Farming systems design: complementarities between experts' prototyping and modeling

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Introduction

Farmers are facing a great number of constraints that complicate the process of farming system (FS) adaptation (Le Gal *et al.*, 2010). In the Camargue region, Southern France, the farmers must notably (i) adapt to the Common Agricultural Policy reform that implies the suppression of the coupled payment for rice, (ii) reduce pesticide use, (iii) and reduce greenhouse gas emissions while (iv) improving energy efficiency and (v) ensuring food provision for local and global market. To account for these multiple objectives in the design of new (FS), prototyping by experts and modeling have proved their usefulness (Sterk *et al.*, 2007). In this paper, we present the complementary application of these two approaches to design sustainable FS in the Camargue.

Materials and Methods

Three rice farmers were interviewed to identify the objectives and constraints that guide the current state and the possible evolution of their FS. Based on these information two methods were used in parallel to design new FS. First, a panel of eight experts (mostly researchers in agronomy) designed a FS prototype for each farm, consisting in a choice of crop sequences, crop allocations and farming style (e.g. partially or totally organic). Secondly, a bioeconomic optimization model was used to identify FS that would satisfy the multiple objectives assigned to the system (see Delmotte (2011) for the details of the model). The analysis of the current situation, the experts' prototype, and the bioeconomic simulations, were done using a database that describes the economic and environmental performances of the possible agricultural activities in Camargue.

Results and Discussion

Figure 1 presents FSs designed for one farm, for which the farmer objectives were to increase the economic profitability and to maintain the labor requirements. He is constrained by its limited capacity to invest in new machineries to develop or extend the area of crops such as alfalfa, protein pea or sunflower. The experts' prototype is based on the partial conversion of the farm toward organic crops, including rice, soybean and soft wheat (new crops) (Fig 1.B). Some lands of the farm cannot be converted to organic cropping systems due to salt pressure (from capillary rising of aboveground salty water) that requires frequent rice cultivation, what is impossible in organic farming due to weed pressure (Mailly *et al.*, 2013). While the experts' prototype addresses most of the farmers' objectives and improves the socio-economic and environmental performances of the farm (Fig. 1 D.), it failed to cope with the farmer constraints as the acreages of alfalfa would require investing in new machineries. Fig. 1C shows that the system proposed by the model is close to the experts' prototype in term of land use, but cope with all the objectives and constraints of the farmer. Both systems resulted in better socio-economic and environmental performances, however they reduced the global farm production in terms of energy and protein (Fig. 1D).

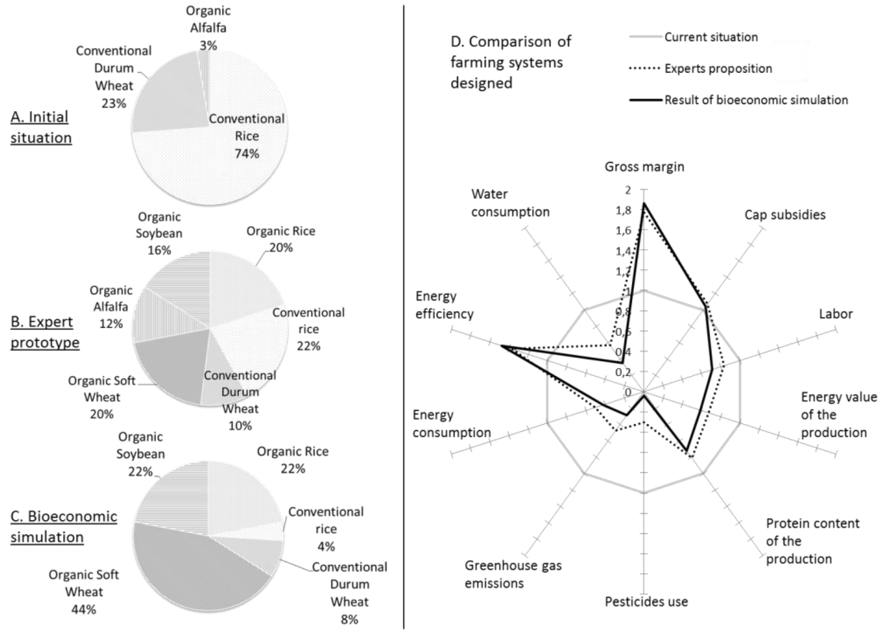

Figure 1. Farm land use for the current situation (A), the experts' prototype (B) and the bioeconomic simulation (C), compared in term of socio-economic and environmental performances.

Conclusions

Prototyping leads to propose innovative FS adapted to the farmers' objectives and constraints but faces difficulties when the number of objectives and constraints to consider increases. On the contrary, the bio-economic optimization model allows incorporating multiple objectives and varying their levels, but has limitations for representing specific constraints of farms such as fields organization. The complementary and iterative use of these two approaches lead to design more sustainable FS that will be presented to the farmers and analyzed in terms of advantages, drawbacks, and possible pathways to be implemented.

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