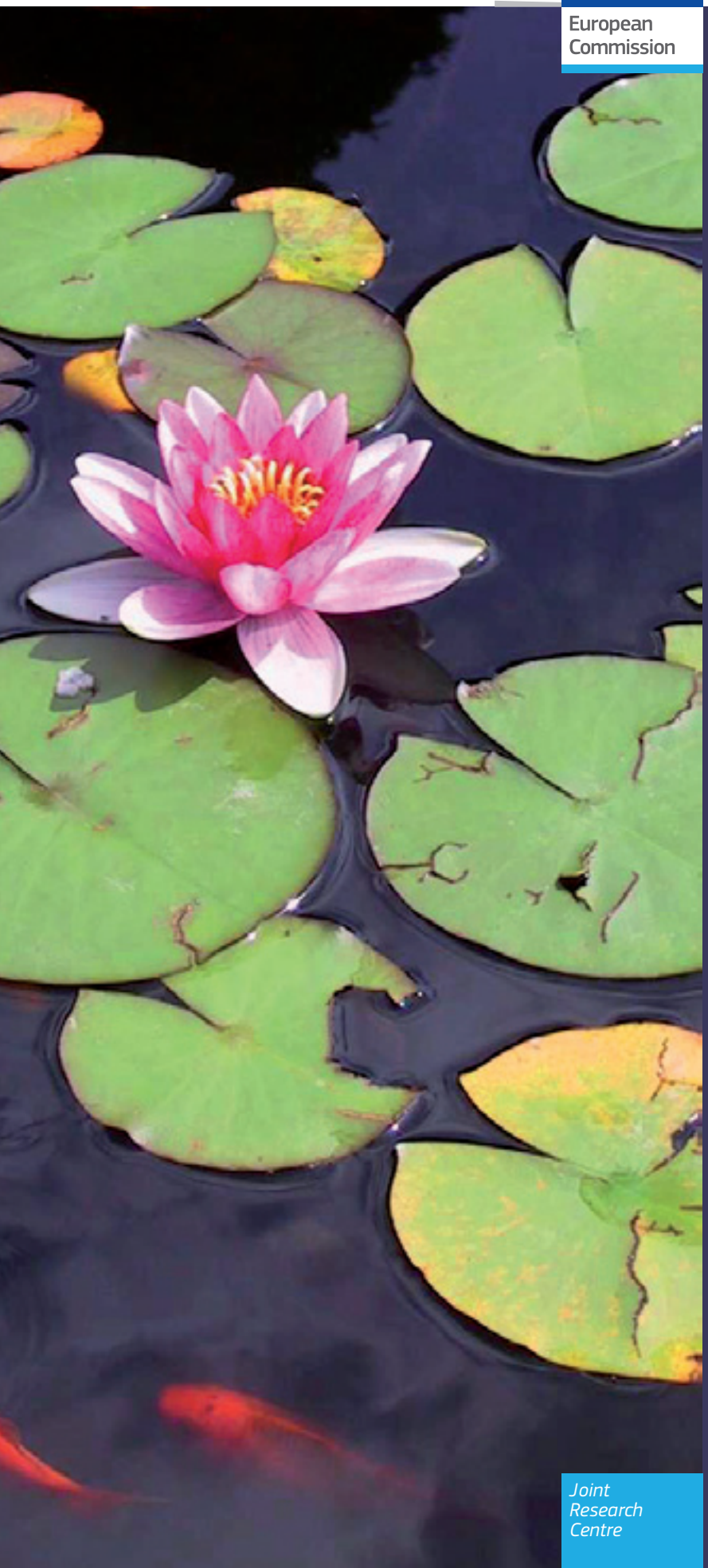

European Commission

Science for Water

JRC thematic report

Joint Research Centre (JRC)

The European Commission's in-house science service

Joint Research Centre

EUR 26066 EN

If you would like to learn more about the activities of the JRC, please contact:

Geraldine Barry
European Commission
Joint Research Centre
External Communication Unit
Head of Unit

B-1049 Brussels

Brussels
Tel. +32 (0)2 29 74181
Fax +32 (0)2 29 96322
Ispra
Tel. +39 0332 78 9889
Fax +39 0332 78 5409

Contact: www.jrc.ec.europa.eu/contact
E-mail: ies-contact@jrc.ec.europa.eu

www.jrc.ec.europa.eu

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Foreword by Máire Geoghegan-Quinn

European Commissioner for Research, Innovation and Science

Water is fundamental for life – we are all aware that most of the earth is covered by water and water is the largest component of the human body. It is equally important to our economy. Food security, transport, energy, sanitation and agriculture all depend on water. We are fortunate to have ready access to a clean water supply in Europe and perhaps we only really think of it when we experience droughts, floods or extreme weather conditions. Yet, competition for water is growing within Europe and across the globe, and better water management is becoming a top priority.

The European Commission has prioritised effective water management since the 1970's. Today, the EU's Water Framework Directive is rightly recognised as a model supra-national arrangement in the way it protects our common water resources. Taking this one step further, the latest proposals aim to accredit all EU waters with good ecological status by 2015.

The EU response is all about maximising the latest science so that policy-makers can make informed choices. To do so, the European Commission's in-house science service, the Joint Research Centre (JRC), leverages its international network of experts and conducts novel research to provide science-based solutions based on the best available, independent evidence.

This brochure gives a glimpse of this scientific work. For example, the JRC established and operates the pan-European Flood Alert System (EFAS) and the European Drought Observatory. Its scientists are heavily involved in global efforts to monitor the impacts of climate change and water scarcity, while coordinating networks of national EU and non-Member State laboratories, to ensure that ecological water quality objectives are reached and adhered to.

The JRC also supports the EU's Danube Strategy. This aims to better coordinate issues around irrigation, navigation, environmental protection and energy production across much of the EU's territory. In responding to weather-driven natural disasters, JRC scientists together with United Nations partners have been instrumental in setting-up tsunami alert systems.

For the future, the European Commission has made water a priority in its Europe 2020 Strategy. I too have emphasised flagship initiatives around water in Innovation Union and Horizon 2020. With the support of our JRC scientists, the Commission is working every day towards greater water efficiency, a reduced water footprint and better protection of aquatic ecosystems.

The JRC's work creates tremendous benefits not only for the European Institutions, but also directly for European citizens. Climate change and resource scarcity are real and present issues. I see the JRC as not only a source of the science upon which we can soundly base today's policy-making, but I want to further develop its strategic capacity to deliver world-class modelling and forecasts for the future.

The highlights in this brochure provide a snapshot of water-related issues the JRC is currently spearheading. Its publication is timely. The JRC has a key role to play in preparing Europe to meet known and emerging water challenges.

Foreword by Dominique Ristori

JRC Director-General

This publication is the first in a series of thematic reports, showing how the Joint Research Centre (JRC) as the European Commission's in-house science service addresses key societal challenges. The JRC is the only Commission service carrying out direct research, and it works in an inter-disciplinary manner, close to society, the scientific community and policy makers at the EU, national and international levels. This collaborative approach enhances the relevance of JRC's work and its solid reputation for scientific excellence.

Access to water is currently very high on the political agenda in the EU as well as internationally, with 2012 the European Year of Water and 2013 the UN's International Year of Water Collaboration. For those living in areas regularly affected by drought and water scarcity, the importance of this topic is hardly news. It already affects one fifth of EU's territory and the problems are expected to be exacerbated by global warming.

Recognising this, a new scientific unit has been created in the JRC specifically on water resources. In the following years the JRC will increase significantly its scientific support to water policy by assessing water quality, predicting climate change impacts on water; assessing future water needs of the economy; studying water governance in developing countries, monitoring ecosystems, mapping water resources and carrying out analyses of how new technologies and innovations may give opportunities for water reuse, saving and harvesting. The recurring theme of all this work is its relevance to policy. The JRC addresses the grand societal challenges on a European and global scale, for which scientific and technological support require more integrated, proactive and cross-policy action.

JRC's research priorities in relation to water focus on water treatment, water savings, desalination and governance. As the report shows, Europe – and the world – have a craving for fresh water that outmatches supply, and keeps increasing. Human consumption, irrigation, environmental requirements, recreational needs, cost, energy consumption and pollution all have an impact on the availability of water. The JRC is building models to analyse the availability and scarcity of water resources to optimise the allocation of available water to competing uses.

Water savings are by far the most cost-efficient way of meeting our society's demand for water overall and the JRC is addressing this through modelling-based scenario analysis on the allocation of available water to competing end users.

Water treatment is necessary to allow modern society to extract water of sufficient quality for its multiple needs. JRC research has shown how rapidly new substances end up in wastewater, rivers and even groundwater. The JRC therefore carries out forward-looking research on emerging chemical pollutants in European waters and works on standards for re-use of waste waters and assesses innovative technologies for water treatment. **Desalination** is a rapidly-growing option for water supply in coastal cities. The JRC is monitoring closely the new techniques and technologies that are being successfully developed for the Mediterranean region, assessing their costs and benefits as well as their environmental impact.

Finally, the JRC provides in many different ways scientific support to **water governance**, by strengthening regional and international efforts to find trans-boundary solutions for the restoration of water quality and the management of water-related risks.

I hope that this report will help to raise awareness of the global water challenges and the need for solid science to meet them.

Introduction

This report aims to give a comprehensive overview of the work of the Commission's in-house science service, the Joint Research Centre (JRC), in relation to global water challenges. The description of the JRC's work on water is divided into six chapters. For each chapter, the detailed policy context is cited, showing clearly how and where the JRC is providing its scientific and technical support to water-related policies. Furthermore, an ample list of publications for further reading is proposed for each topic mentioned in the report as well as useful scientific tools such as online databases, atlases and models.

1. Water: balancing supply and demand

The global demand for water is steadily on the increase. Agriculture and energy are major water users, for irrigation of crops and cooling of thermal power plants respectively. To identify areas that suffer from water stress, JRC maps available water resources and compare them to the demands. It has developed a model to facilitate the allocation of water between different end users in a way that makes environmental and economic sense. JRC is also working on the water footprint concept, which raises awareness of the fact that a consumer does not only consume water through the tap at home, but also through all the products he or she buys.

2. Water quality

European Union water legislation aims to achieve 'good ecological status' for all surface waters in Europe. JRC provides technical and scientific support to the development of indicators and to harmonise data across Member States. Public authorities monitor the waters for chemicals that pose particular risk to the aquatic environment - so called priority substances. JRC maintains an updated list of priority substances and works to identify new substances that can be candidates for inclusion on the priority list. Among the most common pollutants in EU waters are nitrogen and phosphorous which are carried from field runoffs and urban wastewater to rivers, and via the rivers to the sea. JRC is assessing the chemical load of rivers and seas, and is building maps that among other things help to identify pollution hotspots.

3. Preserving ecosystems

Ecosystems are providing services to society which are often taken for granted, such as rivers removing nitrogen from surface waters, or wetlands absorbing heavy rainfall, thereby reducing the risk of flooding. By attributing economic value to such services it is possible to make realistic assessments of the value of the ecosystems to better protect them against land reclamation or pollution. JRC is also working on other threats to the ecosystems, such as the worldwide increase of invasive alien species, often introduced in the ecosystems through human intervention, by accident or on purpose. The JRC is studying the conditions that facilitate migration of invasive species and also works on harmonising the available data.

4. Water-related hazards and climate change

According to UN data, 90% of all natural hazard events are linked to water. Nearly 300 000 people were killed in water-related disasters in 2010 alone. With global warming, both the frequency and the severity of such events are expected to increase. The JRC is working in different ways, through satellite observations and data collection in collaboration with its many partners, to get accurate and reliable information on the real situation at all times. This knowledge is used to better understand the mechanisms that cause flooding, drought, desertification, tsunamis and other events, to help prevent them or at least reduce their impact by giving early and reliable warnings.

5. Water governance – working together

Many of the world's rivers flow across several different countries, seas are shared by all, and pollution knows no borders. Solving global water challenges can only be achieved in co-operation with key actors. A networking organisation by its very nature, the JRC actively promotes and supports efforts to improve water governance, for instance in the Danube river basin and in the Mediterranean. In collaboration with developing countries and donors, JRC works to improve access to clean water.

6. Water innovation

Water and wastewater treatment represent a third of the rapidly growing eco-industry sector in Europe. JRC is contributing to innovation in this field. The JRC is actively working to deliver references and indicators in eco-labelling, green public procurement and pollution control, which can all act as drivers for innovation if set up correctly. Through its advanced capabilities in satellite observations, modelling and data managing, the JRC also carries out essential work to help standardising georeferenced data to unblock innovation in this field by making the data readily interoperable.

From water savings through to water innovation, this report outlines the relevance and necessity of the JRC's scientific support. With its unique role as the Commission's science service, the JRC plays a key role in addressing current and future water challenges, in Europe and beyond.

1. Water: balancing supply and demand

While 70% of the Earth's surface is covered by water, only 1% of this amount is freshwater that can actually be used by humans and ecosystems. Water scarcity and droughts already affect almost 20% of the EU territory, and yet more than 44% of abstracted freshwater is used to cool thermal power plants and a further 24% for irrigation.

The rising demand for clean water in a world with a steadily growing population makes the sustainable management of water resources an increasingly pressing concern. Water availability and water efficiency are therefore important issues worldwide. JRC research in this area focuses particularly on the complex links between water, agriculture and energy.

JRC scientific support in this area is mainly provided for the EU Water Framework Directive (WFD), a cornerstone of EU water legislation. Adopted in 2000, the WFD is the only supranational water arrangement of its kind in the world. The JRC is also deeply involved in the development of the EU's 2012 Blueprint to Safeguard Europe's Waters. This Blueprint takes an integrated approach based on developing river basin management strategies to help achieve good status of all EU waters by 2015.

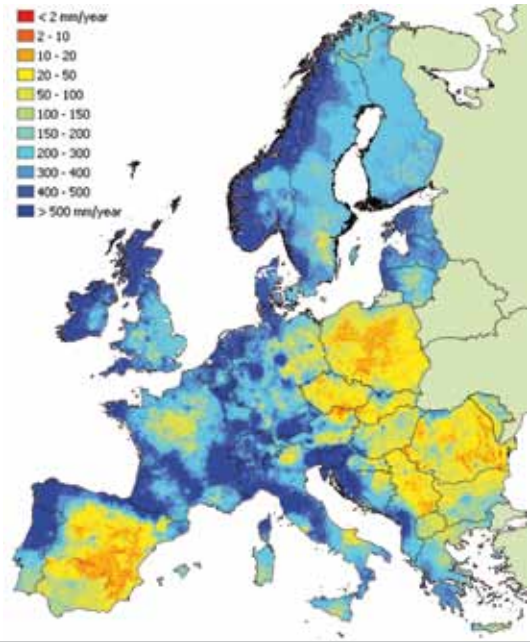
1.1 Current and future water availability

JRC activities in this area provide scientific support to the following policy initiatives:

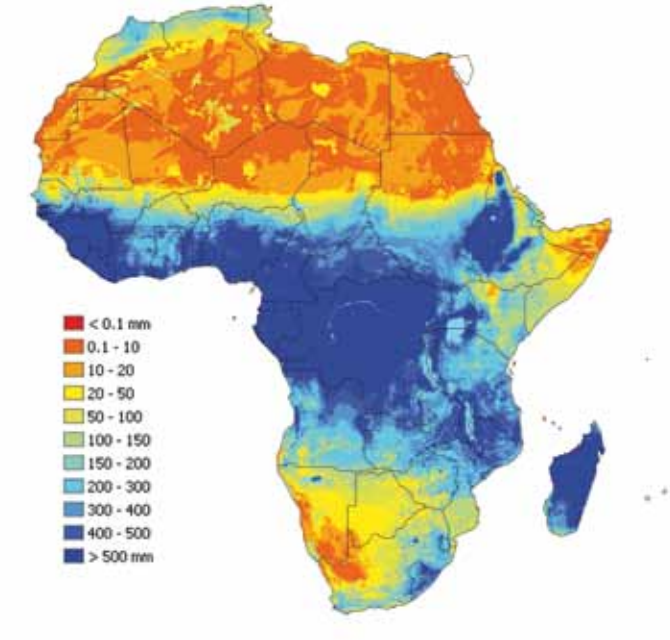
- Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive)
- Directive 2007/60/EC of 23 October 2007 on the assessment and management of flood risks
- 2012 Blueprint to Safeguard Europe's Waters
- Communication of 20 September 2011 on a Roadmap for a Resource Efficient Europe, COM(2011) 571

Water availability in the different regions of the world is affected not only by geography and climate conditions, but also by consumption patterns. The JRC carries out hydrological modelling activities to assess current and future availability and demand for water from different economic sectors. These scientific assessments also address floods, droughts and water scarcity issues.

Figure 1: Water availability in Europe and Africa (March 2012)



Average available net runoff (mm) (1990-2010).



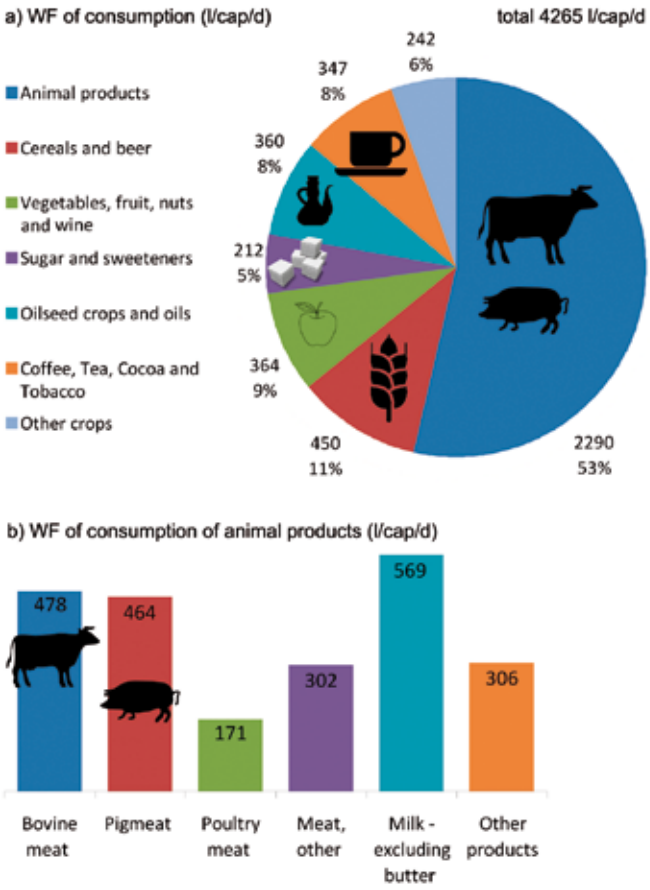
Annual available net runoff (mm) (1989-2010). Source: JRC

Within the JRC's integrated water modelling platform, state-of-the-art hydrological models developed by the JRC are combined with other models that simulate domains such as land use (LUMP model), agriculture (CAPRI) and energy (POLES). Data from Eurostat, satellite imagery, and meteorological and hydrological organisations are also incorporated. These modelling activities are mainly carried out at the continental scale, currently for Europe and Africa. Global scale modelling and analyses are planned for the near future.

JRC scientists also study the **water footprint** concept. The water footprint gives a measure of the amount of water that is consumed or polluted over the full production cycle of a product, both directly (for instance through agricultural irrigation) and indirectly (for instance the water involved in the production of imported products). A deeper understanding of the water footprint will help achieve the sustainable management of water. It is important to note that the EU's water footprint extends to other continents. It includes the water resources that were used in the production of goods that are imported to and consumed in the EU. This must be taken into account when making recommendations on water efficiency in production processes and consumption behaviour.

An average EU citizen uses around 120 litres of water per day but, as a result of agricultural and industrial products consumed, his/her daily water footprint amounts to 4265 litres.

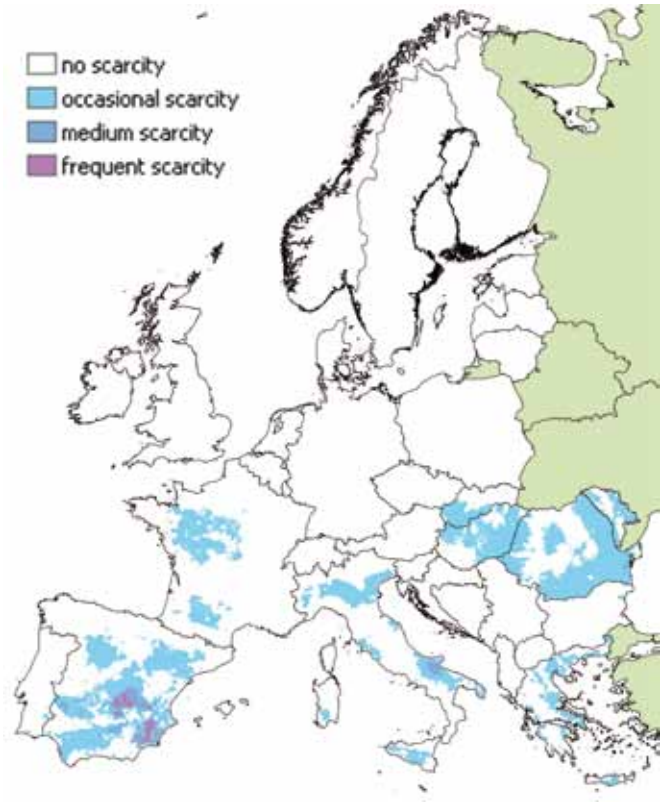
Figure 2: Daily water footprint (WF) per capita in the EU-27 and Croatia as a result of the consumption of different product groups



Graph produced by the JRC, based on data from Mekonnen and Hoekstra (2011).

By comparing the available water with water footprint values, it is possible to identify water stress regions. An EU assessment matching water demand and supply yielded a map of stress regions, suffering from regular water scarcity.

Figure 3: Water stress regions in the EU



The map displays areas where river-basin supply is not sufficient to meet the demands for fresh water; based on data from 1990-2010, and the JRC's LISFLOOD model.

In 2011, the JRC produced high resolution datasets on irrigation water use and demand for Europe and Africa. For crops, this demand can range from a minimum of 13 mm per year in Switzerland to 900 mm in Spain, Portugal, Greece and Italy. The JRC has also developed datasets of water used for livestock in Europe and 20-year simulated daily run-offs and river discharges in Europe and Africa (see page 6).

Work in progress:

The JRC aims to

- improve the existing knowledge on water transfers between river basins and regions;
- improve the statistics about water demand at regional levels;
- further study the relation between weather and river discharge observations; and
- develop models of past and future water withdrawals and consumption by the agricultural, domestic, manufacturing and electricity sectors.

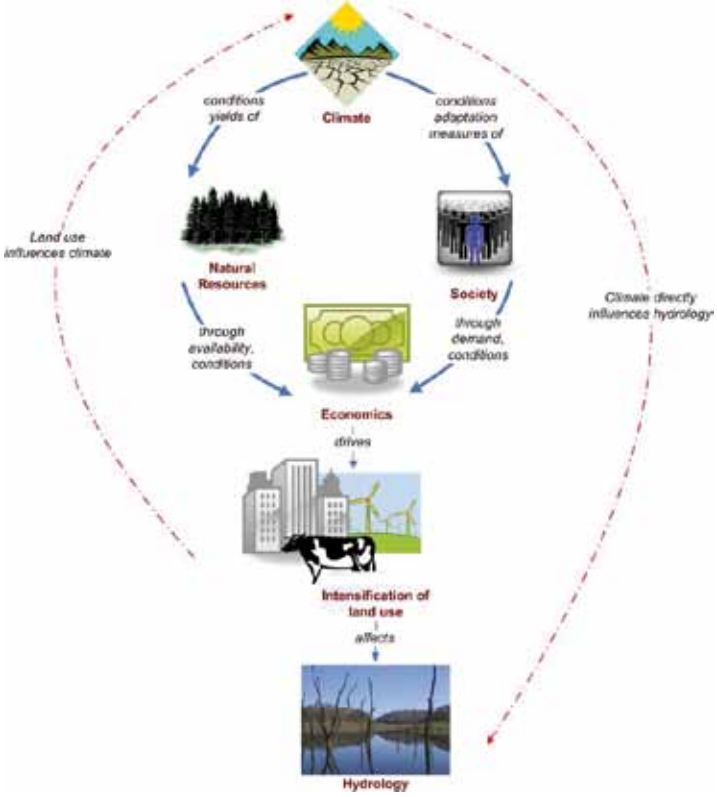
1.2. Addressing water efficiency in Europe

JRC activities in this area provide scientific support to the following policy initiatives:

- Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive)
- Directive 2007/60/EC of 23 October 2007 on the assessment and management of flood risks
- 2012 Blueprint to Safeguard Europe's Waters

Water is a valuable resource for a wide variety of sectors. In order to meet all needs and ensure the sustainable management of water, it is vital that it be used efficiently. The JRC has integrated an optimisation model into its water modelling platform that simulates the effects of policy options on water quality and water quantity, together with their associated costs and benefits. The availability and development of water resources is evaluated within the JRC in terms of human consumption, irrigation, environmental requirements, recreational needs, costs, energy consumption and pollution.

Figure 4: An overview of the integrated modelling approach developed by the JRC



Based on economic and environmental constraints, the JRC optimisation model is designed to deliver the best options for allocating available water to all end users while ensuring environmental and economic sustainability. The model aims to provide a systematic means of comparing tradeoffs and selecting alternatives that best satisfy policy objectives and users' needs.

*Sustainable and efficient **land use management** is crucial to both water quality and quantity. One of the scenarios evaluated by the JRC addresses water retention measures and the extent to which they reduce surface runoff. This has an impact on the inflow of pollutants into rivers as well as the risk of floods. The effects of land use on local and regional hydrology are evaluated by the JRC using a multi-model approach, in which climate change simulation models are combined with a land use modelling platform. Land use and climate change results are fed into agricultural and forestry models. Finally, the effects of all interrelated changes of land use, climate, agriculture and forestry on the water cycle are evaluated using a hydrological model.*

Work in progress:

The JRC will further integrate the water quality and quantity models and extend the modelling framework to identify options that can optimise water efficiency.

1.3. Water for use in agriculture

JRC activities in this area provide scientific support to the following policy initiatives:

- Common Agricultural Policy
- Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive)

Access to sufficient water resources is essential for agriculture. 18% of the world's land area is used for agriculture and accounts for about 85% of global freshwater use. Irrigated crop yields are globally about 2.7 times higher than those of rainfed farming, according to the Food and Agriculture Organization (FAO). Increasing demand for food will certainly have an impact on the future need for irrigation. Freshwater demand of non-food crop production is also increasing on a global scale. While most European crops rely on rainwater, water abstraction for agricultural irrigation purposes accounts for on average 24% of total water abstraction in Europe. There are, however, broad geographical differences. For example, France, Greece, Italy, Portugal and Spain account for 75% of the total irrigated agricultural land in the EU-27.

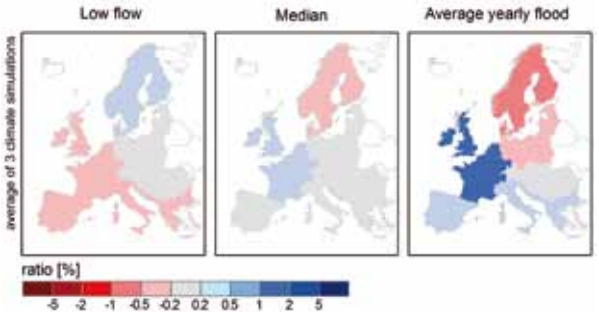
Pressures on water resources culminate during the summer (dry season), when the irrigation demand of agriculture is highest. Changes in water availability may lead to changes in irrigation patterns, which may affect agricultural production. For instance, a significant decrease in irrigation has been reported by the European Environment Agency (EEA) in eastern European countries and, to a lesser extent, in western countries, while a large increase has been observed in southern Europe and Turkey. The increased pressure on water resources affects both water quality and quantity.

Irrigation has led to a decline in groundwater levels in many aquifers (underground layers of rock or other material that

carry groundwater) and is partly responsible for the change in the hydrological regime of several European rivers. Intensive agriculture is also responsible for the degradation of the quality of surface and groundwater, for example as a result of contamination by pesticides and nitrates. Limited rainfall and shortages of water have an important impact on food availability and food security. Climate change is expected to intensify irrigation requirements and, more generally, water scarcity. This will put an additional burden on water abstraction and land use, as the demand for irrigation may increase and spread to other areas in order to mitigate the effect of a drier, warmer climate.

The JRC is actively involved in studying the impact of agriculture on the quantity and quality of water resources in Europe, as part of its support to the Resource Efficiency Roadmap of the Europe 2020 initiative. It carries out modelling activities to compare the water requirements during the crop growing season with available water in the soil. Such activities will increasingly rely on integrated modelling and scenario analyses to provide the best options for alleviating the increasing pressure on water and land use, and finding the optimal balance between available water resources and the requirements of agriculture, industry and human consumption.

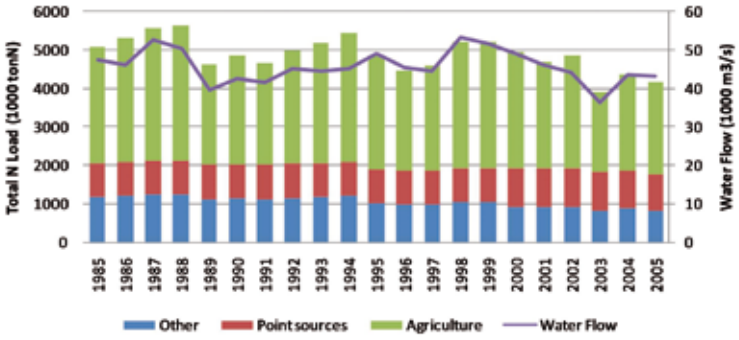
Figure 5: Changes in river flows resulting from land use change between 2006 and 2030, as simulated using the JRC's LISFLOOD model



Blue colours on the maps indicate increased runoff, while red indicate decreased runoff.

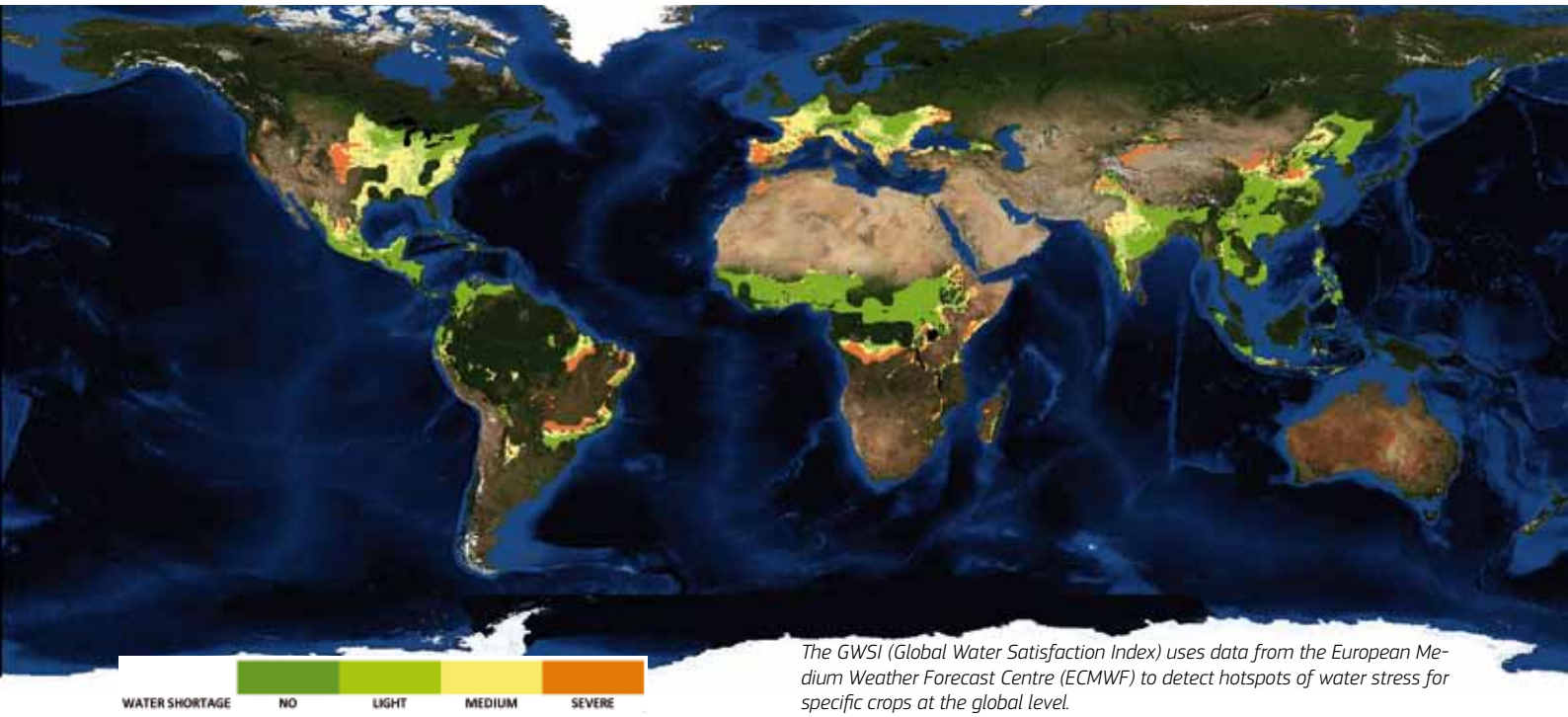
A number of tools have been developed by the JRC to quantify agricultural crop production in relation to water resources. The results of advanced modelling and remote sensing activities are integrated with global environmental databases to forecast crop production and provide accurate estimates of irrigation requirements. As an example of ongoing activities, the JRC has modelled the decline of a large aquifer in Spain, which would lead to the drying of many wetlands. The JRC has also developed modelling methodologies to assess the impact of agriculture on water quality. Recent results indicate that agriculture is responsible for about 60% of the total nitrogen entering all European seas.

Figure 6: An overview of the integrated modelling approach developed by the JRC



JRC is investigating the efficiency of EU environmental regulations in controlling the emissions of pollutants and nutrients, in particular in surface and sub-surface waters, to understand why the nitrogen concentration is increasing in many European rivers, despite the stringent environmental regulations in place. In addition, the JRC is developing tools to study potential intrusion of sea water in aquifers along the European Mediterranean coast, due to over-abstraction of groundwater to meet the demands of agricultural and tourism activities.

Figure 7: Water satisfaction index for maize as assessed on 31 July 2010



The GWSI (Global Water Satisfaction Index) uses data from the European Medium Weather Forecast Centre (ECMWF) to detect hotspots of water stress for specific crops at the global level.

1.4. The water and energy nexus

JRC activities in this area provide scientific support to the following policy initiatives:

- Communication from the Commission of 11 October 2010 – Energy 2020: A strategy for competitive, sustainable and secure energy, COM(2010)639
- 2012 Blueprint to Safeguard Europe's Waters
- Communication from the Commission of 7 October 2009 – Investing in the Development of Low Carbon Technologies (SET-Plan), COM(2009) 519
- Communication from the Commission of 15 December 2011 – Energy roadmap 2050, COM(2011) 885
- Directive 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources

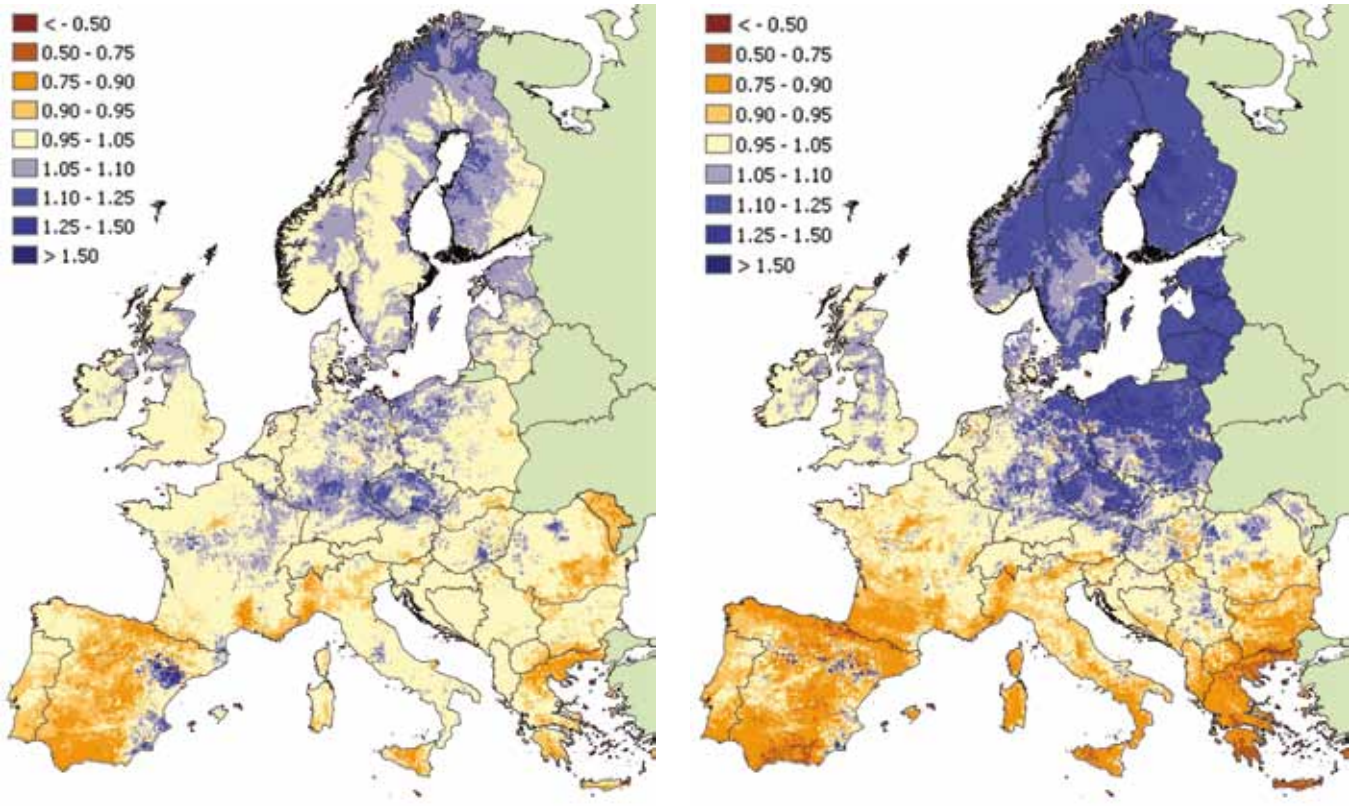
According to the International Energy Agency (IEA), in 2009 1.4 billion people – 20% of the world's population – did not have access to electricity. By 2035, global energy consumption is expected to increase by about 50% over its 2007 levels, with non-OECD countries accounting for 84% of this increase.

The transition to a low carbon economy is a key priority of the EU. The large-scale deployment of low carbon energy technologies is essential to achieving this goal. Various options for the decarbonisation of the power system are currently being considered based on their associated financial costs and benefits.

The impact of such technologies on water resources has, however, largely been overlooked. To give an example: according to the European Environmental Agency (EEA), more than 44% of freshwater abstraction in Europe is carried out to cool thermal power plants. Water is also necessary for alternative or renewable forms of energy such as hydropower, concentrated solar energy and biofuels.

On the other hand, a JRC analysis found that the deployment of low carbon technologies could lead to decreased water consumption by 2050, to 25-90% of current levels depending on the technology mix. The critical factor in future water consumption is the penetration rate of renewable energy technologies (such as wind or solar power) and of carbon capture and storage technologies after 2030.

Figure 8: European hydropower potential

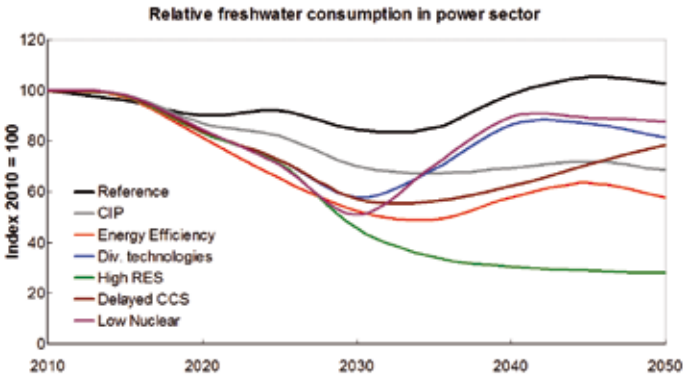


Projected changes in gross hydropower potential per year for the periods 2011-2040 (left) and 2041-2070 (right).

While renewable energies consume insignificant water quantities for their operation, carbon capture and storage requires higher quantities of water (for cooling and other processes) compared to conventional fossil fuel plants of similar capacities.

As a contribution to the ongoing dialogue on the optimal evolution of the energy system, the JRC has analysed the impacts of new power generation technologies on freshwater consumption in support of the 2012 Blueprint to Safeguard Europe's Waters. This assessment is based on the scenarios laid out in the European Energy Roadmap 2050.

Figure 9: Freshwater consumption in the European power sector in the period 2010-2050



The calculation is based on the decarbonisation scenarios described in the European Energy Roadmap 2050.

The JRC is developing methods to assess the current and future potential of hydropower in Europe in relation to the availability of water. In the reference scenario of the European Energy Roadmap, water consumption in 2050 is projected to remain at current levels. This could be potentially problematic, given the fact that projections carried out by the JRC of water consumption under climate change conditions find that gross hydropower potential (the energy potentially available if all natural runoff at all locations were to be harnessed) is projected to decrease in southern Europe by 2070.

Work in progress:

Looking to the future, more research is needed in the following areas:

- life-cycle analysis of the water requirements of low carbon technologies
- economic analysis of the technology options available for reducing water requirements in carbon capture power plants
- development of alternative cost competitive cooling technologies, increased water efficiency and use of alternative water resources, such as water recovery from flue gases.

2. Water quality

In the early nineties, the increasing contamination levels of freshwaters (rivers and lakes) and their impacts on receiving coastal areas led the European Commission to adopt a series of directives to reduce pollution from, for example, agricultural activities (the Nitrates Directive), households (the Urban Waste Water Treatment Directive), and industry (the Integrated Pollution Prevention and Control Directive).

These political measures were reinforced in the past decade by the Water Framework Directive (WFD) and the Marine Strategy Framework Directive. In addition, the wide array of legislation for controlling pressures on European waters are complemented by various international conventions for the protection of the European seas of which EU countries are members.

The 2012 Blueprint to Safeguard Europe's Waters is the result of an integrated analysis of the WFD river basin management plans, the Water Scarcity and Droughts Strategy and the vulnerability of water resources to climate change and other man made pressures. It aims to verify that the WFD requirements for achieving the good status of all EU waters by 2015 are fit for purpose.

2.1. Assessing the good ecological status of waters in Europe

JRC activities in this area provide scientific support to the following policy initiatives:

- Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive)
- Commission Decision 2008/915/EC of the 30 October 2008 establishing, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, the values of the Member State monitoring system classifications as a result of the intercalibration exercise
- Directive 2008/105/EC of 16 December 2008 on environmental quality standards in the field of water policy

The general objective of the WFD is to achieve 'good status' for all surface waters by 2015. 'Good status' means both 'good ecological status' and 'good chemical status'. The WFD classification scheme for water quality includes five status classes: high, good, moderate, poor and bad.

'High status' is defined as the biological, chemical and morphological conditions associated with no or very low human pressure. This is also called the 'reference condition' or 'benchmark', as it is the best status achievable. These reference conditions are different for rivers, lakes and coastal waters. Assessment of quality is based on the extent the quality of the water deviates from these reference conditions.

The JRC has played a pivotal role in providing scientific and technical support to the **definition of good ecological status** of waters.

During the past decade, Member States have developed a multitude of methods for defining good ecological status, tailored to local conditions. The **intercalibration exercise**, a legal requirement of the WFD, ensures that all of these methods follow the requirements of the Directive and that their results are comparable. The technical aspects of the intercalibration exercises are coordinated by the JRC. Because an exercise of this scale had never been attempted before, novel methodologies had to be invented and tested. Initial results were published in 2008 and further results are expected in 2012.

Assessing the ecological status of EU waters has revealed the need for more robust bio-indicators and a reduction in the uncertainty of the results. The JRC carries out scientific research leading to the development of novel methods to fill in these gaps. Examples include a tool for quantifying the frequency of algal blooms and a tool that monitors invertebrate organisms in lake sediments to measure eutrophication pressure.

Stemming from this intercalibration exercise, the JRC has established a pan-European intercalibration network for rivers, lakes, and coastal and transitional waters. It consists of more than 50 expert groups.

JRC is also developing novel methodological approaches for harmonising classification methods and for addressing statistical uncertainty in ecological classification.

Work in progress:

Despite considerable progress, significant knowledge gaps still hinder the implementation of the WFD. The main remaining gaps relate to the comparison of large river assessment systems, heavily modified water bodies, transitional waters, and assessment systems in the Mediterranean and Eastern European regions. Therefore, the JRC will continue to be engaged in the further efforts required to develop and/or intercalibrate bioassessment methods for the remaining ecosystem types and regions.

2.2. Chemical pollutants

JRC activities in this area provide scientific support to the following policy initiatives:

- Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive)
- Directive 2008/105/EC of 16 December 2008 on environmental quality standards in the field of water policy
- Directive 2009/90/EC of 31 July 2009 laying down, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, technical specifications for chemical analysis and monitoring of water status
- Directive 2006/118/ of 12 December 2006 on the protection of groundwater against pollution and deterioration
- Revision of the Council Regulation (EC) No 166/2006 of 18 January 2006 concerning the establishment of a European pollutant release and transfer register and amending Council Directives 91/689/EEC and 96/61/EC

Chemicals that are used as part of daily life can often end up as waste deposits in water. Pharmaceuticals that heal human diseases may be dangerous to fish, personal care products can pollute lakes and rivers and chemicals used to grow food crops can poison our drinking water. Over the past decade, efforts to observe and quantify these chemicals have led to better information and raised awareness. A deeper understanding of water, made it evident that research was needed not only on single substances, but also the 'cocktail of substances' that humans release on a daily basis. Research showed that single substances, harmless in dose and effect, can become a threat to health and the environment if combined with other chemicals.

The Water Framework Directive (WFD) is an essential element of European environmental legislation and a key pillar of the European strategy for the reduction of water pollution. The Directive describes how, and by which date, Environmental Quality Standards for pollutants should be developed. These standards set maximum concentrations of pollutants or groups of pollutants in water, sediments and lists of living organisms in an area. The Directive requires the periodic identification and update of **priority substances**, which present a significant risk to or via the aquatic environment.

Between 2006 and 2011, the JRC elaborated a comprehensive prioritisation scheme for toxic substances under the Directive. JRC scientists used modelling methods based on the principle that the properties of a chemical substance depend on its intrinsic nature and can be directly predicted from its molecular structure and the properties of similar compounds whose characteristics are known. The JRC also supported the development of Environmental Quality Standards for these priority substances.

In parallel, the JRC together with the UK Environment Agency, evaluated over two thousand substances put forward by Member States, stakeholders and NGOs, of which 78 substances were classified as being of "high concern" based on their hazard risk and plausible exposure scenarios.

The computational methods used by the JRC allow the quick analysis of a considerable number of chemicals, including substances that are not routinely monitored in the environment.

On a more general level, the JRC carries out extensive research to **assess the impact of pollutants** in aquatic ecosystems and studies their potential future impact on the environment as they break down. The JRC coordinates several campaigns to measure and monitor nutrients and chemicals in aquatic environments at regional and pan-European levels, including industrial, agricultural and domestic persistent organic pollutants (POPs). In addition, it maintains the regularly updated list of priority substances.

In December 2011, the JRC contributed to the 'Technical Guidance for Deriving Environmental Quality Standards' as part of the Common Implementation Strategy for the Water Framework Directive. The setting up of quality standards for water, sediment and biota was coordinated by the JRC. The project was led by the UK and supported by a JRC working group on chemical aspects. Member States, EFTA countries, Candidate Countries and more than 25 European umbrella organisations representing a wide range of interests (industry, agriculture, water, environment, etc.) participated in this setting of standards.

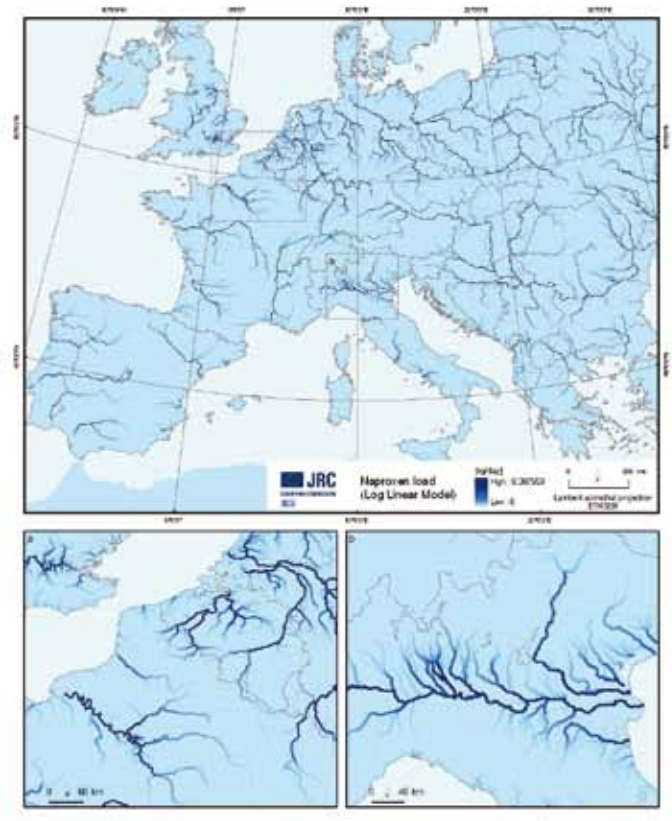
The final Guidance Document represents the 'state of the art' in terms of the assessment of how regulations can have an impact on water quality. The methodology presented has been used to establish environmental quality standards for new lists of priority substances and for river-basin-specific pollutants, based for the first time not only on the water column but also on sediment and biota matrices.

The work that needs to be carried out to identify and quantify the substances that could be candidates for inclusion on the priority list cannot be achieved by a single organisation working alone. It is crucial to network with research groups, national administrations and stakeholders. A monitoring mechanism is currently being discussed by the European Water Directors to support the identification of future candidate priority substances for the Water Framework Directive. This mechanism will significantly involve the JRC, given its position at the science-policy interface and its water monitoring experience.

The JRC maintains the latest chemical measurement facilities and can detect even extremely low concentrations of substances such as flame retardants, ingredients of perfumes or residues of pharmaceuticals. This information is complemented by other environmental information, creating a dataset which can help to, for instance, estimate loads released into our oceans or assess the efficiency of wastewater treatment processes.

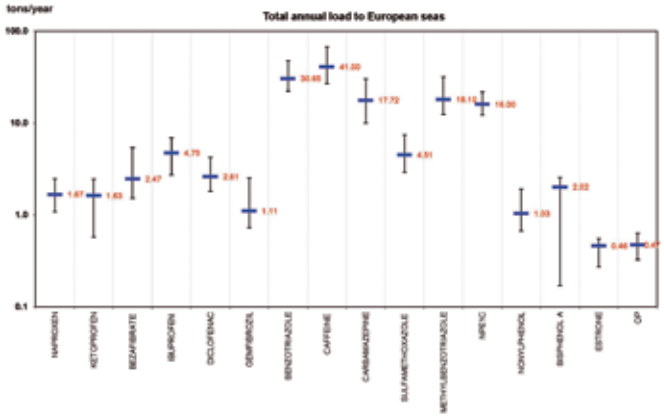
Modelling-based scenario analyses of the impacts of various policy options for controlling pollutant emissions to aquatic bodies are also carried out by the JRC. In 2011, the JRC published several maps that identify 'hotspots' of pollutants, their fluxes and their proximity to water ecosystems at a European and regional scale.

Figure 10: Example of a European map of chemical load to rivers for Naproxen



The map is based on a combination of inverse modelling and measurements from pan-European monitoring campaigns.

Figure 11: Model estimates of chemical loads to European seas



The model estimates several widespread water contaminants such as pharmaceuticals, personal care products, substances widely used in households or from industrial activities. The numbers in the graph indicate the median values of loads while the bars show the expected load ranges.

The JRC also promotes innovative solutions to investigate and quantify the effects of chemicals and mixtures of chemicals in water bodies. In particular, the use of genomic approaches provides a novel insight into how manmade chemicals interact with animals and plants. Cutting-edge research carried out by the JRC on DNA from fish, crustaceans and algae is preparing the way forward for regulating chemicals in a completely new way.

The JRC has conducted several EU-wide screening exercises of new and less-investigated substances, focusing on emerging chemical pollutants in treated wastewater, sewage sludge and biowaste such as compost. An analysis was carried out on over 200 different substances in some 300 samples taken from wastewater treatment and biowaste generating plants across Europe. The researchers used information generated in previous screenings of groundwater and surface waters, and assessed chemical contamination of more than 500 different sites.

The results showed that substances that had recently been introduced to the European Market were present in the water and could be detected in the groundwater within a few years. The JRC demonstrated that the artificial sweetener sucralose could be detected in quantifiable amounts in 50% of all investigated samples in surface and groundwater. Three years after its introduction to the European market, significant concentrations were reported in samples from eight countries, which illustrates how fast such persistent substances can reach the groundwater aquifer.

The findings generated by the JRC supported the Commission proposal to add 15 chemicals to the list of 33 pollutants that are monitored and controlled in EU surface waters. These include industrial chemicals as well as substances used in biocides, pharmaceuticals and plant protection products, and have been selected on the basis of scientific evidence that they may pose a significant risk to health.

Work in progress:

Currently, the JRC is carrying out a pilot research exercise to investigate the technical feasibility of a 'watch list' mechanism, designed to anticipate and identify future priority substances. Other projects and activities are being carried out in parallel to achieve a more structured access to monitoring information. In addition, an EU-wide assessment of the applicability of effect-based bioassays has been launched. This assessment aims to investigate viable options to help the Member States prioritise among emerging pollutants and link the results of chemical analyses with a real status assessment of water environments.

2.3. Pollution: from source to sea

JRC activities in this area provide scientific support to the following policy initiatives:

- Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive)
- Directive 2008/56/EC of 17 June 2008 establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive)
- Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption
- Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources
- Directive 2009/128/EC of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides
- Council Decision 2006/507/EC of 14 October 2004 concerning the conclusion, on behalf of the European Community, of the Stockholm Convention on Persistent Organic Pollutants

Despite the EU's legislative efforts to avoid water pollution, the generalised contamination of freshwater, worldwide eutrophication and anoxia (absence of oxygen) in coastal areas are still prevalent. The JRC has carried out a series of studies to support policymakers in identifying new management and policy scenarios that can improve the status of European waters. These studies assess the pressures of pollutants on aquatic ecosystems in Europe and to what extent these pressures are affected by spatial and temporal changes of, for example, agricultural practices, and industrial and regulatory options. To this end, the JRC has developed a set of continental-scale models and harmonised environmental databases for the whole of Europe. Even though the studies carried out using these models have marine water bodies as the final recipients of pollutants, they focus on inland freshwaters and on management measures taken at the river basin scale.

The studies, which were carried out over the past few years, aimed to identify the main sources of pollutants (i.e. nitrogen and phosphorus) entering European marine waters. This then contributed to determine which inland-based sectors pollute coastal and marine waters. It also helped to evaluate the efficiency of various environmental directives and the environmental impact of land use, point-source management and pollutant emission patterns on the load of pollutants. The scenarios studied included a better use of animal waste as a fertiliser, the ban of phosphate-based detergents, and the reduction of meat in the human diet. The JRC also initiated an innovative inverse modelling approach to provide emissions data for emerging contaminants.

The studies have shown that:

- despite the implementation of environmental legislation, the loads of nitrogen and phosphorus entering European coastal waters have not declined as expected. However, strong regional differences were found to exist.
- agriculture is responsible for about 60% of the total amount of nitrogen entering all European seas, while urban wastewater discharges are responsible for 66% of the total load of phosphorus.
- a better use of animal manure was shown to be the most effective approach to reduce the pressure of agriculture on surface water quality, while the ban of phosphorus-based detergents could further reduce the regional emission of phosphorus by 7% to 57%.

Figure 12: Annual phosphorus loads entering European seas split by sector of activity

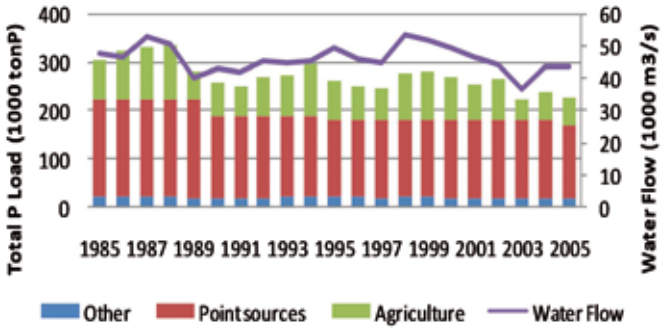
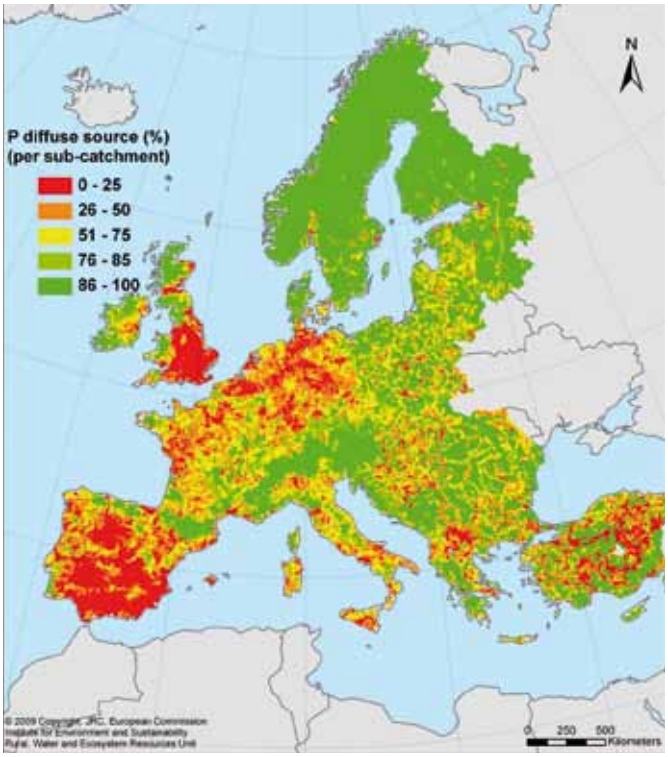


Figure 13: Contribution of diffuse sources to total phosphorus loads in surface waters



The JRC has developed a model for the Multimedia Assessment of Persistent Organic Pollutants in the Environment (MAPPE). This model generated maps of annual chemical concentrations and fluxes in Europe with 1 km^2 resolution. These maps can be used for screening hotspots or hazard zones and in European decision-making scenarios.

Work in progress:

JRC is working on the evaluation of the effects of excess contaminants on ecosystems' resilience and on human health. The JRC's assessment will be extended beyond Europe, as many scenarios that are linked, for instance, to human diet or the impact of nutrient emissions, have a direct link to global food trade, and many organic contaminants found in Europe's waters have their origin in other parts of the world.

2.4. Assessing marine and coastal waters

JRC activities in this area provide scientific support to the following policy initiatives:

- Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive)
- Directive 2008/56/EC of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)
- Commission Decision 2010/477/EU of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters
- Commission Staff Working Paper SEC(2011) 1255 on the relationship between the initial assessment of marine waters and the criteria for good environmental status
- Communication of 10 October 2007 on an Integrated Maritime Policy for the European Union, COM(2007) 575
- Communication of 26 June 2008 on Guidelines for an Inte grated Approach to Maritime Policy: Towards Best Practice in Integrated Maritime Governance and Stakeholder Consultation, COM(2008) 395
- Communication of 25 November 2008 on the Roadmap for Maritime Spatial Planning: Achieving Common Principles in the EU, COM (2008) 791

The coastal and marine environment is a major provider of goods and services and hosts an invaluable biodiversity, ranging in size from microbes to whales. Human activities, such as agriculture, fisheries, aquaculture, shipping, urbanisation and tourism, affect the integrity and functioning of marine ecosystems, and consequently the goods and services they provide.

A marine area is considered to have good environmental status when the species distribution, species abundance, chemical composition and physical conditions of the water and sea bed do not significantly deviate from the state it would have without human interference (the unimpacted state). An in-depth knowledge of how ecosystems function and a regular assessment of the state of the marine environment are needed in order to take measures to prevent degradation and ensure sustainable interaction with the sea.

The JRC provides scientific and technical support by reviewing the state of the art and setting concepts and principles for adequate, comparable and harmonised marine assessment and monitoring programmes.

It also carries out a systematic and synoptic assessment of key environmental indicators of marine and coastal areas using a unique combination of repeated satellite observations and numerical modelling simulations. This analysis of remote sensing data, combined with hydrodynamic and biogeochemical modelling results, supports the development

of a marine and coastal knowledge base that focuses on physically and biologically sensitive areas in European and other waters. The models and imagery highlight regions at high risk of physical and biochemical change, such as oxygen depletion events, eutrophication, anomalous blooms, shifts in periodic bloom dynamics and changes in water productivity and water quality. This knowledge base constitutes the starting point from which to assess geographical units characterised by a coherent set of ecological properties. Such an assessment is a prerequisite for developing a consistent ecosystem approach to integrated coastal management and maritime spatial planning.

The JRC develops tools to accurately monitor eutrophication based on satellite images. This optical remote sensing of the sea, which is based on an analysis of ocean colour obtained from satellite data, can provide daily maps of the biogeochemical characteristics of seawater or the concentration of non-living matter. This information is essential for water quality monitoring, the evaluation of marine resources and biodiversity, ecosystem modelling and for carrying out climate change studies.

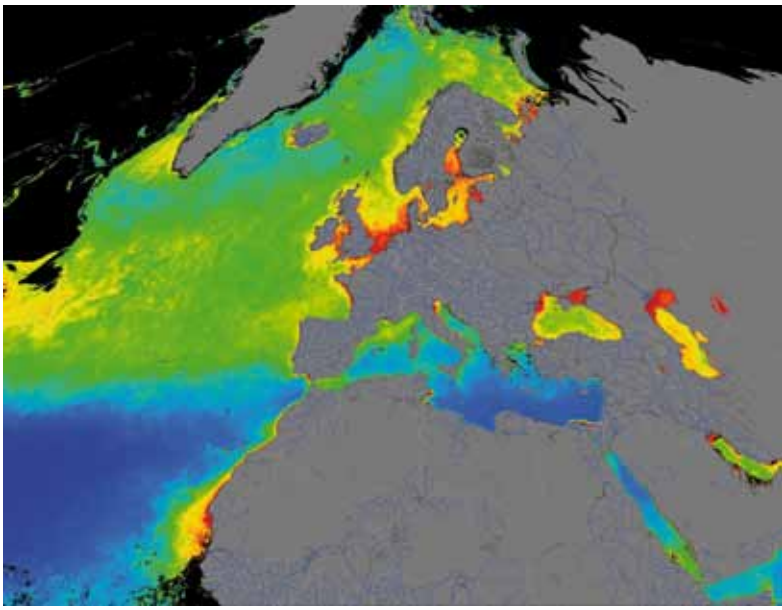
Wide dissemination of spatial marine and coastal knowledge is ensured via the JRC's online Environmental Marine Information System (EMIS) for the waters around Europe and the Marine Information System (AMIS) for waters in and around Africa. The JRC also helps ensure that marine data provided follows the specifications set by the INSPIRE Directive in order to achieve interoperability of spatial datasets and spatial data services.

The JRC has also addressed the problem of marine litter, which increasingly threatens ecosystems, and has published a report with technical recommendations on how to monitor this phenomenon. The Marine Strategy Framework Directive lays down marine litter reduction targets that EU countries shall reach by 2020.

Work in progress:

JRC is developing devices to analyse floating marine litter through a camera system installed on ships. Good ecological status indicators for this topic need to be refined and renewed. The JRC is also contributing to the European Marine Observation and Data Network (EMODnet) initiative by providing data, supporting the planning of environmental policies and carrying out impact assessments.

Figure 14: Chlorophyll-a concentration in seas



Satellite image showing low (blue), moderate (green), high (yellow) and very high (red) Chlorophyll-a http://emis.jrc.ec.europa.eu/)

3. Preserving ecosystems

Aquatic ecosystems have an important role in water purification, flood prevention, maintenance of fish stocks and carbon storage. These benefits received from nature are called ecosystem services, as they link natural ecosystems to our society and economy. Their effectiveness is directly linked to the health of the habitats. Therefore, these habitats must be preserved.

For example, aquatic ecosystems contribute to supplying clean water by absorbing or filtering pollutants such as heavy metals, excess nutrients, and pesticides as water moves through wetlands, rivers, streams, etc. In periods of heavy rainfall, many of these ecosystems act as buffers, storing water that would otherwise flood cities, industries and farms. In particular, estuaries, coastal marshes and habitats such as mangroves moderate sea-borne storm surges and hence protect coastal lands from flooding.

Ecosystem services are being mainstreamed in the EU water policy, which assumes that there is a connection between the good ecological status of surface and marine waters and the provision of ecosystem services. Other policies on climate, agriculture, fisheries, or regional development are also adopting ecosystem-based approaches as a guiding principle for reaching sustainability targets and for aligning with the Europe 2020 strategy for smart, sustainable and inclusive growth in the EU.

3.1. Mapping and valuation of ecosystem services

JRC activities in this area provide scientific support to the following policy initiatives:

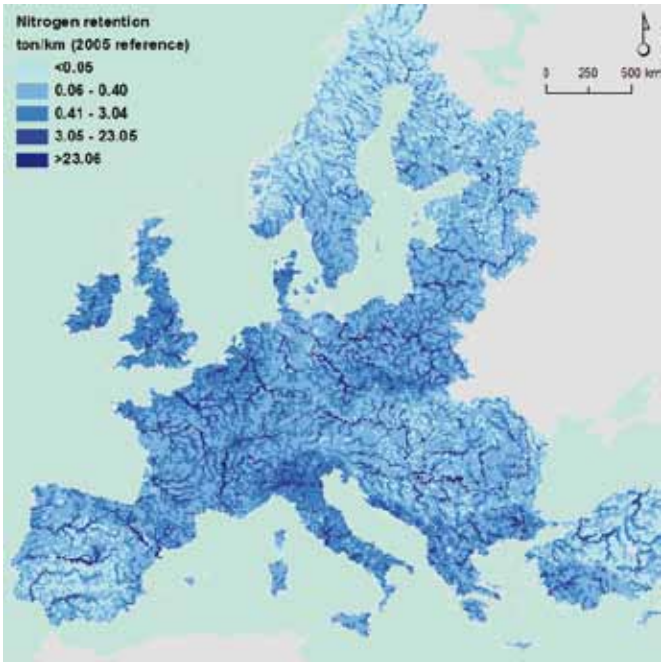
- Communication of 3 May 2011 - Our life insurance, our natural capital: an EU biodiversity strategy to 2020, COM(2011) 244
- Blueprint to Safeguard Europe's Waters
- Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora, amended by Directive 97/62/EC, Regulation (EC) No 1882/2003 and Directive 2006/105/EC (Habitats Directive)
- Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive)

There is a growing consensus that nature-based solutions, such as using wetland ecosystems for water purification, might be more cost-effective than technical infrastructures that carry out the same function. It is important to map and value ecosystem services in order to be able to preserve them, as they are vulnerable to climate change, land use reclamation and pollution. More research is needed on the links between the state of biodiversity, ecosystem functions and services to better understand and protect them.

When ecosystem services have been valued, they can be integrated into the decisions made by scientists and policy makers. The JRC is developing European indicators that quantify the provision of ecosystem services by freshwater and marine habitats. These indicators are based on the JRC's modelling capacity and the data it has collected over the years. The aim is to integrate ecosystem and biodiversity conservation into spatial planning measures that avoid ecosystem degradation and biodiversity loss.

The JRC is assessing the role of water bodies (wetlands, lakes and rivers) in water purification services using nitrogen as a common water quality reference. Excessive nitrogen loads are a leading cause of water pollution worldwide, triggering eutrophication in coastal zones, a process that eventually results in extremely low oxygen conditions or dead zones. European water bodies are able to remove 1.5 million tonnes of nitrogen from surface waters. Conventional treatment of water to remove nitrogen is an expensive process (up to 30€/kg), which illustrates the economic benefits of having a healthy ecosystem in which water bodies can provide natural ecological processes free of charge.

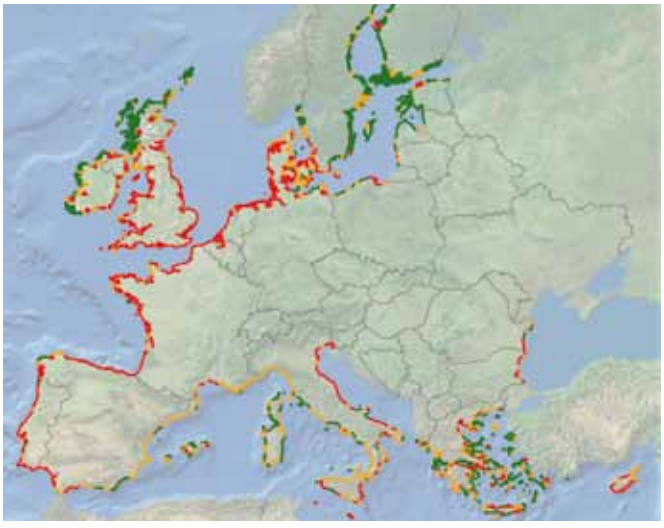
Figure 15: Nitrogen retention by rivers and lakes



Europe's rivers and lakes remove high quantities of excess nitrogen and contribute to better water quality in downstream reaches.

Depending on their state, coastal habitats can help protect populations in coastal areas from adverse weather consequences, such as flooding. Such habitats represent crucial breeding grounds for fish and provide fisheries nurseries, which are essential for replenishing commercial fish stocks. By combining data on coastal topography, habitats and geomorphology using models of wave exposure, storm surge, tidal range and sea level rise, the JRC identified vulnerable areas where the population and infrastructure may be exposed to natural disasters, as well as areas naturally protected against such hazards. The results indicate that large portions of the European coast lack the natural capacity provided by ecosystems to protect against damage caused by storms. These results will help implement measures to protect coastal populations and infrastructures against storm hazards.

Figure 16: Provision of coastal protection



The red coastline indicates areas in which demand for coastal protection is expected to be higher than the natural provision of this service. The green coastline represents areas in which supply is higher than demand.

Work in progress:

In support of the good conservation status of habitats, the JRC will continue to provide scientific support to EU policies to link innovative approaches based on ecosystem services to current conservation activities. This will include integrated economic and environmental modelling approaches that assess the impacts of these policies in order to identify the best scenarios for sustainable land use and water management.

3.2. Alien species: a significant threat to biodiversity

JRC activities in this area provide scientific support to the following policy initiatives:

- Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive)
- Communication of 3 May 2011 - Our life insurance, our natural capital: an EU biodiversity strategy to 2020, COM(2011) 244
- The development of a dedicated legislative instrument on Invasive Alien Species which is due to be adopted in 2012
- Directive 2008/56/EC of 17 June 2008 establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive)

Another factor that threatens ecosystems is the invasion of alien (non indigenous) species. Natural physical barriers (such as oceans, mountains, deserts, rivers, climate conditions, etc.) have restricted the range of flora and fauna to certain areas, thereby substantially contributing to the planet's rich biodiversity and the development of indigenous bio-communities that are typical to particular regions.

However, through human activities such as shipping, aquaculture, canal construction, and trade, these physical barriers have been overcome, and species are often found in regions far from their normal range. These alien species rarely have natural predators and are often so successful in their new areas that they constitute a major pressure to several aquatic ecosystems, with both ecological and economic impacts. They are recognised as one of the main pressures directly driving biodiversity loss worldwide, a phenomenon that severely affects Europe.

The JRC addresses questions related to the role of alien species in the ecological status of aquatic systems. It evaluates the sensitivity of national biological assessment methods to determine pressures caused by these species. A selection of countries by surface-water category (lakes, rivers and coastal waters) combinations was tested, covering nearly 40 000 water bodies. The prevalence of invasive alien species was found to be strongly associated with poor quality of surface water.

The JRC has started reviewing the pressures facilitating alien species invasions. The potential impacts of restoration measures to avoid alien species were also investigated. In particular, bio-manipulation, commonly used in the management of water quality in European shallow lakes, has been investigated to assess its effect on freshwater alien species populations.

Recent research efforts have led to growing information on the rate of arrivals, spread, vectors and pathways of introduction of alien species, which is often accessible through online databases.

After a comparative analysis of the 43 existing European databases, JRC scientists noted that even the most comprehensive database failed to include 27% and 31% of the alien species reported in freshwater and marine environments respectively. In addition, approximately 20% of the alien species documented in European seas were not listed in any of the databases.

To overcome this discrepancy, the JRC has created an online platform called EASIN (European Alien Species Information Network), which aims to improve access to information on alien species in Europe. This platform allows scientists to get an up-to-date overview of current situations, and supports their efforts to raise early warnings and prevent further invasions.

Work in progress:

The JRC is tackling the inconsistencies and gaps in the alien species information available on online databases, especially regarding the nomenclature. In addition, it will continuously monitor alien species on country and regional levels and help create monitoring infrastructures throughout Europe which will facilitate the regular updating of the database. The future distribution of alien species in relation to climate change will also be investigated.

In the Eastern Mediterranean, two invasive herbivore fish species, Siganus luridus and Siganus rivulatus, were introduced from the Red Sea through the Suez Canal. They have become dominant in coastal areas of the Eastern Mediterranean and contributed to the transformation of the ecosystem from one dominated by lush and diverse brown algal forests (up) to one dominated by bare rock (down).

4. Water-related hazards and climate change

According to United Nations data, 90% of all natural hazard events are related to water. The intensity of these hazard events is rising. In 2010, some 370 water related disasters led to the deaths of nearly 297 000 people, had an impact on nearly 208 million others, and led to damages costing around 83 billion euros. Water-related phenomena such as drought, desertification and floods are expected to increase as a result of climate change.

Water is closely linked to climate. Any alteration in the climate system leads to changes in the hydrological cycle. There have already been substantial changes to the global hydrological cycle over the past 50 years that might be attributed to changes in climate, such as an increased runoff of continental rivers, increased precipitation in northern Europe, a drier Mediterranean region and more frequent extreme precipitation events.

For the coming decades, global warming is projected to further affect the hydrological cycle and to considerably alter the distribution in time and space of freshwater resources. The impacts will be felt worldwide and will probably be more severe than those observed to date. This will aggravate the impact of other factors that lead to water stress, such as land use, and demographic and socio-economic changes.

4.1. Floods

JRC activities in this area provide scientific support to the following policy initiatives:

- EU Regulation No 911/2010 of 22 September 2010 of the European Parliament and the Council on the European Earth Monitoring Programme (GMES) and its initial operations (2011 to 2013)
- Directive 2007/60/EC of 23 October 2007 on the assessment and management of flood risks
- Communication of 26 October 2010 – Towards a stronger European disaster response: the role of civil protection and humanitarian assistance, COM(2010) 600
- Communication of 23 February 2009 – A Community approach on the prevention of natural and man-made disasters, COM(2009) 82

Floods are among the most devastating natural disasters worldwide, and have an increasingly significant socio-economic impact. Although appropriate planning and protection measures can reduce the severity of floods and limit the damage they cause, floods can never be entirely prevented.

As rivers often flow through several countries, floods are a transnational concern. For example, in 2010 more than five countries in Central Europe were severely affected by floods at the same time. This transnational aspect of floods represents a major challenge with respect to the coordination of national and international aid.

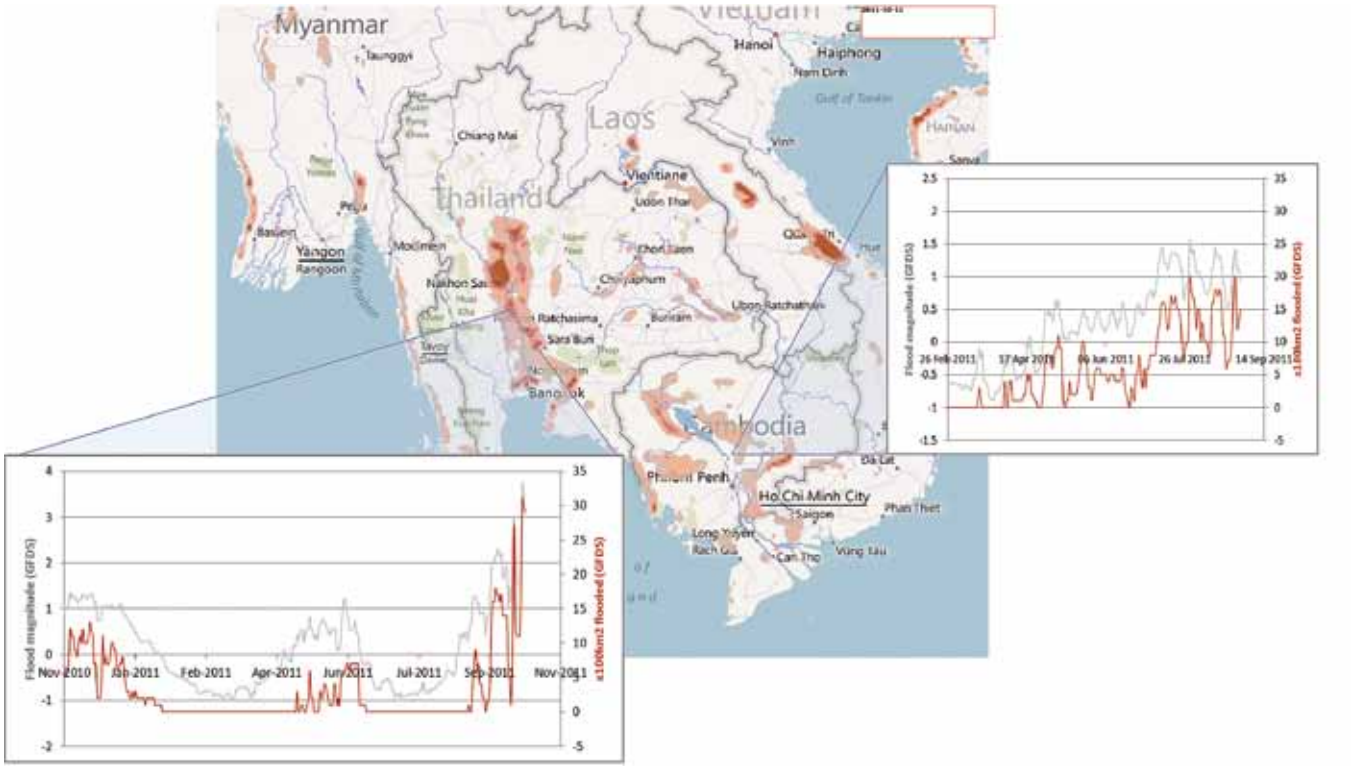
The JRC's contribution to flood monitoring aims to help increase preparedness to and provide support during a crisis. The JRC has set up several systems to forecast the probability of floods.

The European Flood Awareness System (EFAS) forecasts floods in Europe up to 10 days in advance of their occurrence. It was launched in 2003 following the disastrous Elbe and Danube floods. EFAS provides these forecasts to national water authorities and gives a European overview to the European Civil Protection Mechanism, thus directly contributing to improved preparedness and management at the national and European level. Since 2011, EFAS is part of the initial operational phase of the Global Monitoring of Environment and Security (GMES) initiative emergency management service.

The Global Flood Detection System (GFDS) was developed in collaboration with the Dartmouth Flood Observatory (US). It is a real-time satellite-based flood monitoring system. Using innovative processing of passive microwave remote sensing, the GFDS provides virtual satellite-based information about all major rivers in the world, as well as daily updated regional flood maps. This real time information on the impact and extent of floods occurring across borders is particularly useful for rivers on which little monitoring information is available (e.g. in Namibia).

The GFDS uses an innovative procedure based on satellite observations to estimate the volumes of surface waters and generate daily regional flood maps. Contrary to optical (photographic) imagery, the microwave remote sensing imagery can provide daily information independent of weather conditions and anywhere in the world.

Figure 17: GFDS near real-time flood for South East Asia, with quantitative measurements of flooded area for the Chao Phraya (Thailand) and the lower Mekong (Cambodia) on 11 October 2011



The JRC is working on combining innovative forecasting and monitoring tools to support emergency response and humanitarian aid interventions in affected global regions. The Global Flood Awareness System (GloFAS) is being developed by the JRC and the European Centre for Medium-Range Weather Forecasts (ECMWF, UK). GloFAS is an experimental system that produces real-time flood forecasts for the entire globe, independent of administrative and political boundaries. It couples state-of-the art weather forecasts with a hydrological model.

The system will be further developed by the JRC together with end-users such as the World Meteorological Organisation and the Mekong River Commission in order to meet their specific needs.

In October 2011, unusually strong monsoon rains and powerful typhoons in Southeast Asia brought about the worst floods of the past decade in the area. They were successfully predicted by GloFAS two weeks in advance and subsequently monitored with the GFDS throughout the event.

Work in progress:

The JRC is integrating its global flood activities into a single multi-hazard information platform that will help monitor, forecast and manage the risks associated with global natural hazards.

Figure 18: GloFAS 45-day probabilistic discharge forecasts for the Chao Phraya (Thailand) and the lower Mekong (Cambodia) on 22 September 2011

4.2. Drought and desertification

JRC activities in this area provide scientific support to the following policy initiatives:

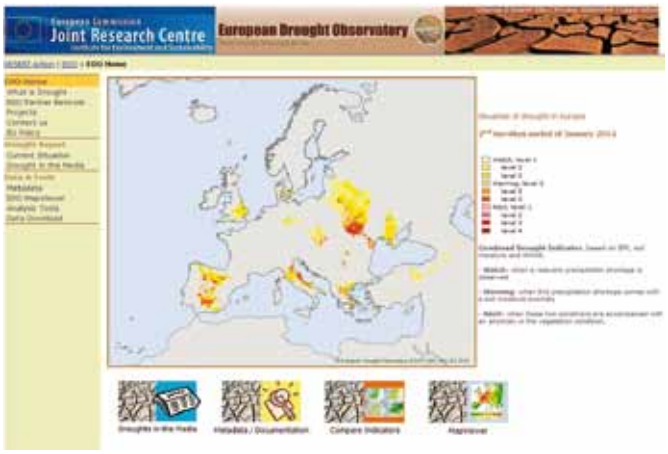
- Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive)
- Communication of 18 July 2007 - Addressing the challenge of water scarcity and droughts in the European Union, COM(2007) 414
- The United Nations Convention to Combat Desertification (UNCCD), 12 September 1994
- UNCCD Ten-year Strategic Plan and Framework to Enhance the Implementation of the Convention (2008–2018), Decision 3/COP.8, ICCD/COP(8)/16/Add.1, 14 September 2007
- Decision 1600/2002/EC of 22 July 2002 laying down the Sixth Community Environment Action Programme

Drought and desertification pose significant threats to the environment and society, and are very likely to increase as a result of climate change. While drought is a natural phenomenon, water scarcity and desertification result from the combined impact of drought and unsustainable land use. Water scarcity refers to a long term imbalance between natural water supply and human demand. Drought, desertification and water scarcity are serious issues in many parts of the world, including the European Union.

In 2007, faced with recurrent droughts and situations of water scarcity in many parts of Europe, the Commission called for action to be taken to monitor and mitigate drought situations.

The JRC responded to this request by developing the online European Drought Observatory (EDO). EDO should become a major tool for the monitoring and forecasting of droughts at a range of spatial scales across Europe. It is being implemented in close collaboration with international, national and regional authorities. Through EDO, the JRC monitors, assesses and forecasts drought phenomena at regional and European scales. Similar experiences are being transferred and tested outside Europe, particularly in Africa and Latin America. The aim is to contribute to a global drought early warning system that will facilitate the better understanding of the location and impacts of droughts.

The first internet portal of the European Drought Observatory was put online in 2011, providing up-to-date information on the occurrence and evolution of drought events in Europe. It includes a map server that provides access to a suite of drought indicators, documentation, search facilities and analysis tools (http://edo.jrc.ec.europa.eu).



The European Drought Observatory provides information on the occurrence and evolution of drought events in Europe.

The JRC also contributes to the development and testing of advanced drought indicators to facilitate the implementation of the Water Framework Directive.

Regarding desertification, the JRC supports the European Commission as a signatory of the United Nation's Convention to Combat Desertification (UNCCD). Its main activities include contributions to expert networks and research projects, and the development of a new World Atlas on Desertification (WAD). This atlas is being elaborated by a global network of experts, coordinated by the JRC. As a major contribution to the atlas, the JRC developed new integrated concepts and a scientific, transparent and repeatable methodology for the global assessment and mapping of desertification.

JRC research and development helps further the development of adequate and efficient mitigation and adaptation measures to cope with climate variability and climate change. The JRC's close collaboration with all EU countries and its strong global networking experience are important assets in addressing these global challenges.

Work in progress:

The JRC is working on the new World Atlas of Desertification, which is scheduled for publication in 2013. As part of this initiative, the JRC develops methodologies for the medium- to long-range forecasting of droughts and contributes to the development of a global monitoring and early warning system for drought and desertification, specifically in Europe, Africa and Latin America.

4.3. Tsunamis

Tsunamis are among the natural hazards that can result in the largest number of victims per event. The 2004 Indian Ocean tsunami and the 2011 Japanese tsunami caused over 250 000 and 25 000 casualties respectively. While the earthquakes that cause them cannot be predicted, it is possible to provide early warning about tsunamis if there is enough distance between the seismic source and the coast. Following the 2004 Indian Ocean tsunami, the JRC developed a system that uses sophisticated seismic and hydraulic modelling equipment coupled with communication technologies to alert the humanitarian operators and civil protection bodies about tsunamis.

Several tsunami warning systems, used to alert the population in case of safety threats, are currently in operation around the world. The UNESCO-IOC (Intergovernmental Oceanographic Commission) relies only on seismic signals and provides information on the arrival times of the tsunami wave along coastal areas. Other national systems are more advanced, for example, the Japanese system relies on pre-calculated tsunami scenarios, allowing it to give a first alert within 3 minutes of an earthquake that scores more than 6.5 on the Richter scale. The JRC developed and operates the only worldwide operational automatic alerting system, which is different from the warning systems, as it informs of a potential risk and not of confirmed threats. This alert system is based on pre-calculated tsunami scenarios and the alerts can be fed into international or national warning systems.

The JRC's tsunami assessment modelling system, part of the EU-UN Global Disaster Alerts and Coordination System (GDACS), helps to evaluate potential consequences of tsunamis of seismic origin.

The JRC´s tsunami assessment modelling system includes four main components: a global tsunami scenario database, an online tsunami calculation system, a tsunami analysis tool and a tsunami alerting device.

The Global Tsunami Scenario Database (GSD) is a set of 136 000 calculations performed using a theoretical model, with epicentres established around historical tsunami events. It provides a preliminary, immediate estimate of the consequences of a tsunami as soon as the epicentre of the real earthquake is known. The scenario database identifies the locations potentially affected as well as the predicted wave height. The Tsunami Online Calculation System (OCS) starts calculating the impact as soon as an earthquake with potential tsunami consequences is identified. The calculation time period is in the order of 30 – 40 minutes.

The Tsunami Analysis Tool allows a proper analysis of tsunami events in real time, to quickly estimate the real potential consequences of a tsunami. The objective is therefore to prepare to launch warning messages. The software allows the direct comparison of scenario databases (GSD) or online calculations (OCS) with sea level measurements in real time through international channels. The Tsunami Alerting Device (TAD) has been designed for installation in tsunami-prone coastal areas. The TAD delivers warning messages to the population at risk as quickly as possible. A prototype is currently in operation in Setubal (Portugal).

Figure 19: Estimated flooding after the Tohoku Tsunami of 11 March 2011, as calculated by the JRC´s analysis system

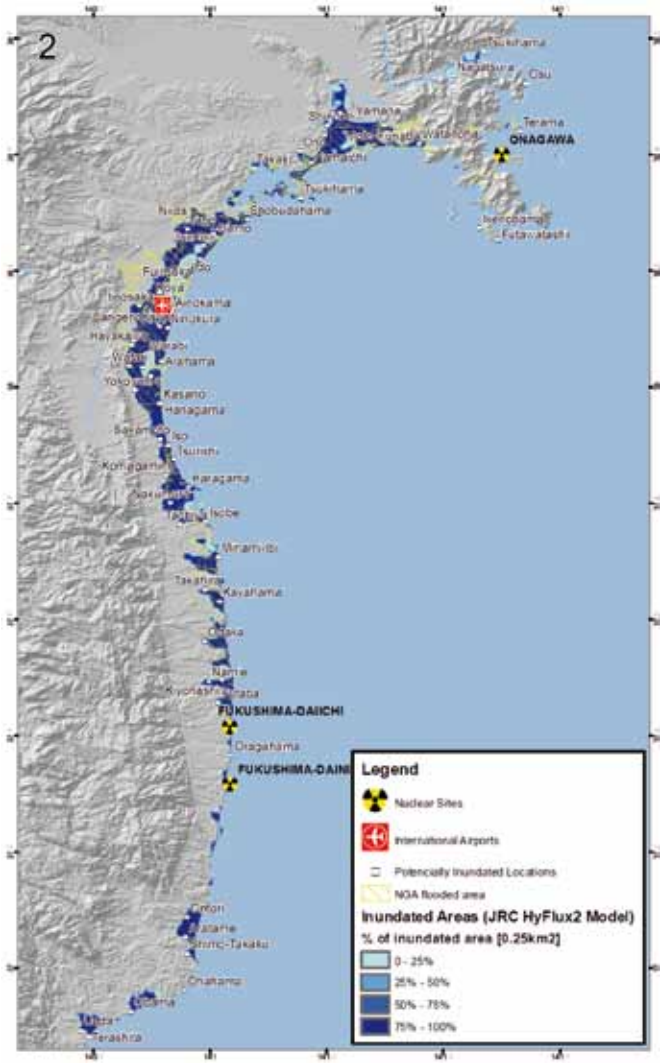
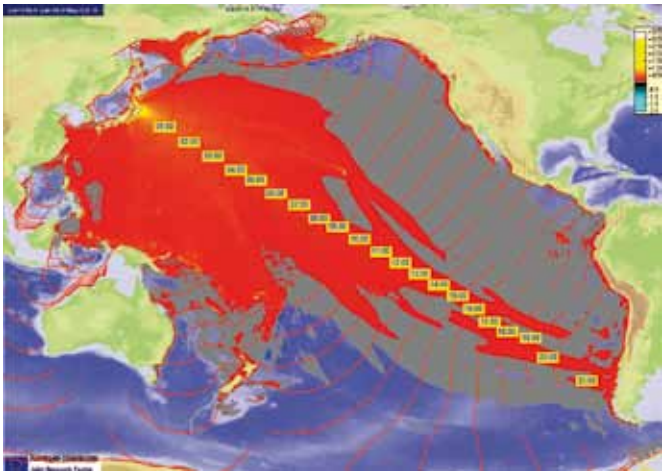


Figure 20: Maximum estimated height and travel time of the Tohoku Tsunami as calculated by the JRC



Maximum estimated height and travel time of the Tohoku Tsunami as calculated by the JRC. The wave extended from the Japanese coast to South America in about 24 hours.

4.4. Water and climate change

JRC activities in this area provide scientific support to the following policy initiatives:

- Directive 2007/60/EC of 23 October 2007 on the assessment and management of flood risks
- Communication of 18 July 2007 - Addressing the challenge of water scarcity and droughts in the European Union, COM(2007) 414
- Blueprint to Safeguard Europe's Waters
- The future EU Climate Change Adaptation Strategy (under preparation)

The availability of water is projected to change in Europe as a result of climate change. Northern regions will have more water, although summer flows may decrease. Southern and South-eastern regions, which already suffer most from water stress, will be particularly exposed to reductions in water resources and will experience an increase in drought frequency and intensity.

On the other hand, an increased occurrence of river floods is projected for large parts of Europe due to the more frequent heavy rain events, even in regions that will become drier on average.

In support to EU climate change policy, the JRC integrates datasets, expertise and modelling tools from different disciplines to assess the impacts of global warming and of adaptation and mitigation policy options, and their effects on water resources, extreme events and water-related sectors. The scale of application of the integrated assessment framework allows for the identification of regions in Europe that may be particularly vulnerable to the effects of global warming. It complements national and local studies that often provide more detailed, small-scale information.

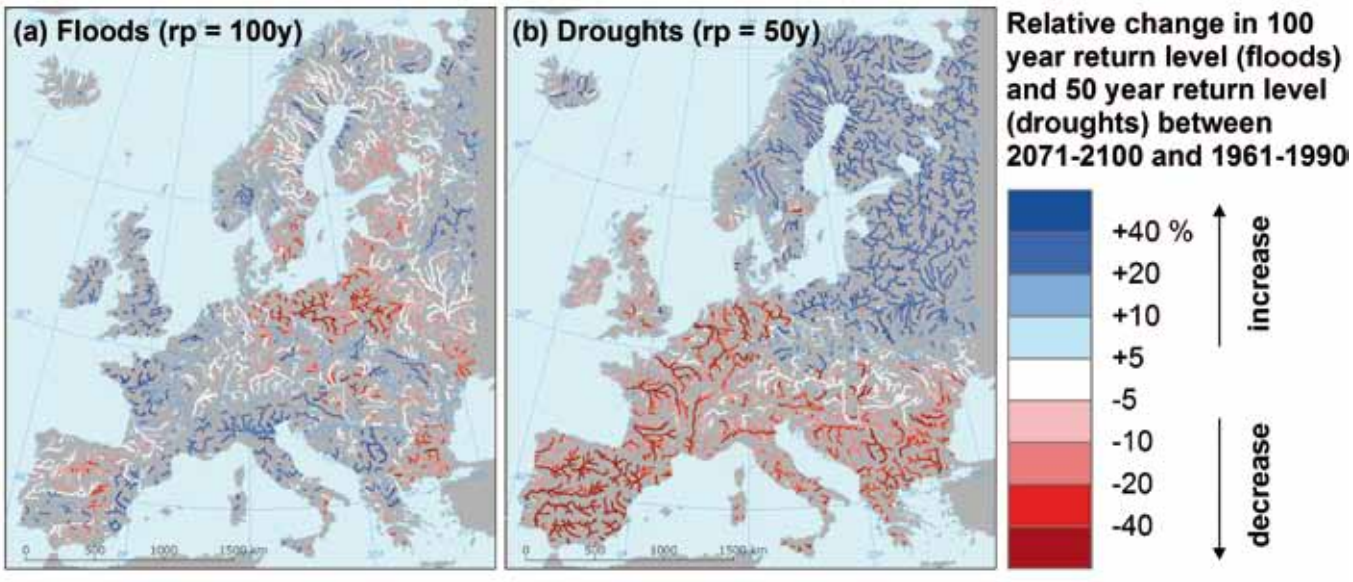
To make this assessment, JRC scientists identify, develop and evaluate different environmental and socio-economic scenarios and management options, taking into account possible feedback and the mutual impacts of the human-ecological system. This includes projections of climate change based on greenhouse gas emission scenarios, management practices (e.g. flood control measures, storage reservoirs, water saving measures), changes in land use (e.g. the expansion of urban areas, changes in cultivated land driven by agricultural policy), and changes in water use (e.g. change in irrigation requirements or public water use).

The scenarios and their associated impacts provide a reference point for the medium- and long-term strategic planning of adaptation measures in Europe, they alert policy-makers and stakeholders about emerging sectoral problems and allow river basin managers to test the adaptive capacity of their management plans.

The first internet portal of the European Drought Observatory was put online in 2011, providing up-to-date information on the occurrence and evolution of drought events in Europe. It includes a map server that provides access to a suite of drought indicators, documentation, search facilities and analysis tools (http://edo.jrc.ec.europa.eu).

JRC research has predicted that climate change will increase the frequency and intensity of droughts in many regions of Europe as a result of higher temperatures, reduced levels of summer rainfall, and more and longer dry spells. Regions in Southern and South-eastern Europe are more exposed to drought than other regions, but the level of water in rivers will also be significantly reduced in many other parts of Europe, especially during the summer period.

Figure 21: Projected change (in %) in flood with 100-year return period (rp) (a) and in drought with 50-year return period (b) between the reference period 1961–1990 and 2071–2100



Note that for floods (a) blue indicates more severe floods, whereas for drought (b) red indicates more severe drought conditions. Source: JRC

Climate change will also most likely exacerbate drought and desertification in many regions in the world, including large parts of Africa. Besides the immediate negative effects of recurrent droughts and often persistent situations of water scarcity, long term impacts can lead to the irreversible damage of natural ecosystems, making them incapable of sustaining human societies. Analysis of floods shows that there is likely to be a significant increase in flood hazard by the end of this century in Western Europe, the British Isles and northern Italy. In snow-dominated regions, spring snowmelt floods will become less severe due to reduced snow accumulation in warmer winters.

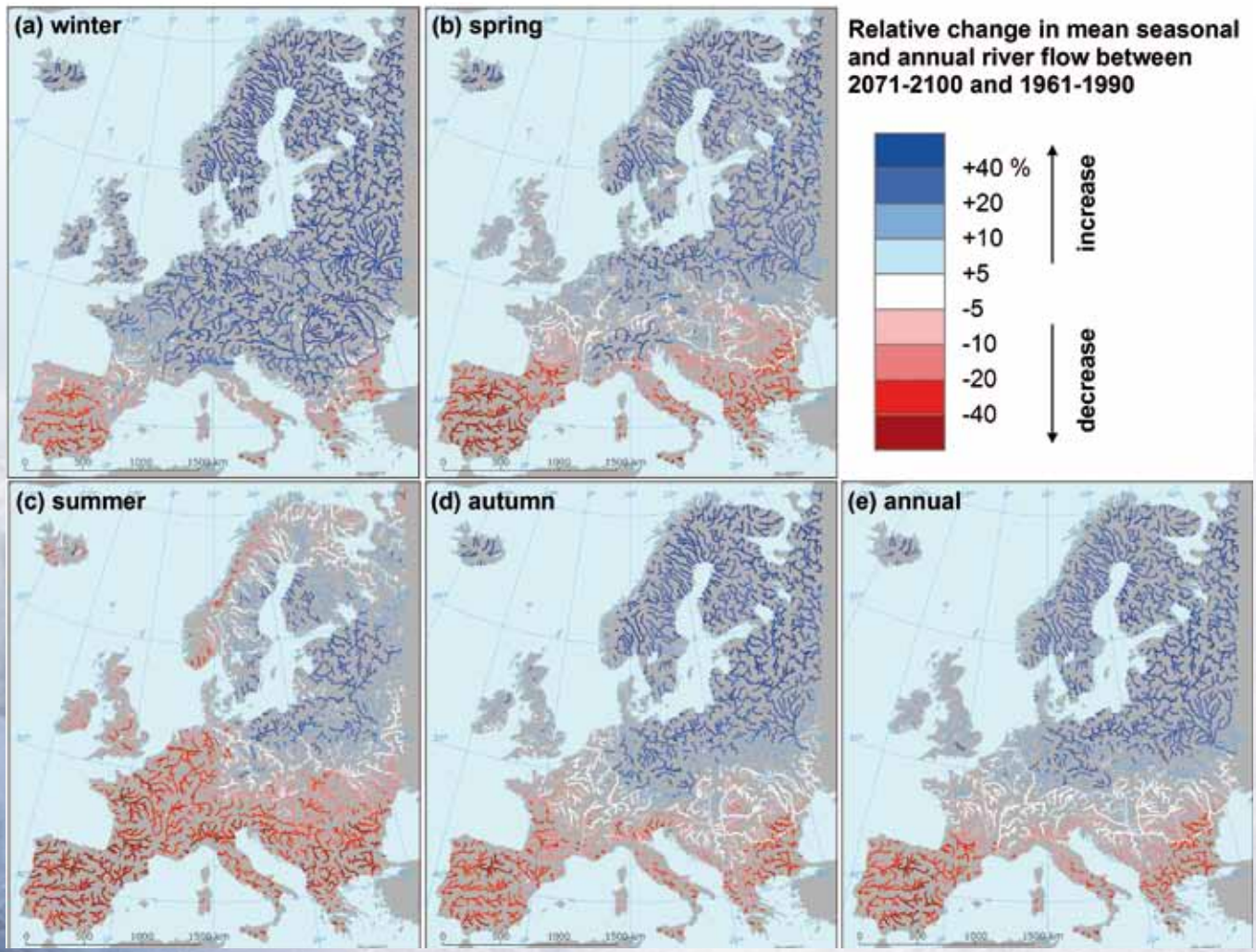
Under the business-as-usual scenario, the expected damages aggregated for the EU-27, currently amounting to approximately €5.5 billion/year, are projected to increase to €45.7 billion/year by the 2050s as a result of climate and socio-economic changes. The number of people affected by flooding is projected to rise from 167 400 to 291 100 per year. Future flood protection measures will cost €3.4 billion/year by the 2050s, with associated benefits in the order of €19 billion/year.

Work in progress:

In support to climate change and water policy, the JRC will continue to step up its integrated modelling activities in order to provide a consistent and comprehensive analysis of the full costs of climate change. In addition, the JRC is working towards sustained, high-quality climate and hydrological observations, reference datasets and improved re-analyses of historical data for climate change detection studies, trend analyses and model development and testing. It seeks to advance scientific understanding of the climate mechanisms that trigger or alter the probabilities of extreme climate events, and improve the capabilities of regional and local climate and hydrological models to predict water resource availability and extreme events also need improvement.

Interactions between climate change and other pressures such as land dynamics and water consumption are currently poorly understood. New models are required to link the geophysics of climate with the socioeconomic drivers of land use and water demand. Improvements are also necessary in quantifying the socioeconomic consequences of climate change, including the monetary evaluation of environmental impacts and the costs and benefits of structural and non-structural adaptation options.

Figure 22: Projected change (in %) in mean seasonal and annual river flow between the reference period 1961–1990 and 2071–2100



5. Water governance – working together

Rivers and seas are a common resource of the countries that share their basins. Key examples in Europe are the Danube River, which is 2 800 km long and flows through 10 countries, passing through four European capitals, and the Mediterranean Sea, which is shared by 21 countries. Scientific support on how to handle these water resources can benefit all the countries involved.

Developing countries often have a very complicated relationship with water. Water stress can be a major concern, not only related to dry climate conditions, but also due to overburdened water systems, fast-growing urban areas, mismanagement of resources, poor long-term investment and a lack of environmental research. According to the United Nations, by 2025 1 800 million people will be living in countries or regions with absolute water scarcity, and two-thirds of the world's population could be under water availability stress conditions. The JRC works with a vast array of partners in order to contribute to the integrated and sustainable management of this precious resource.

5.1. The Danube: a transboundary challenge

JRC activities in this area provide scientific support to the following policy initiatives:

- Communication of 8 December 2010 - European Union Strategy for Danube Region, COM(2010) 715
- Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive)

The Danube flows through 10 countries and is a large biodiversity-rich delta before finally entering the Black Sea. The sustainable management of its river basin represents a transboundary challenge for water management in Europe.

In June 2011, the European Council endorsed the EU Danube strategy and action plan, which recognises environmental protection as an opportunity for growth. This strategy encourages an integrated approach to the management of freshwater resources for irrigation, industry, power generation, transport and tourism, while respecting natural assets as drivers of sustainable regional development.

By working closely with the International Commission for the Protection of the Danube River (ICPDR) and countries in the Danube region, the JRC helps identify solutions for the restoration of water quality in the Danube and the management of water-related risks. For example, it contributes to the assessment and monitoring of water pollutants in the context of the Joint Danube Surveys. These surveys are organised by the ICPDR to investigate water quality for the entire Danube and many of its tributaries.

In 2013, the JRC will take part in the third Joint Danube Service that will focus on known and emerging hazardous substances. It will provide monitoring support and will promote the exchange of best practices on chemical monitoring, standardisation and quality assurance issues.

Modelling-based impact assessments are also carried out by the JRC. They elaborate scenario analyses for different pollutant emission patterns and facilitate the development of strategies for the optimisation of water allocation across different uses (agriculture, environment, energy and industry). The analyses help determine the major sectors of activities that contribute to the load of pollutants discharged from the Danube River Basin to the Black Sea.

In collaboration with national organisations and the Black Sea Commission, the JRC uses satellite time-series data to monitor long-term changes in the biological and physical properties of the Black Sea. By measuring parameters such as suspended matter and phytoplankton biomass, the JRC contributes to the assessment of its ecological status.

In April 2012, the JRC organised a high level conference on scientific support to the Danube strategy.

The JRC´s European Flood Awareness System (EFAS) has also been adapted to be used in the Danube River Basin, providing early, large scale and cross-border flood information.

As the Carpathian mountains are an important source of water for the Danube, the JRC also provides scientific and technical support to local institutions for developing a harmonised digital climate atlas and database for the Carpathian region (CARPATCLIM). Changes in the climate of this area have significant impacts on the Danube and could result in more frequent and intense floods or droughts further downstream.

The JRC has provided a snapshot of past and present situations of water quality in the Danube River Basin and carried out spatial analyses of explicit "what if" scenarios. These focused on the effects of, for example, improving the rate of connection to sewage systems and the treatment level in wastewater treatment plants and encouraging farmers to adopt alternative strategies to fertilise their fields in the river basin.

The business-as-usual scenario, using 2005 as a baseline year and assuming no change in nutrient inputs to agricultural land, taking into account changes in population density and changes in land use as a result of the reform of the Common Agricultural Policy, estimates that no substantial variations in nitrogen load to the Black Sea can be expected by 2020.

Considering instead a 2020 scenario that includes an optimised supply of livestock manure not exceeding the net demand of crops, a decrease of about 13% (53 000 tonnes) in the discharge of nitrogen load to the Black Sea has been estimated.

Work in progress:

In 2011, the JRC launched an initiative to provide scientific support for the implementation of the Danube Strategy. This initiative is being developed in close cooperation with national science academies of the Danube region.

5.2. The Mediterranean dimension

JRC activities in this area provide scientific support to the following policy initiatives:

- Communication of 5 May 2006 – Establishing an Environment Strategy for the Mediterranean, COM(2006) 475
- EU water initiative: EU Council resolution on water management in developing countries: policy and priorities for EU development cooperation – COM/2002/0132
- Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive)
- Directive 2008/56/EC of 17 June 2008 establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive)

As a region in which various borders meet – political, social, cultural and economic – the Mediterranean area is a good test bed for the effectiveness of European policies and international conventions to improve water management. Freshwater is at risk in the Mediterranean region due to the increasing demand for water for domestic and industrial use, tourism activities and the expansion of irrigated areas. Overexploitation of groundwater for urban and agricultural purposes has led to the lowering of water tables, the draining of wetlands and infiltration of seawater into coastal aquifers. Moreover, the periodic shortage of fresh water across the region and seasons will be exacerbated by climate change. In the North-African and Middle Eastern countries it will be further exacerbated by the rapid population growth.

The JRC has set up an informal network of experts in the Mediterranean region that focuses on water availability and quality. This network contributes to the assessment of present and future water availability, taking into account structural causes of scarcity, climate change and extreme events. The network also studies the effects on water quality produced by modifications in EU legislation and international conventions.

The first internet portal of the European Drought Observatory was put online in 2011, providing up-to-date information on the occurrence and evolution of drought events in Europe. It includes a map server that provides access to a suite of drought indicators, documentation, search facilities and analysis tools (http://edo.jrc.ec.europa.eu).

The JRC also contributes to the Horizon 2020 initiative to tackle the main sources of Mediterranean pollution by 2020, which has been endorsed by the Union for the Mediterranean. This initiative recognises water as a growing societal challenge and a priority for innovation. Its objective is to help the EU achieve its water policy objectives while ensuring the good status of waters.

Further examples of JRC activities in the Mediterranean region include the simulation and forecasting of flash floods, which is typical in this area. These simulations and forecasts are based on high resolution weather forecasts and rainfall radar data, and aim to help improve warning systems. The JRC has also been instrumental in using coastal lagoon networks as research sites from which to gain a better understanding of coastal ecosystems.

Work in progress:

The JRC will join efforts with the research community and stakeholders to build an observational network in the Mediterranean region that would serve as a testing ground for tools and solution strategies in water management and scenario analyses.

5.3. Access to water in developing countries

JRC activities in this area provide scientific support to the following policy initiatives:

- Integrated water resource management principles of the Dublin statement at the International Conference on Water and the Environment (ICWE) 26-31January 1992
- Resolution of the Council and the Representatives of the Governments of the Member States, meeting within the Council of 1 February 1993 on a Community programme of policy and action in relation to the environment and sustainable development – A European Community programme of policy and action in relation to the environment and sustainable development, OJ C 138, 17.5.1993, p. 1–4.
- United Nation's Millennium Development Goals Initiative is supported by EU as shown in various communications:
- Paris declaration on aid effectiveness (2005) and Accra agenda for action (2008) – OECD
- Communication of 13 October 2011 – Increasing the impact of EU development policy: an agenda for change, COM(2011) 637

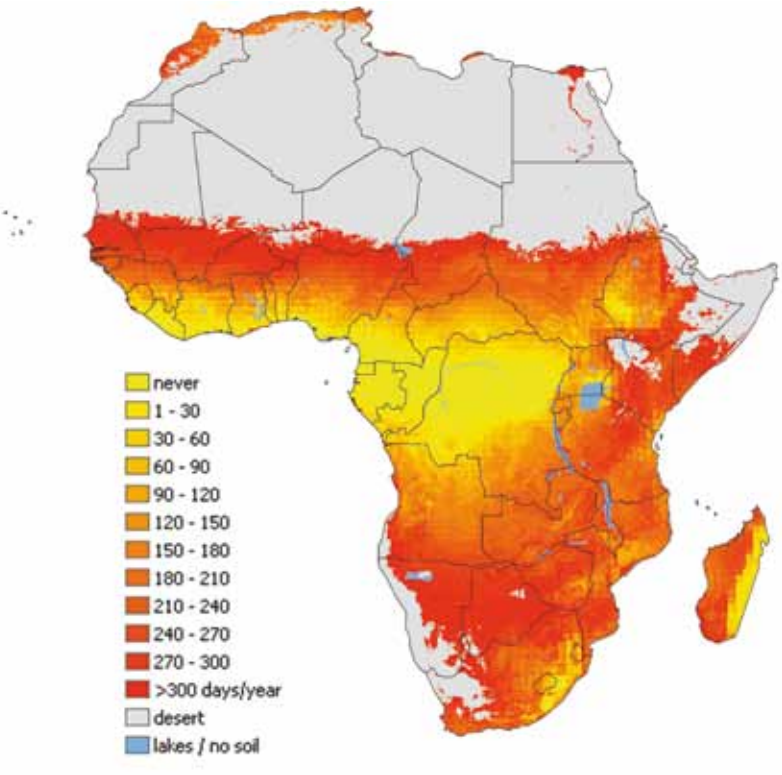
Two and a half billion people do not have access to proper sanitation facilities; 1.2 billion of them have no sanitation facilities at all. About 1 billion people do not have access to clean water. As a consequence, over 3.5 million people die each year from water-related diseases. Furthermore, people living in slums often pay 5-10 times more per litre of water than wealthy people living in the same city.

The efforts made by the international community to address these issues are undermined by factors such as population growth, economic crises, climate change and unstable political situations in various developing countries. Progress towards water and sanitation access for all may require even more efforts in the near future because of these rising constraints.

New and innovative approaches are needed to tackle such water access issues. The scientific community has been encouraged to support local and regional policy makers. The JRC itself is strongly committed to supporting developing countries, mostly in sub-Saharan Africa and Latin America, in finding their own sustainable solutions to water crises.

The JRC actively supports technology transfer and capacity building by implementing scientific networks. It collaborates with more than 40 water science centres of excellence in Africa and Latin America, aiming at establishing the scientific basis for defining a sustainable water policy for growth and development. In Africa, for instance, the JRC uses biophysical modelling and hydrological simulations to provide scientific assessments of water availability, floods, droughts and water scarcity. It also assesses the impacts of different management and climate scenarios and strategies on agricultural production and the environment (e.g. by evaluating potential crop production and its associated irrigation and nutrient requirements).

Figure 23: Soil moisture stress in Africa as simulated with the JRC LISFLOOD model



The average number of days per year on which there is insufficient soil moisture for natural crop and vegetation growth, based on simulations from 1989-2010.

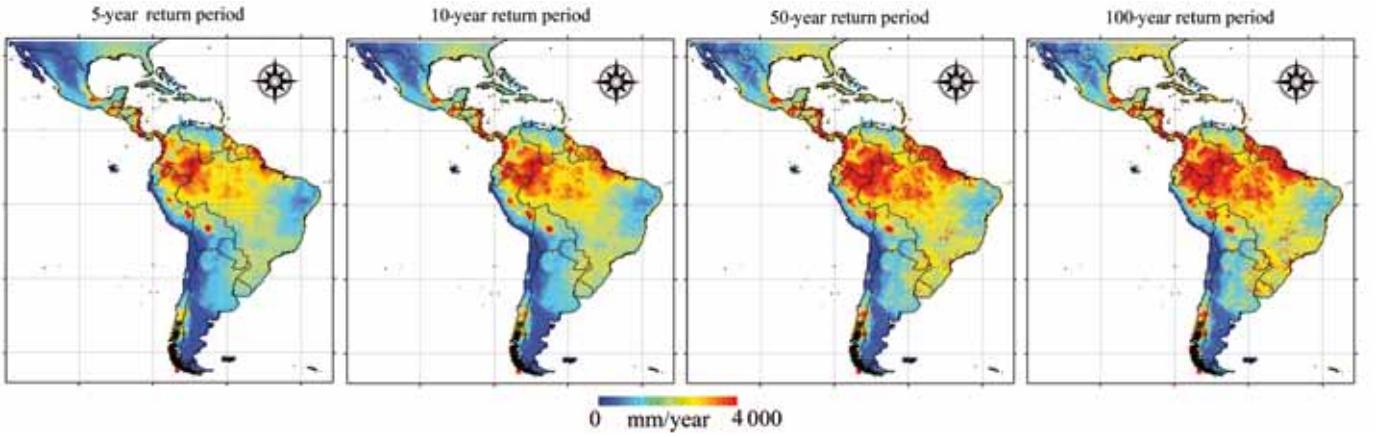
The JRC has developed the AquaKnow web portal, the first interactive online platform dedicated to technical and scientific knowledge about water and its sustainable use. AquaKnow integrates a series of innovative scientific online tools to support sustainable resource management policies related to water:

- The Water Project Toolkit is designed to help international practitioners and stakeholders use best practices to translate policies into concrete actions.
- The WatSan4dev and WEIRS databases model the relation between environmental, governance, socioeconomic, health and educational indicators in developing countries, leading to a better understanding of how to improve water supply and sanitation. They also help partners to better orient their investments by testing and improving the effectiveness of policies.

Work in progress:

The JRC is developing an integrated water supply and sanitation analysis system that contains environmental, educational, health, socio-economic, governance and financial aid indicators. This new system will be freely available to facilitate knowledge exchange. The development of such a tool will allow the JRC to deliver products such as maps, graphics, guidelines for best practices in water resource management, and scientific and technical reports giving direct and immediate information about the key elements involved in improving access to water and sanitation.

Figure 24: Precipitation return periods in Latin America



The figure shows the precipitation associated with 5-, 10-, 50- and 100-year return periods in Latin America. The return period provides an estimate of the time interval between precipitation events of determined intensities. This information is useful for determining potential floods and drought areas and planning water resources management.

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6. Water innovation

Innovation is recognised as a key component in the sustainable and efficient use of water and the European Commission is currently (2012) setting up a new European Innovation Partnership on water.

At the JRC, innovation is central to several water-related initiatives.

6.1. Water as an eco-industry

JRC activities in this area provide scientific support to the following policy initiatives:

- Blueprint to Safeguard Europe's Waters
- European Innovation Partnership on Water

European eco-industries have an annual growth rate of 5.9%. Considering that water supply and wastewater management account for one third of the total number of European eco-industries, the water sector has great potential for contributing to the realisation of the EU 2020 objectives for growth and jobs.

One of the targets of the European Innovation Partnership on Water is to increase by 20% the EU's turnover from eco-industries related to water management by 2030.

Research is essential to achieving these targets. The JRC is examining the potential and the environmental impacts of emerging technologies to address solutions for water saving, water reuse and the harvesting of new water resources from the sea, groundwater and wastewater.

The JRC is collaborating with other research institutions to assess innovative technologies for treating groundwater and drinking water. Research specifically focuses on those technologies that use nano-zero-valent iron and nanofiltration membranes to remove hardness, natural organic matter and synthetic organic chemicals from water.

Current filtration and purification systems for drinking water have only limited success due to the relatively low efficiency of the active materials, whereas nanostructured materials are significantly more reactive than micron or bulk materials with the same chemical composition. This is due to their large surface areas, size, and shape-dependent optical, electronic and catalytic properties.

The JRC also works with sub-Saharan Africa and Latin American partners in the framework of the European Commission's support to the centres of excellence on water in developing countries. The University of Dakar, a partner institution of the Western African network, has developed solar-powered portable water purification and desalination units.

Desalination plants are another rapidly growing new option for water supplies in European coastal cities that will benefit from research activities on renewable energy. The JRC monitors and supports the development and application of renewable energy technologies, mapping the resource potential of various renewable energy sources for desalination.

Nano-enhanced membranes, which combine nanoengineering with membrane technology, have better performance levels than conventional membranes. They are increasingly used for the purification of drinking water and the recycling of industrial water.

As part of the ObservatoryNano project, the JRC collaborates with leading international experts in this field to examine the efficiency, potential risks and regulatory issues associated with the use of such membranes in replacing reverse osmosis water purification systems with increased flux rates.

Membranes with various types of nanoparticles such as titanium dioxide, silver and carbon nanotubes are being tested to reduce fouling, which is still the most significant challenge in membrane technology. The membranes can be coated by either a sol–gel or chemical vapour deposition process to achieve the required antifouling properties. Efforts are being made to develop more efficient and cost-effective reactive membranes for water purification and desalination.

6.2. Standardisation of satellite observations

JRC activities in this area provide scientific support to the following policy initiatives:

- United Nations Framework Convention on Climate Change (UNFCCC)
- Communication of 12 November 2008 - Global Monitoring for Environment and Security (GMES): we care for a safer planet, COM(2008) 748

Global and continuous observations of the Earth's surface are fundamental to detecting the evolution of the environment. These observations guide the definition and application of adequate policies to find solutions and help monitor the effectiveness of mitigation and adaptation measures. Satellite observations facilitate the mapping of Essential Climate Variables (ECVs), which are an effective way of delivering environmental information.

The JRC carries out pre-normative research on the standardisation of the production and verification of marine ECVs, namely ocean-colour-derived products such as phytoplankton concentration. These marine ECVs are fundamental to the accurate quantification of the Earth's carbon sources and sinks. The aim is to generate highly accurate ECVs regardless of the geographic area or bio-optical properties of the water basins.

In defining and assessing ECVs from satellite observations, highly accurate in situ measurements are also required. These measurements enable indirect calibration of the space sensor, the validation of primary products (such as the radiance measured just above the sea surface without the perturbing effects of the atmosphere), the development of models measuring the effect of visible seawater components on radiance (e.g. how phytoplankton affects the spectrum of underwater solar light) and the validation of high level satellite derived products (e.g. chlorophyll concentration used as an index for phytoplankton).

Since the early 2000's, the JRC has invested significantly in the collection of in situ reference measurements to help define ECVs across the various European seas. These measurements are carried out in the Baltic Sea, the North Sea, the Mediterranean Sea and the Black Sea on dedicated oceanographic ships and through laboratory activities, using standardised state-of-the-art instrumentation, methodologies, calibration procedures and quality assurance schemes.

The objectives are to collect highly standardised and accurate in situ reference data, to apply them to the development of models for generating marine ECVs from satellite observations and to validate the derived satellite products at each stage (e.g. from the basic radiance values resulting from the atmospheric correction process up to the final maps of chlorophyll concentration).

The JRC has contributed to the creation of a European in situ reference dataset for satellite ocean colour research. This dataset is the result of more than a decade of regional oceanographic measurements taken within the framework of the Bio-Optical mapping of Marine Properties (BiOMaP) programme. A unique feature of the BiOMaP dataset is its consistency, obtained through the application of standardised instrumentation, methodologies, calibration procedures and quality assurance schemes.

The BiOMaP dataset currently includes measurements taken in regions representative of marine waters which are heavily dominated by coloured dissolved organic matter (e.g. the Baltic Sea), by sediments (e.g. some regions of the Black Sea and the Adriatic Sea) or by phytoplankton (e.g. the Eastern Mediterranean Sea and areas of the Western Mediterranean Sea).

This spatial and bio-optical variability allows for the development of models specific to the various seas, which are intrinsically more accurate than any global model currently being used for the generation of ECVs using satellite imagery.

Work in progress:

The JRC is expanding the BiOMaP dataset to embrace more European marine regions and to increase seasonal representation of measurements. This will be accompanied by further improvement of measurement methods to support the forthcoming Sentinel-3 satellite mission, which is expected to produce ECVs of unprecedented accuracy. This satellite mission, managed by the European Space Agency, will be supported by the European Commission.

6.3. Multidisciplinary interoperability for water, weather, ocean and ecosystem data

JRC activities in this area provide scientific support to the following policy initiatives:

- Communication of 26 August 2010 - A digital agenda for Europe, COM(2010) 245
- Communication of 6 October 2010 – Europe 2020 Flagship Initiative, Innovation Union, COM(2010) 546

The JRC is the scientific coordinator of a research project that supports the development of the Global Earth Observation System of Systems (GEOSS) by increasing the multidisciplinary interoperability of data and services about water runoff, ocean ecosystems and weather prediction.

In the hydrological domain, a very heterogeneous landscape of data sources exists. Water related data obtained by sensors are provided through a large variety of interfaces and data formats. To integrate new hydrological data sources

into application systems, it is therefore often necessary to build bridges across these formats and interfaces through specific software tools and middleware.

GEOWOW (GEOSS interoperability for Weather, Ocean and Water), a research project co-funded by the European Commission, contributes to international standardisation processes. It includes 15 international partners under the technical coordination of the European Space Agency and the scientific coordination of the JRC. Through GEOWOW, previously independent information catalogues and systems can now be connected and compared, and the scientific resources they contain can be made available to a much wider audience. This accessibility of data facilitates research on topics such as global freshwater resources, the flux of sediments into coastal regions and the sea, the influence on oceanic circulation patterns or the potential impacts of climate change on river discharge and its effects on water supply and ecosystems.

The GEOWOW application is available online.

GEOWOW helps link multiple scientific communities, building on the achievements of the earlier EuroGEOSS project, which was also coordinated at the scientific level by the JRC. EuroGEOSS was developed to search thousands of Earth observation catalogues, increasing the number of datasets and products publicly available for scientific research. This went up from a few hundred in 2011 to more than 28 million in 2012.

This was possible thanks to a novel application, a software middleman or broker, which bridges the multitude of complex standards used by scientists. This approach has been so successful that it has been adopted by the Group on Earth Observation, a global partnership of 87 countries and 64 international organisations plus the European Commission, all of which have a stake in Earth Observation.

6.4. Water in eco labelling and green public procurement

JRC activities in this area provide scientific support to the following policy initiatives:

- Communication of 16 July 2008 on «the sustainable consumption and production and sustainable industrial policy – Action plan» COM (2008) 397
- EU Ecolabel
- Communication of 16 July 2008 on «public procurement for a better envionrment» COM (2008) 400

Approximately one third of total water used in households is delivered via taps, followed by the water use of toilets (25%) and bathtubs and showers (14% each). Dishwashers, high-pressure cleaners, swimming pools and sprinklers only account for very small shares (up to 2%) of domestic water use.

In order to achieve the considerable water saving potential existing in this area, the JRC is carrying out research to establish EU Ecolabel and Green Public Procurement criteria for taps, showerheads, toilets and urinals.

This research will also provide information and data to assist the potential future development of other environmental policy instruments such as implementing measures under the Ecodesign Directive.

Based on its research on water using products the JRC has developed draft Ecolabel and Green Public Procurement criteria for taps and shower heads. Once adopted, these criteria will be the central piece of EU policies that aim to promote the greening of these products.

6.5. Best available techniques for waste water in chemical industries

JRC activities in this area provide scientific support to the following policy initiatives:

- Directive 2010/75/EU of 24 November 2010 on Industrial Emissions (Integrated Pollution Prevention and Control)

Industrial activities play an important role in the economic well-being of Europe. However, they are also responsible for a considerable share of the overall pollution. Emissions from industrial installations have been subject to EU-wide legislation. The main piece of legislation that aims to reduce emissions to air, water and soil from such installations is the Directive on Industrial Emissions (IED) (2010/75/EU), which follows on from the Integrated Pollution Prevention and Control (IPPC) Directive (2008/1/EC).

The IED is based on an integrated approach aiming to protect the environment as a whole. The installations covered by the Directive must be operated in accordance with a permit granted by the competent authorities in the Member States. The permit conditions are based on the best available techniques (BAT) conclusions adopted by the Commission. Some 50 000 installations across the EU are subject to them.

The JRC hosts and manages the European Integrated Pollution Prevention and Control Bureau (EIPPCB), set up to organise the exchange of information between Member States, industry, environmental NGOs and services of the Commission on Best Available Techniques. This exchange leads to the development of BAT reference documents, called BREFs. There are nearly 40 BREFs already available.

The BREF on common wastewater and waste gas treatment and management systems in the chemical industry (CWW) is currently under review. This review process is expected to be finalised within 2012.

In order to revise the CWW BREF, an EU-wide survey is being carried out by the European IPPC Bureau (EIPPCB) for the chemical industry. This survey will collect installation-specific wastewater emission data, taking into account a wide range of potential pollutants of key environmental importance of wastewater discharges from the chemical industry.

The EIPPCB plays a key role in the analysis and the assessment of the survey data in order to propose BAT based on scientific and technical data. These BAT will be the basis for setting permit conditions for wastewater discharges from the chemical industry.

Useful tools

JRC has developed numerous scientific tools to study different water-related topics. Most of them are available to the general public.

Overview of JRC's water-related research - The water resources unit at the JRC Institute for Environment and Sustainability (IES): http://ies.jrc.ec.europa.eu/the-institute/units/water-resources.html

Water availability

- Hydrological modelling (LISFLOOD): http://floods.jrc.ec.europa.eu/lisflood-model.html
- Land use modelling platform: http://moland.jrc.ec.europa.eu/lump/lump.htm
- Monitoring agricultural resources (access to water stress maps): http://www.marsop.info
- River basins network (RBN) on Water Framework Directive and agriculture: http://prb-water-agri.jrc.ec.europa.eu/

Water quality

- Assessment of fate and impacts of pollutants in terrestrial and aquatic ecosystems: http://fate.jrc.ec.europa.eu
- Water bodies in Europe – Integrative System to assess Ecological status and Recovery (WISER): http://www.wiser.eu/results/method-database/

Marine information

- Environmental Marine Information System (EMIS): http://emis.jrc.ec.europa.eu/
- African Marine Information System (AMIS): http://amis.jrc.ec.europa.eu/

Preserving ecosystems

- European Alien Species Information Network (EASIN): http://easin.jrc.ec.europa.eu

Floods

- Floods portal: http://floods.jrc.ec.europa.eu/
- European Floods Forecast System (EFAS): http://efas-is.jrc.ec.europa.eu
- Global Flood Detection System (GFDS): http://www.gdacs.org/flooddetection
- Integrated flood map: http://dma.jrc.it/map?application=floods
- Climate change impact assessment in floods: http://floods.jrc.ec.europa.eu/climate-change-impact-assessment.html

Droughts and desertification

- European Drought Observatory (EDO): http://edo.jrc.ec.europa.eu
- World Atlas of Desertification (WAD): http://wad.jrc.ec.europa.eu

Tsunamis

- Global Disaster Alert and Coordination System (GDACS): http://www.gdacs.org

Water governance

- Aquaknow – virtual space for collaboration and information on the water sector: http://www.aquaknow.net
- Global water scarcity information system: http://www.glowasis.eu

Water and innovation

- Ocean colour portal: http://oceancolour.jrc.ec.europa.eu/
- EuroGEOSS broker (developed for the Firefox browser): http://www.eurogeoss-broker.eu
- Geowow project: http://www.geowow.eu/
- EU Ecolabel and green public procurement for tapware: http://susproc.jrc.ec.europa.eu/ecotapware/ and toilets: http://susproc.jrc.ec.europa.eu/toilets/index.html
- Best available techniques for common waste water and waste gas treatment/management systems in the chemical sector: http://eippcb.jrc.es/reference/cww.html

Useful contacts: JRC-water@ec.europa.eu

Further reading

Water: balancing supply and demand

Current and future water availability

De Roo, Ad, Faycal Bouraoui, Peter Burek, Berny Bisselink, Ine Vandecasteele, Sarah Mubareka, Peter Salamon, Marco Pastori, Mauricio Zambrano, Vera Thiemig, Alessandra Bianchi, Carlo Lavalle (2012), Current water resources in Europe and Africa. Matching water supply and water demand.
ISBN 978-92-79-23340-1. doi: 10.2788/16108. Luxembourg: Publications Office of the European Union

Estimation of Water Fluxes into the Mediterranean Sea.
Bouraoui F., Grizzetti B., Aloe A. (2010). Journal of Geophysical Research-Atmospheres, Vol. 115. DOI: 10.1029/2009JD013451.

GISEPIC AFRICA: A modelling tool for assessing impacts of nutrient and water use in African agriculture. Pastori M., Bouraoui F., Aloe A., Bidoglio G. (2011).
Publications Office of the European Union, DOI 10.2788/49150.

LISFLOOD: a GIS-based distributed model for river-basin scale water balance and flood simulation. Van der Knijff J.M., Younis J., De Roo A.P.J. (2010).
International Journal of Geographical Information Science, Vol. 24, No.2, pp. 189-212. DOI: 10.1080/13658810802549154.

The water footprint of the European Union, Manuscript in preparation. Vanham D., Bidoglio G. (2012).

A spatially distributed assessment of water allocation in EU27 for Year 2000. Wriedt G., Bouraoui F. (2011).
Publications Office of the European Union, DOI: 10.2788/51970.

Addressing water efficiency in Europe

Improving pan-european hydrological simulation of extreme events through statistical bias correction of RCM-driven climate simulations. Rojas R., Feyen L., Dosio A., Bavera D. (2011).
Hydrology and Earth System Sciences, Vol. 15, pp. 2599-2620. DOI: 10.5194/hessd-8-3883-2011.

Fluvial flood risk in Europe in present and future climates. Feyen L., Dankers R., Bódis K., Salamon P., Barredo J.I. (2011).
Climatic Change, DOI: 10.1007/s10584-011-0339-73.

Implementation of the CAP Policy Options with the Land Use Modelling Platform - A first indicator-based analysis. Lavalle C., Baranzelli C., Mubareka S., Rocha Gomes C., Hiederer R., Batista e Silva F., Estreguil C. (2011).
Publications Office of the European Union, DOI: 10.2788/44614.

A high resolution land use/cover - Modelling framework for Europe; introducing the EU-ClueScanner100 model. Lavalle C., Baranzelli C., Batista e Silva F., Mubareka S., Rocha Gomes C., Koomen E., Hilferink M. (2011).
Lecture Notes in Computer Science, Vol. 6782, pp. 60-75. DOI: 10.1007/978-3-642-21928-3.

LISFLOOD: a GIS-based distributed model for river-basin scale water balance and flood simulation. Van der Knijff J.M., Younis J., De Roo A.P.J. (2010).
International Journal of Geographical Information Science, Vol. 24, No.2, pp. 189-212. DOI: 10.1080/13658810802549154.

Water for use in agriculture

Impacts of extreme weather on wheat and maize in France: evaluating regional crop simulations against observed data. Van der Velde M., Tubiello F.N., Vrieling A., Bouraoui F. (2011). Climatic Change, DOI: 10.1007/s10584-011-0368-2.

Estimating irrigation use and effects on maize yield during the 2003 heatwave in France. Van der Velde M., Wriedt G., Bouraoui F. (2010). Agriculture, Ecosystems and Environment, Vol. 135 (1-2), pp. 90-97.

Estimating irrigation water requirements in Europe. Wriedt G., Van der Velde M., Aloe A., Bouraoui F. (2009). Journal of Hydrology, Vol. 373 (3-4), pp. 527-544. DOI: 10.1016/j.agee.2009.08.017.
The water and energy nexus

Pan-European regional-scale modelling of water and N efficiencies of rapeseed cultivation for biodiesel production. Van der Velde M., Bouraoui F., Aloe A. (2009). Global Change Biology, Vol. 15 (1), pp. 24-37. DOI: 10.1111/j.1365-2486.2008.01706.

Water quality

Assessing the good ecological status of waters in Europe

Three hundred ways to assess Europe's surface waters: an almost complete overview of biological methods to implement the Water Framework Directive. Birk S., Bonne W., Borja A., Brucet S., Courrat A., Poikane S., Solimini A., Van de Bund W., Zampoukas N., Hering D. (2012).
Ecological Indicators, Vol. 18, pp. 31-41. DOI: 10.1016/j.ecolind.2011.10.009.

Bringing European river quality into line: an exercise to intercalibrate macro-invertebrate classification methods. Bennett C., Owen R., Birk S., Buffagni A., Erba S., Mengin N., Murray-Bligh J., Ofenböck G., Pardo I., Van de Bund W., Wagner F., Wasson J. G. (2011).
Hydrobiology, Vol. 667, pp. 31-48. DOI: 10.1007/s10750-011-0635-2.

Lake ecological assessment systems and intercalibration for the European Water Framework Directive: Aims, achievements and further challenges. Poikane S., Van den Berg M., de Hoyos C., Hellsten S., Ortiz-Casas J., Pall K., Portielje R., Phillips G., Lyche Solheim A., Tierney D., Wolfram G., Van de Bund W. (2011).
Procedia Environmental Sciences, Vol. 9, pp. 153-168. DOI: 10.1016/j.proenv.2011.11.024.

Revision of the consistency in Reference Criteria application in the phase I of the European Intercalibration Exercise. Pardo I., Poikāne S., Bonne W. (2011).
JRC Scientific and Technical Reports. DOI: 10.2788/27809.

Defining Chlorophyll-a Reference Conditions in European Lakes. Poikāne S., Alves M. H., Argillier C., Van den Berg M., Buzzi F., Hoehn E., de Hoyos C., Karottki I., Laplace-Treyture C., Lyche Solheim A., Ortiz-Casas J., Ott I., Phillips G., Pilke A., Pádua J., Remec-Rekar S., Riedmüller U., Schaumburg J., Serrano M. L., Soszka H., Tierney D., Urbanič G., Wolfram G. (2010).
Environmental Management, Vol. 45(6), pp. 1286–1298. DOI: 10.1007/s00267-010-9484-4.

Towards Holistic Assessment of the Functioning of Ecosystems Under the Water Framework Directive. Solimini A., Ptacnik R., Cardoso A.C. (2009).
TRAC-Trends in Analytical Chemistry, Vol. 28 (2), pp. 143-149. DOI: 10.1016/j.trac.2008.10.015.

Chemical pollutants

Continental scale inverse modeling of common organic water contaminants in European rivers. Pistocchi A., Marinov D., Pontes S., Gawlik B. (2012).
Environmental Pollution, Vol. 162, pp. 159-167. DOI: 10.1016/j.envpol.2011.10.031.

Pan-European Survey for the Occurrence of Selected Polar Organic Persistent Pollutants in Ground Water. Loos R., Locoro G., Comero S., Contini S., Schwesig D., Werres F., Balsaa P., Gans O., Weiss S., Blaha L., Bolchi M., Gawlik B. (2010).
Water Research, Vol. 44 (14), pp. 4115-4126. DOI: 10.1016/j.watres.2010.05.032.

Sucralose Screening in European Surface Waters Using a Solid-Phase Extraction-Liquid Chromatography-Triple Quadrupole Mass Spectrometry Method. Loos R., Gawlik B., Boettcher K., Locoro G., Contini S., Bidoglio G. (2009).
Journal of Chromatography A, Vol. 1216, pp. 1126-1131. DOI: 10.1016/j.chroma.2008.12.048.

Hazardous substances in Europe`s fresh and marine waters - An overview. Collins R., Brack W., Holten Lutzhoft H., Eriksson E., Bjerregaard P., Hutchinson T., Adler N., Kuester A., Backhaus T., Dubus I., Reiersen L., Part P., Jarosinska D., Jarosinski W., Christiansen T., Jacobsen B., Werner B., Csagoly P., Rodriguez Romero J., Clayton H., Loos R., Gawlik B. (2011).
Publications Office of the European Union, (EEA Technical report No 8/2011).ISSN 1725-2237.

Diatoms for omics applications in water monitoring. Carvalho R. N., Antonio D. C., Lettieri T. (2011).
Hydrology: Current Research, DOI: 10.4172/2157-7587.S1-001.

Transcriptomics responses in marine diatom Thalassiosira pseudonana exposed to the polycyclic aromatic hydrocarbon Benzo[a]pyrene. Carvalho R. N., Bopp S. K., Lettieri, T. (2011).
PLoS ONE, Vol. 6(11). DOI: 10.1371/journal.pone.0026985.

Gene biomarkers in diatom Thalassiosira pseudonana exposed to polycyclic aromatic hydrocarbons from contaminated marine surface sediments. Carvalh R.N., Burchardt A.D., Sena F., Mariani G., Mueller A., Bopp S.K., Umlauf G., Lettieri T. (2011).
Aquatic Toxicology, Vol. 101, pp. 244–253. DOI: 10.1016/j.aquatox.2010.10.004.

Pollution: from source to sea

Continental scale inverse modeling of common polar organic chemicals in European rivers. Pistocchi A., Marinov D., Pontes S., Gawlik B.M. (2012).
Environmental Pollution, Vol. 162, pp. 159-167. DOI: 10.1016/j.envpol.2011.10.031.

Scenario analysis of pollutants loads to European regional seas for the year 2020. Part II: Assessment of priority chemicals – an example with three pilot substances. Marinov D., Pistocchi A., Trombetti M., Bidoglio G. (2011).
Publications Office of the European Union, DOI: 10.2788/46554.

Spatially explicit multimedia fate models for pollutants in Europe: State of the art and perspectives. Pistocchi, A., Sarigiannis D.A., Vizcaino P. (2010).
Science of the Total Environment, Vol. 408 (18), pp. 3817-3830. DOI: 10.1016/j.scitotenv.2009.10.046.

Changes of nitrogen and phosphorus loads to European seas. Grizzetti B., Bouraoui F., Aloe A. (2011).
Global Change Biology, Vol. 18 (2), pp. 769-782. DOI: 10.1111/j.1365-2486.2011.02576.

Long term change of nutrient concentrations of rivers discharging in European seas. Bouraoui F., Grizzetti B. (2011).
Science of the Total Environment, Vol. 409 (23), pp. 4899-4916. DOI: 10.1016/j.scitotenv.2011.08.015.

Assessing nitrogen pressures on European surface water. Grizzetti B., Bouraoui F., De Marsily G., (2009).
Global Biogeochemical Cycles, Vol. 22, GB4023,
DOI:10.1029/2007GB003085.

Scenario analysis of pollutants loads to European regional seas for the year 2020. Part I: Policy options and alternative measures to mitigate land based emission of nutrients. Thieu V., Bouraoui F., Aloe A., Bidoglio G. (2012).
Publications Office of the European Union, Scientific and Technical Research series, ISBN 978-92-79-22712-7, pp. 83. DOI: 10.2788/46067.

Assessing marine and coastal waters

MSFD GES TSG Marine Litter, Marine Litter: Technical Recommendations for the Implementation of MSFD Requirements. EUR 25009 EN. Luxembourg (Luxembourg):
Publications Office of the European Union; 2011. DOI: 10.2788/92438.

Scientific support to the European Commission on the Marine Strategy Framework Directive. Management Group Report.. A. C. Cardoso, S. Cochrane, H. Doerner, J. G. Ferreira, F. Galgani, C. Hagebro, G. Hanke, N. Hoepffner, P. D. Keizer, R. Law, S. Olenin, G. J. Piet, J. Rice, S. I. Rogers, F. Swartenbroux, M. L. Tasker & W. van de Bund 2010.
JRC Scientific and Technical Report. EUR 24336 EN – 2010.

Review of Methodological Standards Related to the Marine Strategy Framework Directive Criteria on Good Environmental Status. Piha H. & Zampoukas N. 2011.
JRC Scientific and Technical Report. EUR 24743 EN – 2011.

Monitoring for the Marine Strategy Framework Directive: Requirements and Options. N. Zampoukas, H. Piha, E. Bigagli, N. Hoepffner, G. Hanke & A.C. Cardoso (2012).
JRC Scientific and Technical Report. EUR 25187 EN- 2012.

Toward and Ecosystem Approach to ICM: Aseessing Ecological Provinces at Sea by Remote Sensing. Barale, V. (2010).
Journal of Coastal Conservation, Special Issue on "Advances in Integrated Coastal management (ICM) for the Mediterranean and Black Sea", Vol. 14, pp. 317–326.

A clear delimitation of coastal waters facing the EU environmental legislation: from the Water Framework Directive to the Marine Strategy Framework Directive. Liquete Garcia M, Somma F, Maes J.
Environmental science and policy 14 (4); 2011. p. 432–444. JRC61592.

Preserving ecosystems

Mapping and valuation of ecosystem services

A European assessment of the provision of ecosystem services - Towards an atlas of ecosystem services. Maes J., Paracchini M., Zulian G. (2011).
Publications Office of the European Union, DOI: 10.2788/63557.

A spatial assessment of ecosystem services in Europe: methods, case studies and policy analysis - phase 1. Maes J., Braat L., Jax K., Hutchins M., Furman E., Termansen M., Luque S., Paracchini M.L., Chauvin C., Williams R., Volk M., Lautenbach S., Kopperoinen L., Schelhaas M-J., Weinert J., Goossen M., Dumont E., Strauch M., Görg C., Dormann C., Katwinkel M., Zulian G., Varjopuro R., Ratamäki O., Hauck J., Forsius M., Hengeveld G., Perez-Soba M., Bouraoui F., Scholz M., Schulz-Zunkel C., Lepistö A., Polishchuk Y., Bidoglio G. (2011).
PEER Report No 3, Ispra: Partnership for European Environmental Research. DOI: 10.2788/41581.

Alien species: a significant threat to biodiversity

Task Group 2 Report, Non-indigenous Species. Olenin S., Alemany F., Cardoso, A. et al. (2010).
Publications Office of the European Union, DOI: 10.2788/87092.

Online information systems with alien species occurrence records in Europe. Coverage, complementarity and compatibility. Vandekerkhove J., Cardoso A.C. (2011).
Publications Office of the European Union, DOI: 10.2788/65974.

Water related hazards and climate change

Floods

The European Flood Alert System EFAS - Part 2: Statistical skill assessment of probabilistic and deterministic operational forecasts. Bartholmes J. C., Thielen J., Ramos M. H., Gentilini S. (2009).
Hydrology and Earth System Sciences, Vol. 13, pp. 141-153. DOI: 10.5194/hess-13-141-2009.

Early flood detection and mapping for humanitarian response. De Groeve T., Riva P. (2009).
Proceedings of the 6th International ISCRAM Conference, Gothernburg, Sweden, May 2009. JRC52652.

Global real-time detection of major floods using passive microwave remote sensing. De Groeve T., Riva P. (2009).
Proceedings of the 33rd International Symposium on Remote Sensing of Environment Stresa, Italy, May 2009. JRC52654.

Flood monitoring and mapping using passive microwave remote sensing in Namibia. De Groeve T. (2010).
Geomatics, Natural Hazards and Risk, Vol. 1 (1), pp. 19-35. DOI: 10.1080/19475701003648085.

Quality Control, Validation and User Feedback of the European Flood Alert System (EFAS). De Roo A., Thielen J., Salamon P., Bogner K., Nobert S., Cloke H.L., Demeritt D., Younis J., Kalas M., Bodis K., Muraro D., Pappenberger F. (2011).
International Journal of Digital Earth, Vol. 4(sup1), pp. 77-90. DOI: 10.2788/46126.

The European Flood Alert System. Part 1: Concept and development. Thielen Del-Pozo J., Bartholmes J., Ramos M.H., De Roo A. (2009).
Hydrology and Earth System Sciences, Vol. 13, pp. 125-140. DOI: 10.5194/hess-13-125-2009.

Ensemble Flood Forecasting in Africa: A Feasibility Study in the Juba-Shabelle River Basin. Thiemig V., Pappenberger F., Thielen Del-Pozo J., Gadain H., De Roo A., Del Medico M., Bodis K., Muthusi F. (2010).
Atmospheric Science Letters, Vol. 11 (2), pp. 132-138. DOI: 10.1002/asl.270.

Drought and desertification

Drought and Drought Mitigation in Europe. Vogt J.V., Somma F. (eds) (2000). Kluwer Academic Publishers, Dordrecht/Boston/London, 325 pp. ISBN 0-7923-6589-5.

JRC Experience on the Development of Drought Information Systems. Horion S., Carrão H., Singleton A., Barbosa P., Vogt J.V. (2012). JRC Scientific and Technical Reports, DOI: 10.2788/15724, 70 pp.

Forecasting Drought in Europe with the Standardized Precipitation Index. Singleton A. (2012).
JRC Scientific and Technical Reports, DOI: 10.2788/16459.

Understanding Land Degradation Trends – Proceedings of the UNCCD First Scientific Conference, 22-24 September 2009, during the Ninth Conference of the Parties, Buenos Aires, Argentina. Winslow, M., Sommer S., Bigas H., Martius C., Vogt J.V., Akhtar-Schuster M., Thomas R. (2011).
JRC Scientific and Technical Reports, DOI: 10.2788/62563.

Science for improving the monitoring and assessment of dryland degradation. Winslow M., Vogt J.V., Thomas R.J., Sommer, S., Martius C., .Akhtar-Schuster M., (2011).
Land Degradation and Development, Vol. 22(2), pp. 145-149. DOI: 10.1002/ldr.1044.

Tsunamis

'Global Disaster Alert and Coordination System: for more effective and efficient humanitarian response' – 14th Conference of the International Emergency Management Society, Trogir, Croatia. De Groeve T. (2007).

The Tsunami Assessment Modelling System by the Joint Research Centre. Annunziato A. (2007). Science of Tsunami Hazards, Vol. 26(2), pp. 70-92. JRC41955.

Shoreline tracking and implicit source terms for a well balanced inundation model. Franchello G. (2010). International Journal for Numerical Methods in Fluid, Vol. 63, pp. 1123-1146. DOI: 10.1002/fld.2121.

Water and climate change

Fluvial flood risk in Europe in present and future climates. Feyen L., Dankers R., Bódis K., Salamon P., Barredo J.I. (2011).
Climatic Change, DOI: 10.1007/s10584-011-0339-7.

Improving pan-European hydrological simulation of extreme events through statistical bias correction of RCM-driven climate simulations. Rojas R., Feyen L., Dosio A., Bavera D. (2011).
Hydrology and Earth System Sciences, Vol. 15(8), pp. 2599-2620, DOI: 10.5194/hess-15-2599-2011.

Flood hazard in Europe in an ensemble of regional climate scenarios. Dankers R., Feyen L. (2009).
Journal of Geophysical Research, Vol. 114, D16108,
DOI: 10.1029/2008JD011523.

The impact of global warming on streamflow drought in Europe. Feyen L., Dankers R. (2009).
Journal of Geophysical Research, Vol. 114, D17116,
DOI: 10.1029/2008JD011438.

Climate change impact on flood hazard in Europe: An assessment based on high-resolution climate simulations. Dankers R., Feyen L. (2008). Journal of Geophysical Research, Vol. 113, D19105, DOI: 10.1029/2007JD009719.

Water governance – working together

The Danube – a transboundary challenge

Joint Danube Survey 2 (JDS-2) – Final Report (2008). ICPDR – International Commission for the Protection of the Danube River.

Characterization of the Danube River sediments using the PMF multivariate approach, Comero S. et al. (2012). submitted to Environmental Science and Technology

Flash flood detection through a multi-stage probabilistic warning system for heavy precipitation events. Alfieri L., Velasco D., Thielen Del-Pozo J. (2011).
Advances in Geosciences, Vol. 29, pp. 69-75. DOI: 10.5194/adgeo-29-69-2011.

The Mediterranean dimension

Estimation of water fluxes into the Mediterranean Sea. Bouraoui F., Grizzetti B., Aloe A. (2010).
Journal of Geophysical Research: Atmospheres, Vol. 115 (21), D21116. DOI: 10.1029/2009JD013451.

Flash flood detection through a multi-stage probabilistic warning system for heavy precipitation events. Alfieri L., Velasco D., Thielen Del-Pozo J. (2011).
Advances in Geosciences, Vol. 29, pp. 69-75. JRC59819, DOI: 10.5194/adgeo-29-69-2011.

Fluxes of Water and Nutrients from River Runoff to the Mediterranean Sea Using GIS and a Watershed Model. Strobl R, Somma F, Zaldivar Comenges J, Evans B.
JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS 114 (G3); 2009. p. G03012 (1-14). JRC50783.

Eutrophication in Transitional Waters: An Overview. Zaldivar Comenges J., Cardoso A., Viaroli P., Newton A., De Wit R., Ibañez C., Reizopoulou S., Somma F., Razinkovas A., Basset A., Holmer M., Murray N. (2008).
Transitional Waters Monographs, Vol. 2 (1), p. 1-78. JRC44890.

Towards a LOICZ Biogeochemical Budget for the Mediterranean Sea - Initial Steps. Strobl R., Evans B., Somma F., Garcia Gorriz E., Stips A., Zaldivar Comenges J. (2008).
Land-Ocean Interactions in the Coastal Zone, INPRINT 2. pp. 3-6. DOI: 10.1285/i18252273v2n1p1.

Access to water in developing countries

Dublin Statement on water and sustainable development, the International Conference on Water and the Environment (ICWE),

Ireland, 26-31 January 1992. http://www.gdrc.org/uem/water/dublin-statement.html

Analysing inter-relationships among water, governance, human development variables in developing countries: WatSan4Dev database coherency analysis. Dondeynaz C., Carmona Moreno C., Céspedes Lorente J.J. (2012).
Hydrology and Earth System Sciences, Discussions, Vol. 9, pp. 485-539. DOI: 10.5194/hessd-9-485-2012.

LISFLOOD: a GIS-based distributed model for river-basin scale water balance and flood simulation. Van der Knijff J.M., Younis J., De Roo A.P.J. (2010).
International Journal of Geographical Information Science, Vol. 24, No.2, pp. 189-212. DOI: 10.1080/13658810802549154.

GISEPIC AFRICA: A modeling tool for assessing impacts of nutrient and water use in African agriculture. Pastori M., Bouraoui F., Aloe A., Bidoglio G. (2011).
Publications Office of the European Union, DOI: 10.2788/49150.

Software Specification Document: Regional frequency analysis of climate variables. Carmona-Moreno C., Maeda Eduardo E., Arevalo Torres J., Giacomassi M., Mainardi P. (2011).
Publications Office of the European Union, JRC66809.

Water Resources Management in Latin America: Analysis of the actors and their capacity building needs. Indij D., Donin G., Leone A., (2011).
Publications Office of the European Union. JRC66336. DOI: 10.2788/55747.

Water-related innovation

Water as an eco-industry

Application of nano zero valent Iron (NZVI) for groundwater remediation in Europe. Mueller N.C., Braun J., Bruns J., Cernic M., Rissing P., Rickerby D.G., Nowack B. (2012).
Environmental Science and Pollution Research, Vol. 19, pp. 550-558. DOI: 10.1007/s11356-011-0576-3.

Nanofiltration and nanostructured membranes - should they be considered nanotechnology or not? Mueller N.C., Van der Bruggen B., Keuter V., Luis P., Melin T., Pronk W., Reisewitz R., Rickerby D.G., Rios G.M., Wennekes W., Nowack B. (2012).
Journal of Hazardous Materials, Vol. 211-212, pp. 275-280.

Renewable energies in Africa - current knowledge. Belward A., Bisselink B., Bódis K., Brink A., Dallemand J.F., De Roo A., Huld T., Kayitakire F., Mayaux P., Moner-Girona M., Ossenbrink H., Pinedo I., Sint H., Thielen J., Szabó S., Tromboni U., Willemen L. (2011).
Publications Office of the European Union, DOI: 10.2788/1881.

Standardisation of satellite observations

Cross-site consistent in situ measurements for satellite ocean color applications: the BiOMaP radiometric dataset. Zibordi G., Berthon J.F., Mélin F., D'Alimonte D. (2011).
Remote Sensing of Environment, Vol. 115, pp. 2104–2115. DOI: 10.1016/j.rse.2011.04.013.

Multi-sensor satellite time series of optical properties and chlorophyll a concentration in the Adriatic Sea. Mélin F., Vantrepotte V., Clerici M., D'Alimonte D., Zibordi G., Berthon J.F., Canuti E. (2011).
Physical Oceanography, Vol. 91, 229–244. DOI: 10.1016/j.pocean.2010.12.001.

AERONET-OC: a network for the validation of Ocean Color primary radiometric products. Zibordi G., Holben B., Slutsker I., Giles D., D'Alimonte D., Mélin F., Berthon J.F., Vandemark D., Feng H., Schuster G., Fabbri B.E., Kaitala S., Seppälä J. (2009).
Journal of Atmospheric and Oceanic Technology, Vol. 26, pp.1634–1651. DOI: 10.1175/2009JTECHO654.1.

Multidisciplinary Interoperability for water, weather, ocean and ecosystem data

Inter-disciplinary Interoperability for Global Sustainability Research. Craglia M., Nativi S., Santoro M., Vaccari L., Fugazza C. (2011).
GeoSpatial Semantics, Proceedings of the 4th International Conference, Geos 2011, Brest, France, May 2011. DOI: 10.1007/978-3-642-20630-6.

Best Available Techniques for waste water in chemical industries

Best Available Techniques (BAT) reference document on Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector industries (CWW). Commission Decision of 11 February 2003 adopting the complete text of the CWW BREF (2003/C 40/07) OJ L 257, 10.10.1196, p. 26.

Second formal draft of the revised CWW BREF, July 2011, European IPPC Bureau, http://eippcb.jrc.es/reference/

Useful contacts: ies-contact@jrc.ec.europa.eu

Partners

The JRC works in close contact with a vast array of institutions, research networks and science-led public and private partners and is continuously strengthening co-operations on global issues with international partners and organisations.

On the water field, cooperation is developed world-wide, with close collaboration with universities, environmental ministries and agencies, water authorities, meteorological organisations and research bodies. A representative sample of these partners can be found on this page.

European Environment Agency (EEA), Utrecht University, Free University of Amsterdam, Universidad Rey Juan Carlos, Universidad Politecnica, Baltic Marine Environment Protection Commission (Helsinki Commission – HELCOM), Administrator of the Oslo and Paris Conventions for the protection of the marine environment of the North-East Atlantic (OSPAR Commission), United Nations Environment Programme (UNEP), International Energy Agency (IEA), Instituto Nacional de Tecnologia Agropecuaria (INTA), Malaysian Palm Oil Board (MPOB), Umweltbundesamt, Masaryk University, Vlaamse instelling voor technologisch onderzoek (VITO), Umeå University, University of Birmingham, EAWAG, PEER: Partnership for European Environmental Research, Regional Sea Conventions, Hadley Centre, Met Office, Center for Environmental Systems Research, University of Kassel, Fondazione Eni Enrico Mattei,- International Institute for Applied Systems Analysis, Danish Meteorological Institute, Max Planck Institute, Alterra, National and Regional Water Authorities, National Civil Protection of Germany (BBK), European Centre for Medium-Range Weather Forecast (ECMWF), World Meteorological Organization (WMO), Mekong River Commission (WMO), Dartmouth Flood Observatory , Drought Management Centre for South-Eastern Europe (DMCSEE), United Nations Food and Agriculture Organization (FAO), Observatorio de la Sostenibilidad de España (OSE), US National Drought Mitigation Centre (NDMC), US National Oceanic and Atmospheric Administration (NOAA), Council for Scientific and Industrial Research (CSIR), the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Economic Commission for Latin America and the Caribbean (ECLAC-CEPAL), Centro del Agua para Zonas Áridas y Semiáridas de América Latina y el Caribe (CAZALAC), DesertNet International, Consiglio Nazionale delle Ricerche (CNR), International Commission for the Protection of the Danube River (ICPDR), International Black Sea Convention, Medcoast Network, National Networks of transitional water bodies (LAGUNET-IT, RedMarismas-ES, ELNET-GR, PLANET-PT, BALOON-Baltic countries), Water centres of excellence (Africa and Latin America), Environment Minsitries and Agencies, Organização do Tratado de Cooperação Amazônica (OTCA), Andean Parliament, African Ministerial Conference on Water (AMCOW), New Partnership for Africa's Development (NEPAD), African Union, Economic Community Of West African States (ECOWAS), International Development Bank, US National Aeronautics and Space Administration (NASA), US National Institute of Standards and Technology (NIST), UK National Physical Laboratory (NPL), International Oceanographic Commission of UNESCO, University of Bonn, Meteo France, Bundesanstalt fuer Gewaesserkunde, the Brasilian Institute for Space Research (INPE), Tokio University, Karlsruher Institut fuer Technologie, Terradue, Kisters AG, International Water Association (IWA), Organisation de Coopération et de Développement Économiques (OECD), New Partnership for Afrcia's Development (NEPAD), International Council for the Exploration of the Sea (ICES), L'Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER), Office for Coordination of Humanitarian Affairs (UN-OCHA), United Nations Educational, Scientific and Cultural Organization (UNESCO), GFZ German Research Centre for Geosciences, NOAA/PMEL – National Oceanic and Atmospheric Administration – Pacific Marine Laboratory, CEMADEN (Centro Nacional de Monitoraemtno e Alertas de Desastres Naturais), Ministério da Ciência, Tecnologia e Inovação, European Space Agency (ESA), Centre for Environment, Fisheries & Aquaculture Science (CEFAS)

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Abstract
This report aims to give a comprehensive overview of the work of the Commission's in-house science service, the Joint Research Centre (JRC), in relation to global water challenges. The description of the JRC's work on water is divided into six chapters. For each chapter, the detailed policy context is cited, showing clearly how and where the JRC is providing its scientific and technical support to water-related policies.

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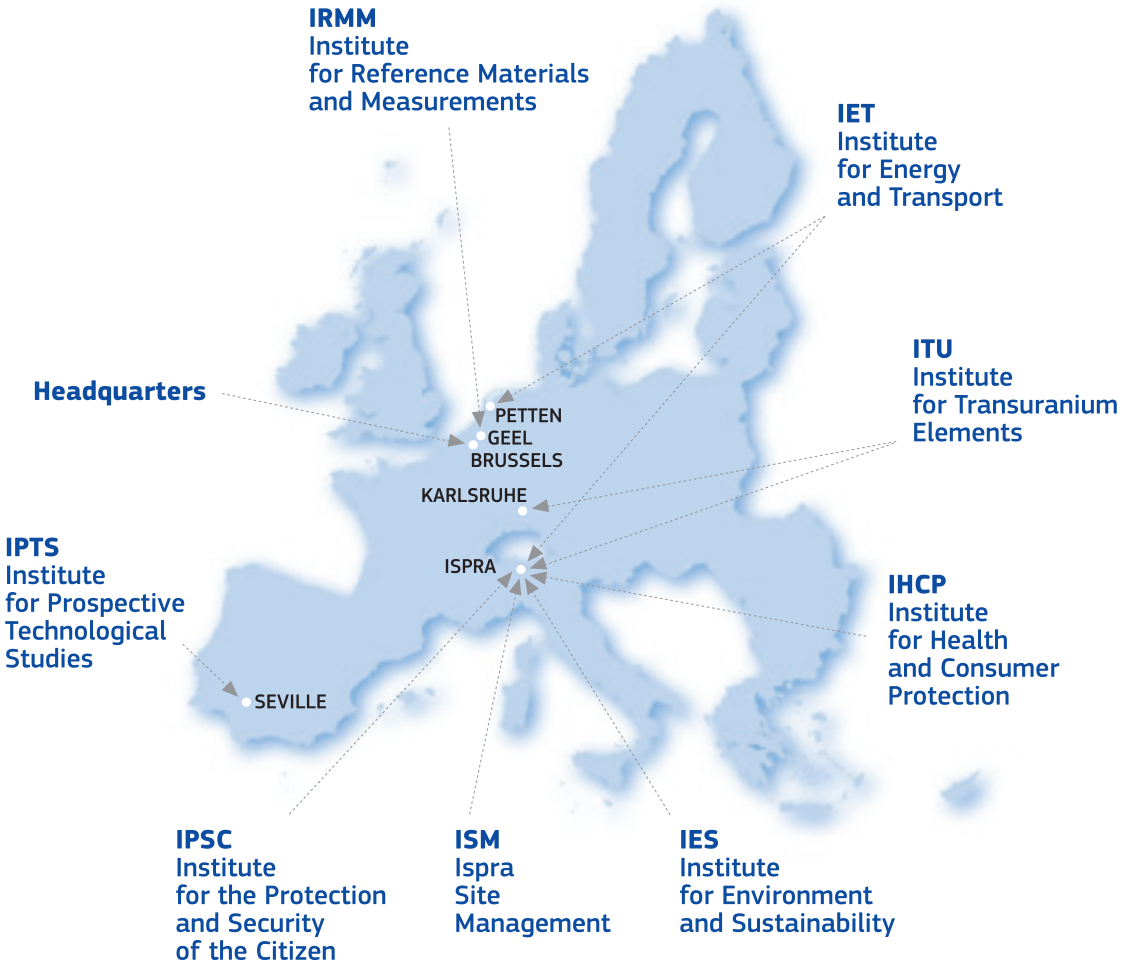
JRC Mission

As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new methods, tools and standards, and sharing its know-how with the Member States, the scientific community and international partners.

Key policy areas include: environment and climate change; energy and transport; agriculture and food security; health and consumer protection; information society and digital agenda; safety and security including nuclear; all supported through a cross-cutting and multi-disciplinary approach.



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