DSIRR
A DSS FOR AN ECONOMIC AND ENVIRONMENTAL ANALYSIS OF IRRIGATION

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DSIRR
Decision Support tool for Irrigation

A scenario manager for agro-economic models

The present beta non commercial version operates as a 32 bit Windows application on a PC with at least 32 MB of RAM

The code is written in Visual Basic
The program requires GAMS package installed on the PC
In most countries agriculture represents the higher percentage of water demand (60-80%)

Many experts suggest to reduce this amount via economic instruments

In this direction moves also the EU Water Framework Directive 60/2000 (WFD) defining criteria for water management, regulation and pricing
## Water Framework Directive (60/2000)

<table>
<thead>
<tr>
<th>Purposes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goal:</strong> Environmental sustainability</td>
<td>Achievement of a “good environmental status”</td>
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</tbody>
</table>

**Principles and instruments**

- Adoption of the Polluter Pays Principle (PPP) and User Pays Principle (UPP)
- Economic instruments are recommended to provide users with adequate incentives for sustainable use

**From supply expansion to demand control**

- Consideration of the economical and social constraints to expanding demand and possibly to evaluate the opportunity of adopting resource saving measures

**Adequate financial resources**

- Cost Recovery (art. 9) to ensure that utilities dispose of adequate financial resources in order to sustain the costs even with a decreasing role of the public sector
WFD

Implementation at catchment scale

Definition of river basin plans

Long term forecasts of supply and demand for water
What happens if …

in the agricultural sector
Market (input/output prices)
Policy (subsidies, constraints,…) change
Technologies (innovation)

Water regulation and economic instruments change
(institutions, rights, prices, tariffs, quota,…, )
The European “Common Agricultural Policy” (CAP)

- It is undergoing a widespread reform (Agenda 2000 - Mid Term Review)
  - not motivated by environmental reasons
- CAP does not give up the policy objective of sustaining farmers’ income
- support prices eliminated
- adopted direct income compensations
  - “decoupled” from commodities production - ecosussidiariety
    (support conditioned to good environmental practices)
  - recognition of positive environmental impacts (externalities)
  - promotion of quality
Irrigation in an economic context

• Water is an input / production factor
  – Increase quantity
  – Improve quality
  – Reduce risk
    • Increase production set (new crops)
    • Reduce variation over time
Crop water yield function
Technical optimum
Economical optimum
water yield function
The demand curve
Many crops – many farms

\[ P_w \]

\[ Q_w \]

\[ P_w' \]

\[ Q_{wA} \quad Q_{wB} \quad Q_{wTot} \]

\[ A \quad B \quad \text{Tot}=A+B \]
A WATER PRICING POLICY MODEL

0) $p_0 \rightarrow q_0$

Ir. Agency Revenue = $A+B$
Farmer surplus = $E+C+D$

1) $p_1 \rightarrow q_1$

Ir. Agency Revenue = $A+C$
Farmer surplus = $E$

Welfare loss = $B+D$
revenue lost for I.A. = $B$
surplus lost for F. = $D$

Transfer from farmer to irrigation agency = $C$
What are demand curves for?

They permit to anticipate farmer behaviour supporting policy definition

Prices, subsidies, tax

in general all the market mechanisms can be utilized
How can water demand curves be obtained?

simulating farmers’ behaviour

by mathematical models
The methodology (1)

In order to assess the policy impact on:

- Water demand
- Farm income
- GDP contribution
- Employments
- Environmental Sustainability Indicators

DSIRR considers relevant agriculture systems (case-studies)

analysis is carried out via a microeconomic technique based on mathematical programming optimisation models
The methodology (2)

- Identification of the basin
  - Homogeneous production district
- Data collection - statistical data and ad hoc survey
  - Cropping systems
  - Crop mix
  - Production/irrigation technologies
- Modelling
  - Calibration
  - Scenario Analysis (what-if)
- Results interpretation and policy recommendations
Location of case studies in Italy in EU WADI Project

① Fruit (perennial)
② Cereal - industrial
③ Rice
④ Vegetables
⑤ Citrus (perennial)
Agricultural sector

Cropping systems

Representative farms

Farm choices

Production: What and How cultivate

Economic results
Social effects
Environmental impacts

Different behaviours

Criteria

Preferences

Objectives

Irrigation:
How - technologies
How much - water demand
Source - supply
GAMS
General Algebraic Modelling System

OUTPUT
Text and Excel files
water demand function
employment
income
Water Agency revenue
environmental indexes
...

POLICY
agricultural water

FARM PARAMETER
Surface
Labour
Capital

SOIL DATA
Water tableau

CLIMATE
rain

FARM MODEL
A) Objective function
B) Constraints: Land, Labour, Capital
Water balance, Investments, Policy,…
C) Indexes: Water, Nitrate, …

FARMER BEHAVIOR
preferences, knowledge, …

ECONOMIC THEORY

MULTICRITERIA ANALYSIS

IRRIGATION DATABASE
Irrigation technologies

WATER SUPPLY DATABASE

AGRONOMIC DATABASE
Water- yield functions

ECONOMIC DATABASE
Inputs/outputs prices

MATHEMATICAL PROGRAMMING TECHNIQUES

GAMS
General Algebraic Modelling System

ECONOMIC THEORY
Multiattribute analysis (1)

A set of possible attributes is defined (income, risk, labour, complexity, …)

Each attribute is defined as a function of the decisional variables \( X \) \( f_i = f_i(x) \)

\[
U = \sum_{i=1}^{q} \frac{w_i}{k_i} f_i(x)
\]

Where:
- \( q \) number of relevant attributes
- \( w \) objectives weights
- \( f_i \) calculated value of attribute \( j \)
- \( k_i \) normalizing factor

How to define \( w \) objectives relative importance?
Multiattribute analysis (2)

1) The observed $f_{obs}$ values are quantified (given the existing crop mix)

2) The best pay-off matrix is quantified (2 stages)
   $f_{ij}$ the value of objective $i$ when objective $j$ is optimized

\[
\sum_{j=1}^{q} w_j f_{ij} = f_{obs_i}
\]

3) Since an exact solution to the previous problem does not exist
   total standardized deviation are minimized (goal programming)

\[
\min \sum_{j=1}^{q} \frac{n_i + p_i}{f_{obs_i}}
\]

\[s.c.\]

\[
\sum_{j=1}^{q} w_j f_{ij} + n_i - p_i = f_{obs_i}
\]

Where $n$, $p$ negative and positive deviations
<table>
<thead>
<tr>
<th>OBJECTIVE</th>
<th>Time horizon</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short</td>
<td>Long</td>
</tr>
<tr>
<td><strong>INCOME</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GROSS MARGIN</td>
<td>Ma</td>
<td>LP</td>
</tr>
<tr>
<td>NET INCOME/ PROFIT</td>
<td>Ma</td>
<td>MIP</td>
</tr>
<tr>
<td><strong>RISK</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E/V</td>
<td>mi</td>
<td>NLP</td>
</tr>
<tr>
<td>MOTAD</td>
<td>mi</td>
<td>LP</td>
</tr>
<tr>
<td>MAX NEG. SEMIVAR</td>
<td>mi</td>
<td>LP</td>
</tr>
<tr>
<td>TOTAL NEG. SEMIVAR.</td>
<td>mi</td>
<td>LP</td>
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<tr>
<td>INC. CONCENTRATION</td>
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<td>LP</td>
</tr>
<tr>
<td><strong>LABOUR</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FAMILY</td>
<td>mi</td>
<td>LP</td>
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<tr>
<td>HIRED</td>
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<td>LP</td>
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<tr>
<td><strong>DIFF</strong></td>
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<td></td>
</tr>
<tr>
<td>COMPLEXITY INDEX</td>
<td>mi</td>
<td>LP</td>
</tr>
</tbody>
</table>

Legend:  
Ma = maximizing, mi = minimizing  
LP linear, NLP non linear, MIP integer, MINLP integer non linear programming model
Income definition and time horizon

A) Gross output
   Income
   Subsidy
   Other

B) Expenses  [intermediate consumption]
   Variable costs
     Inputs
     Services
     Salary
     Rent

C) A-B  GROSS MARGIN

D) Fixed costs
   Asset Depreciation
     Existing
     New investments
   Irrigation Fees

E) C-D  NET INCOME

F) Remuneration
   Own labour
   Interest on asset
   Own land

G) E-F PROFIT
The farm model
(income objective)

\[
\max_{\{X,W\}} \text{INC} = \sum_c \sum_i \sum_s \left\{ X_{c,i,s} \left[ p_{c,i} q_{c,i,s} \left( w_{r,c,i,s} \right) + s_{uc} - v_{c,i,s} \right] \right\} - \sum_k \sum_l \sum_p W_{k,l,p} w_{p,k,l,p} \\
\text{s.c.} \\
\ldots \\
\sum_s \sum_c \sum_i X_{c,i,s} i_{r,c,i,s} \leq \sum_l W_{k,l,p} \quad \forall k, p
\]

where:
c crop, i irrigation level, s type of soil, k water source, l water provision level, p period.
INC income (€), \(X_{c,i,s}\) activities (ha), \(p_{c,i}\) crop market price (€/t), \(q_{c,i,s}(w_{r,c,i,s})\) crop production as function of water (t), \(w_{r,c,i,s}\) crop water requirements (m³), \(s_{uc}\) subsidies (€), \(v_{c,i,s}\) variable costs (€), \(W_{k,l,p}\) water consumption (m³), \(w_{p,k,l,p}\) water price (€/m³), \(i_{r,c,i,s}\) crop irrigation requirements (m³)
<table>
<thead>
<tr>
<th>Decision variables</th>
<th>N. Ob.</th>
<th>Time horizon</th>
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<tr>
<td></td>
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</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>&gt; 1 MAUT</td>
<td>x</td>
</tr>
<tr>
<td>Farm</td>
<td>Enlargement / reduction</td>
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</tr>
<tr>
<td>Crop</td>
<td>Annuals change mix</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>Plantation abatement</td>
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<tr>
<td></td>
<td>New plantation</td>
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<tr>
<td>Irrigation</td>
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<tr>
<td></td>
<td>Techniques change among existing</td>
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</tr>
<tr>
<td></td>
<td>New techniques</td>
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<tr>
<td>Labour</td>
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<tr>
<td></td>
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<tr>
<td>Fin.</td>
<td>Indebtment</td>
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</tbody>
</table>
Data requirements

- Farms
- Irrigation techniques
- Crops
- Irrigation supply
- Climate
- Others parameters

Relations
Farm

- Soil by types
  - Availability
  - Property (ha)
  - Rentable (ha)
  - Water tableau (m$^3$)
  - Reclamation fees (€)

- Labour
  - Availability by periods
  - Family (h)
  - External (h)

- Financial capital
  - Availability
  - Own (€)
  - External (€)

- Fixed costs (€)
Irrigation techniques

- Characteristics
  - Type (fixed-moving)
  - Volume (l/s)
  - Efficiency (%)
  - Engine type (cod)
  - Power requested (CV)

- Labour requirements
  - Irrigation (%)
  - Maintenance (h)

- Economic
  - Cost (Quota) (€)
  - External cost (€/h)

- Availability
  - Existing (n)
  - Maximum (n)
Crops

**Agronomic data**
- Production by water req. (t)
- Water req. by periods (m³)
- Rotation requirements (n)

**Indicators**
- Energy (index)
- Nitrate (index)
- Soil coverage (gg)
- ...

**Economic**
- Price (€/t)
- Subsidy (€)
- Variable cost (€)

**Labour req. by periods**
- Excluding irrigation (h)

**Constraints**
- Political (set aside)
- Commercial
Mais water yield function
Water supply

by levels

• Availability
  – Maximum (m³)

• Economic
  – Price (€/m³)
Climate

• Rain
  – by periods (mm)

• Water tableau
  – by periods (m³)
Other parameters

• Technical
  – Energy consumption coef.
  – Energy price

• Remuneration
  – Family labour (€/h)
  – Own land (€/ha)
  – Asset (€)
  – Financial capital (%)

• Political
  – COP equivalent surface (ha)
  – Set aside requirement (%)
Relations

- Crops / Soils
- Soils / Irrigation techniques
- Crops / Irrigation techniques
- Water supply / Irrigation techniques
Irrigation requirement

\[
I_{r_{c,i,j,p,s}} = \frac{W_{r_{c,i,p,s}} - W_{ta_{s,p}} - R_{ain_p}}{Eq_{_ef_j}}
\]

Ir crop irrigation requirement (m³)
Wr crop water requirement (m³)
Wta water tableau apport (m³)
Rain (m³)
Eq_ef equipment irrigation efficiency (%)
\[ \text{Ir}_{\text{te}}_{c,i,j,p,s} = \frac{\text{Ir}_{c,i,j,p,s}}{\text{Eq}_{\text{vol}}_{j} \times 3.6} \]

Ir\_te crop irrigation duration (h),
Ir crop irrigation requirement (m\(^3\)),
Eq\_vol irrigation volume (l/s)
Output

- Crops mix by soil, irr. lev, irr. tecn.
- Irrigation techniques adopted
- Water consumption by supply and periods
- Employment by types and periods
- Economic indicators (Profit, NI, GM, GDP, …)
- Sustainability indicators
### INDICATORS

<table>
<thead>
<tr>
<th>Area</th>
<th>Selected indicators</th>
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<tbody>
<tr>
<td>Economic balance</td>
<td>Farm income</td>
</tr>
<tr>
<td></td>
<td>Farm contribution to GDP</td>
</tr>
<tr>
<td></td>
<td>Public support</td>
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<tr>
<td>Social impact</td>
<td>Farm employment</td>
</tr>
<tr>
<td></td>
<td>Seasonality</td>
</tr>
<tr>
<td>Landscape and biodiversity</td>
<td>Genetic diversity</td>
</tr>
<tr>
<td></td>
<td>Soil cover</td>
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<tr>
<td>Water use</td>
<td>Irrigation technology</td>
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<tr>
<td></td>
<td>Water use</td>
</tr>
<tr>
<td></td>
<td>Marginal value of water</td>
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<tr>
<td>Nutrients and pollutants</td>
<td>Nitrogen balance</td>
</tr>
<tr>
<td></td>
<td>Pesticide risk</td>
</tr>
<tr>
<td></td>
<td>Energy balance</td>
</tr>
</tbody>
</table>
THE MODEL IS SOLVED IN GAMS
(GENERAL ALGEBRIC MODELLING SYSTEM)

BUT THE USER DO NOT SEE IT

THE USER DEFINE THE MODEL
INTRODUCE ALL THE COEFFICIENTS
IN DSIRR

LOOK AT THE RESULTS
IN
EXCEL
TXT.FILES
DSIRR

Version 1.0.0

GAMS Interface for Farm Irrigation Model

Maximum dimensions: 14 crops, 3 types of soil, 1 water supply system, 3 irrigation levels, 3 irrigation periods, 5 irrigation techniques

Beta version with extended potential

Programme developed by Guido M. Bazzani and Chiara Rosselli Del Turco
DSIRR Graphical User Interface (GUI)
PERIODS DEFINITIONS AND WATER SUPPLY

WATER OFFER CURVE – by PERIOD
(BLOCK TARIFF)
Water demand by irrigation technologies
Cereal/industrial Farm in the NW Po Basin

Water demand

Crop mix in the LT

### ST indices

<table>
<thead>
<tr>
<th>WP</th>
<th>WQ</th>
<th>LTot</th>
<th>Revenue</th>
<th>Subsidy</th>
<th>C.Specif.</th>
<th>C.Water</th>
<th>G.M.</th>
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<td>292</td>
<td>1227</td>
<td>115</td>
<td>1096</td>
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</table>

### LT indices

<table>
<thead>
<tr>
<th>WP</th>
<th>WQ</th>
<th>LTot</th>
<th>Revenue</th>
<th>Subsidy</th>
<th>C.Water</th>
<th>G.M.</th>
<th>N.Inc.</th>
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<tr>
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<td>2026</td>
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<td>29</td>
<td>880</td>
<td>414</td>
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<tr>
<td>10.0</td>
<td>363</td>
<td>10</td>
<td>1530</td>
<td>377</td>
<td>36</td>
<td>873</td>
<td>407</td>
</tr>
</tbody>
</table>
Problem definition: indexes

- Crops \( C \)
- Soils \( S \)
- Periods \( P \)
- Irrigation levels \( I \)
- Irrigation techniques \( J \)
- Irrigation modality \( M \)
- Water supply modality \( K \)
- Water supply levels \( L \)
PARAMETERS (1)

- **Cmax(c)**: max. surface (Ha)
- **Cmin(c)**: min surface (Ha)
- **COP92**: equivalent surface to 92 tonnes cereals (Ha)
- **Fcost**: fixed cost (EURO)
- **Ir_su(k)**: irrigable surface (ha)
- **Ir_fee(k)**: irrigation unitary fee (EURO)
- **Ir_ha(j)**: surface irrigable by 1 unit of equipment (Ha)
- **Ir_mort(j)**: irrigation equipment mortgage (EURO)
- **Ir_eff(j)**: irrigation efficiency (n.p.)
- **Ir_cap(j)**: irrigation capacity (m³/h)
- **Ir_cost(f)**: irrigation distribution cost (EURO)
PARAMETERS (2)

- $L_{fa}(p)$: labour available (gg)
- $L_{ea}(p)$: family labour available (gg)
- $L_{esal}$: family salary (EURO)
- $L_{r}(c,i,j,p)$: requirement without irrigation (gg)
- $L_{ri}(c,i,j,p)$: requirement for irrigation (gg)
- $R_{l}(c)$: rotation length in years (n)
- $N_{ro}(c,i,s,j,p)$: run off (kg)
- $P_{r}(c)$: price (EURO)
- $Q_{u}(c,f,i,s)$: production (t)
PARAMETERS (3)

Rain(p)    rain
Rem        family labour
Subsidy(c) subsidies and compensation (EURO)
Set-aside  set a side percentage (%)
Su(s)       surface (Ha)
Vc(c,i,s)   variable cost (EURO)
Wa(k,l,p)   water available ()
Wp(k,l,p)   water price (EURO)
Wr(c,i,s,j,p) water requiremens ()
Ir(c,i,s,j,p) irrigation requiremens ()
VARIABLES

HA(c,f,i,s,j,p) productions (Ha)
IR_EQ(j) equipments (n) [INTEGER]
LF(t) family labour (gg)
LE(t) not family labour (gg)
W(k,l,p) water (m³)
Objective function

\[ T = \]

\[ Pr(c) \times Qu(c,i,s) \times HA(c,f,i,s,j,'p1') \quad \text{[market income]} \]
\[ + \quad \text{Subsidy}(c) \times HA(c,f,i,s,j,'p1') \quad \text{[subsidies]} \]
\[ - \quad Vc(c,i,s,j) \times HA(c,f,i,s,j,'p1') \quad \text{[variable costs]} \]

\[ - \quad \text{Sup}_\text{ir}(k,s) \times \text{Ir}_\text{fee}(k) \quad \text{[irrigation fee]} \]
\[ - \quad W(k,l,p) \times Wp(k,l,p) \quad \text{[water cost]} \]
\[ - \quad \text{IR}_\text{EQ}(j) \times \text{Ir}_\text{q}(j) \quad \text{[irrigation equipment mortage, conserv.]} \]
\[ - \quad HA(cir,f,i,s,j,p) \times Wrrr(cir,i,s,j,p) \times \text{Ir}_\text{cost}(f) \]
\[ \quad \text{[irrigation water distribution cost]} \]

\[ - \quad \text{LE}(p) \times \text{Lsal} \quad \text{[extra family labour]} \]
\[ - \quad \text{Rem} \quad \text{[family labour and capital]} \]
\[ - \quad \text{Fcost} \quad \text{[fixed cost]} \]
Irrigation constraints

water balance
EWB\(p\) .. \(\text{HA}(\text{cir},f,i,s,j,p) \times \text{Wr}(\text{cir},i,s,j,p) \leq W(k,l,p)\)

irrigation equipments (investments)
EIREQ\(j,p\) .. \(\text{HA}(\text{cir},'f',i,s,j,p) \leq \text{IR_EQ}(j,p) \times \text{Ir}_\text{ha}(j)\)
Legislation

• The largest part of environmental legislation in Italy can be regarded as a consequence of the implementation of European Directives

• The Italian legislative and institutional framework of water policy is now broadly coherent with the rest of Europe

• There is a gap between legislation and its implementation
Law 36/1994 on water

• All water uses, including abstractions from the underground, need to be licensed.

• The implementation of this measure is not easy: thousands of private abstractions need to be individuated and monitored (Pollution control and Environmental monitoring have been reorganized under the Regional Environmental Agencies).
Water quality policy

- The enforcement of a discharge regulation, based on emission standards set up at a national level [Dir. 91/271 (wastewater) and 91/676 (nitrates)]
- The financing and construction of the baseline sewage treatment network
- Regions are free to regulate discharges into watercourses according to a plan that individuates water quality objectives and use destinations
- Regional water quality plans can introduce special measures in order to protect the water environment from pollution; the approach based on “water protection zones”
  - nitrate vulnerable areas
  - sensitive areas for eutrophication
# Water Use in Italy (hm³/year)

<table>
<thead>
<tr>
<th>Region</th>
<th>Civil</th>
<th>Industrial</th>
<th>Irrigation</th>
<th>Energy</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NorthWest</td>
<td>2268</td>
<td>3520</td>
<td>8193</td>
<td>1863</td>
<td>15844</td>
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<tr>
<td>NorthEast</td>
<td>1453</td>
<td>1648</td>
<td>5277</td>
<td>2538</td>
<td>10916</td>
</tr>
<tr>
<td>Center</td>
<td>1618</td>
<td>1482</td>
<td>970</td>
<td>72</td>
<td>4142</td>
</tr>
<tr>
<td>South</td>
<td>1803</td>
<td>879</td>
<td>3506</td>
<td>36</td>
<td>6224</td>
</tr>
<tr>
<td>Islands</td>
<td>798</td>
<td>457</td>
<td>2191</td>
<td>-</td>
<td>3446</td>
</tr>
<tr>
<td>Italy</td>
<td>7940</td>
<td>7986</td>
<td>20137</td>
<td>4509</td>
<td>40572</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Region</th>
<th>Civil</th>
<th>Industrial</th>
<th>Irrigation</th>
<th>Energy</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NorthWest</td>
<td>14.3%</td>
<td>22.2%</td>
<td>51.7%</td>
<td>11.8%</td>
<td>100.0%</td>
</tr>
<tr>
<td>NorthEast</td>
<td>13.3%</td>
<td>15.1%</td>
<td>48.3%</td>
<td>23.3%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Center</td>
<td>39.1%</td>
<td>35.8%</td>
<td>23.4%</td>
<td>1.7%</td>
<td>100.0%</td>
</tr>
<tr>
<td>South</td>
<td>29.0%</td>
<td>14.1%</td>
<td>56.3%</td>
<td>0.6%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Islands</td>
<td>23.2%</td>
<td>13.3%</td>
<td>63.6%</td>
<td>-</td>
<td>100.0%</td>
</tr>
<tr>
<td>Italy</td>
<td>19.6%</td>
<td>19.7%</td>
<td>49.6%</td>
<td>11.1%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
Italian Agriculture

• Agriculture’s share of total national Added Value (AV) at basic prices for the primary sector, including forestry and fishing, was about 2.8% in 2000.

• Large regional differences

<table>
<thead>
<tr>
<th></th>
<th>AV</th>
<th>Employment (measured in standard work units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre-North</td>
<td>2.6%</td>
<td>4.8%</td>
</tr>
<tr>
<td>South</td>
<td>5.3%</td>
<td>12.2%</td>
</tr>
</tbody>
</table>

## Irrigable/Irrigated Used Agricultural Area (ha)

<table>
<thead>
<tr>
<th>Region</th>
<th>Irrigable area</th>
<th>Irrigable area/UAA (%)</th>
<th>Irrigated area</th>
<th>Irrigated area/UAA (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piemonte</td>
<td>482 302</td>
<td>42.1</td>
<td>396 838</td>
<td>34.6</td>
</tr>
<tr>
<td>Valle d’Aosta</td>
<td>26 847</td>
<td>31.0</td>
<td>18 893</td>
<td>21.8</td>
</tr>
<tr>
<td>Lombardy</td>
<td>785 563</td>
<td>70.1</td>
<td>671 209</td>
<td>59.9</td>
</tr>
<tr>
<td>Trentino-Alto Adige</td>
<td>70 625</td>
<td>16.5</td>
<td>64 111</td>
<td>15.0</td>
</tr>
<tr>
<td>Veneto</td>
<td>476 966</td>
<td>54.0</td>
<td>298 832</td>
<td>33.8</td>
</tr>
<tr>
<td>Friuli-Venezia Giulia</td>
<td>114 069</td>
<td>42.2</td>
<td>59 229</td>
<td>21.9</td>
</tr>
<tr>
<td>Liguria</td>
<td>13 070</td>
<td>15.4</td>
<td>19 846</td>
<td>23.3</td>
</tr>
<tr>
<td>Emilia-Romagna</td>
<td>621 275</td>
<td>50.7</td>
<td>279 870</td>
<td>22.8</td>
</tr>
<tr>
<td>Tuscany</td>
<td>131 196</td>
<td>14.1</td>
<td>70 677</td>
<td>7.6</td>
</tr>
<tr>
<td>Umbria</td>
<td>58 035</td>
<td>15.7</td>
<td>45 105</td>
<td>12.2</td>
</tr>
<tr>
<td>Marche</td>
<td>59 910</td>
<td>10.0</td>
<td>37 852</td>
<td>6.3</td>
</tr>
<tr>
<td>Lazio</td>
<td>164 654</td>
<td>20.2</td>
<td>111 475</td>
<td>13.6</td>
</tr>
<tr>
<td>Abruzzo</td>
<td>74 667</td>
<td>14.4</td>
<td>49 251</td>
<td>9.5</td>
</tr>
<tr>
<td>Molise</td>
<td>30 297</td>
<td>12.4</td>
<td>8 562</td>
<td>3.5</td>
</tr>
<tr>
<td>Campania</td>
<td>150 306</td>
<td>23.0</td>
<td>121 517</td>
<td>18.6</td>
</tr>
<tr>
<td>Puglia</td>
<td>383 408</td>
<td>26.5</td>
<td>256 299</td>
<td>17.7</td>
</tr>
<tr>
<td>Basilicata</td>
<td>75 544</td>
<td>12.2</td>
<td>42 371</td>
<td>6.8</td>
</tr>
<tr>
<td>Calabria</td>
<td>136 800</td>
<td>21.6</td>
<td>101 387</td>
<td>16.0</td>
</tr>
<tr>
<td>Sicily</td>
<td>263 418</td>
<td>16.9</td>
<td>209 272</td>
<td>13.4</td>
</tr>
<tr>
<td>Sardinia</td>
<td>193 998</td>
<td>14.6</td>
<td>81 905</td>
<td>6.2</td>
</tr>
<tr>
<td><strong>ITALY</strong></td>
<td><strong>4 312 952</strong></td>
<td><strong>28.8</strong></td>
<td><strong>2 944 500</strong></td>
<td><strong>19.7</strong></td>
</tr>
</tbody>
</table>

Main crops production and irrigation

<table>
<thead>
<tr>
<th>Crop</th>
<th>Volume (‘000 tonnes)</th>
<th>% change 2000/99</th>
<th>Value (million €)</th>
<th>% change 2000/99</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft wheat</td>
<td>3 152</td>
<td>-2.4</td>
<td>715</td>
<td>-1.3</td>
</tr>
<tr>
<td>Durum wheat</td>
<td>4 313</td>
<td>-4.5</td>
<td>1 086</td>
<td>0</td>
</tr>
<tr>
<td>Maize</td>
<td>10 412</td>
<td>3.9</td>
<td>1 856</td>
<td>0.4</td>
</tr>
<tr>
<td>Rice</td>
<td>1 230</td>
<td>-13.8</td>
<td>419</td>
<td>-7.6</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>11 561</td>
<td>-18.1</td>
<td>527</td>
<td>-6.7</td>
</tr>
<tr>
<td>Tobacco</td>
<td>130</td>
<td>3.2</td>
<td>341</td>
<td>7.7</td>
</tr>
<tr>
<td>Soya</td>
<td>923</td>
<td>6.1</td>
<td>316</td>
<td>2.8</td>
</tr>
<tr>
<td>Sunflowers</td>
<td>456</td>
<td>5.2</td>
<td>184</td>
<td>-2.6</td>
</tr>
<tr>
<td>Potatoes</td>
<td>2 155</td>
<td>4.1</td>
<td>444</td>
<td>-6.5</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>7 730</td>
<td>4.1</td>
<td>1 104</td>
<td>1.3</td>
</tr>
<tr>
<td>Dessert grapes</td>
<td>1 256</td>
<td>2.2</td>
<td>458</td>
<td>14.3</td>
</tr>
<tr>
<td>Sold grapes</td>
<td>4 227</td>
<td>-4.1</td>
<td>1 023</td>
<td>-7.4</td>
</tr>
<tr>
<td>Wine (‘000 hl) (1)</td>
<td>23 638</td>
<td>-7.2</td>
<td>1 924</td>
<td>-11</td>
</tr>
<tr>
<td>Sold olives</td>
<td>276</td>
<td>-28.6</td>
<td>135</td>
<td>-29.9</td>
</tr>
<tr>
<td>Oil (1)</td>
<td>459</td>
<td>-29.8</td>
<td>1 827</td>
<td>-21.1</td>
</tr>
<tr>
<td>Apples</td>
<td>2 241</td>
<td>-4.4</td>
<td>643</td>
<td>-11.7</td>
</tr>
<tr>
<td>Pears</td>
<td>941</td>
<td>16.1</td>
<td>376</td>
<td>14.1</td>
</tr>
<tr>
<td>Peaches and nectarines</td>
<td>1 655</td>
<td>-6.3</td>
<td>685</td>
<td>2.2</td>
</tr>
<tr>
<td>Oranges</td>
<td>2 276</td>
<td>31.3</td>
<td>586</td>
<td>14.7</td>
</tr>
<tr>
<td>Lemons</td>
<td>708</td>
<td>30.1</td>
<td>283</td>
<td>16.8</td>
</tr>
<tr>
<td>Mandarins and clementines</td>
<td>672</td>
<td>13</td>
<td>223</td>
<td>-0.1</td>
</tr>
<tr>
<td>Kiwi</td>
<td>353</td>
<td>5.7</td>
<td>240</td>
<td>-5.5</td>
</tr>
<tr>
<td>Total</td>
<td>15 389</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

At basic prices.

(1) Only wine and oil made from the farm’s own grapes and olives are considered.
EU WADI PROJECT

objective is to evaluate the

Economic

Social Sustainability

Environmental

of European irrigated agriculture

under Water Framework Directive (WFD) and different scenarios concerning the Common Agricultural Policy (CAP)
EU WADI PROJECT

Spain
Portugal
Italy
Greece
England
## Environmental policy instruments

<table>
<thead>
<tr>
<th><strong>Planning</strong></th>
<th><strong>Water resources use and quality</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basin plans</strong></td>
<td>Water resources plans  &lt;br&gt;Basin plans should program water balances for relevant sections of watercourses according to use destinations and related water quality requirements</td>
</tr>
<tr>
<td><strong>Licenses</strong></td>
<td>All water uses <em>(groundwater since 1994) and discharges into watercourses and into public sewers need to be licensed</em>  &lt;br&gt;Discretional definition of “public interest” for the release of licenses  &lt;br&gt;<em>Priority ladder with respect of minimum flows and environmental needs</em></td>
</tr>
<tr>
<td><strong>Regulation / prevention</strong></td>
<td>Weak monitoring and control of actual abstractions.  &lt;br&gt;Code of good agricultural practice obligatory in vulnerable areas</td>
</tr>
<tr>
<td><strong>Zoning</strong></td>
<td>Water resources plans can vinculate particular resources to drinking supply schemes and define appropriate protection measures</td>
</tr>
<tr>
<td><strong>Pricing</strong></td>
<td>Abstraction fees (very modest)  &lt;br&gt;<em>Charges for water services set on a cost recovery base (not full-cost)</em></td>
</tr>
<tr>
<td><strong>Environmental taxation</strong></td>
<td>Water transfer infrastructure almost totally financed by the state. Public budget covers a relevant part of the operational budget of water supply organizations, especially in the case of irrigation</td>
</tr>
<tr>
<td><strong>Environmental subsidies</strong></td>
<td>Not used</td>
</tr>
<tr>
<td><strong>Management agreements</strong></td>
<td>Codes of good practice voluntary outside vulnerable areas  &lt;br&gt;Voluntary programs for reducing pesticides and fertilizers</td>
</tr>
</tbody>
</table>
Considerations

It must be stressed that water is a fundamental input for Italian agriculture:

it can be estimated that
• 40% of the added value in agriculture
• 60% of agricultural export
depends on irrigation (Anbi 1992)

Given that a large part of the agricultural system especially the “productive” part has been organized according to the expected availability of water short term losses due to water shortage can be severe
The Reclamation Boards

The reclamation boards (RB) are public bodies.

The participation is compulsory for owners of real estates in the RB area.

They are administered by associates.

Ims:

design and implement land reclamation and irrigation infrastructures.
There is a variety of payment schemes often building on ancient rules about water use.

Tariff system is mainly based on the distribution of RB costs among beneficiaries.

Investment costs (funded by state/UE) are not taken into account.

Full cost recovery is not achieved.

No environmental cost is considered.

Tariffs are usually established on per unit of surface. A few RB have tariffs per unit of water consumption.
Pricing

- Volumetric water pricing cannot be applied in a large part of Italy
  - the existing network (open channels) do not allow metering only flat rate can be used

- Where volumetric pricing is enforceable due to modern on pressure network water demand is quite rigid (fruit and vegetable)
  - high irrigation efficiency is achieved (>90%)
    - Volumetric water pricing affects the net farm income but does not reduce the water demand
    - A full-cost pricing of collectively supplied water could favour the use of private wells
Considerations

- Irrigated agriculture in Italy determines many positive function (externalities) among which: aquifer recharging and landscape creation.

- A mix of policy instruments both in agriculture and water pointing to an integrated water management focusing on the reduction of negative impacts seems the best solution to meet the overall sustainability of the system:
  - technical advice
  - research and innovation in irrigation and agriculture
  - renovation and maintenance of the existing infrastructure
Integrated management

The Water Management System WMS is increasingly characterized by

- **territorial integration** (Basin approach)
  - for water supply and sewerage “optimal management areas”
  - a gradual increase of water prices allowed to reach operational cost coverage, with some extra margin for depreciation

- **water users** (agriculture-industrial-civil)
  - multiple use of infrastructures
  - reusing wastewater for irrigation

- **water resources** (surface and underground)
  - interconnection of water networks at the provincial level eases a policy in which both surface and underground waters are used in a sustainable way
Future orientation

Multiperiod models
Water markets

...
Main features

- direct control of the simulation by the user (GUI)
- a rich set of models to apply multicriterial MPT
- quantifiable results covering socio, economic and environmental aspects related to irrigated agriculture
- great flexibility
- reduction of time and cost to conduct sound studies

DSIRR a tool to support water initiatives and take sustainable decisions in a participatory process with stakeholders
Any possible integration?

Thank you for your attention

G.Bazzani@ibimet.cnr.it