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From stakeholders narratives to modelling plausible future agricultural systems. Integrated assessment of scenarios for Camargue, Southern France

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ABSTRACT

European farmers are facing challenges that call for important transformations on their agricultural production systems, including an increasing number of regulations aimed at reducing environmental impacts from farming practices. Climate change is also expected to affect agricultural production in most European regions, and in Southern Europe this effect is expected to negatively impact yields. In this study, we present the application of an innovative participatory approach to assess the potential of innovative agricultural systems to reconcile environmental sustainability with economic viability while contributing to local and global food security. Our approach consisted of combining (1) the participation of local stakeholders in the design of narrative scenarios, and (2) an integrated assessment of scenarios through the calculation of indicators at different scale with a bio-economic model. We tested our approach with a case study situated in the Camargue region of Southern France. Rice is currently the main crop in this region, but farmers there face adverse economic conditions linked to the recent reform of European Common Agriculture Policy. After identifying the main drivers of change, local stakeholders developed narrative scenarios and described how farmers would adapt within the context of those changes. These elements were then translated into model inputs. At the regional level, the four scenarios led to variations in farmland acreage (28,000–33,000 ha), as well as the proportion of rice crops (19–75%) and areas cultivated under organic farming standards (8–43%). The four scenarios also led to different values for indicators of agricultural economic welfare, food production, and environmental impacts. Trade-offs between these indicators and the associated objectives assigned to agriculture were identified and discussed with the stakeholders. We end with a discussion of the limitations and advantages of our approach to the participatory development and assessment of locally developed narrative scenarios.

1. Introduction

1.1. Challenges for agricultural systems

European farmers are facing challenges that call for important transformations on their agricultural production systems, such as new regulations that constrain their management practices, especially in terms of their environmental impacts (e.g., pollution from leaching of nitrates and pesticides). The new rules pressure farmers to use practices that favour the reduction of pesticides use (European Commision, 2009, 2013). The emission of greenhouse gases (GHG) and the energy consumption of agriculture are also increasingly monitored to assess their contribution to, and potential for mitigation of, CC in Europe (see, for example, Smith, 2012; Bell et al., 2014). In the meantime, numerous studies (e.g., Olesen and Bindi, 2002; Maracchi et al., 2005; Miraglia et al., 2009; Olesen et al., 2007) contend that climate change (CC) is expected to affect agricultural production in most European regions, but differently between Northern and Southern Europe. While climate change may have positive effects on crop production in the North, southern areas could face water shortage and extreme events leading to lower yields, especially in Mediterranean areas (Olesen and Bindi, 2002; Maracchi et al., 2005; Miraglia et al., 2009). In these regions, climate change may threaten the achievement of food security

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objectives. New agricultural systems need to be developed with the objective of balancing environmental sustainability, economic viability, social acceptability and contribution to local and global food security.

Low input and organic farming (OF) systems have been suggested as potential ways to reconcile these issues (see, for example, International Assessment of Agricultural Knowledge, 2009; Loyce et al., 2012). Both of these farming systems use less chemical inputs and/or energy (Matson et al., 1997; Hossard et al., 2016), however, recent studies have highlighted yield losses of 19–25% for organic crops when compared to yields from conventional farming methods (Badgley et al., 2007; de Ponti et al., 2012; Seufert et al., 2012; Ponisio et al., 2015). Relative yield loss under low-input systems has been shown to range from zero to 12% for maize and soft wheat crops, respectively (Hossard et al., 2014, 2016). What's more, the profitability of these low-input systems is still variable. When cereal prices are high, even low yield losses may not be compensated by the reduction of input costs (Hossard et al., 2014). Examining the potential of these systems to simultaneously meet environmental, economic, and food security objectives in a future undergoing climate change requires integrated studies that combine research on these objectives and their potential trade-offs.

There is a large body of recent research analysing climate change scenarios and their impacts on crop production see, for example, Berg et al. (2013) and Donatelli et al. (2015). Projections have been made for impacts at regional, national and global levels, but in most cases these studies concern large areas, and few studies have simultaneously analyzed the impacts of CC and the evolution of local dynamics and constraints. These latter factors have considerable impact on viable adaptation and mitigation strategies for agricultural systems in a given region. This deficiency has led a number of authors to call for more studies involving smaller regions (such as ecoregions) that evaluate the potential impact of CC on agricultural systems (Abildtrup et al., 2006; Sleeter et al., 2012), and include the assessment and design of adaptation and mitigation strategies at the scale of farms (Reidsma et al., 2015).

Since the magnitude of CC and its consequences on crop physiology and resources (such as water) remain uncertain, relevant studies must be conducted using different CC scenarios. IPCC climatic scenarios project how CC impacts future weather conditions on a large scale, and modeling approaches attempt to down-scale these projections to regional and local levels (Abildtrup et al., 2006; Sleeter et al., 2012). However, the use of these results by local stakeholders of a given area often remains limited, and requires integration with the parallel evolution in local drivers of change that effect these same stakeholders.

1.2. Scenario studies

Therefore the development of regional scenarios that focus on potential agricultural systems in locally defined contexts should include both local and global drivers (including CC) (Ebi et al., 2014). This requires appropriate methods for scenario development. Narrative scenarios and Representative Agricultural Pathways (RAPs) are considered as a logical framework for studying the evolution of agricultural systems at different scales (Rosenzweig et al., 2013). Narrative scenarios can include both local and global changes: local dynamics such as urban development or specific environmental constraints, and global variables such as the evolution of the crop and energy markets, and climate change (e.g., Kok et al., 2006, 2007; Hossard et al., 2013; Reed et al., 2013). Narrative scenarios have been used to encourage stakeholders to think creatively about the evolution of land use and the possible consequences on indicators that are often related to socio-economic aspects (see, for example, Folhes et al., 2015) or ecological services (see, for example, Peterson et al., 2003; Bohensky et al., 2006; Plieninger et al., 2013). Such scenarios are often written as a short, coherent story, which is seen as a format suitable for being communicated to stakeholders (Rasmussen, 2005). A common practice includes the use of four different scenarios simultaneously delineated on the basis of two drivers that could evolve in two opposite directions (van 't Klooster and van Asselt, 2006). This enables stakeholders to quickly understand the explorative nature of the scenarios. Such scenarios usually include four elements: (1) a representation of the initial situation (reference), (2) a description of the drivers of change, (3) a description of the evolution of the system, and (4) a description of the future state of the system (Alcamo and Henrichs, 2008).

Scenarios can then be assessed in term of their capabilities to create good conditions for agricultural sustainability (Delmotte et al., 2013). The process of integrated assessment and modelling has proven to be capable of producing useful information about the possible future states of agricultural systems, and about the consequences of changes in agricultural systems on a wide range of sustainability issues (van Ittersum et al., 2008; Castoldi and Bechini, 2010; Bezlepkina et al., 2011; Reidsma et al., 2015). In this study, we present a method to (1) develop narrative scenarios related to the evolution of the agricultural systems by combining drivers of changes related to global changes and local constraints and opportunities, and (2) perform an integrated assessment of these scenarios. This method is aimed at foreseeing the possible future states of agricultural systems from the perspective of stakeholders, and assessing the consequences of these states with a model. We applied the method in collaboration with stakeholders in the Camargue, a wetland region in southern France. After presenting the case study and methods used for scenario development and analysis, we present an assessment of these scenarios. We then discuss the implications of these results for the case study, the methodological lessons learned, and the further improvements needed.

2. Methodology for narrative development and the modelling of plausible futures

This study was conducted during 2014 and 2015 in the Camargue, a deltaic region in the South of France. Following a brief introduction of the region's characteristics and an outline of the method for scenario development and integrated assessment, we present the four steps used in the methodology for scenario assessment, and the bio-economic model used to assess the scenarios.

2.1. The Camargue region

The Camargue is home to large tracts of protected wetlands which are recognized for their importance to biodiversity. These wetlands are in close proximity to agricultural land primarily used for livestock (extensive systems raising local landrace), and for intensive cultivation (c.a. 55% in rice crops, 30% in durum wheat). The Camargue is the only place in France where rice is grown on a large scale, and all industries associated with the supply chain are located in this region. The salinity of the region's groundwater tables is compounded by evapotranspiration that is on average twice as important as annual rainfall (Heurteaux, 1994). An irrigation and drainage system used for rice cultivation plays a crucial role in providing fresh water to the natural wetlands and controlling soil salinity in flooded fields. However, these rice fields represent a potential loss to the environment of pesticides (Comoretto et al., 2008) and greenhouse gases (GHG) (Linquist et al., 2012). Alternative farming systems, such as Organic Farming (OF) or low input systems, are expected to improve the sustainability of agriculture in the region (Lopez Ridaura et al., 2014). Since 2012, rice cultivation also faces challenges from the reform of the

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