Application of a Crop-Farm-Indicators modelling chain to assess the impact of the EU nitrate directive in the Midi-Pyrenees region

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Key-words : crop model, farm model, indicators, sustainability, nitrate, integrated assessment.

The rapid evolution of economic and environmental constraints on farming systems require cropping systems design or assessment to be conducted in the context of market instability as well as economic (e.g. CAP in EU) and environmental policy changes. The Nitrate Directive (91/676/EC) is one of the oldest EU environmental policy, designed to reduce water pollution by nitrate from agricultural sources, through a set of measures, defined at regional level, and mandatory for farmers of vulnerable zones.

Methodology

On the basis of methodologies developed in the SEAMLESS Integrated Project (van Ittersum et al., 2007), we have combined a crop model (CropSyst), a farm model (FSSIM), a farm typology and a set of indicators. The objective was to simulate how these "virtual" farmers react to the external constraint (price changes, CAP reform, Nitrate Directive) and what is the impact on environmental and economic indicators at farm and regional levels. This study was conducted in a French region (Midi Pyrenees) and we have compared, for the 2003-2013 period, a business as usual scenario (CAP, 2003 CAP reform until 2013) and an alternative scenario adding to the previous one the Nitrate Directive (CAP+ND). The latter combined alternative N management (based on target yield and soil type) proposed as a ND measure in the region, and a range of penalties applied to the CAP subsidies if this measure was not selected by the virtual farmer. CropSyst was previously calibrated on field experiments conducted in the region and FSSIM was calibrated on crops area per farm type using FADN data (Louhichi et al., 2008). For this application the model chain was applied to a set of 3 farm types representing the arable farming systems in Midi-Pyrenees, defined in term of size, intensity, land use and specialisation. Biophysical data, policy parameters and exogenous assumptions were combined to define each scenario (Belhouchette et al., 2007).

Results

With a 3% penalty none of the farm types adopted entirely the alternative N management but they changed their cropping systems in comparison with the CAP scenario (Table 1). The CAP+ND scenario induced minor reductions of farm income compared to CAP and between –6% and +5% on N leaching, depending on the farm type. For both scenarios, the average nitrogen leaching was almost the same (45 kg N/ha) for the two dominant soil types in the region. The major changes occurred on soil erosion which was reduced by 16 to 29%, depending on farm

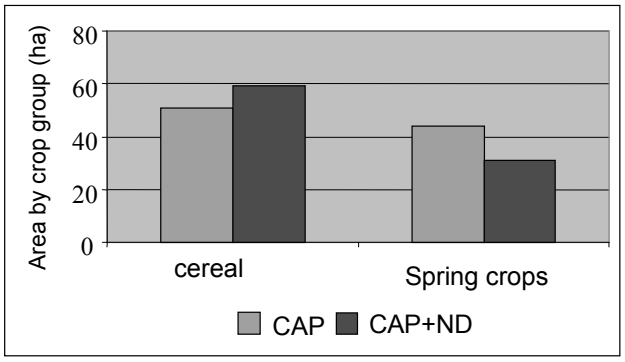

Figure 1. Farm type 1: Area by crop group and soil type for the CAP and the CAP+ND scenarios.

type, mainly because of the reduction of spring crops (sunflower, soybean, maize) to the benefit of winter wheat, thereby reducing the bare soil area during winter (fig 1). A sensitivity analysis showed that 13 to 17% of penalty, according to farm type, was required to force the farmer to adopt the alternative N management. It allowed to maintain farm income (-6% on average), despite a 28% reduction of N fertilisers compared to the CAP scenario, nitrate leaching was reduced by only 9%.

Table 1. Economic and environmental impacts of the CAP+ND scenarios compared to the CAP scenario at farm scale.

Economic and environmental indicators	ND + CAP (% change to CAP scenario)		
Farm Type	Farm type 1 (cereal)	Farm type 2 (cereal/fallow)	Farm type 3 (mixed)
Farm income	-1.0 %	0.0 %	0.0 %
Premium	-3.0 %	-3.0 %	-3.0 %
Nitrate leaching	5.0 %	1.0 %	-6.0 %
Soil Erosion	-16.0 %	-21.0 %	-29.0 %

The analysis of the two scenarios shows that the irrigable area was partially used e.g. 70%, 50% and 20% respectively for farm types 1, 2 and 3. This result can be explained by the fact that the gross margin of the irrigated maize (the major irrigated crop) was decreased by almost 10% with the CAP reform, mainly because of the reduction of the premium for irrigated crops. For the CAP scenario, the main rotation with irrigated crops selected by the model was maize-soybean. This rotation was substituted in the CAP+ND scenarios by the irrigated crop rotation maize-maize which becomes more profitable with the adoption of the better N management. Thanks to this kind of substitutions, the loss of farm income due to the implementation of 3% of penalty was entirely compensated. Despite some differences between farm types, the trend obtained at the farm level was conserved after aggregation at the regional level: (i) no modification of farm income and a marginal decrease of premium (-3 %) due to penalty and a modification in the crop patterns ; (ii) a very low decline of nitrate leaching attributed to the modification in the crop pattern, and iii) a significant reduction of soil erosion (- 22 %).

Conclusions

The results presented in this study represent a first application of the model chain CropSyst-FSSIM-indicators in real application conducted in interaction with users and stakeholders for the definition and the analysis of the scenarios in the Midi-Pyrenees region. The results show that this modeling chain can be functional for complex scenarios combining economic and environmental drivers and provides sound results, with regards to current knowledge and when discussed with local experts. This work provides insights in some key methodological aspects for future improvements and further uses of the meso backbone modeling chain of SEAMLESS-IF. The main aspects are the need for: i) several interactions with local experts and further methodological development for a better models calibration and validation at farm and regional levels, ii) a sensitivity analysis for each application before defining the final scenario to be used for communication with the users.

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