Combining systems analysis tools for the integrated assessment of scenarios in rice production systems at different scales.

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Jean-Marc Barbier∗±1, Stefano Bocchi2, Sylvestre Delmotte1, Andrea Porro2, Francesca Orlando2, Mirco Boschetti3, Pietro Alessandro Brivio3, Giacinto Manfron2,3, Simone Bregaglio2, Giovanni Capelli2, Roberto Confalonieri2, Françoise Ruget4, Vincent Courderc1, Laure Hossard1, Jean-Claude Mouret1, Santiago Lopez-Ridaura1,5.

1 INRA, UMR Innovation 951, Montpellier, France; 2 University of Milano, Milano, Italy; 3 CNR-IREA, Milano, Italy; 4 INRA, UR Emmah, Avignon, France; 5 CIMMYT, Texcoco, Mexico
SCENARICE
SCENArio integrated assessment for sustainable RICE production systems.
Which future for these farming systems?
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For example, what would be the consequences of different scenarios of development of OF in Camargue?
Which future for these farming systems?

Scenario development and integrated assessment as a way to improve our preparedness for future (unexpected) changes
Framework for scenario development

Phase 1 • Socio-economic and ecological context, farming systems and stakeholders

Phase 2 • Narrative scenarios and technological innovations

Phase 3 • Sustainability indicators and data for integrated assessment

Phase 4 • Quantification of the performance of the farming activities

Phase 5 • Farming system modeling

Phase 6 • Scenarios assessment with the stakeholders
Identification of the main drivers of change

- Technical innovations
- Water management
- Climate change
- Environmental concerns
- Regulations
- Public subsidies
- (New) supply chain
- Agrotourism and pluriactivity
- Land ownership
- Traceability and labelling
- Farms transmission
- Prices of commodities
- Prices of energy
- Prices of inputs
- Diets changes

Scale:
- Local and regional
- Country
- Europe
- World
The four narrative scenarios

- Agri-environmental measures on legumes and protein crops
- Cross-compliance of subsidies on pesticides and synthetic nitrogen fertilizers
- Limited climate change
- Straw burning prohibition
- Higher rice prices
The four scenarios

- Cap payment reduction and suppression of the Agri-environmental measures
- Greater salt pressure, more frequent extreme rainy events and summer drought due to climate change
- Straw burning prohibition, greater prices for water, reduction of synthetic nitrogen fertilizer
- Greater consumers’ interest for organic products
- Economic conditions unfavorable to rice cultivation
- Specialization of the farming systems
Modeling for scenario development

- Agronomical and environmental performances
  - Cultivated plot
  - Crop models

- Agricultural practices
- Technological changes

- Scenarios
- Integration
- Simulations
- Restitutions

- Initialisation and calibration of crop models
  - Spatial distribution of soil characteristics

- Remote sensing and spatial modelling
  - Regional scale
  - Territorial (landscape and farming) characteristics and dynamics

- Land cover and land use dynamics
  - Calibration data

- Farming activities and farm management
  - Farm
  - Typology – Decision models
General question: which impact of climate change scenarios impact on crop yield and farming systems?

- Analysis of current crop practices (notably sowing dates) → Adaptation strategies at the field level
- Impacts on crop performances with crop modeling
- Impacts at the farm and regional level with a bioeconomic model
Use of remote sensing for retrieving information about crop practices
Estimation of intra and inter-annual variability of winter wheat crop practices in Camargue
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Calibration of STICS and WARM crop models

- **measured leaf area index (LAI)**
- **measured aboveground biomass (AGB)**
- **simulated leaf area index (LAI)**
- **simulated aboveground biomass (AGB)**

**Graphs:**

- **Graph a:** ID 62lob06
- **Graph b:** ID Lom2
- **Graph c:** ID 512lb06
- **Graph d:** ID Lom6
- **Graph e:** ID Lom7
- **Graph f:** ID 610lb01
Use of the crop models for climate change scenarios
General question: can we make hypothesis about adaptations of farming systems in future scenarios?

- Development of a farming system typology based on land use trajectories
- Retrieving land use trajectories through remote sensing of satellite images
- Clustering analysis to improve farming systems typologies
- Inclusion of new typologies (and constraints) in bio-economic modeling
Land use trajectories at the farm scale
Land use trajectories at the farm scale

Graphs showing land use changes over time from 2003 to 2013, with trajectories labeled as Cluster1_summer, cluster1_winter, Poly. (Cluster1_summer), and Poly. (cluster1_winter) for Cluster 1, and cluster2_summer, cluster2_winter, Poly. (cluster2_summer), and Poly. (cluster2_winter) for Cluster 2.
Typologie des exploitations rizicoles camarguaises

- céréalier diversifié (35% riz)
- céréalier diversifié biologique (35% riz)
- Elevier (35% riz)
- Elevier biologique (35% riz)
- riziculteur partiellement biologique (70% riz)
- riziculteur céréalier (60% riz)
- riziculteur (80% riz)
The bio-economic model

**Inputs**
- **Parameters and exogenous conditions**
  - Price of the crops
  - CAP direct and coupled payment
  - Subsidies for agrienvironmental measures and organic farming
  - Cost of labour
  - Cost of water

- **Possible optimisation variable and indicators at farm level**
  - Gross margin
  - Cost benefit ratio
  - Labor
  - Treatment frequency index

- **Possible optimisation variables and indicators at regional level**
  - Value of production
  - Employment
  - Water use
  - Proportion of organic agriculture

- **Farm types’ specific constraints**
  - Min and Max area of specific crops
  - Min and Max of organic area
  - Labor available

**Outputs**
- **Indicators value at farm level**
  - Gross margin
  - Cost benefit ratio
  - Labor
  - Treatment frequency index

- **Optimal land use**
  - Area of each agricultural activity
  - Area of each crop

- **Indicators value at regional level**
  - Value of production
  - Employment
  - Water use
  - Proportion of organic agriculture

**Optimisation by a solver**

**Agricultural activities**
- Yield
- Labor (total and period)
- Costs of production
- Pesticide and fertilizer use
- Machineries and fuel
- Water use

**Land and soil**
- Area of each farm type at the regional level
- Average proportion of each soil type at the farm type level

**Agronomic constraints**
- Unsuitable cultivation area
- Stable cropping plan
- Crop return time
- Number of successive crops
Integrated assessment of the scenarios

- 471,000 people fed
- 764,000 people fed
- 15 M€
- 1670 €/ha
- 272k hours
- 2.5 MJ/MJ (Unitless)
- 595M MJ
- 91k kgPM10
- 79 Mteq CO2
- 263M m³
- 81k t
- 220k t
- TFI 2.4
- 471,000 people fed
- 764,000 people fed
Each farmer is an agent, deciding the land use for its farm.

Up-scaling through farm typology.

Individual reflection and collective discussion among farmers about possible adaptation strategies and issue related to the transition toward a given situation.

3 sessions of interactive simulation with 14 farmers to assess a scenario related to the CAP reform (suppression of the rice coupled payment).
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**USE OF AN AGENT-BASED MODEL FOR INTERACTIVE SIMULATION SESSIONS**
TRADE-OFFS AND SYNERGIES AT THE FARM LEVEL

A.

CAP reform

Gross margin (€/ha)

Labor (in % of year 1)

Subsidies over gross margin ratio (%)

Area on rice (% of year 1)

Area converted to OF (% of farm area)

Gross margin (€/ha)

All 4 other variable in %

Year

1  2  3  4  5  6  7

0  200  400  600  800  1000

0  20  40  60  80  100  120

(Submitted to Agricultural Systems)
TRADE-OFFS AND SYNERGIES AT THE REGIONAL LEVEL

B.

CAP reform

Rice and OF proportions, food crop production and employment

Regional value of productions and subsidies (10M€) and TFI

- Rice proportion in the area
- Proportion of OF
- Food crop production
- Employment
- Regional value of productions (10M€)
- Amount of subsidies (10M€)
- TFI

Year of simulation

1 2 3 4 5 6 7
Integration of information coming from different system analysis tools to improve integrated assessment:

- Improving our understanding of the current system diversity
- Better characterization of farm diversity and functioning
- Taking into account potential effects of climate change
THANK YOU

And many thanks to our founders:

FranceAgriMer