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# MODELLING CROP ALLOCATION DECISION-MAKING PROCESSES TO SIMULATE DYNAMICS OF AGRICULTURAL LAND USES AT FARM AND LANDSCAPE LEVEL

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## INTRODUCTION

Agriculture, as the largest land user in Europe, is increasingly questioned about its impacts on the environment. The mutual relationship between land and farmer practices is an important factor to consider for studying land use decisions. Land management is part of the whole technical management of agricultural production at farm level and partly determines farm profitability. The collective dynamics generated by all individual farm land use choices impacts on ecological processes occurring on larger space. Therefore, to improve resource use efficiency at farm level (e.g. land, water) and to better manage environmental resources at landscape level (e.g. erosion), one needs to consider processes of crop allocation to land.

In the past, modelling crop allocation has been extensively addressed (Aubry et al., 1998), but most of the approaches used were static (Dogliotti et al., 2003). The cropping plan choices were usually summarized as a single decision occurring once a year. The dynamic processes, ie modelling the allocation choices as a succession of reactive and planned decisions along annual and long term horizons, were rarely used. Crop allocation choices involve an important part of uncertainty and risk (e.g. price, weather) that have to be accounted for. Further, in most existing modelling approaches, the latter was not spatially represented and was usually summarized as single crop acreage distributions across land types.

Although modelling agricultural decision-making is not new, it has never been carried out into details on crop allocation decisions at farm scale. Based on three complementary PhD works we propose to model these crop allocation decisions at farm scale, in order to: i) understand and model the relationships between different types of decision and the time farmers take them, ii) support farmers in their annual and long term crop allocation strategies and iii) support the design of environmental public policies by simulating their effects on individual land use decisions and their environmental impacts at landscape level through a bottom up approach.

## MATERIALS AND METHODS

In order to explore the variability of crop choices and crop allocation on the farm territory in relation with farmers' objectives, we carried out two different sets of farmer interviews in France. We focused on farm constraints (spatial organization of the farm territory, climate and soils characteristics, labour organization), and on regional and larger scale constraints (socio-economic context, CAP requirements). In set 1 (11 farms in the "Niort Plain" region), we sought to formalize the links between crops and animal production and its impact on cash-crop surfaces vs. forage surfaces choices on farm, considering the variable annual forage needs for livestock. In set 2 (30 farms scattered into Midi-Pyrénées, Poitou-Charentes and Centre) we focused on the effect of water availability and irrigation rules on crop choices in arable farms. In this survey, parts of the

questionnaire aimed at assessing farmers' aversion towards risk.

Based on collected information completed by a literature review, we sketched towards a conceptual model which includes spatial and temporal dynamics of the crop allocation decision-making processes at farm scale.

## RESULTS AND DISCUSSION

Preliminary data analysis showed that farmers' decisions to chose crops, define acreage and allocate them to land are strongly dependant on each other and can hardly be solve independently. Further there are strong relationships between annual and long term thinking while farmers take these decisions.

Some farm specific constraints which drive the crop allocation decision-making process are hardly manageable on short term perspective. Field characteristics (e.g. area, shape, soil type, water accessibility) and their spatial distribution into the territory (distance, access) are the first structural constraints that strongly affect the decision-making process. Based on these constraints, farmers organize their farming territory into homogeneous land units in relation to their own production objectives (e.g. cash crop, forage for animal). This spatial organization implies annual and/or long term plot division strategies that appear to be dependant on the farm territory structure and the nature of production. The management units receive different crop rotations or perennial crops (e.g. grasslands) generating different and complementary crop management systems. These crop management systems are relatively stable in time but are very likely to evolve when important changes of the context and/or farmers' objectives occur. Understanding how farmers organize the farm territory is therefore a key element for modelling crop allocation decision-making processes because it structures crop productions.

Annual scheduling of decision-making processes leading to the cropping plan are very different from farm to farm and strongly depends on farmers' strategies, socio-economical context and available information. However, in all cases, the decision-making process is a succession of embedded anticipatory and reactive phases (Garcia et al., 2005). The different phases can be identified in relation to specific farmers' strategies, constraints and events (e.g. price change, water attribution), and can therefore be incorporated into a generic modelling framework.

Modelling the crop allocation decision-making processes requires to explicit the interactions between a set of constraints from very different natures fitted into different time scale dynamics and integrated into various spatial entities within the farm territory. At this stage, the paper has just sketched the basic needs for modelling crop allocation processes. The model has not been implemented yet, since it first requires a translation of the decisional-model into formalisms usable in combination with biophysical crop models. Using modelling and simulation platform (RECORD, DYPAL), these formalisms will be coupled with biophysical models and optimization algorithm to simulate crop management strategies.

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