Food (In)security: the New Challenges Ahead

Les nouveaux défis de l'(in)sécurité alimentaire

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Abstract

Producing more, with less, is the consensus to solve the current food security equation of feeding a projected nine billion people by 2050 under growing water scarcity, energy competition and land degradation constraints. This wide consensus however can be challenged by the outcomes of other future studies. The purpose of this article is to use a wide range of recent future studies related to agriculture and rural development to critically review this paradigm. Drawing from a meta-analysis of 38 recent foresight studies at various levels, we identify future key drivers of change and discuss their implication for food security. The sample of futures studies, though not exhaustive, is the most comprehensive state-of-the-art of foresight applied to agriculture and rural development. We found that foresight in agriculture is entering into a third generation where key drivers of change include social and political forces as potential sources of discontinuities. As a consequence we propose a shift from the food security equation to the exploration of food insecurity whose multiple roots are anchored in social, political, economic and institutional dimensions. We also advocate for future studies to focus on ruptures and discontinuities rather than trends. Present and future technology development plays a pivotal role either as a pre-active instrument to adjust (partly) to the food security equation or a pro-active instrument to answer (partly) the food insecurity challenges.

Keywords : Food Security, Foresight, Agriculture, Policies, Societal Values, Technology

résumé

Produire plus avec moins, c'est le consensus pour résoudre l'équation actuelle de la sécurité alimentaire : nourrir plus de neuf milliards de personnes en 2050 malgré la rareté croissante de l'eau, la compétition pour l'énergie et les contraintes de la dégradation des terres. Ce large consensus peut cependant être remis en cause par les résultats d'études prospective. Le but de cet article est d'utiliser un large éventail de futures études récentes liées à l'agriculture et le développement rural pour un examen critique de ce paradigme. Un inventaire de 38 études récentes de prospective à différentes échelles permet d'identifier les futurs moteurs du changement et de discuter de leurs implications pour la sécurité alimentaire. Cette étude montre que la prospective en agriculture est entrée dans une troisième génération où les principaux moteurs de changement et sources potentielles de discontinuités sont les forces sociales et politiques. En conséquence, nous proposons le passage de l'équation de la sécurité alimentaire à l'exploration de l'insécurité alimentaire dont les racines sont ancrées dans de multiples dimensions sociales, politiques, économiques et institutionnelles. Nous plaidons également pour que les études du futur se concentrent sur les ruptures et les discontinuités plutôt que les tendances. Le développement technologique actuel et futur peut jouer un rôle important, soit comme un instrument pré-actif d'ajustement (partiel) à l'équation de la sécurité alimentaire, soit comme un instrument pro-actif de réponse (partielle) aux défis de l'insécurité alimentaire .

Mots-clés: sécurité alimentaire , prospective , agriculture , politiques , valeurs sociétales , technologie

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Introduction

Trend based projections and simulations applied to food security conclude that in order to ensure food security a steady growth of productivity is required along with more attention to sustainability. Under the assumption of the pursuit of a business-as-usual scenario these studies derive their conclusions from a combination of several factors, mainly linked to demography, urbanization, climate change and yields. Demographic projections vary greatly but there is today a shared belief that by 2050 there will be 9 billion people to feed in the world. Most studies indicate that achieving food security would mean providing an increased amount of calories per capita, as a growing number of consumer will live in cities, as middle-classes will grow, all leading to some significant global changes towards a more western-like consumption pattern. This would happen at a time when, under trend/business-as-usual scenarios, resources, in particular land, water, minerals and energy would be subject to growing competition and likely for most of them, further scarcity, degradation or depletion. Climatic uncertainties, price volatility are projected to remain or further increase and add to the challenges of food security. As a response most studies propose productivity growth along with some more attention to sustainability as the only way to cope with the widely spread notion of a "perfect storm" (Godfray et al. 2010). The concept of sustainable intensification crystallizes the current rhetoric of the international agricultural research and development community.

The future of agriculture and beyond, the future of rural and world poverty, the future of food and nutrition security and the future of our natural resources, depend all on the decisions we are making today. These decisions have not only to answer the urgent and burning issues we are currently facing; they have also to integrate the challenges of the future. Research, innovation and policies are expected to provide answers or solutions to current problems where they can. They are also expected to anticipate and prevent future problems.

Foresight is defined here as "a process which combines three fundamental elements: prospective (long-term or forward-looking) approaches, planning (including policy-making and priority-setting) approaches, and participative approaches (engaging stakeholders and knowledge sources)" (Popper 2009:8).

The 2nd Global Conference on Agricultural Research for Development (GCARD2) organised in Punta del Este, Uruguay, last year provided the opportunity for key stakeholders of the world's Agricultural Research for Development system to learn more about foresight, to exchange experiences and to reflect on the need for improved foresight (Holderness et al. 2013).

The preparation of the GCARD2 foresight sessions was based on an extensive review and analysis of recent foresight studies focusing both on content and processes. This article presents the main findings of this review related to the content of these foresight studies.

Materials and Methods

Source of data and data collection

This meta-analysis of recent foresight works in agriculture combined different approaches to enable verification of information from different. The methods included a worldwide survey, examination of websites of organizations for information related to foresight and document review.
The survey was prepared in seven languages . It included questions about the activities of the individuals/organizations contacted related to exploring the future evolution of, or future challenges in agriculture or rural development in the next 20 years. Questions focused on the outcomes, the topics, and the involvement of the respondents in these activities.

We used a web-based survey provider to administer the questionnaire. The survey was available online for seven weeks with three reminders sent during this period. Of the 5848 emails sent, 93% were successfully delivered. We received 1136 responses, of which 54.6 % were completely exploitable. The data was organized and analysed using MS Windows Excel and NVivo.
A total of 411 respondents indicated that they had engaged in foresight activities related to agriculture, rural development or farming systems and informed us that their work was documented and that they were willing to share it. We contacted all of them and asked for the documents. A group of 11 foresight specialists1 screened these documents using the three following criteria: i) recent (less than 5 years), ii) looking at least 10 years ahead, and iii) related to agriculture/rural development/farming systems. Only documents scoring a positive answer to all three criteria were finally kept for the analysis.

Simultaneously, a multi-lingual group of interns conducted a bibliography and web review in search for other works which might have been overlooked. In total, survey plus web search included we found 65 relevant studies. Some relevant foresight studies might not have been included, but we believe that these would not be so many as our search process was quite extensive and used also our respondents to inform us about other studies they might be aware of. The selected relevant cases provide, so far, the most comprehensive update on recent foresight studies in agriculture.

Most of the cases are based on a great variety of documents, ranging from slide shows to referred journal articles, including various type of grey literature such as internal reports. In order to enable a wider audience (including civil sector organizations) to access these works and easily find their key messages, we proposed to the authors to produce shorter, concise and attractive four-page Briefs. Each Brief had to provide the same set of key elements and messages on content, process, impact and lessons learned.

We organized three write workshops for the authors to enable them to produce the briefs and interact with their colleagues. One workshop was conducted for Europe, Central Asia, Near East and Africa, one for Asia and the Pacific, and one for the Americas. Some of the authors who could not attend the write accepted to work on the Brief remotely. We created a series “The Futures of Agriculture” which is available with open access2. The series has so far 41 Briefs of which 38 are foresight studies or synthesis of future studies studies and three are regional updates on research needs.
Thie meta-analysis on which this paper is based draws information from these 38 Briefs. The results presented here focus on the content of these foresight studies, not on their elaboration process.

Results

Focal topic of the foresight works

The 38 foresight studies from which information has been collected directly from their authors and published in the series “The Futures of Agriculture” present the following characteristics

- Twelve global foresight studies, all of them with a focus on agriculture;
- Ten regional foresight studies, four focusing on food and agriculture, three on rural societies, one on low carbon society

[1] Reviewers were from International Research Centers (4), Universities (3), National research Centers (3), and National research Organizations (2) and eight different countries: Argentina, Australia, Brazil, France, Germany, The Netherlands, South Africa, Tanzania and the UK.
[2] http://www.egfar.org/our-work/shaping-future-together/global-foresight-hub/publications

- Sixteen national foresight studies: seven focusing on the future evolution of agriculture, three on research priorities and research systems, two on territorial development and one on climate change.

Food security is the pre-dominant topic at global scale and regional scale, while productivity and sustainability are more ,important at national/local scale (table 1).

Table 1. Distribution of topics according to the scale of the studies

Scale of the studies	Food security	Productivity	Sustainability
12 global	12 (100%)	7 (60%)	8 (75%)
10 regional	5 (40%)	3 (30%)	3 (30%)
16 national/local	4 (25%)	6 (40%)	6 (40%)

The drivers of the future are factors which are considered in a future study as the forces which have potential in shaping the transformation to come. We distinguish here the "usual" drivers which have been traditionally at the core of most of the past foresight work ans very often associated with the trends which will induce the pursuit of the current path in a somehow predictable way, and "new/emerging drivers" which are becoming increasingly recognised in recent foresight as potential forces which can bring discontinuities leading to different paths.

In the first category we include climate change (cited 22 times), technology (12), market forces (10), demography (9) and growth and income (5). In the second category we put policy and governance (cited 28 times), consumer behaviour (12) and social values (10).

The "usual" drivers

Climate change

Nine of the twelve global studies incorporated climate change in their analysis. Five of them include climate change as a global constraint that has to be taken into consideration though adaptation strategies (Briefs 1, 2, 16, 17, 38). Four directly and explicitly integrate climate change as a key driver from which they built their futures scenarios (Briefs 21, 40, 42, 43).

Nine of the ten regional studies incorporated climate change in their analysis. Seven of them take climate change as a global constraint that has to be taken into consideration though adaptation strategies (Briefs 3, 7, 8, 14, 25, 31). Only two directly and explicitly integrate climate change as a driver from which they built their futures scenarios (Briefs 11, 19).

Five of the 16 local/national studies incorporated climate change in their analysis. Two of them take climate change as a global constraint that has to be taken into consideration though adaptation strategies (Briefs 20, 41). Three studies directly and explicitly integrate climate change as a driver from which they built their futures scenarios (Briefs 23, 30, 34).
Foresight studies which incorporate climate change as a direct driver did not develop their specific scenarios but were basing their work on existing foresight work (11, 30, 34, 43)

Demography

Four global, four regional and two local studies included demography and population related issues. The most frequently cited are population growth (Brief 07, 08, 21, 38, 39, 40, 41, 42) followed by variables linked to the distribution of population such as urbanisation, migration and density (Brief 08, 11, 21, 31, 41) and structure of the population including ageing (Brief 08, 11, 21, 31). In most

cases demography variables were part of the general context shaping the transformation to come (Briefs 08, 11, 38, 39, 41, 42. Four cases explicitly take demographic variables as key drivers of change (Briefs 07, 21, 38, 40).

Trade and markets

Two global, three regional and five local studies included trade and market related issues as drivers of change. The most frequently cited issues are related to trade regulation, such as barriers, liberalisation (Brief 07, 16, 25, 36, 28, 41) followed by commodity prices (Briefs 10, 15). In only one case trade and market variables were part of the general context shaping the transformation to come (Brief 34). All other cases take explicitly trade and markets variables as key drivers of change. It is important to note here that an additional seven cases included trade an market issues as output variables without making them explicit drivers (Briefs 01, 11, 14, 19, 27, 42).
Income and growth

Four global and two regional studies included income and growth related issues as drivers of change. They highlight two types of drivers: economic development and growth (Briefs 07, 21, 31, 40) and income level (Briefs 13, 38). In two cases income growth variables were part of the general context shaping the transformation to come (Brief 21, 38). Four cases take explicitly income or economic development and growth variables as key drivers of change (Briefs 07,13, 31, 40). Three additional cases included farmer income as output variables without making them explicit drivers (Briefs 27, 35, 43).

Technology

Of the 38 studies, 29 of them include a reference to technology. However, 12 of them of which five global, four regional and four national studies included technology related issues as drivers of change. They mainly take technology in a broad sense of technological development (Briefs 07, 09, 10, 16, 18, 21, 25, 28, 40, 41). In one case technology variables were part of the general context shaping the transformation to come (Brief 10). All other cases take explicitly technology variables as key drivers of change. These cases do not include the particular situation for technology being incorporated in the future studies as the response to the challenges, while not being considered as the key drivers or the contextual elements of transformation. This gives technology a very particular dimension in foresight studies which is discussed in the next session: technology related issues are a stake as such or through establishing research priorities (Briefs 01, 02, 04, 05, 11, 17, 19, 20, 23, 26, 31, 34, 35, 36, 37, 38, 43) and can be either conducive to continuation of the existing trends (adaptive technologies as presented in the Productivity Narrative presented in Brief 1) or the source of strong discontinuities (breakthrough technologies).

The new/emerging drivers

Policies matter!... And can be included in foresight. The most important point we can highlight in terms of content from this inventory is that policies[3] are increasingly recognized in foresight as key drivers of change. This is particularly true for qualitative foresight at national level. Actually, policies are considered as the drivers of change towards non-trend scenarios, as potential factors of discontinuity. Domestic policies are making one of the two axes of uncertainty used to build scenarios of the future of agriculture in Southern Africa (Brief 14) and in Thailand (Brief 23). They are also one of the six drivers on which scenarios for nature conservation and agricultural development were built in Kapuas Hulu district, Indonesia (Brief 18) and several policy variables were combined to build scenarios for collaborative land use planning on Seram Island, also in Indonesia (Brief 39).

[3] Policy refers here to how and why a government acts at various levels. It is about the principles guiding action taken by the administrative or executive branches of the state.

National trade policy is the main driver of the three scenarios in the case of agriculture in Morocco (Brief 41). Policies are also constitutive of the axis on the national environment for Research Development and Innovation in the scenarios used to build the 5th Action Plan of EMBRAPA in Brazil (Brief 36).

That policies matter is thus not just a general statement; some of the foresight works go deeper and contribute to define how policies can shape the future. These include for example governance/cooperation styles such as the respective role of state and non state actors (Brief 03), or power relation (Brief 40).

Societal values matter! Not just agriculture. Ten foresight cases include societal drivers of change, under the form of values, behavior (excluding consumer behavior) and education. Seven of them are national or local foresight studies showing the importance of developing more locally specific foresight works in order to capture drivers which are disregarded at more global level due to their specificity. These cases usually directly express them as drivers of change for example in preparing for emerging challenges to animal health (Brief 26), evolving towards more sustainable use of resources society (Briefs 19, 32), land use planning (Briefs 18, 39), building scenarios for research or development (Briefs 28, 41).

Consumption patterns

In twelve foresight studies we analysed, dietary patterns are explicitly considered as key determinants of food security and evolution of diets is seen as a strong driver of future production patterns. Of these studies eight are global foresight works. They tackle consumer behaviour as a global driver and largely relate changes in consumption patterns, especially the animal content of the diets (Brief 01, 15) to other drivers such as income growth and urbanisation (Brief 13, 38). Policies targeting consumers are seen as having a substantial role through their potential to influence food consumption habits, empowering consumer to choose their diets (Brief 01). Waste management emerges as an area where policies can influence both production and consumption sides.

The main controversy arising from the exploration of future consumer behaviour relate to the trend toward the standardization of a Westernized consumption patterns with more animal proteins and higher calorie intake as projected in many global scenarios and projections (Brief 01, 15, 38, 42) with a massive demand of food supplied through international markets versus regional and diversified consumption patterns supplied by local/proximity production systems. This controversy is fed by possible contrasted evolutions of the dietary patterns, and the existence of alternative options to "consumption as usual" including signs or simulations of decreasing consumption of animal protein and healthier more diversified diets (Brief 01, 15, 16, 42) noting also that convergence of dietary patterns is not inevitable (Brief 13, 38). Uncertainty about the impact of healthier diets on GHG emissions adds to this controversy (Brief 13).

Farming patterns of the future

A paradoxical result from this inventory is that while many stakeholders are concerned with the livelihood of smallholder farmers, the future of farmers and farming patterns of the future are rarely the central point in future studies. This is true for our sample of 38 case but also worldwide. Most future works focus usually include one or another aspect of production patterns (technology, farm size, productivity), with the exception of the Oxfam case study (Brief 02) introducing a typology of farms.

However, many cases display the possibilities of different futures with different ways of farming providing insights on potential evolution and challenges (Briefs 02, 03, 04, 05, 17, 23, 41 or priorities (Briefs 20, 36, 41) for farmers and future farming patterns. Some indicate that alternative options to the current paradigm of intensified productivity, short term profit and related drivers of the "business as usual scenario" in farming exist (Brief 01, 02, 03, 08, 16, 41), indicating also that location matters due to bio-physical and socio-economic variations (Brief 07).

Farming patterns of the future are often characterized by an opposition between two types: more technologically oriented capital-intensive systems often industrialized at large-scale or more ecologically-oriented systems that rely strongly on environmental services often associated with small-scale, largely family based, agriculture (Brief 17). The first type is associated with trends towards more and more concentrated commodity production for mass consumption. The second type could take different forms according to the location (small-size family farming in regions where people are poorer and levels of education are low or where it can play an important role in the economy and social life – Brief 41), hobby or part time farming for a more diversified consumption and/or niche markets. Interaction between different types of farms is also highlighted leading to the questions How can different farms co-exist in the same geographic and economic space? (Brief 02, 03, 08, 41).

Most of the works agree that the futures of farming patterns are determined by the simultaneous and interconnected play of multiple drivers. In addition to more "conventional drivers, such as technology, market, climate change and population dynamics, new or emerging drivers, such as policies, societal values and consumption patterns as mentioned above, are increasingly taken into consideration. The future of smallholder farming patterns in particular appears to be determined by the conjunction of rather predictable economic, market and demography trends on one hand and the potential counteracting forces of public policies, consumer behaviour and societal values regarding agriculture, food, and rural life. These results are consistent with observations from the few other foresight works on agriculture which were not included in this inventory (Gomez-Limon 2009).

Discussion: implication for food security and foresight

The current paradigm on food security is shaped by the combined projection of trends related to food demand and food supply. On the demand side, projections are about the amount of food that the world will need in order to feed 9 billion people by 2050 and thus ensure food security. These projections, based on mathematical models and expert inputs, have progressively varied downhill from 100% (as announced in one of the UN General Assembly meeting in 2008[4]), to 70%[5] and now 60% (Alexandratos and Bruinsma 2012). I will take here the concept "food security equation" coined by Rukuni and Eicher (1988) to describe this future challenge of food security from the demand side as follows:

> FS (Food Security) = 2050 (time frame) + 9 billion (people to feed) + X% (more of food neede)
>
> X being the variable of adjustment.

The food security equation is today a widely accepted, but erroneously called, "fact". It usually introduces reports, declaration, articles around the world referring to various issues including food security, agriculture, health, development, aid. There is no more discussion about it; food security issues concern today what do we do to resolve the equation, meaning mainly how do we produce more.

The supply side projections relate to the conditions under which the demand can be met, that is the X value of the food security equation can be attained. Contrasting with former projections, the latest value of X (60%) can be achieved with the projected reduced yield and productivity growth of 1.1% per year (Alexandratos and Bruinsma 2012. How much more to produce is thus not anymore the core challenge. The challenge is to at least maintain this excepted growth under growing resource constraints in particular water, land, energy, and fertilizers. However, so far this has translated in the

[4] http://www.un.org/News/Press/docs/2009/gaef3242.doc; see also Bruinsma 2003.
[5] http://www.guardian.co.uk/environment/2011/nov/28/un-farmers-produce-food-population

question how to produce "more, with less"[6] the core of FAO's "Save and Grow" strategy (FAO 2012)[7] .

As pointed by Tomlinson (2013) the international community has even made of it a normative policy goal whereas it had never been intended to be so. Indeed the authors of this projection constantly and honestly said that they were trying to represent the most likely future, not the most desirable one (Bruinsma, 2003; FAO 2006, Alexandratos and Bruinsma 2012). Yet, it became almost immediately the international norm. Other projections with different assumptions could have been developed by the authors, but they weren't. In the latest release Alexandratos and Bruinsma write: "*While at present the continuation of these trends does not seem likely, the high degree of uncertainty suggests the need to analyze alternative scenarios, which are not handled in this paper*" (2012:1). Thus only the trend projection (this is what was meant by "most likely", also usually called "business as usual") was produced.

This food security equation was obtained using a model which was operating with available macro-level quantitative data, fundamentally economic growth, population growth, yield growth and consumption trends. What the key results of the inventory of a diversity of foresight works tell us is that these usual drivers may not be the most relevant forces which are shaping the future of food security, and in particular the question of food insecure populations.

In addition, the food security equation does not (and was not designed nor intended to) say anything about how and by whom the projected production increases would be obtained. Yet, other works on the futures of the food system do exist as the results of the inventory indicate. A scoping study on the futures of the food system, including different diets, different types of production systems and different land use intensities, for example confirm our findings that the global food system can be re-thought and this would have to include changes in political, social and economic processes (Erb et al 2009).

From food security to food insecurity

The current process of revision of the MDG into post 2015 SDG represents a critical juncture and offers the possibility to devise a different approach to the nutrition of the human population than the current global food security equation. To start with, food security has been widely recognized in foresight works as a distribution, an access problem not a global availability problem (Hubert et al 2010). Key players of the international community also acknowledge that "*Global food security is not only about producing enough food for the world's population. Questions of access need to run alongside those of availability*" (The Royal Society 2009). The core issue, as stated by Ingram (2011) is that while there is enough food currently produced to feed the world's population, around 1 billion people are food insecure today.

With the latest revision of the food security equation giving X = 60%, food security is not anymore a production and productivity problem. In the most recent version of FAO's Outlook 2050 Alexandratos and Bruinsma calculate that the expected trend in yield growth rate will lead to that increase of 60%: "*Based on our assessment of world agricultural resources, it seems that at the global level there should be no major constraints to increasing agricultural produce by the amounts required to satisfy the additional demand generated by population and income growth to 2050"*. In clear this means that the total amount of food we are most likely to produce by 2050 will be enough to satisfy globally the demand.

However not all will be able to access it and food insecurity will become a core issue along with its deeper roots: poverty and social inequity. Focusing on food insecurity compels us to reconsider the true contribution of agriculture alone to improved access to food for those who, today and

[6] An internet search with Google UK using the following terms "produce more with less" and "agriculture", for the period 01 January 2013-20 July 2013 yielded 241 references (accessed on July20th, 07:45 GMT).
[7] See also http://www.fao.org/fileadmin/user_upload/FAODG/docs/2013-06-05-glast-keynote-DG-speech-en.pdf

tomorrow, will not be in condition to acquire the quantity and quality of food they need to nourish themselves. The question is not how to feed the world future 9 billion, but how can we ensure that those who are currently food insecure will not remain food insecure and that other segments of the world's population and the new generations will not become food insecure?

Scope of Future studies

This requires also a different focus of foresight, looking not anymore at the drivers of food security, food supply and food demand, but at the drivers of food insecurity, at the forces which make or could make people to remain or become food insecure in the future. Our inventory shows that there is significant amount of knowledge building up through foresight and in particular through scenario-based future studies, leading to a more comprehensive ans systemic understanding of the drivers of the future. Yet it remains to be turned into systematic exploration of these drivers as potential forces which may challenge the trends building the current food security equation, in particular the drivers of the demography, rural-urban migration and related consumption patterns. We need to understand what and who controls the current state of these drivers and their future states to see if the orientation toward more sustainable food systems is consistent with them. For example we observe growing food insecurity in high income countries where food is more than plentiful.

In future studies we need to explore more systematically rupture scenarios and then couple them with modelling to measure also their implications. We need new ways and concepts to demonstrate that the current and future constraints to production have been created by the current and past production system which we are using in order to calculate the future production growth rates. Current and future land degradation and water scarcities are directly linked to the type of farming activities that have developed along the business-as- usual path of production intensification.

At least some foresight studies of food insecurity should be undertaken in order to provide answers to the growing concerns of citizens, as expressed for example in a WWF study: *Why are more than one billion people hungry in a world which has for decades produced enough food to feed every person on this planet? What are the main factors driving people into hunger and poverty? How do consumer behaviour and agricultural policy in industrialized countries affect hunger and rural poverty worldwide? Who is going to manage the use of natural resources in the future and what does a sustainable agriculture system look like in times of decreasing fossil resources?*(Grethe et al 2011:5).

Unfortunately, turning the current focus of future studies from the food security action paradigm to a diversity of topics bearing implications on food insecurity and sustainable development is not an easy task. A possible path, as demonstrated by the characteristics of the more local foresight work is to bring the question of the future of food insecurity into a foresight agenda at a more disaggregated level and having it handled by national and local organizations rather than by the international community and then build a more comprehensive (in the sense of global) picture through an ascending process.

Yet, the emergence of policy, social and behavioural drivers in foresight studies as witnessed in the inventory is a noticeable rupture which has implications for our understanding of the food security stakes and the future related challenges. Indeed, foresight works in the past, especially technology foresight, usually concluded with policy recommendations but they saw policies as external factors. That situation was leading to the limited capacity of policies to make a use of the content of foresight as these were seen as exogenous factors, whose connection with the drivers of the future was rarely included in the foresight analysis. In most recent foresight works, from global to local level policy-makers and more generally stakeholders are now no longer mere end users. This finding is consistent with the results of the European Foresight Monitoring Network inventory which concluded that "policy shift" is the most common call for change resulting from foresight works (Popper 2009:92). Foresight on food security, agriculture and rural development is entering what foresight scholars working on other questions have coined the third generation of foresight (Georghiou and Keenan 2006). Third generation foresight adds a social perspective to the traditional technology and market

perspectives; social factors and behaviour are becoming major drivers of change (Cachia et al. 2007). This evolution can be harnessed to challenge the food security equation and its base of biological, demographic and economic trend.

Implications for research and technology

The immediate consequence of the food security equation has been the call for research to provide solutions to the problem of producing 100%, then 70%, and now 60% more food in order to feed 9 billion people in 2050. As research mainly focuses on the supply side, this translated in devising a research strategy to develop technologies to produce more, with less. The true challenges for research are to make the likely production growth rate much more sustainable than before, not much more intensive. It is a qualitative challenge not a quantitative challenge. It means that the usually de-coupled economic, environmental and social dimensions of sustainability must be brought together in the research and innovation agendas. The answer provided in the global debate of the international R&D community to meet these challenges is the concept of sustainable intensification. Definitions of sustainable intensification abounds and sometimes contradicts or differ, in particular in the emphasis given to the concept as an operational or an aspirational one and in the type of research and technologies that would match with it, ranging from intensification while preserving the resource base to agro-ecology to zero-input agriculture (Sonnino, 2013, personal communication[8]).

The purpose of this paper is not to discuss this concept. However the controversies it generates illustrate one of the finding of this inventory regarding research and technology. The results of the inventory lead us to suggest that technologies represent a domain which is simultaneously influenced by the drivers of trends (demography, trade, income growth, urbanisation, climate change) and the drivers of discontinuities (policies, consumer behaviour, social values). In a systemic approach of recursivity and rupture between factors of trends and factors of discontinuity, technologies can play different and contrasted roles. They may become embedded in a pre-active posture with respect to trends, meaning that they will offer adjustment solutions through incremental changes around the business-as-usual (trend/projections) path. Alternatively they can become sources of discontinuities in a pro-active posture where some trends, in particular regarding the use of natural resources and social justice, is considered as not acceptable from a social value perspectives. Existing and new or emerging technologies and research path can be directed either way.

Conclusion

We may keep thinking that the main challenge of the future is how to provide more food to feed nine billion people in 2050. We may keep thinking that the food security equation which is today on the top of the research and development agenda of the international community may stay there for many decades. We may keep using forecast and projections of past trends as the guidelines for the future and the directions for acting in the present. We may keep thinking that our best option is to identify the most likely future and just do what needs to be done to adapt.

Yet, our analysis of recent foresight works indicate that the future of the populations who are insecure today is not bound to the total amount of food that will be available in the future. More diverse approaches of the future of agriculture and rural development at various scales show that the future does not lie just in the continuity of current trends but also in ruptures. Our study shows that policies, cultural values and individual and collective behaviour can induce discontinuities against the pursuit of undesirable paths driven by current demographic, climatic, and economic trends.

[8] Sonnino, Roberta (2013) 2012-2013: Assessing Sustainability in the Context of Food Security, Paper prepared for the Joint Research Centre, European Commission, personal communication.

Our study shows that with policies, societal values and behaviours emerging as new drivers, research and technology can either be directed to adapt to the most likely scenario or to break from the likely scenario. The future of food security has been scrutinised with deep attention, isn't it time to turn our attention and the focus of foresight to the future of food insecurity, focusing on people and society?

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