European Commission

Flagship cluster fiche:

THE DANUBE WATER NEXUS (DWN)

1. RATIONALE

The 2012 Blueprint to Safeguard Europe's Water Resources has identified agriculture and energy as the priority sectors in which water saving and efficiency should be improved in order to ensure a balance between future water demand and supply. This general conclusion for Europe matches the findings of the 2009 River Basin Management Plan for the Danube, where hydropower generation, physical modification and overexploitation of water bodies and diffuse pollution from agriculture have been addressed as significant pressures with cross border impacts. Water has been identified as a central issue also in the four vertical priorities of the "Scientific Support to the European Union Strategy for the Danube Region":

- ***Environment protection:***
  The Danube river basin is a transboundary ecosystem comprising a large number of tributaries, lowlands, a remarkable delta and incorporating a rich and unique flora and fauna. Deteriorating water quality would affect the provision of ecosystem services. The Danube Region is also facing growing water-related risks related to the increased frequency of extreme weather phenomena and global climate change.

- ***Navigability:***
  Although navigation is an environment-friendly mode of transportation, the Danube River and its tributaries are not exploited to their full potential and often impeded by seasonally varying water levels.. At the same time, any measures aiming to improvement of navigability (e.g. through major infrastructure works) shall also take due consideration of their possible impact on the modification of river ecosystems.

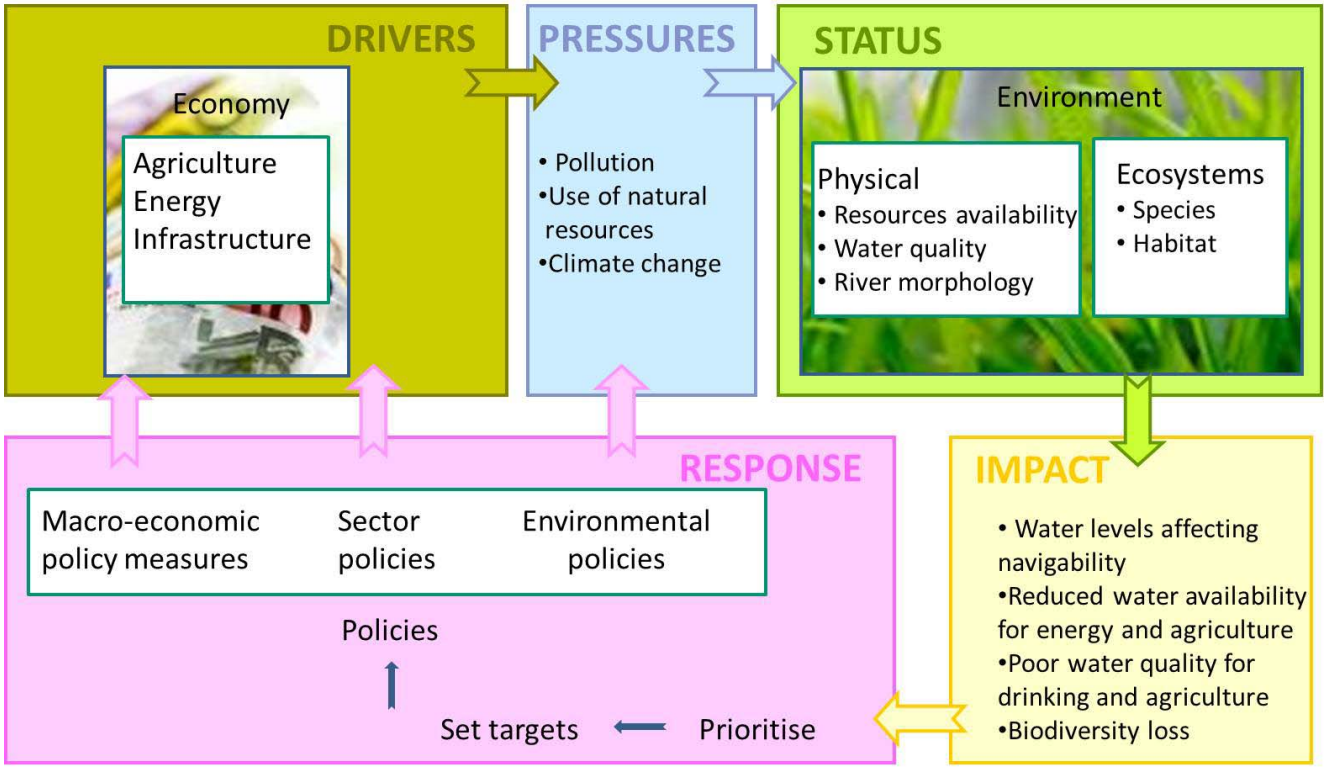
- ***Irrigation and agricultural development:***
  Tackling pressures on water caused by agriculture represents one of the main challenges to the achievements of the quality objectives of the Water Framework Directive (WFD) in Europe and in the Danube Region. The reform of the EU Common Agricultural Policy (CAP) will increase the opportunities for assisting in the implementation of water protection policies through an efficient use of Cross Compliance and of Rural Development plans.

- ***Energy production:***
  Energy is another intensive water using sector, e.g. water abstraction for hydro-power generation and for cooling of power plants Altered flow regimes in the Danube river basin due to climate-induced water level fluctuations or hydro-peaking associated to peak energy supply can impact the water status should a minimum ecological flow not be secured, at the same time putting at risk the capacity of energy supply.

The JRC is providing scientific support to the implementation of a range of EU policies some directly related to water (e.g. the Nitrates Directive, the Urban Waste Water Treatment Directive, the Water Framework Directive, the Priority Substances Directive, the Flood Directive, the Community civil protection mechanism) and others affecting status and availability of water through regulations of sectoral activities (e.g. the Common Agricultural Policy). The JRC is also fully engaged in the development of initiatives to support the Roadmap for a Resource Efficient Europe, which identifies water as an area where innovation is necessary to set us on a path to sustainable growth.

The transboundary nature of the Danube river basin provides an opportunity for testing impacts of innovative policy actions. The JRC is collaborating with several research bodies and international organisations in the Danube Region, e.g. on monitoring of water quality in the context of the Joint Danube Surveys, the development of databases to help predict climate change and to support soil protection, the deployment of modelling-based flood alerting systems for the entire river basin. Information obtained is of direct use to stakeholders in the region and the lesson learnt, also in terms of methodological development, exportable to other river basins in Europe and beyond. In this context, the JRC is proposing to carry out an assessment of the Water-Agriculture-Energy nexus for the Danube river basin.

A pressure-impacts relationship for water



Related priorities of the JRC Scientific Support to the Danube Strategy initiative:

Environment protection
Navigability
Irrigation and agricultural development
Energy production

Related priority areas of the EUSDR:

PA 1A - Mobility – Waterways (coordinated by Austria and Romania)
PA 02 - Energy (coordinated by Hungary and the Czech Republic)
PA 04 - Water Quality (coordinated by Hungary and Slovakia)

PA 05 - Environmental Risks (coordinated by Hungary and Romania)
PA 06 - Biodiversity, landscapes, quality of air and soils (coordinated by Bavaria and Croatia)

Policy context and related legislation:

EU reference documents:

EU Water Framework Directive and EU Blueprint to safeguard Europe's water resources

EU Floods Directive

EU Roadmap for a Resource Efficient Europe

Common Agricultural Policy Reform

EU Climate and Energy package

Other reference documents:

Danube River Basin Management Plan (adopted by the ICPDR in the framework of the implementation of the EU Water Framework Directive)

Joint Statement on Guiding Principles for the Development of Inland Navigation and Environmental Protection in the Danube River Basin (by the ICPDR, the Danube Commission and the International Sava Commission)

Declaration of Transport Ministers on effective waterway infrastructure maintenance on the Danube and its navigable tributaries

International partner organisations:

UNESCO
International Commission for the Protection of the Danube River (ICPDR)
Visegrad Group

2. FLAGSHIP CLUSTER DESCRIPTION

The 2012 Communication on the Blueprint to Safeguard Europe's Water Resources has set out key actions that need to be considered by water managers and policy makers in EU Member States to ensure balance of water availability and demand from different sectors and respect the needs of nature. In this context the JRC has developed a hydro-economic model to assess the impact of measures on water resources availability and allocation at European scale. One of the key actions of the Blueprint Communication concerns the further improvement of the hydro-economic model and its application at regional and river basin scale. This is intended to address the challenges of improving efficiency targets at sectoral level and to help Member States in the assessment of the cost-effectiveness of the Programmes of Measures included in their River Basin Management Plans.

The 'Danube Water Nexus' flagship cluster will contribute to build the knowledge base of the Water-Agriculture-Energy nexus, carry out scenario analyses of impacts of measures taking the Danube as pilot river basin and compare results for other regions in Europe, using among others the hydro-economic model developed by the JRC.

Scope:

The 'Danube Water Nexus' flagship cluster will address the environmental and socio-economic consequences of changing agriculture-energy pressures on water. This requires a basin-wide perspective and cooperation with countries in the region taking into account needs of all stakeholders. Allocation of available water across different sectors needs to be integrated into the overall economic strategy of the Danube Region based on optimization concepts in order to maximize growth and minimize the environmental impact. Central to the assessment will be the development and application of an optimisation model linked with dynamic, spatially explicit water quality and quantity models allowing the selection of measures affecting water availability and water demand based on environmental and economic considerations, and hydrological extremes such as floods and droughts. Optimization will particularly focus on the competing demand between the energy, agriculture, domestic, transport and industrial sectors under a changing environment. Outcomes of the bio-physical modelling will also be useful to assess impacts of changing climate on the navigability of the river.

Flagship cluster structure:

The following Work Packages are proposed:

- **Database development**

A database on inter-dependencies across water, agriculture and energy in the Danube Region will be developed. These activities will benefit from data made available through the Danube Reference Data and Services Infrastructure (DRDSI) and at the same time will contribute to populate the DRDSI with the additional datasets collected and/or generated in the framework of the cluster. All new data will be properly documented in order to facilitate their re-use. The access to the data will be governed by rules and procedures defined for the DRSDI.

- The database will cover quantity and quality aspects related to the use of water in agriculture (e.g. irrigation, animal rearing, reuse), the use of energy for water (e.g. long-distance transfers, pumping, treatment) and of water for energy (e.g. power plants, hydropower, shale gas, biofuels). It will also include socio-economic indicators such as demand functions by economic sectors, households, public utilities and unit costs of selected water management options. Activities in this Work Package will be closely linked to the cluster for the creation of a Danube Reference Data and Services Infrastructure (DRDSI).

- Soil related data for Danube Basin extracted from a range of in-house pan-European assessments will be made available. For example, key soil properties, organic matter, estimated soil erosion, soil sealing intensity, salinisation, land productivity dynamics, etc. It should be noted in almost all cases, individual countries have more detailed data that the JRC. However, the information at national level is very heterogeneous, which makes large area assessment difficult. In many cases, the data held by the JRC are the only pan-Danube level information. In the medium-term, a 'state of the environment' style report on the soils of the Danube Basin, with collaboration of Member States (as a contribution to the State of the Environment Report for 2015)
- Information on mini hydropower generation potential will be incorporated as background for the modelling and scenario analyses. The assessment methodology is under validation for assessing possible locations and productivity of mini-hydro power plants. Information on water need from bioenergy production, following the IEA-bioenergy approach that JRC has contributed to develop.

♦ **Hydro-economic modelling**

The calibration and validation of a hydro-economic model for the Danube region coupling water quantity and quality models with an economic model assessing the damage due to water shortages and with an optimisation model based on multi-criteria approaches will be undertaken. Based on a multi-criteria approach, the model will allow the selection of measures affecting water availability and demand based both on environmental and economic considerations. It will include an assessment of water footprint for energy and agricultural production in the Danube Region taking into account also trade options. This Work Package will build on the development and applications made by the JRC in the preparation of the Impact Assessment of the EU Water Blueprint for all Europe. Follow up modelling to the Blueprint needs to be streamlined at river basin scale, such as the Danube, to more closely reflect the reality in regions.

- The suite of biophysical models part of the JRC Integrated Water Modelling Platform will allow accounting for the variability of the quantity and quality of water resources. Making use of the spatial database developed in the first above-mentioned work package, all hydrological elements in the Danube river basin will be linked to a network of sources and demand sites for energy production, for urban and industrial water uses, for ecological and environmental flows and agricultural needs. The latter will be based on specific modules accounting for river basin scale agricultural practices and their impacts on water. Water withdrawals and return flows will be developed for each of these demand nodes, or determined using empirical relations between water and type of productive uses.
- Simulations will be carried out to assess the effects of water-retention measures, water-saving measures, and nutrient-reduction measures on several hydro-chemical indicators, such as the Water Exploitation Index (WEI), Environmental Flow indicators, the 50-year return period river discharge as an indicator for flooding, and economic losses due to water scarcity for the agricultural sector, the manufacturing-industry sector, the energy-production sector and the domestic sector.
- Water resource use and management involve multiple conflicting objectives and criteria. Selecting the best appropriate combination of water management uses from numerous objectives is difficult and challenging as solutions require compromises that are acceptable by all potential stakeholders. Multi-Criteria Decision Models provide a systematic mean for comparing tradeoffs and selecting alternatives that best satisfy the decision maker's objectives. Taking economic and environmental constraints into account, the optimisation model will allocate available water to all end users while ensuring the best tradeoffs for economic and environmental sustainability.

♦ **Scenario analyses**

This Work Package will carry out analyses of future scenarios of water demand and supply, an assessment of tradeoffs between alternative schemes of water allocation across the agriculture and energy sectors, and the selection of optimal management options to reduce vulnerability of water ecosystems and ensure a sustainable agricultural production and the provision of ecosystem services. Scenarios will be run on the basis of macroeconomic trends involving changing land use and climate conditions for 2030 and 2050

taking into considerations also water requirements by industry, human consumption and the need to ensure a minimum environmental flow. Interaction is required between the JRC Integrated Water Modelling Platform, the JRC Land Use Modelling Platform, the Biophysical Model Applications platform (BioMA), the agricultural sector model CAPRI, the POLES energy model, and the regional climate modelling team. This interlinkage will allow capturing complex relations between biophysical processes and economic developments (e.g. prices, income, land use).

- With the inclusion of 'greening' measures combined with the cross-compliance, the CAP represents an option to ensure that agricultural production uses natural resources in a sustainable way. Furthermore, biofuel policies may potentially impact production structure and land use having implication for farm practice adjustments, land use and overall markets developments. Agro-economic scenarios for the Danube Region will include aspects related to these policy developments and external factors and their relation to water allocation and water scarcity. A particular focus of the agro-economic analysis will be on productivity effects, market impacts, land use changes, development of incomes and their variation across regions and agricultural sectors. This work will be based on the use of the CAPRI model developed and maintained under the agro-economic modelling platform iMAP.
- The changing allocation of water to and within agriculture can have impacts on agricultural production. Through bio-physical and crop modelling the impacts of a water supply modified in space and time as compared to today's situation on cereals yield and production will be analysed and evaluated. Based on feedbacks from the second above-mentioned work package, this study will include the impact of changing irrigation water regimes (blue water) as well as changing patterns of precipitation as the natural water supply to agricultural plants (green water) due to climate change for chosen scenarios.
- Regional climate scenarios will initially be those prepared for the PESETA-II study (Projection of Economic impacts of climate change in Sectors of the European Union based on boTtom-up Analysis). They are based on the work of all major regional climate modeling groups in Europe that collaborated in the FP6 ENSEMBLES project. The JRC has "bias-corrected" the output of the ENSEMBLES models, to make them useful for application in climate impact models. Near the end of 2013, new scenarios will become available in the international community and may be again bias-corrected by JRC. The use of consistent and up-to-date climate scenarios will be a strong element in the project.
- The Land Use Modelling Platform (LUMP) which integrates sector-specific projections and plans (e.g. on macro-economy, agriculture, forestry, demography, transport) will provide results at a detailed geographical scale, taking full account of competing land use demands (for example for household, industrial settlements, etc.) and of spatial policy restrictions (e.g. Nature 2000 sites or other protection mechanisms). Bio-physical interactions between land, water, vegetation, are also considered. Specific scenarios of policy options (concerning e.g. regional development and cohesion) will be assessed and their impacts quantified, following selected environmental, social and economic criteria.
- The energy model POLES has been extensively used in the context of mid- and long-term energy scenarios, under alternative assumptions and for different policy purposes related to the 20-20-20 European initiatives amongst others. The model will be used to address the alternative patterns of exploitation of hydroelectricity in the countries of the Danube region in the scenarios addressed, depending on the water resource availability and the deployment of other power generation technologies.
- The identification of the classes of water management options to be included in the scenario analysis is essential for the definition of the objectives to be evaluated in the multi-criteria decision. This assessment will use as boundary conditions the set of scenarios generated for the Danube region as identified in the previous bullets. Water management measures to be assessed will comprise e.g. improvement of the efficiency in the use of water (irrigation, energy, industrial uses), increase of water retention capacity through natural (floodplains, polders, wetlands) or technical infrastructure (dams, reservoirs), improvement of the quality of available water by changing farming practices, water transfer from one basin to another.

3. OUTPUTS AND BENEFICIARIES

Products:

- Scenarios of environmental and economic impacts of alternative water allocation measures across competing water-using sectors (agriculture, energy, industry, human consumption, environment) for the years 2030-2050, including an assessment of the provision/valuation of ecosystem services provided by aquatic ecosystems in the Danube river basin
- Methodology for modelling of water resources in the Danube river basin, integrating quantity, quality, ecology and hydro-morphology, in coordination with other tools at national and river basin level and extension to non-EU countries of the Danube Region
- Development of information supporting efforts of countries and international cooperation bodies in the implementation process of the WFD and planning of medium and long-term actions for the 2nd cycle of River Basin Management
- Policy relevant data products
- Seminars

Potentially interested actors and/or beneficiaries of the research results:

EU institutions and bodies
National and regional governments of the Danube Region
Other stakeholders of the Danube Region

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