Integrated assessment of agricultural systems; on methods, models and interdisciplinarity

Martin van Ittersum and Frank Ewert – Wageningen University

Johanna Alkan Olsson, Erling Andersen, Floor Brouwer, Thomas Heckelei, Jacques Wery, Jan Erik Wien and Joost Wolf

Marcel Adenauer, Hatem Belhouchette, Irina Bezleplina, Alexander Gocht, Sander Janssen, Argyris Kanellopoulos, Marijke Kuiper, Kamel Louhichi, Olivier Therond
Current developments in agriculture

- High prices of agricultural commodities

- Causes:
  - Lower supply at global scale
  - Higher demand: economic development and higher meat consumption
  - Higher demand for biomass for biofuel

FAO, 2007
What are consequences for European agriculture?

- Competitiveness of EU agriculture
What are consequences for European agriculture?

- Effects on different farming systems across EU
What are interactions with policies?

- CAP reforms
- WTO negotiations - developing world effects
What are environmental implications?

- Pollution
- Natural resource use
What is needed?

- Multi-scale and
- Multi-dimensional analysis

Ewert et al., 2006
What does research have at hand to support?

- Methods, models and partial databases usually targeted at specific scales
  - Market
  - Farming system
  - Cropping systems

- which are ..... 
  - Generally poorly re-used
  - Difficult to link them for integrated studies
  - Not readily used for integrated assessment of indicators
# Aims and methodological approach SEAMLESS

## Aims

- Overcoming fragmentation in research models and data in Europe for assessing agricultural systems
- Better informed impact assessment of new agri-environmental policies

## Methodological approach

- Invest in European or better international models that are modular and re-usable
- Provide operational method for model linkage: conceptually and methodologically

### This aims to advance:

- Consistent micro-macro analysis
- Consistent economic, environmental, social and institutional analysis
- Quality and use of standalone models and databases
What do we need?

- Integrated assessment concept and procedure
- Agricultural sector model (and CGE model)
- Bio-economic farm model
- Cropping system model
- Scaling methods
- Model linkage approach
Integrated assessment procedure

Pre-modelling
- Problem definition
- Scenario description
- Indicator selection

Modelling
- Definition of simulation experiment
- Model selection and composition
- Parameterization and simulation

Post-modelling
- Post-model analysis
- Visualization of results
- Documentation/communication

Integration of
- Disciplines
- Scales
- Stakeholders
Agricultural sector model: CAPRI (EU)

Combination of programming model and multi commodity model

Supply
250 Regional optimisation models

Markets
Multi-commodity spatial market model with 18 regional aggregates and all EU MS

Quantities
Prices

Iterations
Comparative Static Equilibrium
Maximise Income = Profit - Risk

Subject to:
• Resource constraints (land, labour)
• Policy constraints (CAP, decoupling, quotas)

Activities:
• Different enterprises: arable, livestock, perennials
• Yields, costs, environmental effects, labour use, subsidies

Allocation of activities to area, farmer income, total costs, labour use, policy choices

Bio-economic farm model - FSSIM

FSSIM-Agricultural Management (AM)

FSSIM-Mathematical Programming (MP)
Cropping system model - APES
Output - APES

<table>
<thead>
<tr>
<th>rotationYear 1</th>
<th>rotationYear 2</th>
<th>rotationYear 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUNFLOWER</td>
<td>WINTERWHEAT</td>
<td>MAIZE</td>
</tr>
<tr>
<td>PENCOXAPRAPEETIL</td>
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</tbody>
</table>

Crop Operation:
- TILLAGE
- CROP OPERATION
- NITROGEN FERTILIZATION

PESTICIDE

IRRIGATION

Crop Rotation:
1. SUNFLOWER, WINTERWHEAT, MAIZE
2. PENCOXAPRAPEETIL, PENCOXAPRAPEETIL, PENCOXAPRAPEETIL
3. PENCOXAPRAPEETIL, PENCOXAPRAPEETIL, PENCOXAPRAPEETIL

Field Management:
- Soil depth: 0.2m
- Winter wheat operation: Planting
- Sunflower operation: Planting
- Pencoxaprapeetil operation: Planting

Weather Conditions:
- Temperature: 11.1°C
- Rainfall: 7.41 mm
- Solar Radiation: 37 MJ/m²

Note: The diagram shows a graphical representation of the crop rotation and management strategies.
Scaling in SEAMLESS

Levels of organisation
- Global
- Earth system
- National
- Biosphere
- Regional
- Ecosystem
- Farm
- Community
- Field
- Population

Bio-economic farm model
- Economic simulation
- Yields and externalities

Agricultural sector model
- PICA
- APES
- Landscape

GTAP
- Labour
- CAPRI
- FSSIM

Biophysical

Bio-economic

Social

Institutional
Upscaling method: farm type - market

- **FSSIM**
  - Supply response to price and policy changes on Farm level for Baseline

- **EXPAMOD**
  - Extrapolation to regional supply elasticities and non-sample regions
  - Aggregation weights
  - Markov chain analysis

- **CAPRI**
  - Calibration of regional supply models to this supply response
  - Scenario analysis based on new supply response

Price changes

- Price response

Temperature changes

seamless
Survey regions for farm simulation

Environmental Zones

Sample regions and Environmental Zones
Model chain

- **GTAP** | Global CGE
- **CAPRI** | Agriculture EU
- **EXPAMOD** | Extrapolate farm to EU
- **FSSIM-MP** | Bio-economic farm model
- **FSSIM-AM**
- **APES** | Agricultural production & externalities

- Implemented in SEAMLESS-IF
- Not yet implemented in SEAMLESS-IF
Role of ontologies in SEAMLESS

- Between WP’s, models, data sources, indicators, users, etc:
  - **Same concepts that mean something different**
    - For example crop in CAPRI and crop in FSSIM or in APES
  - **Different concepts that mean the same thing**
    - For example expert user, internal user, integrative modeler
  - **Concepts with an ambiguous meaning**
    - For example scenario
  - **Different understanding of relationships between concepts**
    - For example between farm types and agri-environmental zones
Ontology construction for project concepts

Janssen et al. (2008)

x iterations
x participants
x hours

Interdisciplinarity at Work!

Janssen et al. (2008)
What do we have?

- Integrated assessment concept and procedure
- Agricultural sector model (and CGE model)
- Bio-economic farm model
- Cropping system model
- Scaling methods
- Model linkage approach
What can we do with it?

- **WTO - G20 proposal - EU**
  - Top down
  - Export subsidies zero
  - Tarif reductions

- **Nitrate directive – region**
  - Bottom up
  - Improved Agro-management
  - Cross compliance
Model chain

GTAP → Global CGE → Non-agricultural global indicators

CAPRI → Agriculture EU → NUTS-2 and EU indicators

EXPAMOD → Extrapolate farm to EU

FSSIM-MP → Bio-economic farm model

FSSIM-AM → Agricultural production & externalities

APES

Data of Nuts-2 and EU

Data of farms in 23 regions (out of 300 regions in EU)

Implemented in SEAMLESS-IF

Not yet implemented in SEAMLESS-IF
Trade liberalisation - The G20 proposal applied in the EU

Available Projects:
- CAP 2003 reform, Nitrate Directive and conservation agriculture in the Midi-Py
- Trade liberalisation, the G20 proposal applied in EU
- EU-LDC analysis applied to Mali (Hatem&Rabah)
- Auvergne - green intensification
- CAP 2003 reform in Flevoland region (test)
- CAP 2003 reform in Flevoland region (final)

General Information
- Title: Trade liberalisation, the G20 proposal applied in EU
- Description: Integrated assessment of trade liberalisation in order to evaluate possible outcomes of the next WTO (sensitivity analyses of the so called).

State: Created

Details
- Contract Number: N/A
- Commissioner: N/A
- Start Date: 29/01/2008
- End Date: 29/01/2008
- Spatial extent: European Union
- Spatial resolution: Field Types
- Temporal extent: 2030
### Integrative Modeler Application

#### Trade liberalisation - The G20 proposal applied in the EU

**Overview**

<table>
<thead>
<tr>
<th>Ultimate Goal</th>
<th>Environmental</th>
<th>Economic</th>
<th>Social</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Protection of Human Health and ... Water: Quality of Groundwater (NO3...</strong></td>
<td><strong>Mineral Nitrogen Use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Protection of Human Health and ... Water: Quality of Surface Water (NO...</strong></td>
<td><strong>Mineral Nitrogen Use</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Protection of Human Health and ... Water: Quality of Groundwater (NO3...</strong></td>
<td><strong>Nitrate Surplus</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Maintenance of Environmental Balance... Soil Fertility (Organic Matter, N, P, K)</strong></td>
<td><strong>Soil Organic Matter</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Environmental Compartments and... Soil Erosion</strong></td>
<td><strong>Soil Erosion</strong></td>
<td></td>
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</tr>
</tbody>
</table>

**Process for Achievement**

<table>
<thead>
<tr>
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</thead>
</table>

**Means**

<table>
<thead>
<tr>
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</thead>
</table>
New Member States: agricultural income increases mainly due to the introduction of premiums and price support.

Old Member states: agricultural income decreases due to premium and price cuts, despite an increase in supply.
G20 – change in agricultural income (2013)

- Income declines in all regions
- Losses vary between -2.5 and -16%, with an average decline of -6%
G20 – change in agricultural income (2013)

<table>
<thead>
<tr>
<th>Price change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat</td>
</tr>
<tr>
<td>Cereals</td>
</tr>
<tr>
<td>Vegetables &amp; perennials</td>
</tr>
<tr>
<td>Dairy products</td>
</tr>
<tr>
<td>Oilseeds</td>
</tr>
<tr>
<td>Arable crops</td>
</tr>
<tr>
<td>Oils</td>
</tr>
<tr>
<td>Animal products</td>
</tr>
</tbody>
</table>
# G20 – Average impact Midi-Pyrénées

<table>
<thead>
<tr>
<th></th>
<th>Base year</th>
<th>2013 (changes wrt base year)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Baseline</td>
<td>G20</td>
<td>Total</td>
</tr>
<tr>
<td>Farm income (€/ha)</td>
<td>672</td>
<td>-7 %</td>
<td>-4 %</td>
<td>-23 %</td>
<td></td>
</tr>
<tr>
<td>Nitrate leaching (kg N-NO3/ha)</td>
<td>34</td>
<td>13 %</td>
<td>1 %</td>
<td>4 %</td>
<td></td>
</tr>
<tr>
<td>Soil organic matter (%)</td>
<td>2</td>
<td>-0.2 %</td>
<td>-0.1 %</td>
<td>-0.3 %</td>
<td></td>
</tr>
<tr>
<td></td>
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<td>2013 (changes wrt base year)</td>
<td></td>
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<td>--------------------------------------</td>
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<tr>
<td></td>
<td>Baseline</td>
<td>Nitrate directive</td>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farm income (1000 €)</td>
<td>79</td>
<td>-7%</td>
<td>-1%</td>
<td>-8%</td>
<td></td>
</tr>
<tr>
<td>Premiums (1000 €)</td>
<td>41</td>
<td>-26%</td>
<td>-1%</td>
<td>-27%</td>
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<td>-16%</td>
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Nitrate Directive – Some results by farm type

Nitrate leaching (kg NO₃/ha)

Farm income (1,000€)

Base year Baseline & ND (2013)


Type 1 - cereal
Type 2 - cereal with more fallow
Type 3 - mixed

Contribution of baseline and ND policies

Contribution of baseline and ND policies

Base year Baseline & ND (2013)
## Nitrate Directive – Changes in crop pattern by farm type

<table>
<thead>
<tr>
<th></th>
<th>Average farm</th>
<th>FT1 – cereal</th>
<th>FT2 - cereal / fallow</th>
<th>FT3 - mixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>Oil seeds</td>
<td>-2%</td>
<td>-3%</td>
<td>-2%</td>
<td>-2%</td>
</tr>
<tr>
<td>Protein crops</td>
<td>-6%</td>
<td>-7%</td>
<td>0%</td>
<td>-8%</td>
</tr>
<tr>
<td>Fallow</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
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Reflection on this method of Integrated assessment

Advantage
- Components give detailed representation of system aspects
- Components enhance transparency
- Use of ontologies instrumental for integration and interdisciplinarity
- Components allow some independency in development
- Components allow for continuation of development

Disadvantage
- Do components reflect emerging properties of entire system?
- Entire system has fair degree of complexity
- Learning, building and maintaining ontologies
- Challenge to develop and integrate models simultaneously
- Maintenance requires organisation

Challenge to balance disciplinarity and interdisciplinarity
Thank you for your attention!

www.seamless-ip.org
Ontology for model integration and database
Nitrate Directive – Some results by farm type

Nitrate leaching (kg NO₃/ha)

- Contribution of baseline and ND policies

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<td>Initial (2001)</td>
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<td>Baseline &amp; ND (2013)</td>
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Farm income (1,000€)

- Contribution of baseline and ND policies

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