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Abstract: *The development of organic farming is nowadays seen as a possible solution to meet the different objectives of sustainable development. In the Camargue, South of France, environmental issues are strongly linked with agriculture, and stakeholders are in need of integrated approaches to analyse the plausible impacts of alternative farming systems at multiple scales, particularly at regional scale. Evaluating alternative farming systems at multiple scales requires the quantification of different indicators meaningful for different actors in support of the negotiation and decision making process. With this challenge in mind, we developed a framework for Prospective, Integrated, Multiscale and Participative Assessment of Agricultural Systems (PIMPAAS), combining modelling tools and stakeholder meetings. In this paper we present the proposed framework based on the possible complementarities of two modelling approaches using scenario analysis (Bio-economic models and multi-agents systems) for a multiscale, integrated and participatory evaluation. We also present the progresses made in the identification of scales of analysis in relation to actors' objectives and aspirations, in the description of current and alternatives farming systems and in the identification of useful indicators at different scales. The list of the main stakeholders is presented and the objectives and consultation procedures are highlighted with examples. First results concerning the use of crop models are also presented. We conclude on the generic aspects of the approach for a prospective, integrated, multiscale and participatory evaluation of the extension of alternative agro-ecosystem such as organic farming.*

Keywords: *Prospective, Integrated, Multiscale, Participatory, Scenario evaluation, Agro-ecosystem Indicator, Model*

Introduction

Organic farming has been presented as a potential way of reducing the externalities of current agricultural practices, leading the French government to launch a program with a target of 6% of the cultivated area converted into organic by 2012 (Barnier, 2007). However, the extension of such alternative agriculture raises questions in particular at the regional scale such as the Camargue deltaic region in the south of France. Agriculture plays a crucial role in the economic, ecologic and social equilibrium of this region. It has been labeled as a reserve of biosphere (Man And Biosphere Program of UNESCO) since 1977, and it hosts a Natural Regional Park, a National Reserve and many other associative or private protected areas. Many fauna and flora species are protected and tourism oriented to nature observation is an important activity. About 50 000 ha are used for agriculture, among which about 20 000 ha are devoted each year to rice production. It is the only place where rice is cultivated in continental France.

Cropping systems are based on the production of irrigated rice. Such cropping systems play a crucial role in the water dynamics of this deltaic region. Most land is at sea level and salinization is a natural process due to the negative water balance between rainfall and evapo-transpiration. Rice, which is the main irrigated crop in the region, therefore plays a key role in lowering soil salinity. However, continuous rice production uses large quantities of pesticides, especially herbicides. These pesticides disperse throughout the environment and, given the high biodiversity in the Camargue and the interest on preserving local fauna and flora, ecologists have long called for a reduction in the use of pesticides. Irrigation water that enters the delta plays an important role in the level of water and

water quality (salt, nutrient and pesticides concentration) of the Vaccarès lake, an environmental hotspot in the territory.

In organic production, the solution to prevent the build up of weeds and pathogens is to break the continuous rice cropping system and lengthen its rotations with rainfed crops (especially durum wheat and alfalfa). Organic rice has to be rotated with other crops over five years (Mouret et al., 2004), whereas in conventional cropping systems, it is possible to grow continuous rice by using herbicides. The extension of these organic cropping systems in the region would certainly imply a decrease in the area of irrigated rice, compared to the current rice monocropping, and therefore the quantity of fresh water entering the delta. This may induce an increase of salt concentration in the lake and a decrease of the area or feeding and reproduction of wild birds' species. The potential benefit of the reduction of pesticides concentration in the lake on biodiversity may therefore be counterbalanced by these other effects induced by organic farming.

Organic farming might also have an influence in the economy of the farms and of the region (Darnhofer et al., 2009). Developing organic farming may also affect the social, economic and environmental equilibrium of the region through for example employment in farms or the quantity of rice available for processing industries, or improve the visibility of the region through an aura of 'organic region', which would certainly encourage green tourism and activities oriented to nature.

Ecological, economic and social changes can then be expected from a development of organic farming in this territory. Despite the great number of studies on Camargue agriculture (Mouret et al., 2004), ecology (Mauchamp et al., 2002; Comoretto et al., 2007; Roche et al., 2009), economy and sociology (Jaeck and Lifran, 2009), there has not been any integrated assessment of organic or other alternative agroecosystems compared to the current situation. Such evaluation could contribute tothe negotiation and planning of agricultural changes in the Camargue and hopefully support concerted action to improve the coexistence of agricultural and nature conservation activities.

To evaluate the plausible consequences of the extension of alternative agricultural systems in the Camargue, a Prospective, Integrated, Multi-scale and Participative Assessment of Agricultural Systems (PIMPAAS, (Delmotte et al., Submitted)) has to be carried out.

Prospective analysis is required for the evaluation of alternative agricultural systems in the context of a changing environment (economy, climate…). Evaluating the impact of the possible expansion of alternative agricultural systems in a territory implies an ex-ante approach as data are lacking for evaluating alternative systems not yet implemented and as it becomes necessary to be able to study the possible consequence of a given change before implementing it (Sadok et al., 2008; Le Gal et al., 2010).

Integrated methods, that take into account different aspects of the systems have to be used. The combination of different disciplines such as economy and ecology, or social sciences has been shown as necessary for the evaluation of agricultural systems sustainability and integrated assessment has recently emerged as a specific field in agronomic research (van Ittersum et al., 2008; Castoldi and Bechini, 2010; Sattler et al., 2010). As far as agricultural systems are now evaluated regarding their performance and impacts, it is necessary to take into account the multiple functions of agro-ecosystems. This can be assessed through different indicators related to their economic, social and environmental performances and impacts.

To evaluate the impacts of the possible extension of alternative agricultural systems in a territory, a *multi-scale* evaluation is required. The potential impacts of the introduction of alternative systems cannot be assessed at a single scale because some indicators can be specific of a scale or the response of the system can be at different level (Lopez Ridaura et al., 2005; Laborte et al., 2007). For example, economic performance of an alternative farming systems can be evaluated at farm scale; but the contribution of such alternative to the economy and employment as well as its environmental externalities is better analyzed at higher levels of analysis such as the territory or the region.

To evaluate the impacts of the possible extension of alternative agricultural systems in a territory, *participative* approach has to be conducted to take into account the behavior and objectives of the different actors and identify possible conflicts and synergies as well as to make the most out of empirical knowledge about the local context including social constraints (Scoones and Thompson, 1994). Decision-making concerning the development of more sustainable practices in agriculture results from interactions between farmers' objectives and those of other stakeholders and organizations through programs and policies. Van Paassen (2007) reported that one of the key for success in implementing such evaluation process is to be in close cooperation with the stakeholders trough a framework for discussion and negotiation.

The objective of this project is to develop a PIMPAAS methodology and test it on the case study of organic farming in the Camargue region. In this paper we focus on the methodological aspects illustrated with the first results obtained .

Material and methods

Phase 1. From systems characterization to indicators selection

The first phase of the PIMPAS approach is the characterization of the systems by each stakeholder and farmer. An exhaustive list of actors is built from different expert knowledge. Each actor is consulted individually to characterize its vision of the system and identify its scales of analysis. Some conceptual models are developed at the different actors' scales on the basis of a systems approach. The limits of the system, the internal components comprising biophysical aspects, actors and resources are identified and the elements of the environment representing the exogenous factors influencing the system are represented.

The current and alternative agricultural activities at field scale or management systems at higher scale are identified through interviews with the different actors. While talking about alternative activities, actors are expected to expose and classify their visions of the future under the 'desired', 'undesired' and 'expected' classification. This helps in the next phases to build scenarios. Soil and farm typologies are also built during that phase. Finally, each actor proposes indicators at different scales of analysis for evaluating the different scenarios and they are discussed to be sure that we can calculate them.

This first phase make emphasizes the participative nature of the evaluation as it is expected to allow the actors to explain and share their perceptions and visions of the systems. The first interactions are conducted in the form of individual interviews during which the whole framework is presented and first discussions on system characterization are conducted. A second interview with each actor is devoted to the identification of current and alternatives activities and indicators. The aim is to ensure, from the beginning of the process, a good representation of the actors view in the system's definition. Participation at this phase also ensure credibility for the models and calculations and allow to create a group of stakeholders for further collaboration.

Phase 2. Quantification of activities and main processes of the system

The second phase consists in data collection for the quantitative description of current and alternatives activities at different scales. Current activities refer to the main animal and cropping activities, including pastures, perennial crops and vegetable production. Alternatives activities refer to new practices, eventually conducted by some farmers but not developed in the region. It can be new crop rotations, new low input systems and more or less intensive livestock production systems for example.

For this objective, existing crop models, data base, hydrological models, interviews and statistics are used, completed by expert knowledge in case of data unavailability. Some summary models (Tittonell et al., 2010) are being developed for certain processes such as water balance at the regional scale. A technical coefficient generator is being developed consisting on a table with each possible

agricultural activity described by its inputs and (desired or undesired) outputs (Hengsdijk et al., 1999). Examples of input coefficients can be the quantity of nitrogen used and the working time; examples of output coefficients can be yield and grain quality for the performance of the activities, and greenhouse gases emission for its impacts. All the basic information necessary for the technical coefficient generator is obtained using the different tools presented above.

For this phase, besides the use of direct information and models, experts are interviewed to complete and validate the initial quantification of the current and alternatives activities. Some of the actors engaged in the whole process of scenario evaluation are interviewed as experts in a specific domain (for example cropping systems) or for a specific compartment of the system (such as wildlife or surface water). At the end of this step, we plan to carry out a collective information meeting in order to (i) present and share the different views of the system (see Step 1) and (ii) validate and legitimate the data and indicators calculation through a presentation and discussion of models and basic data.

Phase 3. Models for simulation of system's behavior and indicators assessment

The third step is to build the models for scenarios analysis through the indicators calculation. We reviewed different potential methods for PIMPAAS and identified possible complementarities between Bio-Economic Models (BEM) and Agent Based Model (ABM) (Delmotte et al., Submitted).

BEM are economic models that include a biological component to take into account temporal variation of agricultural activities performance and impacts due to climate and soil factors variability (Flichman, 2002). They aim at identifying optimum combination of agricultural activities that maximize or minimize an objective function. Optimum systems are obtained using a multiple goal linear programming model where one goal is defined by an objective function, the others being described in constraint functions (Janssen and van Ittersum, 2007). In a multiple goal linear programming model, data are kept on their original units avoiding the conversion of everything to one utility function based on economic optimization.

Agent Based Models (ABM) represent systems as agents in interactions, with a social structure, and using resources in an environment. Each agent is perceiving, self-representing and acting in its environment by taking decision for its units of management and interacting with other agents, each agent having its own objectives (Ferber, 2006). This type of model is increasingly used to represent the interactions between multiple actors or stakeholders and a shared natural resource. These individual centered approaches have begun recently to be applied to nature-society interactions (Ligtenberg et al., 2004; Monticino et al., 2007), in particular in the domain of natural resources management (Mathevet et al., 2003; Bousquet and Le Page, 2004; Castella, 2009).

Both, BEM and ABM, have strong and weak points for PIMPAAS and possible complementarities have been identified (Delmotte et al., Submitted). They are both suitable for integrated studies as well as for multi-scale analysis. BEM seems to be the most suitable approach for prospective studies able to identify the window of opportunities for agricultural change assessed with a set of indicators. ABM has a clear advantage for participatory research and for formalizing decision making based on negotiations and decisions.

Phase 4. Scenarios assessment with indicators

The last phase consist in the scenarios assessments using the indicators and different representation of the systems at different scales (for example maps) The scenarios are built through the first two phases, starting from the main features of plausible futures from different actors point of view identified in the first phase. For example, farmers may expect an increase of input prices in parallel with a decrease of cereals prices, whereas a nature protection institution may expect an increase of supports for organic farming development or a new legislation concerning pesticides use. The scenarios will be finally defined in detail in the first collective meeting of this phase.

The first evaluation of scenarios is conducted through realistic role playing games. Indicators value is calculated using the ABM and from the quantitative data collected in phase 2. Actors have to specify which decision they would take in front of different situation that could happen. For example, farmers have to explain which activity they choice for their lands considering a change of price of rice. In the quest for realism in the system's representation it is expected that decision will be complex. In this phase, complementarities between BEM and ABM will be studied. For example, BEM could be used as a decision support tool for the different actors while they are playing role playing games. BEM can be used for analyzing conflicting objectives through trade offs curves, possible impacts of change in prices on the land use and impacts of policies and regulations. ABM would serve in that case as a support tool for the role playing game, calculating indicators resulting from actors decision concerning activities. We will also study the possible coupling techniques between BEM and ABM to calculate the indicators at different scales for the different scenarios, the decisions of which activities being simulated by BEM.

Finally, quantitative assessment of scenarios is conducted using the two kind of models, and actors are consulted in focus groups to give their opinion about the performance of the systems in the different scenarios. During the focus groups, they are invited to negotiate and define new scenarios to be evaluated in the next focus group. At least two sessions of focus group are expected for scenario evaluation. We expect to gain strong quantitative insights on plausible consequences of different alternatives agro-ecosystem and to identify the opportunities and bottlenecks for their development.

Results and discussion: advances in the application of the framework to organic farming in Camargue

The two first phases have been developed in parallel and we present here some preliminary results and ideas for future application of the framework.
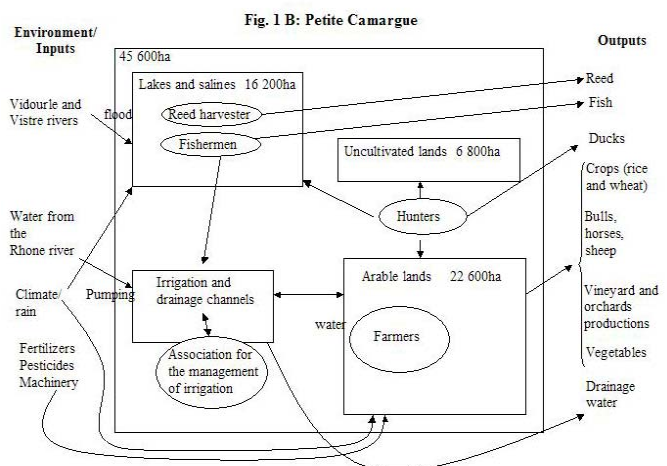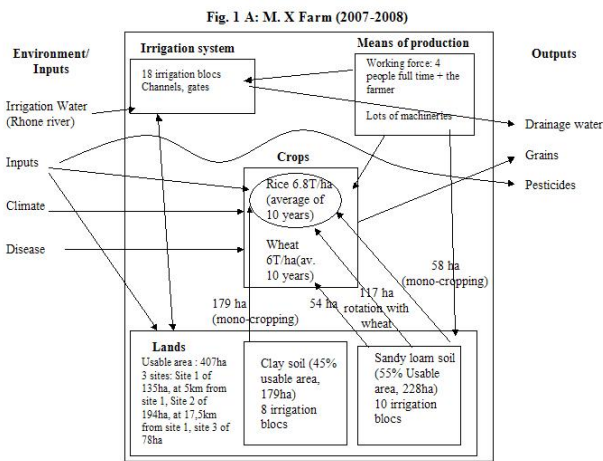
Phase 1

A list of all actors that could be engaged in the evaluation is reported in table 1,. This list includes farmers from five farm types referring to an existing typology (Mendez-del-Villar, 1987). For each actor considered as important players related to agriculture, scales of analysis (extent and grain or minimum resolution) have been identified (Table 1). Other actors are known for this territory but their role in agricultural development are minor. For example, fishermen, reed harvesters and salt producers are important economic actors in Camargue, but the links between these activities and agriculture are weak. Before each interview, we prepare a synthesis of the knowledge available on each actor and stakeholder in the form of a scheme representing their system. Figures 1(a) and (b) are two examples of such synthetic scheme for a farmer and for a local syndicate of water management the Camargue. These scheme are based on a representation of the limits of the system, of its environment, inputs and outputs, and each arrow represent a process, a flux or an exchange of information between two components of the system. Components can be resources or actors. We use this representation as a guideline for the interview, asking the actor to modify it in relation to his/her view of the current functioning of the system and to identify what and where could be changed in the system. Then indicators are identified to evaluate the performances and impacts of the system, mostly referring to the outputs of the system or to individual components.

At this phase, current and alternatives activities are identified and described. For farmers, this means the different crops or livestock systems practiced or desired by them or proposed by the researchers. For the other actors, it represents the different management system they practice or could practice. The different combinations of alternative crop and livestock system with alternatives management system are the first elements for the construction of the scenarios.

Examples of possible indicators are presented in table 1 to show the diversity of domain covered as well as the multi-scale aspect. In fact, indicators are first proposed by the actors on the basis of what they commonly use to evaluate the performance of their system and on what they would want to have as information to take a better decision. Their propositions are further analyzed in terms of data and models available to calculate the indicators in order to propose a set of indicators during the second individual interview. The objective is to identify, with each actor, a shared set of indicators that (i) can be calculated with available models and data, and (ii) l represents the actors objectives at the relevant scale to evaluate the scenarios.

Table 1. List of actors related to agricultural development in the Camargue.

| Actors	Scales	Examples of possible indicators
Farmers (5 types)	Farm, blocs of fields, fields	Gross margin, Working time,
Cooperatives of producers	The Camargue area, grain farms,	Total production of commodities
Input supplier	The Camargue area	Gross margin of sales
Syndicate of grain producers	The Camargue area	Area grown on crops Total production of each crops
Syndicate of livestock breeders	The Camargue area	Area on pasture Number of animals (bulls, horses)
Hunter association	The Camargue area	Available area for hunting
Water management association	Irrigation basin	Irrigated area Volume of water pumped
Natural Regional Park of the Camargue	Central island of the Camargue	
Biosphere Reserve	The Camargue ecosystem	Irrigated area Pesticides uses
National Reserve of the Camargue	South Camargue around the Vaccarès lake	Number of employees in the agricultural sector Average gross margin of the farms
Private research center of La Tour du Valat	East Camargue	

Figure 1. System representation of a farm (A) and of a water management syndicate (B) in the 'Petite Camargue'.

Phase 2

In order to quantify the agronomic performance of the main agricultural activities, we have explored the use of crop growth models for the most common crops (WARM (Confalonieri et al., 2009) and APES (Donatelli et al., 2010) for rice (Vay, 2009) and STICS (Brisson et al., 2003) and APES (Donatelli et al., 2010) for durum wheat (Kichou, 2009)). Both models were calibrated using data that were obtained from on-farm field monitoring conducted during the 2009 growing season and from a database that was reporting technical operations and performance of 300 rice fields over 15 years (Mouret and Hammond, 2003). Soil analysis have been conducted to characterize soil water

characteristics and organic matter, that were inputs for both models. Leaf area index and biomass have been monitored at different dates and were used for model calibration.
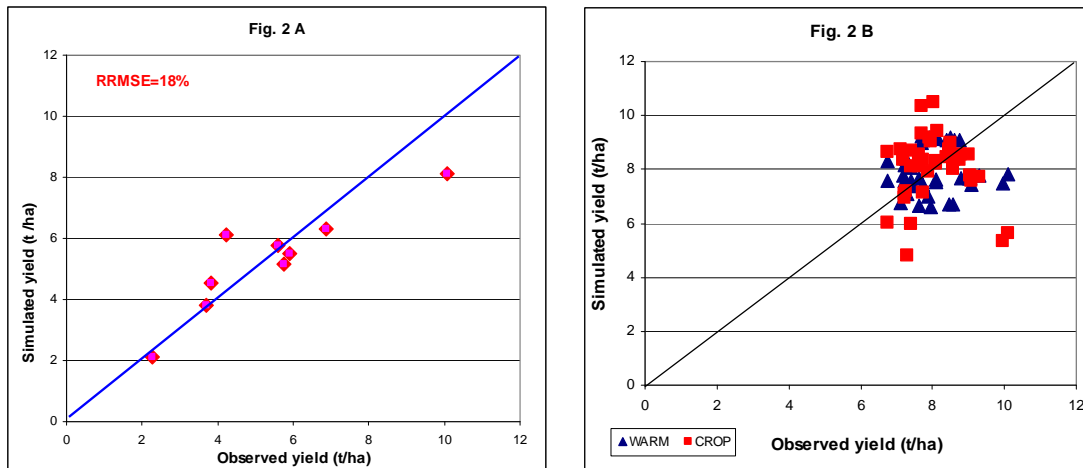
Figure 2. (A) Observed vs simulated yield for durum wheat in the Camargue with STICS. (B) Observed vs simulated yield for rice with two modules of rice (Crop and Warm) within the APES simulation platform.

Figure 2 A and B reports simulated yield for durum wheat and rice respectively, in comparison with observed data in 2009 (Fig. 2A) and 15 years data (Fig. 2B). STICS give a reasonable simulation of durum wheat yield (Relative root mean square error of 18%) but more data is needed to conclude. For rice, none of the models give satisfying results. Therefore it can be related to the lack of data for proper calibration. This work will be further developed in 2010, but it is anticipated that these models are too complex and require a lot of data for proper calibration for the various types of fields and crops covered by our study. They will be mainly used to generate coefficients for summary models (Tittonell et al., 2010). This type of model is build on simple functions relating resource and limiting factors to yield, with a specific set of parameter for each type of crop, soil and crop management. Limiting factors are hierarchized with on field agronomic survey and parameters are derived from the detailed crop growth models. For example, the variation of performance due to inter-annual climatic variation will be simulated using crop growth models for the main crops in Camargue and, based on this results, simple functions will be derived and implemented in simplified models.

This work with crop growth model is only done for the main crop, rice and wheat, for both conventional and organic cropping systems. For the others agricultural activities (for example: oil seed rape, maize, vineyard, orchard and livestock breeding systems) and for data concerning farm scale and regional scale, we are using statistics, reports from previous disciplinary projects and expert knowledge and inquiries of farmers and professional.

Phase 3
All the data collected at field scale in Phase 2 will be used as input for BEM and ABM. BEM models are being developed at farm and regional scale, and are combined with a farm typology to defined farm parameters and to upscale to the region for some indicators (Blazy et al., 2009). The ABM model is being built using a GIS map of the Camargue region, which contains data on water management (irrigation and drainage), soil type and altitude. Linking BEM models and ABM will allow to simulate the modification of agricultural activities in the Camargue area and its impacts for example, the amount of water entering in the system and going into the Vaccarès lake.

Phase 4
A first collective meeting will allow to finalize the choice of scenarios and to build them as a combination of different changes at different scales. Role playing games and focus groups will then be alternatively used to facilitate the discussion among actors concerning the different scenarios and

to identify the advantages and bottlenecks of the different scenarios. Emphasis will be put in this project on the evaluation of the various scenarios concerning organic farming (OF): what happens if the whole region is converted into OF? Which part of the region must be converted to reduce environmental externalities? Which percentage of the area in OF is suitable for regional agricultural economy?

Conclusion

In this paper we presented the PIMPAS methodological framework we are developing for Prospective, Integrated, Multi-scale and Participative evaluation of scenario of the extension of Alternative farming Systems in a given region. The methodology, builds on tools developed by different research communities (BEM, ABM and Land Use Change), and is expected to promote the synergies between these approaches. The framework is currently being applied to evaluate scenarios of the extension of organic farming in the Camargue region, and this test case will be used to improve the participative nature of the framework in interaction with the actors.

This methodology is also targeted for other regions in the world where agriculture is facing issues related to agricultural production and environmental protection and where the human dimension of the various actors is as important as the biophysical and economic or policy aspects.

References

Barnier M. (2007) Agriculture Biologique Horizon 2012. Talk to the Grand Conseil d'Orientation de l'Agence Bio (French Agency for Organic Farming) 12 september 2007.

Blazy J.-M., Dorel, M., Salmon, F., Ozier-Lafontaine, H., Wery, J. and P. Tixier (2009) Model-based assessment of technological innovation in banana cropping systems contextualized by farm types in Guadeloupe. European Journal of Agronomy 31,(1), 10-19.

Bousquet F., C. Le Page (2004) Multi-agent simulations and ecosystem management: a review. Ecological Modelling 176,(3-4), 313-332.

Brisson N., Gary, C., Justes, E., Roche, R., Mary, B., Ripoche, D., Zimmer, D., Sierra, J., Bertuzzi, P., Burger, P., Bussière, F., Cabidoche, Y.M., Cellier, P., Debaeke, P., Gaudillère, J.P., Hénault, C., Maraux, F., Seguin, B. and H. Sinoquet. (2003) An overview of the crop model. European Journal of Agronomy 18,(3-4), 309-332.

Castella J.-C. (2009) Assessing the role of learning devices and geovisualisation tools for collective action in natural resource management: Experiences from Vietnam. Journal of Environmental Management 90,(2), 1313-1319.

Castoldi, N. and L. Bechini (2010) Integrated sustainability assessment of cropping systems with agro-ecological and economic indicators in northern Italy. European Journal of Agronomy 32,(1), 59-72.

Comoretto L., Arfib, B. and S. Chiron (2007) Pesticides in the Rhône river delta (France): Basic data for a field-based exposure assessment. Science of The Total Environment 380,(1-3), 124-132.

Confalonieri R., Rosenmund, A.S. and B. Baruth (2009) An improved model to simulate rice yield. Agron. Sustain. Dev. 29,(3), 463-474.

Darnhofer I., Lindenthal, T., Bartel-Kratochvil, R. and W. Zollitsch (2009) Conventionalisation of organic farming practices: from structural criteria towards an assessment based on organic principles. A review. Agron. Sustain. Dev. PREPRINT.

Delmotte S., Lopez-Ridaura, S., Barbier, J. and J. Wery (Submitted) Scenario assessments for alternative farming systems at different scales. A review. Submitted to Agronomy for Sustainable Development.

Donatelli M., Russel, D., Rizzoli, A.E., Acutis, M., Adam, M., Athanasiadis, I.N., Balderacchi, M., Bechini, L., Belhouchette, H., Bellocchi, G., Bergez, J.-E., Botta, M., Braudeau, E., Bregaglio, S., Carlini, L., Casellas, E., Celette, F., Ceotto, E., Charron-Moirez, M.H., Confalonieri, M., Corbeels, M., Criscuolo, L., Cruz, P., Di

Guardo, A., Ditto, D., Dupraz, C., Duru, M., Fiorani, D., Gentile, A., Ewert, F., Gary, C., Habyarimana, E., Jouany, C., Kansou, K., Knapen, R., Lanza Pilippi, G., Leffelaar, P., Manici, L., Martin, G., Martin, P., Meuter, E., Mugueta, N., Mulia, R., Van Noordwijk, M., Oomen, R., Rosenmund, A., Rossi, V., Salimari, F., Serrano, A., Sorce, A., Vincent, G., Theau, J., Therond, O., Trevisan, M., Trevisiol, P., Van Evert, F., Wallach, D., Wery, J. and A. Zerourou, (2010) A component-based framework for simulating agricultural production and externalities. In: F. Brouwer, M.K. Van Ittersum (Eds.), Environmental and agricultural modelling: integrated approaches for policy impact assessment. Springer, Dordrecht, (In press).

Ferber, J. (2006) Concepts et méthodologies multi-agents. In: F. Amblard, D. Phan (Eds.), Modélisation et simulation multi-agents, applications pour les Sciences de l'Homme et de la Société. Hermes-Sciences & Lavoisier, Londres.

Flichman, G. (2002) Building Agro-Environmental Indicators by the Integration of Biophysical and Economic Models for Assessing Sustainability of Agricultural Trade Liberalisation.Paper presented at the Workshop Methodological Tools for Assessing the Sustainability Impact of EU's Economic Policies, with applications to Trade Liberalisation Policies, Brussels 7-8 November 2002. Organised by CEPII - European Commission, November 2002.

Hengsdijk, H., Bouman, B.A.M., Nieuwenhuyse, A. and H.G.P. Jansen (1999) Quantification of land use systems using technical coefficient generators: a case study for the Northern Atlantic zone of Costa Rica. Agricultural Systems 61,(2), 109-121.

Jaeck, M. and R. Lifran (2009) Preferences, Norms and Constraints in farmers' agro-ecological choices. Case study using a choice experiments survey in the Rhone River Delta, France. 2009 Conference (53rd), February 11-13, 2009, Cairns, Australia 47948. Australian Agricultural and Resource Economics Society.

Janssen, S. and M.K. van Ittersum (2007) Assessing farm innovations and responses to policies: A review of bio-economic farm models. Agricultural Systems 94,(3), 622-636

Kichou, A. (2009) Calibrage d'un modèle de simulation du blé dur biologique et conventionnel en Camargue. SupAgro Montpellier, France, pp. 56.

Laborte A.G., Van Ittersum, M.K. and M.M. Van den Berg (2007) Multi-scale analysis of agricultural development: A modelling approach for Ilocos Norte, Philippines. Agricultural Systems 94,(3), 862-873.

Le Gal, P.Y., Merot, A., Moulin, C.H., Navarrete, M. and J. Wery (2010) A modelling framework to support farmers in designing agricultural production systems. Environmental Modelling & Software 25,(2), 258-268.

Ligtenberg, A., Wachowicz, M., Bregt, A.K., Beulens, A. and D.L. Kettenis (2004) A design and application of a multi-agent system for simulation of multi-actor spatial planning. Journal of Environmental Management 72,(1-2), 43-55.

Lopez Ridaura, S., van Keulen, H., Van Ittersum, M.K. and P.A. Leffelaar (2005) Multiscale methodological framework to derive criteria and indicators for sustainability evaluation of peasant natural resource management systems. Environment, Development and Sustainability 7, 51-69.

Mathevet, R., Bousquet, F., Le Page, C. and M. Antona (2003) Agent-based simulations of interactions between duck population, farming decisions and leasing of hunting rights in the Camargue (Southern France). Ecological Modelling 165, 107-126.

Mauchamp, A., Chauvelon, P. and P. Grillas (2002) Restoration of floodplain wetlands: Opening polders along a coastal river in Mediterranean France, Vistre marshes. Ecological Engineering 18,(5), 619-632.

Mendez-del-Villar P. (1987) Economie des systèmes rizicoles en Camargue. Faculté de droit et des sciences économiques, Université de Montpellier 1, pp. 201.

Monticino, M., Acevedo, M., Callicott, B., Cogdill, T. and C. Lindquist (2007) Coupled human and natural systems: A multi-agent-based approach. Environmental Modelling & Software 22,(5), 656-663.

Mouret J.-C. and R. Hammond (2003) Elaboration de références agronomiques pour la conduite de la culture du riz (Oryza sativa L.) à partir de l'analyse des facteurs de variabiluté du rendement. 3era. Conferencia Internacional de Arroz de Clima Templado, Punta del Este - Uruguay, pp. 19.

Mouret J.-C., Hammond, R., Dreyfus, F., Desclaux, D., Marnotte, P. and F. Mesleard (2004) An integrated study of the development of organic rice cultivation in the Camargue (France)Challenges and opportunities for sustainable rice-based production systems, Torino, 13-15/09/2004, pp. 11.

Roche, H., Vollaire, Y., Martin, E., Rouer, C., Coulet, E., Grillas, P. and D. Banas (2009) Rice fields regulate organochlorine pesticides and PCBs in lagoons of the Nature Reserve of Camargue. Chemosphere 75,(4), 526-533.

Sadok, W., Angevin, F., Bergez, J.E., Bockstaller, C., Colomb, B., Guichard, L., Reau, R. and T. Doré. (2008) Ex ante assessment of the sustainability of alternative cropping systems: review of the implications for using multi-criteria decision aid methods. Agronomy for Sustainable Development 28, 163–174.

Sattler, C., Nagel, U.J., Werner, A. and P. Zander (2010) Integrated assessment of agricultural production practices to enhance sustainable development in agricultural landscapes. Ecological Indicators 10,(1), 49-61.

Scoones, I. and J. Thompson (1994) Knowledge, power and agriculture - towards a theoretical understanding In: I. Scoones, J. Thompson (Eds.), Beyond Farmer First: Rural People's Knowledge, Agricultural Research and Extension Practice. IT Publications, London, pp. 15-32.

Tittonell, P., Corbeels, M., van Wijk, M.T. and K.E. Giller (2010) FIELD--A summary simulation model of the soil-crop system to analyse long-term resource interactions and use efficiencies at farm scale. European Journal of Agronomy 32,(1), 10-21.

van Ittersum, M.K., Ewert, F., Heckelei, T., Wery, J., Alkan Olsson, J., Andersen, E., Bezlepkina, I., Brouwer, F., Donatelli, M., Flichman, G., Olsson, L., Rizzoli, A.E., van der Wal, T., Wien, J.E. and J. Wolf (2008) Integrated assessment of agricultural systems - A component-based framework for the European Union (SEAMLESS). Agricultural Systems 96,(1-3), 150-165.

Van Paassen A., Roetter, R.P., Van Keulen, H. and C.T. Hoanh (2007) Can computer models stimulate learning about sustainable land use? Experience with LUPAS in the humid (sub-)tropics of Asia. Agricultural Systems 94,(3), 874-887.

Vay, S. (2009) Calibrage d'un modèle de simulation du riz aux conditions de culture en Camargue. SupAgro Montpellier, France, pp. 44.