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A protocol for designing a database based on production activity concept: a case study using a bio-economic model

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Context and objectives

The development and implementation of farm bio-economic mathematical programming models requires a good understanding of the concept of "agricultural activity" for ensuring a consistent integration between biophysical and technical production components (Flichman et al., 2011).

With this concept, it becomes possible to i) produce engineering production functions, hence comparing, from biophysical point of view, yield, resource use, and externalities of agricultural production systems (Belhouchette et al., 2011), and to ii) explore hypothesis of resource uses and allow defining adaptation strategies to climate change and scenarios of resource availability, as well as defining thresholds of externalities to limit the environmental impact of production systems (Donatelli et Confalonieri, 2011).

The objective of this study is to describe and discuss steps to build "activity components" (figure 1) and a database in order to assess a scenario targeting the reduction of N use in the Midi-Pyrenees region, France.

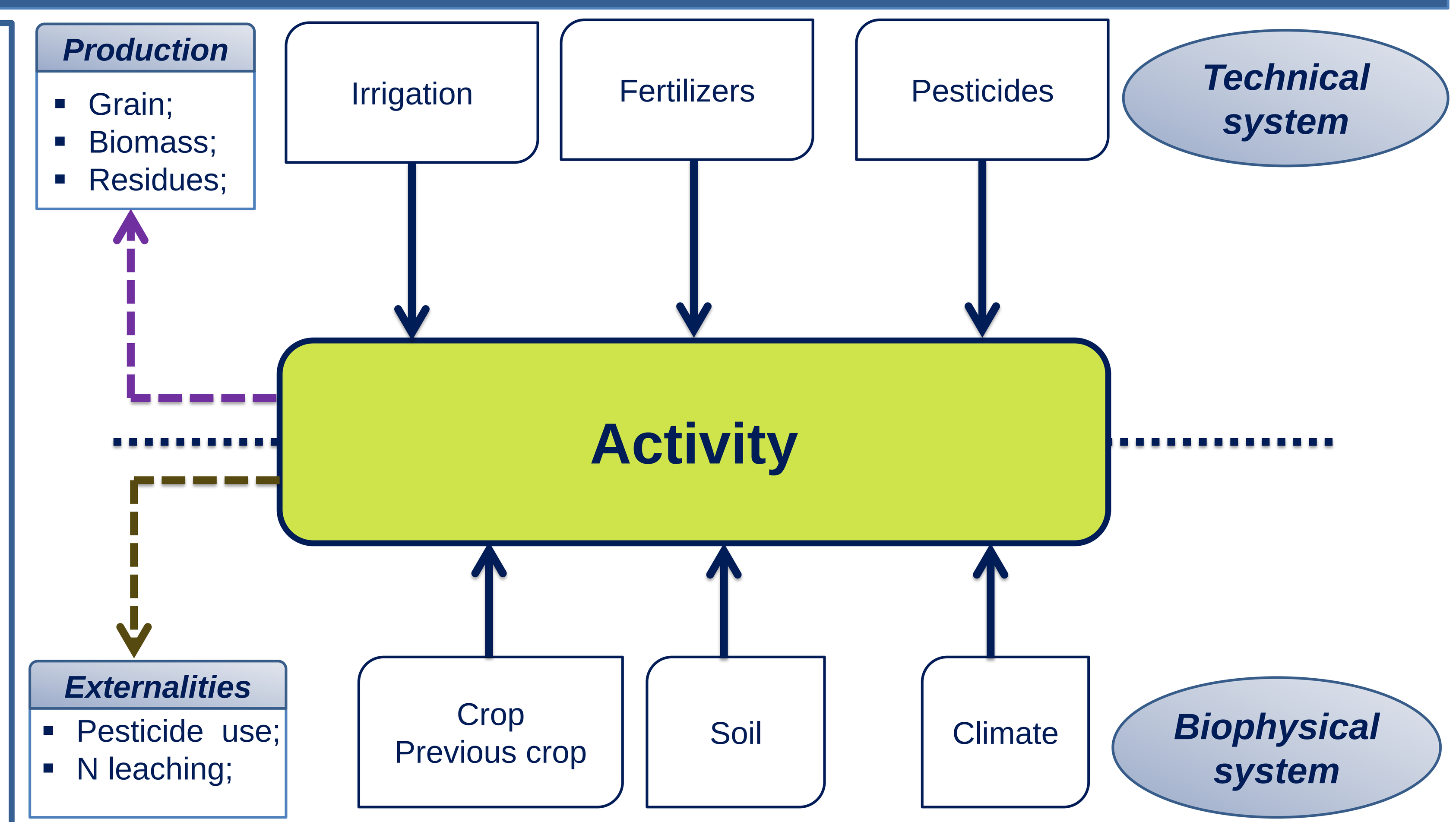

Figure 1. Activity components

Methodology

1. Conceptual framework for « Activity » definition and performance evaluation

Results/scenarios VS stakeholders expectations

1. Definition of agricultural activities

Specify the purpose of the study

Limiting nitrogen pollution, strategic choices in changing economic and institutional conditions (PAC);

Determine the activity « dimension »

Variables considered by taking into account the purpose of the study;

2. Activities' input-output coefficients

Data collection VS data availability/data quality to quantify technicalcoefficients from:

- Experiments;
- Statical data;
- Bibliography;
- Expert knowledge;
- Farm surveys;

Structuration of the database

3. A bio-economic model to assess farmer's production strategies

Bio-economic model:

- Based on linear programming;
- Optimizes the farmer's utilities which includes the revenue and the risk aversion coefficient;

4. Scenarios definition

S0 « Reference scenario »

Current nitrogen use constraint = 180 kg N/farm;

S1 « Reduction scenario »

Limiting nitrogen use at 90 kg N/farm;

2. Case study: farm type specification

Table 1. Farm type located in the Midi-Pyrenees region, France

	Activity dimension					Input coefficients				Output coefficients	
List of activities	*Crops*	*Previous crops*	*Soil type*	*Soil_useful reserve (mm/m)*	*Irrigation technique*	*Area (ha)*	*Irrigation dose (mm)*	*Fertilizers (kg/ha)*	*Treatment frequency index (herbicides)*	*Yield (q/ha)*	*Crop prices (€/t)*
Activity 1	Sunflower	Winter barley	clay	162	dry	6.5	0	140	1.75	20	36
Activity 2	Soya	Meadows	clay	162	irrigated	4	100	0	2.09	33	36
Activity 3	Soya	Soft wheat	clay	162	irrigated	24	100	0	2,09	33	36
Activity 4	Winter barley	Durum wheat	clay	162	dry	17.6	0	100	1.59	65	13,5
Activity 5	Durum wheat	Soya	clay	162	dry	17	0	220	1.69	60	26
Activity 6	Soft wheat	Grain Maize	clay	162	dry	16	0	250	1.67	70	20
Activity 7	Soft wheat	Sorghum	clay	162	dry	14.67	0	200	1.67	65	20
Activity 8	Soft wheat	Meadows	clay	162	dry	6.71	0	250	1.67	70	17
Activity 9	Soft wheat	Soya	clay	162	dry	6	0	200	1.67	65	17
Activity 10	Grain Maize	Meadows	clay	162	irrigated	1.5	180	200	1.52	100	40

Results and discussion

- The reduction of N use at farm scale induces a cultivation of more profitable cereals crops (durum wheat, soft wheat and grain maize) instead of less profitable crops such as sunflower and winter barley (figure 2).
- As a consequence, the total farm income, as well as the average farm TFI, are respectively reduced by 1.4 % and 10 % (figure 3) when the N use scenario is compared to the reference scenario.
- The use of the « activity concept » does not only allow the exploration of complex scenarios, but also the building of a large and shared database with local stakeholders (table 2). This concept is a key issue when strategic decisions concerning production orientation are addressed in a changing socio-economic context.

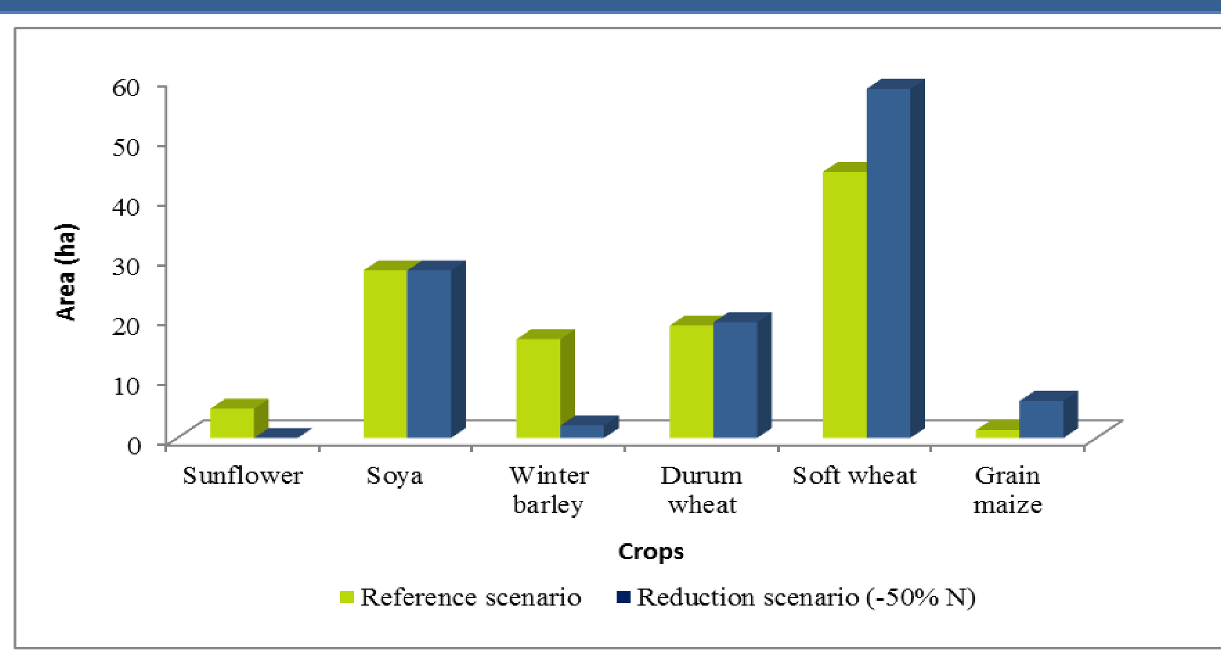

Figure 2. The effect of reducing Nitrogen use on the production plan of crops

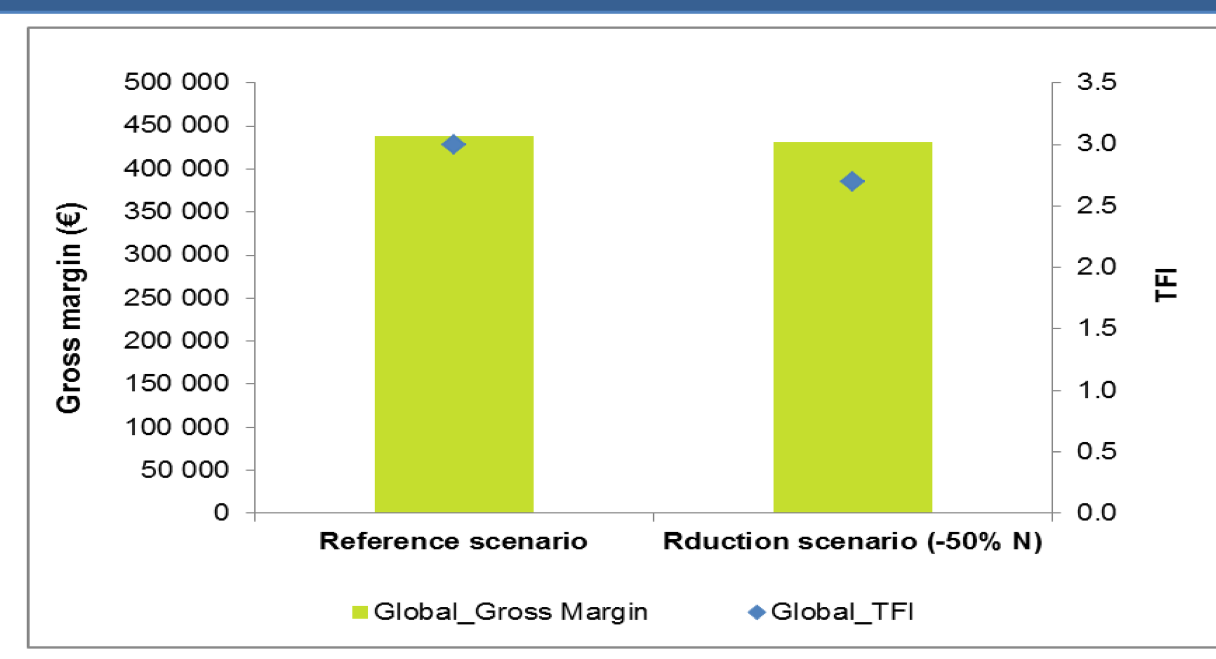

Figure 3. Impacts of reducing Nitrogen use at the farm scale: Gross Margin and TFI (Treatment frequency index)

Table 2. Database based on production activity concept

Crop	Previous crop	Irrigation	Soil_useful reserve (mm/m)	Soil tillage	Herbicide resistance	Yield (qx/ha)	TFI (Treatment frequency index)	Total cost_TFI (€/ha)	Ferti_N (kg/ha)	Ferti_P (kg/ha)	Ferti_K (kg/ha)	Irrigation dose (mm/ha)	Labor (per day) Period 1	Labor (per day) Period 2	Labor (per day) Period 3
Durum wheat	Soya	Dry	162.45	Simplified tillage	NR	52	4.3	358	148	100	0	0	0.26	0.12	0.09
Soft wheat	Grain maize	Dry	162.45	Simplified tillage	NR	57	4	234	191	80	0	0	0.26	0.1	0.09
Soft wheat	Meadows	Dry	162.45	Simplified tillage	NR	58	3.6	234	139	110	90	0	0.26	0.1	0.09
Soft wheat	Soya	Dry	162.45	Simplified tillage	NR	58	3.6	234	122	0	110	0	0.26	0.1	0.09
Soft wheat	Sorghum	Dry	162.45	Simplified tillage	NR	57	3.6	234	191	70	70	0	0.26	0.1	0.09
Winter barley	Durum wheat	Dry	162.45	Simplified tillage	NR	59	4	234	96	30	0	0	0.26	0.1	0.09
Soya	Meadows	Irrigated	162.45	Simplified tillage	NR	35	2	108	0	100	160	100	0.35	0.17	0.09
Soya	Soft wheat	Irrigated	162.45	Simplified tillage	NR	35	2	108	0	90	180	100	0.35	0.17	0.09
Sunflower	Winter barley	Dry	162.45	Simplified tillage	NR	21	2	108	45	80	70	0	0.35	0.17	0.09
Grain maize	Meadows	Irrigated	162.45	Simplified tillage	NR	100	1.8	111	122	0	0	180	0.35	0.23	1.2
Sorghum	Soft wheat	Dry	162.45	Simplified tillage	NR	70	1.8	108	148	40	0	0	0.35	0.21	0.68

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Belhouchette H., Louhichi K., Therond O., Mouratiadou I., Wery J., Van-Ittersum M., Guillermo F. (2011). Assessing the impact of the Nitrate Directive on farming systems using a bio-economic modeling chain. *Agricultural Systems*, Vol 104, pp. 135-144.

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