WATER PRODUCTIVITY: HOW IT WORKS AND HOW IMPROVE IT

A. Battilani

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
BULLET POINTS

1) The report “Toward a water efficient Europe” (EEA, Jan. 2012) underline the need to **INCREASE WATER PRODUCTIVITY** in order to effectively support the EU Green Economy and Agriculture.

2) DG Agriculture reports are claiming that we must **DOUBLE BIOMASS PRODUCTION** in the next 5 to 10 years in order to give a chance to the EU Green Economy.

3) FAO's scenario analysis for year 2050 have shown an increase of 74% of global food demand (up to 100% in LDC) while pro capita arable land will drop of -20%. The expected arable land expansion is of 5 and will produce 12% more food. **Yield increase and higher crop intensity** are expected to contribute to fill respectively 74% and 14% of the gap. Irrigated land will increase of 7%, while irrigation use will be more intense and diffuse even in northern countries. **“MORE CROP PER DROP”**
WATER PRODUCTIVITY: HOW IT WORKS

Still there is not a common agreement on the use of WATER PRODUCTIVITY as indicator.

The WATER PRODUCTIVITY index may only express a physical ratio between yields, or its value, and the water used to produce it.

Water productivity = \frac{\text{Actual Yield}}{\text{Actual water use}}
WATER PRODUCTIVITY: HOW IT WORKS

**ACTUAL YIELD**: produced fresh matter biomasses (total or commercial)

**ACTUAL WATER USE**:

as **Outflow**: Plant Transpiration, Salinity Leaching Factor, Percolation, Runoff, Soil Evaporation

as **Inflow**: Rainfall, Capillary Rise, Soil Water consumption, Irrigation

Max Yield

\[
\text{Max WP} = \text{Opt. Beneficial Water Uses + Min NOT BWU}
\]

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
Water productivities are lower under very high climatic demand because crop water requirements are then the highest.

Are all the parameters correctly estimated under these conditions??

Under stress reduction in yields could be not fully recovered by Irrigation supply, thus the dividend (Yield) decrease while the divisor (Water Use) increase, resulting in a decrease in WP.
WATER PRODUCTIVITY

CER- Hourly Temperature 20 - 26 June 2003

T°C

Tsoil

EU Project FERTORGANIC

A. Battilani – CEPS – Which economic model for a water efficient Europe?, Brussels 27 March 2012
WATER PRODUCTIVITY

ECONOMICALLY VAILABLE

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
Water Productivity

- Little DM production/Minimal Water Use (9.0 t ha\(^{-1}\) DM)
- Optimal DM yield and WU (10.4 t ha\(^{-1}\) DM)
- Potential Max DM yield, no more beneficial WU (12.3 t ha\(^{-1}\) DM)

Battilani, Dalla Costa Lovatti, 2002

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
WATER PRODUCTIVITY: HOW IMPROVE IT

a) TECHNOLOGICAL INNOVATION
b) BETTER GOVERNANCE AND MANAGEMENT
c) DEFICIT IRRIGATION STRATEGIES
d) DECREASE SOIL EVAPORATION
e) IRRIGATION SCHEDULING
f) REDUCE RUNOFF (AND PERCOLATION)
g) CONSIDER ALL THE INPUTS (I.E WATER TABLE)
h) WATER REUSE
i) CROPPING SYSTEM IMPROVEMENT
(BioIntelligence reports -EU ENV 2012)
e) TRADE AND CONSUMERS RESPONSIBILITY

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
TECHNOLOGICAL INNOVATION

- **Improvement of Surface Irrigation**: don't requires new infrastructure such energy supply, changes in conveyance systems or relevant investments by the farmer. Up to 50-60% potential water saving.

- **Convert surface to Sprinkler irrigation**: labour and energy cost will significantly weight upon the irrigation costs. Water conveyance will be positively affected by reduction of irrigation volumes and instant flow. Up to 40% potential water saving.

- **Drip irrigation**: less energy, initial investments and labour costs. The impact on the water conveyance systems could be very high (up to 24 hours a day of irrigation). Up to 60% of water with respect to Surface Irrigation and up to 25% with respect to Sprinkler Irrigation.
TECHNOLOGICAL INNOVATION

SPRINKLER
- Increase uniformity >80%
- Reduce angle impact
- Lower pressure (-0.7/1.5 bar)

LEPA

DRIP
- Better pressure control
- Compensating pressure/CNL emitters, buried driplines, pressure control devices, operating maintenance

TRAVELING SYSTEMS/REEL MACHINES
- Speed compensation
- Low angle gun (18°)
- Adequate operating pressure and maintenance

SOLID SETS
- Proper sprinklers spacing, pressure, uniformity
- Proper sprinkler angle

OVERALL
- Uniformity test (5 year period)
- Irrigation Audit

A. Battilani – CEPS – Which economic model for a water efficient Europe?, Brussels 27 March 2012
TECHNOLOGICAL INNOVATION

<table>
<thead>
<tr>
<th>Application Efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100</td>
</tr>
</tbody>
</table>

- Flood/Border
- Furrow-Gated Pipe
- Furrow-Surge Flow
- Cablegation
- LPS*
- Solid Set
- Side Roll
- Travelling Gun
- Travelling Boom
- Improved Reel Travelling Gun/Boom
- Centre Pivot
- Linear Move
- LEPA
- Mini Sprinkler
- Micro Sprinkler
- Bubbler low-head
- Drip
- Subsurface Drip Irrigation (SDI)
- Ultra Low Flow (ULF)

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
NEW TECHNOLOGIES ARE NOT A PANACEA

In order to improve the productivity of water in irrigated agricultural systems a single step improvement of the irrigation technologies can be not sufficient.

Technological innovation by itself cannot produce the expected results while, when not correctly applied, can cause losses arising on investments made by Farmers, thus decrease the Economic Water Productivity Index.

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
BETTER GOVERNANCE AND MANAGEMENT

Rainwater Harvesting and Storage: Macro Catchment

Micro Catchment

On the spot Catchment

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
BETTER GOVERNANCE AND MANAGEMENT

Canal Lining

Up to 30% water savings

Irrigation Aqueduct (pressurized)

Up to 50% water savings

Intelligent Water Meters

Up to 30% water savings

A. Battilani – CEPS – Which economic model for a water efficient Europe?, Brussels 27 March 2012
DEFICIT IRRIGATION

Hydraulic signals to control and reduce evapotranspiration

Deficit (DI) and Regulated Deficit Irrigation (RDI)
DEFICIT IRRIGATION

No signals

Chemical signals

Alternate PRD

EU Project SAFIR

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
# DEFICIT IRRIGATION

## POTATO

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full Irrigated</td>
<td>PRD</td>
<td></td>
</tr>
<tr>
<td>WUE Total</td>
<td>DW kg m(^{-3})</td>
<td>1.14 b</td>
<td>1.34 a</td>
</tr>
<tr>
<td>WUE Marketable</td>
<td>DW kg m(^{-3})</td>
<td>0.97 b</td>
<td>1.21 a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Avg Water Saving %</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PRD vs FI</td>
<td>15.55</td>
<td>12.98</td>
</tr>
</tbody>
</table>

## PROCESSING TOMATO

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full Irrigated</td>
<td>PRD</td>
<td></td>
</tr>
<tr>
<td>WUE Total</td>
<td>DW kg m(^{-3})</td>
<td>1.22 b</td>
<td>1.41 a</td>
</tr>
<tr>
<td>WUE Marketable</td>
<td>DW kg m(^{-3})</td>
<td>1.00 b</td>
<td>1.13 a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Avg Water Saving %</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PRD vs FI</td>
<td>19.66</td>
<td>9.18</td>
</tr>
</tbody>
</table>

EU Project SAFIR

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
Subsurface Drip Irrigation is worldwide recognized as the most efficient irrigation system, it can virtually eliminate soil evaporation.
IRRIGATION SCHEDULING: PILOT MONITORING STATION

EU Project Water 4 Crops

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
IRRIGATION SCHEDULING: PRECISE IRRIGATION

- UNMANNED DRONE REMOTE SENSING
- SATELLITE REMOTE SENSING
- SOLAR PANEL
- WATER MANAGER
- STORAGE BATTERY
- SOLAR PUMP
- WIRELESS VALVE
- PRESSURIZED MICROIRRIGATION
- SOIL WATER CONTENT WIRELESS SENSOR
- WATER MANAGER CONTROL STATION

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
MODEL AND DSS APPLICATION

Complex technological/technical systems can not be properly managed without model/DSS support.

Involves more than 9000 farms, covering about 33% of the irrigated area in the Emilia Romagna region. More than 50 million m³ of water saved per year thanks to the application.

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
Countless studies underline the relevance of irrigation strategies, mainly when coupled with advanced irrigation technologies and crop husbandry practices.

<table>
<thead>
<tr>
<th></th>
<th>FERTIRRIGERE</th>
<th>TRADITIONAL</th>
<th>t-Student</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Standard Error</td>
<td>Average</td>
</tr>
<tr>
<td>Yield (t/ha)</td>
<td>90.94</td>
<td>1.85</td>
<td>84.94</td>
</tr>
<tr>
<td>Soluble Solids (°Brix)</td>
<td>5.04</td>
<td>0.051</td>
<td>4.52</td>
</tr>
<tr>
<td>Quality Index</td>
<td>8.35</td>
<td>0.27</td>
<td>11.40</td>
</tr>
<tr>
<td>WUE (t/m³)</td>
<td>4.7</td>
<td>0.1</td>
<td>2.0</td>
</tr>
<tr>
<td>NUE (t/kg)</td>
<td>1.17</td>
<td>0.09</td>
<td>0.48</td>
</tr>
<tr>
<td>Fertigation Costs (€/ha)</td>
<td>322.00</td>
<td>5.00</td>
<td>673.00</td>
</tr>
</tbody>
</table>

Processing Tomato, 56 Farms, 5 year survey
C. Pennucci, A. Battilani - Conserve Italia
A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
REDUCE RUNOFF AND PERCOLATION

Estimate precisely the Root Zone Volume is crucial to correctly manage irrigation supplies avoiding percolation and runoff.

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
REDUCE RUNOFF AND PERCOLATION

\[ \text{RZ}_{L,\text{MAX}} = \leq 0.70 \text{ m} \]

\[ \text{RZ}_{VOL,\text{MAX}} = 0.506 \text{ m}^3 \]

\[ \frac{\text{RZ}_{VOL,\text{MAX}}}{\text{SOIL}_{VOL,\text{MAX}}} = 0.211 \]

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
REDUCE RUNOFF AND PERCOLATION

SANDY SOIL

Dripline in the valley every other ridge

Dripline on each ridge top

Silty Clayey Soil

EU Project FERTORGANIC

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
WATER REUSE

Water Reuse can contribute up to 10-15% of irrigation supply, even more with decentralised treatments.
# CROPPING SYSTEMS IMPROVEMENT

<table>
<thead>
<tr>
<th>Action</th>
<th>Costless</th>
<th>Investments Required</th>
<th>Extension Services</th>
<th>Farmer’s Training</th>
<th>Effect on Rural Society</th>
<th>Changes in Water Governance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crop Selection</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drought/saline tolerant varieties</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of more suited Crops</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Higher Harvest Index crops</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changes in crop rotation</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Cropping Pattern</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sowing earlier</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil moisture conserving tillage</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjust timing of field operations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Increase soil organic matter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
Fruit and Vegetable size and aesthetic get happy customers but farmers are forced to oversize products and standardize their aesthetic using more water and nutrients.

From 5 to 40% of the food produced is not even harvested because of its “non standard” size and aesthetical characteristics.

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
TRADE AND CONSUMERS RESPONSABILITY

1400 M
Overweight

400 M
OBESE

SUSTAINABLE AND RESPONSIBLE DIET

REDUCE WASTES

EU, Average Food Waste 179 kg p\(^{-1}\) y\(^{-1}\)

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012
WATER PRODUCTIVITY: PROBLEM Solved ??

A. Battilani - CEPS - Which economic model for a water efficient Europe?, Brussels 27 March 2012