Spatio-temporal dynamics of flood regulating services in the Arno River basin

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HIGHLIGHTS

• Assessment of flood regulating services supply of different CORINE land cover classes using Soil and Water Assessment Tool (SWAT)

• Demand quantification derived by the existing flood management plans which contain the identification and the perimeter of hydraulic hazard classes

• Spatial explicit analysis of flood regulating supply, demand and budget in the Upper Arno River in the center of Italy from 1990 up to 2018 (1990, 2000, 2012, 2018)
**Ecosystem Services (ES):** benefits that people obtain from ecosystems (MA, 20005).

- Supporting services
- Provisioning services
- Regulating services
- Cultural services

Flood mitigation

**Supply**

- The capacity of the environment to provide the service

**Demand**

- The human driven request of that service

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Spatio-temporal dynamics of flood regulating services in the Arno River basin.
This study aims at analyzing the spatio-temporal dynamics of flood regulating ES in the Upper Arno River basin in the center of Italy.
The assessment of flood regulating services SUPPLY is based on the evaluation of the hydrological processes occurring in the catchment.

**SUPPLY ASSESSMENT**

**INPUT VARIABLES**
- LAND COVER
- SOIL TYPE
- DEM
- PRECIPITATION
- TEMPERATURE
- SOLAR RADIATION
- WIND SPEED
- RELATIVE HUMIDITY

**HYDROLOGICAL MODEL (SWAT)**
- 6 HYDROLOGICAL VARIABLES
- 2 INDICATORS
- 8 SUPPLY MAPS

**MANUAL CALIBRATION**

**HYDROGRAPH** (DISCHARGE CHECK)

Maps derived from the CORINE land cover (CLC) dataset
- Data from the Tuscany region dataset
- Data from the global climate database of the National Centers for Environmental Prediction (NCEP) - Climate Forecast System Reanalysis (CFSR)
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SUPPLY ASSESSMENT

Two indicators have been processed by extracting the average annual value of six output variables for each land use. The land cover capacities were assessed and mapped on a relative scale ranging from 0 to 3.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>ET</th>
<th>PERC</th>
<th>SURFQ</th>
<th>GWQ</th>
<th>LATQ</th>
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</thead>
<tbody>
<tr>
<td>Agricultural Land-Generic</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
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<tr>
<td>Barren</td>
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<td>0</td>
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<tr>
<td>Dryland Cropland and Pasture</td>
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<td>1</td>
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<tr>
<td>Cropland / Grassland Mosaic</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Cropland/Woodland Mosaic</td>
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<td>3</td>
<td>0</td>
<td>3</td>
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<tr>
<td>Forest-Deciduous</td>
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<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Forest-Evergreen</td>
<td>1</td>
<td>3</td>
<td>3</td>
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DEMAND ASSESSMENT

DEMAND quantification was obtained from the information derived by the existing flood management plans which contain the identification and the perimeter of hydraulic hazard classes.

<table>
<thead>
<tr>
<th>CLASS</th>
<th>DESCRIPTION</th>
<th>PAI</th>
<th>PGRA</th>
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<tr>
<td></td>
<td>CODE</td>
<td>DESCRIPTION</td>
<td>CODE</td>
</tr>
<tr>
<td>0</td>
<td>No Relevant Demand</td>
<td>-</td>
<td>-</td>
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<tr>
<td>1</td>
<td>Low Demand</td>
<td>PI1</td>
<td>0 &lt; T ≤ 30</td>
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<tr>
<td>2</td>
<td>Moderate Demand</td>
<td>PI2</td>
<td>30 &lt; T ≤ 100</td>
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<tr>
<td></td>
<td></td>
<td>PI3</td>
<td>100 &lt; T ≤ 200</td>
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<tr>
<td>3</td>
<td>High Demand</td>
<td>PI4</td>
<td>200 &lt; T ≤ 500</td>
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</table>

PAI = Piano per l’Assetto Idrogeologico
PGRA = Piano di Gestione del Rischio di Alluvioni
8 maps of flood regulating ecosystem service budget were created as a result of spatial overlay between the supply and demand map layers.

For both indicators:
- SUPPLY maps for 1990 and 2000
- SUPPLY maps for 2012 and 2018

DEMAND map obtained from PAI
DEMAND map obtained from PGRA

<table>
<thead>
<tr>
<th>%</th>
<th>INDICATOR 1</th>
<th>INDICATOR 2</th>
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<tbody>
<tr>
<td>Sub-basin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chiana</td>
<td>2.49</td>
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<tr>
<td>Medium Valdarno</td>
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<td>Bisenio</td>
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<td>Sieve</td>
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<td>-2.38</td>
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<td>Greve</td>
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<td>-0.39</td>
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<td>Casentino</td>
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<td>-1.18</td>
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<tr>
<td>Upper Valdarno</td>
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<td>-1.28</td>
</tr>
<tr>
<td>Arno basin</td>
<td>-0.10</td>
<td>-2.18</td>
</tr>
</tbody>
</table>
CONCLUSIONS

The impacts of socio-economic and land use changes over time on the demand and supply of flood regulation ecosystem services were identified and mapped in the Arno river basin.

These results can:

▪ help decision makers;

▪ facilitate understanding of information which otherwise might be difficult to interpret;

▪ help to discover spatial distributions and patterns about areas of low and high ES supply and demand in the watershed.

Source: https://it.cleanpng.com/cleanpng-gxrb01/download-png.html
CONCLUSIONS

▪ Free data;
▪ SWAT model provides significant information and allows several physical processes;
▪ CORINE land cover allows to see the changes in land use over time.

▪ Demand maps consider only topographical aspects and relative hydrologic analysis.
▪ Assess multiple ecosystem services;
▪ Obtain demand maps with other assessment tools;
▪ Use better input data.