Impact Assessment of Land Use Changes

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The Interaction of Water Policies and Agricultural Policies on Land Use and the Rural Economy:
An Integrated Modeling Framework

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CONTENTS

- Framework of the research
- Introduction
- Objective
- Methodology
- Results
- Conclusions
Two on-going EU projects

**Framework of the research**

*Linking water policies and agricultural policies…*

1. **NEWATER** (New approaches to adaptive water management under uncertainty) (2005-2009) [www.newater.info](http://www.newater.info)
   - IP, 42 research teams, 15 countries, 7 river basins
     - IWM (technical, ecological, socio-economic issues)
     - Strong social component: basin-based stakeholder participation

   - STREP, 11 research teams (3 non EU)
     - Degree and cost of compliance in EU countries
     - Effects on competitiveness of agricultural sectors: dairy, beef, pigs, poultry, cereals, fruits, vegetables, and olives.
Agriculture → 80%

- Extends over 15% of all Arable Land (3.6 M ha)
- 60% of total A. Production
- 80% of Total Farm exports
- Irrigation technology: 35% gravity, 23% sprinkler, 42% localized
- Water tariff: 82% area pricing, 13% volumetric pricing, 5% binomic tariff

AGRICULTURAL POLICIES
(CAP Reform 2003 & Health Check)

WATER POLICIES
The EU context: agricultural and water policies

**AGRICULTURAL POLICIES**
(CAP Reform 2003 & Health Check)

- Direct aid payments decoupled from production
- **Single farm payment** (per ha)
- **Cross-compliance mechanisms** →
  - direct payments are subject to compliance with environmental regulations
- **Rural Development Programs**

**WATER POLICIES**

- **Sustainable use of w. resources** (2015)
- **River Basin Organization** as management unit
- Planning and **integrated management** of all w. resources
- **Cost recovery**, polluter pays principle
- Transparency and **public participation**
IRRIGATED AGRICULTURE

Multifunctional
Competitive
Environmentally sustainable
Adaptable to new challenges (i.e. climate change)

**AGRICULTURAL POLICIES**
(CAP Reform 2003 & Health Check)

- Direct aid payments decoupled from production
- **Single farm payment** (per ha)
- Cross-compliance mechanisms → direct payments are subject to compliance with environmental regulations
- Rural Development Programs

**WATER POLICIES**

- Sustainable use of w. resources (2015)
- River Basin Organization as management unit
- Planning and integrated management of all w. resources
- Cost recovery, polluter pays principle
- Transparency and public participation

The EU context: agricultural and water policies

Introduction
To explore the application of water policies and agricultural policies in two distinct regions in Spain that represent surface and ground water irrigation systems:

- How they will affect irrigated agriculture, water use, land use patterns, conservation of natural resources, and socio-economic development of rural areas?

- How these policies will interact to seek the dual objective of conserving water resources, attaining cost recovery of water services, and maintaining farming activity?
Methodological scheme

Region and study area
Field work

Agronomic model
(CropSyst)

Economic model
(Non-Linear Mathematical Programming Model)

Characterization of the
Irrigation Communities

Technical coefficients &
parameters

Representative farms

Methodology
Methodological scheme

Region and study area
Field work

Agronomic model
(CropSyst)

Technical coefficients & parameters

Characterization of the Irrigation Communities

Representative farms

Economic model
(Non-Linear Mathematical Programming Model)

Combination of policy scenarios

Water policies (WFD)
• Water quotas
• Water tariffs

Agricultural policies (CAP)
• Partial decoupling
  - Nitrates Directive
• Full decoupling

Analysis of policy impacts on:

Environment: water use, cropping patterns, irrigation techniques…

Public sector: government revenue, cost-effectiveness of policies…

Private sector: farmers’ income, expected income loss and risk aversion…
Representative farms

Region and study area
Field work

Agronomic model
(CropSyst)

Technical coefficients & parameters

Characterization of the Irrigation Communities

Representative farms

Economic model
(Non-Linear Mathematical Programming Model)

Combination of policy scenarios

Water policies (WFD)
- Water quotas
- Water tariffs

Agricultural policies (CAP)
- Partial decoupling - Nitrates Directive
- Full decoupling

Analysis of policy impacts on:

WUA level (aggregated results)

Farm level (disaggregated results)
Castilla-La Mancha
Western La Mancha Aquifer:
5 WUA
&
5 farms type

Castilla y León:
2 WUA
&
4 farms type}

Study Regions

Methodology
One of the two Spanish aquifers officially declared overexploited

The most important aquifer in the Upper Guadiana Basin

Castilla-La Mancha

Western La Mancha Aquifer:
5 WUA
&
5 farms type
One of the two Spanish aquifers officially declared as overexploited in Spain is the Western La Mancha Aquifer, which is the most important aquifer in the Upper Guadiana Basin. This aquifer is managed by 5 WUAs and involves 5 farm types.
MPM of constraint optimization → farm model, static, non linear

Objective function → Utility maximization, defined by:
- Expected income → farm’s gross margin
- Risk parameters → risk aversion and income standard deviation
  \[N = 100\] (10 agronomic var., 10 prices/market var.)

Constraints
- Surface, irrigation, labor, water, policy…

Calibration
- Risk aversion coefficients
- Real and simulated crop distribution (water use)

Validation
- Marginal values of land and labor
- Stakeholders' opinions (irrigators)
Policy scenarios

WATER POLICIES

AGRICULTURAL POLICIES
(CAP Reform 2003)

<table>
<thead>
<tr>
<th>Policy Type</th>
<th>Current</th>
<th>Simulated</th>
<th>Current</th>
<th>Simulated</th>
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<tr>
<td><strong>Castilla y León</strong></td>
<td>W. allotments rights</td>
<td>W. tariffs</td>
<td>Partial Decoupling</td>
<td>Full Decoupling</td>
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<tr>
<td>(surface water)</td>
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<tr>
<td><strong>Castilla La Mancha</strong></td>
<td>W. quotas</td>
<td>W. tariffs</td>
<td>Partial Decoupling + Nitrates Directive</td>
<td>Full Decoupling</td>
</tr>
<tr>
<td>(groundwater)</td>
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</tbody>
</table>
Water policy: water tariffs

Results

Castilla y León (surface water)

Price of cost recovery

Castilla La Mancha (groundwater)

Aggregated results

W. reduction (0%)

W. reduction (0%)

W. reduction (-42%)

W. reduction (-52%)

Castilla y León (surface water)

W. reduction (0%)

Castilla La Mancha (groundwater)

W. reduction (0%)

W. reduction (-42%)

W. reduction (-52%)

t=8 cent€/m³

t=6 cent€/m³
Water policy: water tariffs

Castilla y León (surface water)

- t = 0.06 €/m³
- Income loss (-64%)
- Income loss (-32%)

Price of cost recovery

Castilla La Mancha (groundwater)

- t = 0.08 €/m³
- Income loss (-17%)
- Income loss (-50%)

Results

Aggregated results
Effect of cost recovery of the WFD in other Spanish Irrigation areas
Effect of cost recovery of the WFD in other Spanish Irrigation areas

Water demand reduction (%)  Income loss (%)

- Duero: 0-30%, 52%
- Guadiana: 0-30%, 52%
- Guadalquivir: 15-30%, 8-15%
- Segura: 0-10%, 0-40%
- Júcar: 10-40%

Water scarcity regions
Water policy: water tariffs – Crop distribution

Results

Cost recovery

Water Prices (€/m³)

0% 20% 40% 60% 80% 100%

Surface (%)

- Crops very intensives in water (maize, sugar beet, potato)
- Crops not very intensives in water (wheat, barley, sunflower)
- Rainfed crops

Castilla y León (surface water)

- Castilla La Mancha (groundwater)

Rainfed
Extensive Irrigated Crops
Horticulture
Irrigated Vineyard

Cost recovery

Water Prices (€/m³)

0 0,03 0,06 0,09 0,12 0,15 0,18 0,21 0,24 0,27 0,3 0,33 0,36 0,39 0,55 0,63 0,7 0,8 0,83 0,875

Surface (%)

Crops very intensives in water (maize, sugar beet, potato)
Crops not very intensives in water (wheat, barley, sunflower)
Rainfed crops
## Agricultural policy: Full decoupling

### Results

<table>
<thead>
<tr>
<th>REGION</th>
<th>POLICY SCENARIO</th>
<th>WATER CONSUMPTION</th>
<th>INCOME</th>
<th>CROPPING PATTERN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total (m³/ha)</td>
<td>%</td>
<td>Total (€/ha)</td>
</tr>
<tr>
<td><strong>CASTILLA Y LEÓN</strong></td>
<td>Partial Dec.</td>
<td>4650</td>
<td>100</td>
<td>461.94</td>
</tr>
<tr>
<td>(Surface water)</td>
<td>Full Dec.</td>
<td>4650</td>
<td>100</td>
<td>452.58</td>
</tr>
<tr>
<td><strong>CASTILLA-LA MANCHA</strong></td>
<td>Partial Dec.</td>
<td>2904</td>
<td>100</td>
<td>772.32</td>
</tr>
<tr>
<td>(Groundwater)</td>
<td>Full Dec.</td>
<td>2904</td>
<td>100</td>
<td>895.86</td>
</tr>
</tbody>
</table>
### Results

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<th>CROPPING PATTERN</th>
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<td>%</td>
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<td>Partial Dec.</td>
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<td>Full Dec.</td>
<td>2904</td>
<td>100</td>
<td>895.86</td>
</tr>
</tbody>
</table>

**Similar water consumption but…**

**Different effects on farm income and crop distribution across regions!**
Agricultural policy: Full decoupling

**Results**

**Castilla y León (surface water)**
- Rainfed cereals: +2%
- Irrigated cereals: +11%
- Maize: -33%
- Sugar-beet: 0%
- Potato: +23%
- Setaside crops: -2%

**Castilla-La Mancha (groundwater)**
- Rainfed cereals: +22%
- Irrigated cereals: -30%
- Melon: +8%
- Potato: +3%
- Irrigated vineyard: 0%
- Set-aside: -1%
Effects on farm income…

Representative farms of the Western La Mancha Aquifer
(Castilla-La Mancha)
Policy integration: CC (Nitrates Directive) + water quotas

**Results**

**Effects on farm income…**

The Western La Mancha Aquifer (Castilla-La Mancha)

**Aggregated level**

![Bar chart showing farm income (€/ha) for different policy scenarios.](chart_image)

- **Reference situation**: 900 €/ha
- **Reference situation + ND**: 850 €/ha (−5%)
- **WAP**: 700 €/ha (−25%)
- **WAP + ND**: 680 €/ha (−2%)
Policy integration: CC (Nitrates Directive) + water quotas

Effects on land use…

The Western La Mancha Aquifer (Castilla-La Mancha)

Aggregated level
In the EU WFD, attaining cost recovery targets can produce differential effects across irrigation systems and regions:

- **Surface irrigation system (Castilla y León):** no water saving and severe losses to farm profits. It may question the viability of some of these farms → *WFD is low cost-effective*

- **Groundwater irrigation system (Castilla-La Mancha):** important water savings without inflicting great income loss to the irrigated farms → *WFD is high cost-effective*

The New CAP with decoupled payments will not produce clear environmental benefits which is one of the objective of the CAP Reform:

- Induces crop extensification (dec. maize → less water demand)
- Induces horticulture crops (more water demand).
Farm income is much more sensitive to water restrictions than to nitrogen restrictions, being water the main limiting factor for agricultural production in this region (Castilla-La Mancha, groundwater irrigation system):

- Larger farms face lower expected income losses, evidencing the presence of economies of scale in favor of bigger holdings.

There are important synergies between water conservation policy (water quotas) and the agricultural policy (cross-compliance measures):

- Water use limitations is promoting the substitution of water demanding crops with less water intensive crops which require also lower nitrogen dosages, and vice versa.
Thanks for your attention!

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Effect of cost recovery of the WFD in other Spanish Irrigation areas

Water demand reduction (%) - Income loss (%)

- Duero
  - Water demand reduction: 0-30%
  - Income loss: 52%

- Guadiana
  - Water demand reduction: 52%
  - Income loss: 10-40%

- Segura
  - Water demand reduction: 0-10%
  - Income loss: 0-30%

- Guadalquivir
  - Water demand reduction: 15-30%
  - Income loss: 0-10%

- Júcar
  - Water demand reduction: 8-15%
  - Income loss: 0-40%
### Results

#### Effect of compliance with the Nitrates Directive

<table>
<thead>
<tr>
<th>Crop</th>
<th>Tech.</th>
<th>Nitrogen Quantity (kg/ha)</th>
<th>Water consumption (m3/ha)</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ref. situation</td>
<td>ND</td>
<td>Decrease (%)</td>
</tr>
<tr>
<td><strong>BARLEY</strong></td>
<td>RF</td>
<td>49</td>
<td>55</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>SP2</td>
<td>127</td>
<td>110</td>
<td>14</td>
</tr>
<tr>
<td><strong>WHEAT</strong></td>
<td>RF</td>
<td>60</td>
<td>55</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>SP2</td>
<td>160</td>
<td>110</td>
<td>31</td>
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<tr>
<td><strong>MAIZE</strong></td>
<td>SP2</td>
<td>348</td>
<td>200</td>
<td>43</td>
</tr>
<tr>
<td><strong>SUNFLOWER</strong></td>
<td>RF</td>
<td>39</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>SP2</td>
<td>135</td>
<td>80</td>
<td>41</td>
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<tr>
<td><strong>SUGARBEET</strong></td>
<td>SP2</td>
<td>270</td>
<td>200</td>
<td>26</td>
</tr>
<tr>
<td><strong>POTATO</strong></td>
<td>SP2</td>
<td>314</td>
<td>120</td>
<td>62</td>
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<tr>
<td><strong>MELON</strong></td>
<td>DR</td>
<td>189</td>
<td>135</td>
<td>28</td>
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<tr>
<td><strong>PEPPER</strong></td>
<td>DR</td>
<td>203</td>
<td>160</td>
<td>21</td>
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<tr>
<td><strong>GARLIC</strong></td>
<td>SP2</td>
<td>80</td>
<td>80</td>
<td>0</td>
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<tr>
<td><strong>VINE</strong></td>
<td>RF</td>
<td>26</td>
<td>50</td>
<td>0</td>
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<tr>
<td></td>
<td>DR</td>
<td>158</td>
<td>70</td>
<td>56</td>
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<tr>
<td><strong>AVERAGE</strong></td>
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<td>RF</td>
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<td></td>
<td>IRR</td>
<td>32</td>
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</tbody>
</table>
## Effect of the Nitrates Directive on the gross margin by crop

<table>
<thead>
<tr>
<th>Crop</th>
<th>Technique</th>
<th>Gross Margin in reference situation (€/ha)</th>
<th>Gross Margin under Nitrates Directive (€/ha)</th>
<th>Foregone income (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BARLEY</td>
<td>RF</td>
<td>258</td>
<td>258</td>
<td>0</td>
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<tr>
<td></td>
<td>SP2</td>
<td>722</td>
<td>575</td>
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<td>RF</td>
<td>253</td>
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<td></td>
<td>SP2</td>
<td>708</td>
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<td>1461</td>
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<td>RF</td>
<td>283</td>
<td>283</td>
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<td></td>
<td>SP2</td>
<td>618</td>
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<td>2113</td>
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<tr>
<td></td>
<td>IRR</td>
<td></td>
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</tbody>
</table>

Policy integration: Water quotas + CC (Nitrates Directive)
• There are important synergies between water conservation policy and the agricultural policy: Water use limitation is promoting the substitution of water demanding crops with less water intensive crops which require also lower nitrogen dosages, and vice versa.

• both the water conservation policy and the ND lead to less water intensive cropping patterns and diversified farms tend to loose a lesser proportion of their farm income as their capacity to adapt is higher

• Farm income is much more sensitive to water restrictions than to nitrogen restrictions, being water the main limiting factor for agricultural production in this region
A recent vision of the Spanish agriculture

Surface (M ha) and Value of production (1000 M €, year 2000)

Fuente: Anuarios MAPA
A recent vision of the Spanish agriculture

Surface (M ha) and Value of production (1000 M €, year 2000)

Introduction