A GENERIC FRAMEWORK FOR THE MODELLING OF LIVESTOCK PRODUCTION SYSTEMS: MELODIE

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INTRODUCTION

Modeling at farm level is considered as relevant for agricultural sustainable development. However, farm scale raises several methodological issues relating to the superficial attention paid to management aspects or to the integration of multidisciplinary knowledge (animal and crop production…). A specific difficulty is raised by *ex ante* simulations, to ensure the consistency of the system simulated, particularly for those that do not exist in reality. Consequently, the modeling of whole farm, even for a very specific purpose, can be in itself a difficult challenge. Besides, resulting models may have poor genericity and evolving abilities. In the scope of the development of a model for dairy and pig farms, initially focusing on nutrient flows (Chardon et al., 2007), a generic framework for the modeling of livestock system has been developed upstream, by using a production system ontology (Martin-Clouaire and Rellier, 2009). The aim was to be able to generate models for contrasted production systems to study nutrient flows from existing knowledge, while leaving opportunities to further extend the model to new processes, decision rules, or criterions (economic, social…) and possibly to other animal species.

MODEL DESCRIPTION

The modelling approach is organized in five layers (figure 1). The base level concerns the structure for an object-oriented modelling of dynamic systems. The second level provides an ontological ground for the domain of agricultural production system, composed of interactive management and biotechnical subsystems (Martin-Clouaire and Rellier, 2009). The next level corresponds to a specialization for livestock farms. Generic entities (applying to every animal farms) were created wherever possible (i.e. "manager", "animal"…). This work benefits from the appraisal of an expert panel from various disciplines (Melodie Project), for example, to carefully design animal feeding. The result could therefore be seen, to a certain extent, as an ontology of animal production systems. More specialised entities were then created for more specific purposes (e.g. "bovine", "pig", "dairy cow"…). Processes associated to these entities and especially involved in nutrient cycling (N, P, C, Cu, Zn) have been implemented (animal excretion, gaseous emissions during manure storage and treatment…). Similarly, published decisional sub-models have been integrated to simulate farmer's decisions from an overall strategy, climatic conditions and the evolution of the system (i.e., cropping and spreading plans generators, herd simulator…). For example, cropping and spreading plans are generated each simulated year to fit objectives such as desired self-sufficiency, with given available stocks (resulting from previous years), and they could be revised in the course of the year if climatic conditions are not compatible. The structure of the model enables to easily substitute or add sub-models. At the last level, a specific pig and dairy farm can be generated, with all required components to simulate nutrient flows for several years, with a daily time step (Chardon et al., 2007).

RESULTS AND DISCUSSION

Each level is a particularization of the conceptual level below, and can therefore be seen in itself as a modeling result. The generic framework for livestock systems has supported the formalisation of two contrasted production systems (pig and dairy) with numerous common concepts. The generic properties of the model help to structure emerging projects for other animal species (poultry, suckler cows) and at other scales (catchment scale). These projects prove the relevance of this conceptual level. The next conceptual level (pig and dairy farms) has been used to generate six dairy farms and five pig farms. The implemented modules in the framework covered contrasted feeding management (with varying areas of pasture and maize) as well as contrasted manure handling schemes (slurry, solid manure, composting…). The simulation of both biological flows and coherent decisions from an overall strategy resulted in complex interactions between animal, manure and crops. For example, gaseous emissions from animals and manure are not only the result of biological processes at animal and manure level, but it also dynamically depends on crop growth and the strategy of the farmer to feed animals or to spread manure. The flexible adaptation of the system to climatic conditions, in a dynamic way, enables to estimate variations of nutrient flows between or within years (Chardon et al., 2007). The variations between years, for a given overall strategy, takes into account stocks evolutions (feed, manure, organic matter in soils…). Moreover, the simulations can be used to perform comprehensive multicriteria assessments (nutrient balances, LCA…). As a conclusion, the existing framework is powerful to simulate *ex ante* nutrient flows in farms with contrasted productions (dairy cows, pigs, and different crops) and farmer strategies. Moreover, the flexibility of the framework enables the further integration of new sub-models and other criterions, and possibly the extension to other production systems.

REFERENCES

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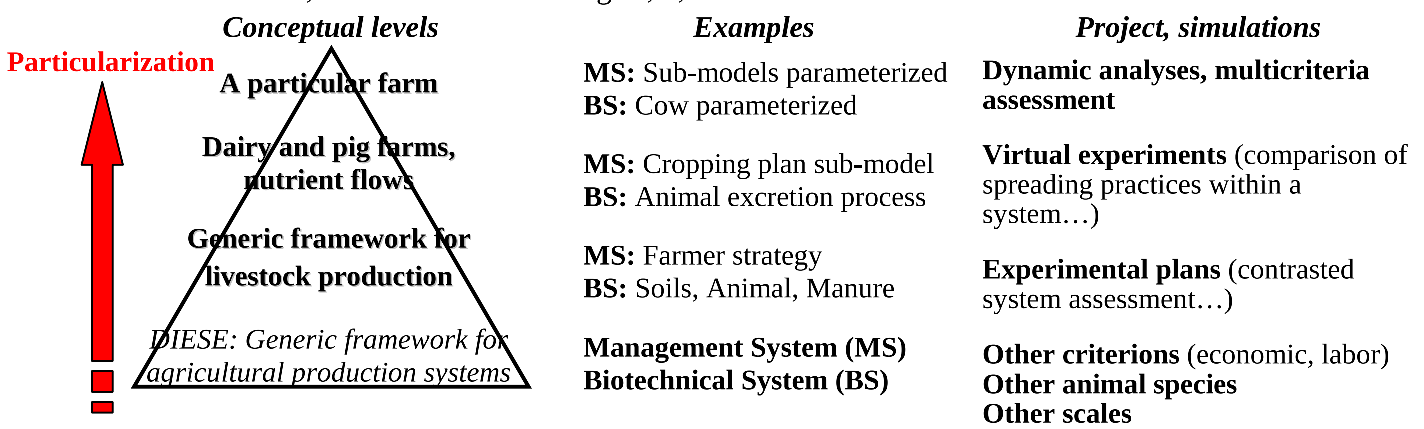

Figure 1: The five levels of the framework, examples and respective implications