Water-Food-Energy-Environment Nexus studies at JRC: Sava and Niger

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Aims of JRC’s hydro-economic modelling

• Using 2 model chains, depending on the focus of the study:
  • SWAT, EPIC, GREEN + OPTIMISATION
  • LISFLOOD/LISQUAL + OPTIMISATION
  • underlying model for EFAS, GloFAS and EDO for realtime flood and drought monitoring and forecasting in Europe and Global

• Address the Water-Food-Energy-Environment Nexus in Europe and at global scale, for current and future climate

• Assess which combination of measures are beneficial to obtain sustainable water futures;
  • Optimum combinations of measures fulfill multi-criteria objectives
    • costs/benefits of measures, potential flood damages, value of ecosystem services, farmer income, industry income
    • reduction of sectorial water shortages (energy production, manufacturing industry, agriculture, public sector, navigation, environment), water quality targets, sustainable groundwater management, environmental flow;
    • Taking into account climate change, land use and socio-economic changes
JRC’s hydro-economic modelling & optimisation

‘conventional’ bio-physical effects:
- River Discharge, (flood risk, low flow risk); soil moisture; groundwater levels, Water Exploitation Index
- N & P concentrations

Quantifying costs and benefits for sectors of water extremes
- High flows: Flood damage
- Low & high flows: Navigation economic effects
- Welfare loss to public sector, ‘willingness to pay’ for water
  - Demand curves household water consumption
  - Effects of water pricing on consumption
- Agriculture:
  - farmer income changes caused by (irrigation) water scarcity, increased irrigation water availability, fertilization changes
  - Losses to livestock farmers in case of water scarcity
- Manufacturing Industry: marginal value of water for industry
- Energy Production: loss/increase of hydropower production
- Quantifying of Ecosystem services
Household demand functions EU-28

- Allows calculation of effect of water price change on water consumption
- Allows calculation of welfare loss in case of water scarcity
### Estimated marginal value of water in industries

<table>
<thead>
<tr>
<th>Country</th>
<th>Period</th>
<th>Spatial Scale</th>
<th>Energy included</th>
<th>Estimated marginal value of water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulgaria</td>
<td>2010</td>
<td>Nuts3</td>
<td>No</td>
<td>17– 68 euros / m3</td>
</tr>
<tr>
<td>Croatia</td>
<td>2008-12</td>
<td>Nuts3</td>
<td>Yes</td>
<td>308 – 660 euros / m3</td>
</tr>
<tr>
<td>Estonia</td>
<td>1998-2012</td>
<td>&lt;Nuts3</td>
<td>No</td>
<td>37– 91 euros / m3</td>
</tr>
<tr>
<td>France</td>
<td>2008-10</td>
<td>Nuts2</td>
<td>Yes</td>
<td>2 – 158 euros / m3</td>
</tr>
<tr>
<td>Lithuania</td>
<td>2008-12</td>
<td>Nuts3</td>
<td>Yes</td>
<td>3 – 300 euros / m3</td>
</tr>
<tr>
<td>Poland</td>
<td>1998-2012</td>
<td>Nuts3</td>
<td>Yes</td>
<td>3 – 133 euros / m3</td>
</tr>
<tr>
<td>Spain</td>
<td>2007-2010</td>
<td>Nuts2</td>
<td>No</td>
<td>45 -252 euros /m3</td>
</tr>
<tr>
<td>Sweden</td>
<td>2000&amp;2010</td>
<td>Nuts3</td>
<td>No</td>
<td>17 – 140 euros /m3</td>
</tr>
<tr>
<td>UK</td>
<td>2000-12</td>
<td>Nuts1</td>
<td>Yes</td>
<td>193 – 262 euros /m3</td>
</tr>
</tbody>
</table>

1 May 2015
Economic Loss model irrigation / farmer income loss

Assumptions:
- Ratio delivered water <> value is taken as 0.1
- Quadratic function

This results in that for every m3 water that is not available for irrigation, the damage is maximally the **choke price** (0.1 euro in this example)

So, e.g., if the required amount of water for irrigation area is 1 Mm3, and

<table>
<thead>
<tr>
<th>Available water (Mm3)</th>
<th>Loss (MEuro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0.0 MEuro</td>
</tr>
<tr>
<td>0.5</td>
<td>0.025 MEuro</td>
</tr>
<tr>
<td>0.1</td>
<td>0.081 MEuro</td>
</tr>
<tr>
<td>0</td>
<td>0.1 MEuro</td>
</tr>
</tbody>
</table>

**Choke price:**
- 0.35 Euro/m3 (low value crops)
- 1.25 Euro/m3 (high value crops)
Sava River Basin – Water Nexus study
Calibration for 42 Sava gauges (using Yearbook and earlier data)
Change in 20-year return period discharge (KNMI RCP45 2051-2100 vs 1990-2005)
6 Mm³ water is currently used for irrigation (maize only, simulated with EPIC).

Irrigation requirements for maximum maize irrigation are quite low in the NW part, moderate in most parts and high in small parts of Sava basin.

Average maize yield could grow from 5.7 tons/ha to 9.9 tons/ha when optimally irrigated but water requirements would grow.
Maximum Irrigation (combining all sources)
Effect of increased irrigation on groundwater resources
Todo:
- map showing where LZ becomes negative sometimes
- bar chart per water region: days with sustainable groundwater abstraction

Days per year with unsustainable groundwater abstraction
KNMI RCP45 2006-2100, max irrigation
Effect of increased irrigation on low flow (1st percentile) under current climate (1990-2005)
All powerstation sites (source: ISRBC urls, KTH)
Sava: Changed Inflow to hydropower stations
Niger River Basin – JRC Water Nexus study
Niger: Average available water resources

Average annual runoff (1989-2010)
Niger:
water resources model validation
land needed for subsistence agriculture
Conclusions

- Revised **Sava** simulations (incl lessons learnt from Oct 2014 feedback); aim to be ready for 25 May 2015 meeting

- JRC will continue the work in the Sava and Danube to support ISRBC and ICPDR and MS in establishing RBMP and Programs of Measures, while benchmarking our tools

- JRC is carrying out Mekrou/**Niger** study as contracted by DG DEVCO, and is ready to contribute to UNECE Niger Nexus study

- With its 5km European and 10km Global model, JRC is ready to discuss to contribute to further river basin Nexus studies