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Two contrasted future scenarios for the French agro-food system

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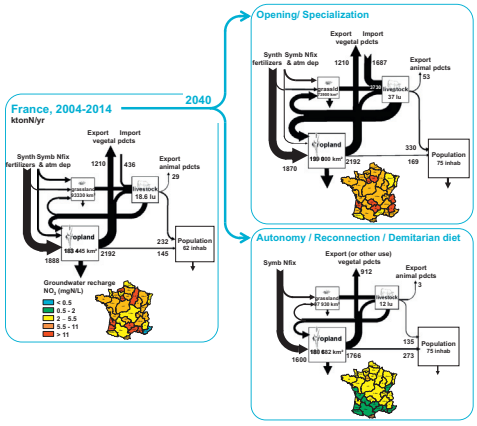
HIGHLIGHTS

- Two prospective scenarios for French agriculture at the 2040 horizon are described.
- O/S pursues the current trends of agriculture opening and specialization.
- A/R/D considers autonomy of farming systems, reconnection and a demitarian diet.
- The storylines are translated into a quantitative nutrient fluxes description.
- The A/R/D scenario can feed France with better environmental performances.

GRAPHICAL ABSTRACT



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ABSTRACT

Narratives of two prospective scenarios for the future of French agriculture were elaborated by pushing several trends already acting on the dynamics of the current system to their logical end. The first one pursues the opening and specialization characterizing the long-term evolution of the last 50 years of most French agricultural regions, while the second assumes a shift, already perceptible through weak signals, towards more autonomy at the farm and regional scales, a reconnection of crop and livestock farming and a more frugal human diet. A procedure is proposed to translate these qualitative narratives into a quantitative description of the corresponding nutrient fluxes using the GRAFS (Generalized Representation of Agro-Food Systems) methodology, thus allowing a comprehensive exploration of the agronomical and environmental performance of these two scenarios. The results show that the pursuit of the opening and specialization of French agriculture, even complying with regulations regarding reasoned fertilization, would result in considerable environmental burdens namely in terms of water pollution. The scenario generalizing organic farming practices, reconnection of crop and livestock farming systems and a demitarian human diet makes it possible to meet the future national food demand while still exporting significant amounts of cereals to the international market and ensuring better groundwater quality in most French regions.

1. Introduction

Being at the junction of several of the UN Sustainable Development Goals (UN, 2015), agriculture and human nutrition systems play a major role in human subsistence and welfare but are also strongly

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involved in the exceedance of safe planetary thresholds regarding N and P cycle perturbations, biodiversity loss and climate change (Rockström et al., 2009; de Vries et al., 2013).

In a short review paper, Smith (2013) showed that the challenge of feeding the future world population while reducing adverse environmental effects of agriculture will only be possible by combining sustainable intensification of cropping systems with fundamental systemic changes in food supply and demand, including changes in diet, reduction of waste and redesign of production systems.

During the last decade several prospective studies have been published exploring scenarios of a possible future for agro-food systems at the global scale. Among them Billen et al. (2015) and Erb et al. (2016) both explored the range of possibilities of feeding the projected 2050 world population by varying agricultural intensification, livestock feed composition and human diet, and demonstrated that a vast range of options exists for feeding the world, without expanding the global agricultural area. As also underlined by Kastner et al. (2012), the human diet (more specifically the fraction of livestock products in total protein ingestion) appeared as the strongest determinant of the "option space."

Lassaletta et al. (2016) and Muller et al. (2017) further showed that organic agriculture, if combined with structural measures including reduction of food wastage and animal product consumption would make it possible to meet the requirements of the current world population with much less pollution, and less long-distance trade, hence a higher degree of food sovereignty. Using the economic and biophysical model MagPIE, Schmitz et al. (2012) concluded that extension of food trade liberalization would increase trade fluxes, reduce global agriculture production costs, but substantially increase environmental damage and GHG emissions compared with a scenario with the current level of trade tariff. The role of trade was also addressed by Kastner et al. (2014), who concluded that the potential to reduce land demand by closing yield gaps with available production techniques is substantially larger than the hypothetical land savings achieved through international trade. The former strategy would also help poor importing regions to increase their self-sufficiency in terms of crop products, making them less vulnerable to global market fluctuations. By comparing the requirements and local production of food and feed at different scales to assess the current food self-sufficiency of populations, Pradhan et al. (2014) found that in 2000 about one billion people from Asia and Africa require cross-continental agricultural trade. By 2050, according to different scenarios regarding the population increase, diet composition and agronomical techniques, the number of people depending on international trade would vary between 1.5 and 6 billion. Further, climate change might increase the need for international agricultural trade by 4–16% (Pradhan et al., 2014).

As seen from this rapid and non-exhaustive overview of the prospective work carried out at the global scale, human diet, cropping techniques (in particular organic versus chemical farming), livestock feeding mode and the role of international trade are four major issues when addressing the challenge of future agro-food systems. These four issues are not independent of each other and two types of contrasted scenarios can be distinguished: those describing a future world with increased long-distance trade exchanges, further specialization and industrialization of agricultural systems, with a wide range of human diet according to economic development, and others privileging local reconnection of food production and consumption, of crop and livestock systems, as well as a more equitable diet.

To give further substance to the debates between these two opposite views of the future global agro-food system, it might be meaningful to apply them at a smaller scale, in order to consider them in view of the practical reality of regional situations. France is an interesting case study regarding industrialized countries, because it is, on the whole, the world's eighth largest producer and fourth largest agricultural exporter (www.fao.org/faostat), but displays a wide range of contrasting regional situations. Indeed, the French agro-food system is presently characterized by a high level of specialization, with territories devoted to intensive crop farming, disconnected from livestock husbandry, and others with very high livestock densities that are highly dependent on feed imports from remote regions, while large areas remain as a form of mixed crop and livestock farming (Le Noë et al., 2017). Examining the long-term trajectory of French regional agro-food systems showed that the current state of affairs has been established during the second half of the 20th century, under the impulse of a voluntarist public policy, from a previous long-lasting situation where connected crop and livestock farming systems dominated everywhere (Le Noë et al., 2018a). This public policy voluntarism diminished considerably after the 1980's, giving way to more liberal governance that reinforced openness and specialization, while environmental measures tended to limit, more or less successfully, the pollution generated (Bureau and Thoyer, 2014).

Here we describe two possible futures for the French agro-food system by exploring the ultimate outcome of a number of opposite trends co-existing in the current situation, leading to two contrasted sets of storylines, each qualitatively describing what the French agro-food system could be at the horizon of 3–4 decades (Section 2). We then use the GRAFS methodology to translate these storylines into a coherent and quantitative description of N and P fluxes throughout the system at the regional scale. The GRAFS approach was first developed by Billen et al. (2014) as an accounting method for providing a picture of N fluxes at the global scale, making it possible to check the coherence of estimates coming from various independent sources, based on the criterion of mass conservation. It was later applied to the scale of 33 regions in France and extended to P and C fluxes by Le Noë et al. (2017). In the present paper (Section 3), we thus further enrich the GRAFS methodology in order to use it as a tool for scenario elaboration, regarding demography and human diet, cropping systems and connection to livestock systems. Finally (Section 4), the detailed descriptions of the two scenarios obtained are used to explore their agronomic performances, their capacity to meet the food requirements of the French population and their position in international exchanges, as well as their environmental imprint in terms of nutrient cycling and resource requirements.

2. The storylines of the scenarios

Two contrasted scenarios of the future French agro-food system were elaborated, not to predict the future or to prescribe what it or should not be. The aim is instead to discern within the present dynamics of the system, a number of trends, currently contradicting each other, and to explore the trajectory that could be followed if these trends were pushed to their extreme. The following storylines therefore mix facts about certain trends that can be perceived in the current French agro-food system and fictions about how they may evolve at the 2040–2050 horizon.

2.1. Pursuit of past trend towards opening and specialization: the O/S scenario

The most striking trend in the development of French agriculture over the last 50 years is its voluntarist integration into international markets. Export of French cereals has regularly increased since the 1960's, while import of feed, mainly soybean from South America, has increased fivefold (Fig. 1a, b). This has gone hand in hand with the specialization, in stockless crop farming of the most fertile lowland regions, such as the Paris and Aquitaine Basins and the Alsace Plain, while the Great West regions specialized in intensive livestock farming (Le Noë et al., 2017, 2018b). Large harbor and land transport infrastructures have been established and are still projected, extending the harbor hinterland to remote grain-producing areas (Duszinski, 2013; Haropa, 2014). Support for this globalization of French agriculture was recurrently re-affirmed in political declarations at the national level, as illustrated by the declaration of former French president Sarkozy, 2009 "*We need to rebuild a policy and maritime ambition for France, around*