Matière
à débattre & décider

Land Use and Food Security in 2050: a Narrow Road

Agrimonde-Terra

Chantal Le Mouël, Marie de Lattre-Gasquet, Olivier Mora, eds

éditions Quæ

2. Agrimonde-Terra's Foresight Approach to Scenario Construction

Olivier Mora and Marie de Lattre-Gasquet

Introduction

THE FORESIGHT APPROACH has become widespread over the past decade, particularly in the fields of climate, energy, agriculture and the environment, as a means of anticipating future developments in a long-term perspective. It differs from work using projections as it takes into account the radical indeterminacy of the future, weak signals and possible ruptures in system trajectories, and the complexity of long-term dynamics. In the words of Gaston Berger, the future from a foresight perspective is not considered "as a thing already decided and which, little by little, will be revealed to us, but as a thing to be done" (1967). By design, it is the domain of contingency and action rather than necessity.

Foresight aims to increase the capacity of actors to prepare and shape their future by informing their decision-making with the anticipation of possible futures. So, foresight has both a heuristic function whose challenge is to better understand the potential and risks of contemporary dynamics (de Jouvenel, 1986), and an empowerment and decision support function (Miller, 2007; Godet, 2000). The Agrimonde-Terra foresight study aims to open and participate in the debate on the possible future of land use and food security, and to contribute to strategic thinking, research and public deliberation.

Choosing a systemic and exploratory approach to understand a complex problem

THE METHOD EMPLOYED HERE is firstly a response to the complexity and the high degree of uncertainty which characterize the issue being studied. It stems from the fact that issues of land use and food and nutritional security can be considered as 'wicked problems' (Rittel and Webber, 1973). According to Rittel's definition, 'wicked problems' are those with ill-defined outlines, marked by a high degree of uncertainty, where it is difficult to consider all the possible consequences of an action because

of the interdependence of factors and a multiplicity of values and actors that are present in the definition of the problem and its solution (Turnpenny *et al.*, 2009). So, depending on the actor under consideration, food security may be defined at a household, country or global scale, it may or may not incorporate nutritional issues (in particular the question of diet-related chronic disease), it may or may not focus on food availability and international trade, it may or may not be concerned with individual access to food and incomes. In addition, the term 'wicked problems' characterizes problems for which a simple and definitive formulation cannot be posed, to which a single solution cannot be applied. Answering one aspect of the problem may lead to or generate other problems because the dynamics are interlocked and the system is constantly changing. So the future relationship between land use and food security cannot be reduced to a single issue, for example population growth, but it is necessary to take into account changes in agricultural, environmental, climate and food systems etc.

Taken separately, the evolution by 2050 of each driver in the 'land use and food security' system (Chapter 1) is subject to great uncertainty, whether it be the impact of climate change, the energy transition, the intensification and transformation of agricultural systems and their impact on natural resources, nutritional transitions and the globalization of food supply chains, but also the processes of urbanization, or changes in international governance and public policies. But by 2050, these dynamics will actually act simultaneously and in an intermingled fashion to determine land use and food security. These interdependencies will increase the uncertainty tenfold. The foresight approach chosen by the Agrimonde-Terra project is a *systemic* approach for exploring the transformations in this complex system of interdependencies.

Agrimonde-Terra has been defined as an *exploratory* study whose goal is to prepare actors for different possible futures, by providing them with elements for understanding and anticipating future issues in the form of scenarios. A scenario describes the trajectory and future state of the system, defined by a plausible and consistent combination of hypotheses about the previously mentioned drivers and their relationships. Each scenario offers both a reformulation of the problem of the relationship between land use and food security by 2050, identifies the issues to be addressed and, in some cases, provides a series of options to solve them.

The scenarios constructed are not strictly *normative* because they also include undesirable situations and situations with ambiguous consequences. Nor are they simply projections or extrapolations of current trends because they take into account possible ruptures and weak signals. The development of *exploratory* scenarios made it possible to update a variety of possible system trajectories. Ultimately, the set of scenarios developed by Agrimonde-Terra aims to contribute to public and scientific debate and deliberative processes by functioning as a learning device (Rhisiart *et al.*, 2015) through which actors can become acquainted with and anticipate the challenges to come.

A scenario approach combining morphological analyses, foresight forums and a quantitative simulation tool

The method adopted by Agrimonde-Terra to consider the future of land use and world food security by 2050 combines various approaches: a scenario method based on morphological analysis (Ritchey, 2011) and applied at various system scales, the implementation of *foresight forums* to discuss hypotheses on evolutions of the system (Jouvenel, 1972; Mermet, 2009), and the construction and use of a modelling and simulation tool, called GlobAgri-AgT. From a methodological point of view, these different types of approaches are inspired by the French *'prospective'* school (Godet, 2000; de Jouvenel, 2000).

The choice of the foresight method meets both the study's objectives and the characteristics of the system being studied. In the case of Agrimonde-Terra, the method responds to both the challenges posed by the complexity of the system, taking into account long-term changes and high degrees of uncertainty, and also to the study's aim of being exploratory. Using the scenario method based on morphological analysis makes it possible to consider a large number of alternative scenarios based on a common analysis of the system's dynamics, while taking into account a high degree of uncertainty (Zurek and Henrichs, 2007). In comparison, a four-quadrant scenario method (Schwartz, 1991), which might seem appropriate for systems with some stability over time, allows for only a small degree of differentiation between scenarios and reduces uncertainties to two factors (the two axes of the quadrants), which structure the future of the system.

Using morphological analysis in scenario construction makes it possible to conduct a systematic analysis and exploration of all the relationships which exist between the multiple dimensions of complex problems (Ritchey, 2011). Developed by Fritz Zwicky in the 1940s, morphological analysis is a qualitative method which alternates analysis and synthesis in order to imagine the multiple states of a given system. It is a rigorous and creative method. In scenario building, morphological analysis begins by analytically breaking down the system into sub-systems or drivers, for which alternative hypotheses of changes to 2050 are constructed. Following this, morphological analysis makes it possible to systematically visualise all the possible combinations of the hypotheses, and to identify among them the alternative combinations, both plausible and internally consistent, which give shape to different scenarios describing the future states of the system. Morphological analysis ensures the traceability of the scenario construction process by making explicit all the hypotheses used in the different phases of the process. Finally, it is a question of reducing the number of possible configurations of the morphological space by defining relevant configurations of hypotheses which trace the contours of a 'space of possible futures', which is a morphological sub-space. It is in this space that organisations and individuals will have to navigate, anticipate and act in the future.

Within Agrimonde-Terra, different morphological analyses were carried out successively, first at the scale of the system drivers and then at the scale of the system as a whole. The various morphological analyses conducted on the drivers provided the base required for constructing a morphological analysis of the entire system, acting as a series of 'nested boxes'. This architecture, coupled with the hypotheses and scenarios, makes the scenarios that have been developed highly robust. Indeed, the construction of hypotheses and the choice of hypotheses forming the scenario are both transparent and traceable and, in particular, comparisons can be made between the hypotheses selected for each scenario.

Each sequence of the foresight work relied on a specific forum of experts to formulate hypotheses for changes and for the scenarios. To study the future evolution of drivers, four separate expert forums worked in parallel to conduct foresight reflections on four themes, bringing together 80 researchers from developed, emerging and developing countries. At the system scale, scenario building was based on the expertise of a Scenario Advisory Committee made up of around 15 international researchers and decision-makers. This committee met four times to discuss and validate the hypotheses about the future of the drivers of the 'land use and food security' system, the combinations of hypotheses and the scenario narratives, the quantification of the scenarios and the results of the simulations.

Finally, Agrimonde-Terra brings together a qualitative approach to scenario building through morphological analysis and a modelling approach based on the construction of a data platform and the Globagri-AgT biomass balance model (Chapter 3). As Laurent Mermet (2005) points out, "conducting foresight reflection using models requires the ability to take into account very heterogeneous levels of analysis, from the philosophical concepts underlying the architecture of the suggested model, through to the choice of the data used, or the writing of certain model equations". In Agrimonde-Terra, the choice was made to use a conceptually relatively simple biomass balance model. The advantage of balance models is the high degree of flexibility for which they can be used. The balance model can easily be adapted to a variety of relationships between system drivers and can simulate highly contrasting scenarios. The fact that the scenarios are based on morphological analysis makes it possible to systematically link the qualitative hypotheses and their quantitative translation into simulation input data (Chapter 14). The morphological table in which the hypotheses used in each scenario are listed provides a unified reasoning framework which enables the use of the quantified model. This approach responds to some of the issues identified in the scientific literature by explaining the relationship between the quantification model and the consistency of the hypotheses (van Vuuren *et al.*, 2012). The coherence of hypotheses at the system scale is qualitatively assured by the morphological analysis on which the scenarios are built; while the biomass balance model specifies the scale and scope of changes described in the scenarios and provides the elements to compare scenarios.

The steps in scenario construction

THE CONSTRUCTION OF THE SCENARIOS took place in four steps: (1) the definition of the 'land use and food security' system; (2) the construction of the alternative hypotheses of changes to 2050 for each driver of the system; (3) the development of land use and food security scenarios by combining hypotheses and the construction of narratives describing the scenarios, and (4) the implementation of simulations illustrating the quantified impact of the qualitative assumptions on land use and food security.

Step one: Defining the 'land use and food security' system

Through an analysis of land use and food security, the Agrimonde-Terra foresight study identified a system of land use and food security defined by four direct drivers and three external drivers of changes in land use (Chapter 1). All of these drivers were considered separately, first by examining their possible changes to 2050 (see Step 2), and then interacting within the framework of the construction of scenarios where the drivers are linked according to pertinent and consistent configurations (see Step 3 and 4).

Step two: Construction of alternative hypotheses to 2050 for direct and external drivers of changes in land use

In order to construct alternative hypotheses describing the state of each driver in 2050, past changes in the direct and external drivers of the 'land use and food security' system, as well as the weak signals of change and possible ruptures in the future, were studied in detail.

The four direct drivers – urban-rural relationships, farm structures, cropping systems and livestock systems – were examined by four expert groups comprising 20 or so national and international specialists in each field. The prospects for each driver by 2050 were the subject of at least two days of thematic workshops which brought the experts together. In advance of the thematic workshops, a dedicated team composed in general of two scientific managers and a coordinator (Box 2.1), conducted an analysis of the past dynamics of the driver's evolution through a preliminary review of the literature. These results were discussed in the two-step workshops. After characterizing each driver according to a set of variables (Table 1.1, Chapter 1), past trends, weak signals of changes and possible future ruptures were identified for each variable on the basis of the literature review and expert analysis (Chapters 6 to 12). Based on a morphological analysis, hypotheses describing the possible evolution of the driver by 2050 were then sketched out with the experts in the field. Downstream of the workshops, the dedicated team developed and formalized the conclusions of the workshops in the form of alternative hypotheses for the evolution of the driver, making these results available for the following step. This process was repeated for each of the four direct drivers of land-use change.

With regard to the three external drivers of change – climate, diet and the global context – the hypotheses for their evolution to 2050 were developed on the basis of a literature review of existing trends and scenarios, and the development of a morphological analysis.

Step three: Building land use and food security scenarios

Step three involved the construction of land use and food security scenarios. It was carried out with constant interaction between the project team and the group of international experts forming the Scenario Advisory Committee (Box 2.1) over a period of one and a half years.

Box 2.1. Agrimonde-Terra Organization

Agrimonde-Terra was composed of:

- Project team: Marie de Lattre-Gasquet (Coordinator, CIRAD), Chantal Le Mouël (Coordinator, INRA), Olivier Mora (INRA, organiser for scenario building), Catherine Donnars (INRA), Patrice Dumas (CIRAD) and Olivier Rechauchère (INRA), with the collaboration of Thierry Brunelle (CIRAD), Stéphane Manceron (INRA), Elodie Marajo-Petitzon (INRA), Clémence Moreau (CIRAD), Marco Barzman (INRA), Agneta Forslund (INRA) and Pauline Marty (INRA).
- Steering committee: Pierre Fabre (replaced in 2015 by Alain Billand) (CIRAD), Hervé Guyomard (INRA), Etienne Hainzelin (CIRAD) and Bertrand Schmitt (INRA).
- Scenario Advisory Committee (international experts chosen *intuitu personae*): Agnes Andersson Djurfeldt (Lund University, Sweden), Leïth Ben Becher (Synagri, Tunisia), Mohamed Elloumi (INRAT, Tunisia), Adama Faye (IPAR, Senegal), Richard Guissou /Yves-Gérard Bazie (Ministry of Agriculture and Food Security, Burkina Faso), Holger Kray (World Bank, USA), John Lewis (Terra Global Capital, USA), Patrick Meyfroidt (Louvain University, Belgium), Marc Mueller (FAO, Italy), Siwa Msangui (IFPRI, USA), Antonio Onorati (International Planning Committee on Food Sovereignty, Italy), Stéphane Parmentier (Oxfam, Belgium), Alain Retière (Cap 2100, France), Roberta Sonnino (Cardiff University, UK), Sébastien Treyer (IDDRI, France), Dominique van der Mensbrugghe (AgMIP, Purdue University, USA), Joost Vervoort (CCAFS and Oxford University, UK) and Hisham Zehni (IFAD, Italy).
- Scientific coordinators and managers of the thematic workshops:
  - Urban-rural relationships: Olivier Mora (Coordinator, INRA), Francis Aubert (AgroSup Dijon) and Frédéric Lançon (CIRAD).
  - Production structures: Catherine Donnars (Coordinator, INRA), Jacques Marzin (CIRAD) and Laurent Piet (INRA).
  - Cropping systems: Olivier Réchauchère (Coordinator, INRA), David Makowski (INRA), Eric Malézieux (CIRAD) and Florent Maraux (CIRAD).
  - Livestock systems: Stéphane Manceron (Coordinator, INRA), Patrice Dumas (Coordinator, CIRAD), Philippe Lecomte (CIRAD), Alexandre Ickowitz (CIRAD) and Philippe Lescoat (AgroParisTech).
- 80 experts who participated in the thematic workshops.

The composition of the Scenario Advisory Committee and the choice of experts were driven by the need for a multidisciplinary approach, for expertise in various fields and for expertise from stakeholders. On the one hand, the construction of scenarios on land use required the involvement of experts from different fields in order to understand the complexity of the phenomena of land use and food security. On the other hand, in order to take into account the point of view of actors engaged in these fields and their visions of the future, experts from international and national institutions (World Bank, FAO, IFAD, IFPRI and Ministries of Agriculture) and civil society stakeholders were included in the committee. The latter were leaders of farmers' organisations and non-governmental development organisations involved in the international arena where food security and land use issues are debated.

In the first step, the Scenario Advisory Committee examined and discussed all the alternative hypotheses for the evolution of the direct and external drivers produced in previous workshops. A basis for analysis was created, describing the current situation of the 'land use and food security' system and its past dynamics. On this basis, the project team constructed a morphological table showing all the alternative hypotheses for the evolution of all the drivers in the system (Figure 13.1). This table served as the basis for the rest of the forward-looking thinking as well as for the simulations carried out using the GlobAgri-AgT model, and for the production of the scenarios, followed by the regionalization of the scenarios. In a second step, five land use scenarios were constructed in close collaboration with the Scenario Advisory Committee. Each scenario consistently and plausibly combines the evolution hypotheses for each driver and provides an image of the state of the system in 2050. A narrative was elaborated for each scenario describing the change trajectories in land use and food security and the causal relationships which link drivers to each other were identified. Finally, the scenarios were enriched by the production with the committee of regional variations for each scenario. This work was based on a retrospective analysis of regional changes in land use and each driver of the system in six world regions.

Step four: Quantifying of hypotheses and simulating scenarios

The scenarios were illustrated quantitatively using the GlobAgri-AgT data and model developed and run by a dedicated team. The results and the consistency of the scenario simulations were discussed with the Scenario Advisory Committee, an exchange which made it possible to specify the ways of quantitatively translating the evolution hypotheses for the drivers, to finalise the results of the simulations and to interpret them. This simulation work made it possible to evaluate how each region fits into a scenario and to identify regional issues.

The outcomes of Agrimonde-Terra and their use

THE WHOLE PROCESS led to the finalization of the scenarios presented in Chapters 13, 14 and 15, with the five scenarios constructed by Agrimonde-Terra available for different

world regions. For each scenario, a narrative of the future situation in the 'land use and food security' system in 2050 details land use in five dimensions, and food and nutritional security in four dimensions (availability, physical and economic access, food utilization and stability of access over time). The narrative specifies the system's trajectory, in other words, the events, ruptures, causal relationships and public policies that have influenced the evolution of the system (Chapter 13). Based on the morphological analysis of the 'land use and food security' system, simulations from the GlobAgri-AgT model provide quantified estimates for each scenario in terms of changes in land use, production and use of agricultural products, international trade and food availability at global and regional scales (Chapter 14).

Agrimonde-Terra's outputs have been developed to provide a tool for dialogue and reflection for stakeholders in decision-making on land use and food security. Three Agrimonde-Terra outputs are likely to be used in other regional or national foresight reflections: the retrospective and prospective analysis of the factors of change (Chapters 6 to 12), the five Agrimonde-Terra scenarios (Chapter 13) and their quantitative illustration using the GlobAgri-AgT model (Chapters 3 and 14). At the regional scale, Agrimonde-Terra's conceptual framework and outputs provide elements for analyzing the current land use and food security situation, the current trends leading to each scenario and possible changes to the 'land use and food security' system by 2050, as has been done for sub-Saharan Africa (Chapter 15). Furthermore, Agrimonde-Terra's outputs and the existing methodology can be reused by *ad hoc* groups of public and private actors in order to build land use and food security scenarios at the territorial, national or large regional scale. This has already been done, for example, in Tunisia (de Lattre-Gasquet *et al.*, 2017a).

Conclusion

The foresight method developed within Agrimonde-Terra combines a consideration of complexity, an exploratory approach envisaging a plurality of futures and a combination of qualitative scenarios and model-based simulations. The partial and overall results from the study can be used within the context of national or regional foresight exercises conducted by groups of actors (researchers, professionals, NGOs and public decision-makers) reflecting on the links between land use and food security in the long-term.