Chapter 12

Agricultural Transformation Pathways toward the SDGs

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12.1 Introduction

Achieving the 17 Sustainable Development Goals (SDGs) conjointly is generally presented as a transformation agenda.¹ Although the notion of transformation is not explicitly defined in official texts, it is associated with profound changes in social and economic systems and presented as a necessary process if the ambition is to achieve the economic, social, and environmental objectives. Food and agriculture systems are at the heart of this challenging transformation, and changes in these systems impact nearly all of the SDGs (ICSU, 2017). Yet many pieces of the foresight literature concur that current trends in food and agriculture systems are incompatible with the conjoint achievement of economic, social, and environmental objectives (Godfray *et al.*, 2010; Paillard *et al.*, 2011; IAASTD, 2009). Although these foresight studies propose various elements for assessing the performance of sustainable or agroecological intensification options, they lack consensus on the nature and magnitude of the transformations of food and agriculture systems that would be

¹Resolution 10/1 of United Nations General Assembly on September 25, 2015, under which all governments adopted the SDGs, is entitled “Transforming our world: the 2030 Agenda for sustainable development.”

needed to achieve the SDGs. Missing in their analysis are the transformation pathways that can shift these systems from their current state toward a future sustainable state.

This chapter builds on two research fields that focus on transformation in the agricultural sector from two different perspectives: first, an agronomy-centered farming system transformation aimed at improving environmental performance, and second, national-scale transformation of the agricultural sector and its links with the rest of the economy in view of improving its socioeconomic performance. The analysis of transformation pathways is a critical challenge for each approach. Such an analysis requires linking a rigorous historical analysis of past transformation pathways to a future-oriented perspective. The chapter shows not only the commonalities between these two approaches, but also their differences and complementarities in scope and scale. It suggests that achieving the SDGs requires linking these two analytical perspectives in order to take into account the diversity of national-scale situations and to assess the performance both of generic solutions and of these diverse possible transformation pathways in each specific national case.

12.2 Environmental and Socioeconomic Performance and Changes in Farm Structures

The environmental impacts of agricultural production systems are studied in a variety of communities with respect to their impact on, for example, global carbon or nitrogen cycles (Billen *et al.*, 2013). Long-term transformation of these production systems is considered necessary both to mitigate these impacts and to adapt to global environmental changes. Mainly centered on the field of agronomic sciences, the debate about how to achieve such transformation is polarized between support for incremental change and support for radical change in farming systems: one side consists of changes in practices and technologies to optimize efficiency in resource use and identify opportunities for input substitution; the other side consists of a complete redesign of the

production system (in line with the Efficiency–Substitution–Redesign framework initially developed by Hill and MacRae, 1995).

In some of these analyses, technological changes are presented as delivering win-win solutions for both economic and environmental objectives: for instance, precision agriculture can limit environmental impacts and increase profitability by reducing the level of input use (Plant *et al.*, 2000). Such studies do not deal with longer-run transformation pathways; nor do they analyze whether such changes can tackle the magnitude of long-term environmental challenges. More specifically, they do not address the linkage between technical changes and changes in other farm structure characteristics—in particular, changes in labor intensity. The substitution between labor and capital linked to technological changes and investment in technology are rarely analyzed in conjunction with achievements in terms of environmental performance. The long-term socioeconomic performance of such technology changes would require analysis of their differentiated impact on different types of farms, depending on their level of labor intensity and capital intensity (physical capital and land), their capacity to access credit, and the consequences for concentration or specialization processes in farms at a regional level (Laurent *et al.*, 1999). To what extent do such changes contribute to transformation pathways that deliver both environmental and social results—assessed, for instance, in terms of employment and income levels in the farming sector at a regional or national scale? This may seem like a basic research question, but developing and assessing such a regional- or national-scale scenario remains a methodological challenge.

At the other end of the spectrum, system-scale changes are viewed as enabling better environmental performance, for example, by rediversifying farming systems and reintroducing legumes in cereal production systems. Such changes would help reduce fertilizer inputs. Integrated pest management or conversion to organic agriculture would help drastically reduce pesticide use. System redesign proposals also include the reintegration of livestock and crops to close nutrient cycles (Franzluebbers *et al.*, 2014). Given the systemic nature of the environmental challenges, system-redesign changes are presented as having a greater potential to address these challenges conjointly

(Freibauer *et al.*, 2011). Larger-scale studies also provide tools for analysis of the changes necessary at the scale not only of farming systems, but also of the whole food system to ensure better management of nutrient cycles, as in the case of nitrogen management at the scale of a large country like China (Schwoob *et al.*, 2016). Some scenarios even assess the feasibility and consistency of global-scale changes towards organic agriculture or agroecological systems. Muller *et al.* (2017) provide an exhaustive analysis of the agronomic characteristics of a systemic change to organic agriculture, enabling an assessment of how carbon and nitrogen cycles could be better closed and exploring important system-scale changes such as the changes in feed flows between regions. Agronomic studies of nutrient and material flows at a macro-scale have enabled considerable headway to be made in the debate on the environmental performance of different technical options.

These studies also provide some insights for analyzing the potential for system redesign—for instance, a redesign based on agroecological principles—to achieve both environmental and social objectives. These analyses rely on the fact that such changes generally lead to more labor-intensive systems: the hypothesis is that the agricultural sector would thus provide more employment opportunities. This could have a positive social impact, provided labor productivity also increases, in contexts where other sectors of the economy are failing to provide enough job opportunities, as argued by some such as Dorin *et al.* (2013). In the longer run the economic performance of such system-redesign transition pathways is documented in different contexts and shows a capacity to maintain or increase benefits at farm scale by reducing input and operating costs (Guillou, 2013). However, the impact of such system-scale changes not only on labor intensity but also on the income generated as a result of the jobs created still needs to be assessed at a larger scale. Making this assessment would require, for example, analyzing at a regional scale how to make farm-scale diversification strategies compatible with the strategies of collecting and processing industries, which are generally focused on economies of scale (Meynard *et al.*, 2013). Regional-scale scenarios would be necessary to assess the effects of such changes on social dimensions such as jobs and incomes.

All the above-mentioned studies concur that solutions to the sustainability challenge will be highly knowledge-intensive. They will have to take into account, much more than the agricultural modernization of the late 20th century did, the fact that each local situation, and each national context, presents specific challenges. Innovations will need to be designed with the objective of conjointly addressing the specific environmental, economic, social, and even historical and political conditions in which these solutions will need to develop through changes in existing farming systems (Godfray, *et al.* 2010; IAASTD, 2009).

Most studies—whatever type of solution they examine—do not undertake a diachronic analysis of the future transformation pathway of a given agricultural sector (at a local, regional, or national scale). This type of analysis, however, was exactly what was advocated by Lamine (2011) among others. Current studies of the relative performance of different agronomic options focus on the consistency of the future state of the farming system but do not discuss whether a pathway can ensure the shift from the present situation to this hypothetical future state.

An even more challenging issue is that these studies are not designed to integrate the changes that farm structures are already experiencing. These changes include the following: the impacts of technological changes, the substitution of labor by capital to increase productivity, the consolidation of farms and consequent increase in farm size, the decrease in farm size owing to demographic growth, concentration and specialization, the dynamics of the land tenure market, and the dynamics of investment and capital intensity and their impact on debt levels (Bosc and Bélières, 2015). A proper analysis of transformation pathways to reach sustainability on all three dimensions (economic, social, and environmental) would require assessing not only the agronomic consistency of a given future state of the system, but also the ways in which envisioned technical changes interact with current trends in farm structure, or are even able to reverse these trends if necessary, to reach social objectives.

For instance, the Agricultural Transformation Pathways initiative (Schwoob *et al.*, 2016) was an exercise based on various pilot country case studies (China, United Kingdom, and Uruguay). It aimed to develop a backcasting approach capable of identifying the main obstacles, the

levers for change, and the sequence of actions and investments needed to reach by 2030 a future state of the agricultural sector deemed by national stakeholders to be radically more sustainable than the sector's present state. For example, in Uruguay, participatory processes with national stakeholders made it possible to identify critical points for such a transformation pathway (e.g., public investment in extension services). However, the methodology did not allow for identification of current trends in the evolution of farm structure, precluding an exploration into whether these trends would favor or block the dissemination of the intended changes in agricultural practices.

For a more effective analysis of transformation pathways toward sustainability, a better understanding of current trends in structural changes will be necessary. A few studies do link changes in practices, changes in farm structure, and macroeconomic changes (Losch *et al.*, 2012; Bosc and Bélières, 2015). As will be presented in the next section, there is also a substantial literature on structural transformation, some of which incorporates sustainability issues (see Timmer and Akkus, 2008, for a review). The methodological challenge is to use these existing retrospective analyses to develop future transformation pathways at a regional or national scale.

To better structure the debate on the different agronomic options or different levels of systemic change involved in transforming farming systems, specific change scenarios need to be developed. These scenarios will make it possible to address situations at regional or national scales given that each situation is different from others in terms of both initial conditions and current trends in farm structure transformation. Developing such regional or national transformation pathways toward sustainability still poses important methodological challenges, particularly when it comes to assessing the plausibility and feasibility of a transition pathway in light of current trends and evaluating the social, economic, and environmental performance of such scenarios.

12.3 The Critical Role of Agriculture in Economic Transformations and the Heterogeneity of National Pathways

Another key field of research for discussion on pathways to sustainability focuses on the structural transformation of the economy in different national contexts. The role of the agricultural sector in contributing to poverty reduction in this transformation perspective is now well recognized, particularly since the 2008 *World Development Report* (World Bank, 2007). In recent political debates, strong emphasis has been placed on the need for jobs in the agricultural sector in countries and economies where the other sectors will apparently not be able to provide jobs for a growing population (FAO, 2017). Given that there is a high risk of a future lack of employment opportunities in countries with strong demographic growth, the role and place of the agricultural sector in each country need to be better understood: for instance, jobs in primary production are not necessarily attractive for younger generations; on the other hand, many diverse linkages exist between the agricultural sector and the rest of the economy. Studies on the structural transformation of national economies and the role of agriculture in these processes lay particular emphasis on the plurality and heterogeneity of possible future transformation pathways depending on national circumstances, and in light of past structural transformation histories. They also clearly show the importance, in most cases, of a dynamic agricultural sector.

The developing world has not followed a uniform trajectory of sustained agricultural and structural transformation, and this has resulted in sharply different pathways of economic growth (Figure 12.1). This broad heterogeneity reveals diverse dynamics in development processes over the past six decades.

Fig. 12.1. Annual rates of GDP growth per capita by year for Asia and Sub-Saharan Africa (SSA) (1950–2016). Source: Data from the Conference Board, Total Economy Database, 2016.

One way of drilling deeper into these dynamics is to explore the wealth of historical records that show not only the great diversity of agricultural transformations underlying the structural transformation, but also how changes in agricultural labor productivity have heightened this diversity. The research program at Lund University, which has provided material for this chapter, attempts such in-depth exploration by taking as a key variable how productivity of the rural labor force compares with that of the urban labor force. This variable is specified as the difference between the share of GDP produced by the agricultural labor force and the share of total employment made up by agricultural labor. The gap between these two variables (hereafter referred to as GAP) reflects the difference between labor productivity of agricultural labor and that of non-agricultural labor, and it is an indicator for how far the agricultural transformation has progressed. A large GAP signals a failed or stalled transformation and denotes a country where poverty is widespread and the urban-to-rural income gap is large. Analyzing the development of the

GAP over time and space can reveal trends in the transformations and show the various ways that countries have been able to close this gap in the past. Such knowledge can offer both inspiring and cautionary lessons for latecomers.

The diversity of pathways of structural transformation and the varying roles of agricultural change in reducing or increasing that diversity are quite vivid when one compares GAP dynamics across countries or between regions. Figures 12.2 and 12.3 illustrate these GAP dynamics for Asia and Sub-Saharan Africa from 1950 to 2012. The historical tendency of this GAP to widen in the early stages of rapid economic growth before converging to zero as countries become rich is well documented (Timmer and Akkus, 2008). Managing the political tensions created by a widening GAP (urban incomes rising more rapidly than rural incomes) has been the basic test of modern political economies, especially in a rapidly growing Asia (Timmer, 2015). As Figure 12.2 shows, the Asian pattern of widening and then narrowing GAPs is quite obvious. There is diversity in the levels and speed of change, but the general pattern is unmistakable.

There is nothing obvious about the changing patterns of the GAP in Figure 12.3, which presents the available evidence for Sub-Saharan Africa. If we are looking for diversity not just in the levels and speed of change in the GAP, but in the overall process that generates it, Sub-Saharan Africa is the place to look. This region provides evidence not only of the diversity of structural transformation processes but also of the ability—or inability—of development pathways to sustainably reduce poverty. It is important to understand the drivers of diversity in structural transformation and the dynamic forces that shape the GAP over time and find ways of avoiding pathways that increase this GAP.

Fig. 12.2. Pathways of structural transformation in Asia, 1950–2012: Evolution of the GAP in labor productivity between the agricultural and nonagricultural sectors. The y-axis shows the intersectoral productivity gap between agriculture and non-agriculture; the x-axis shows logged income per capita. Source: Data from the Groningen Growth and Development Centre, 10-Sector Database.

Fig. 12.3. Pathways of structural transformation in Sub-Saharan Africa, 1950–2012: Evolution of the GAP in labor productivity between the agricultural and nonagricultural sectors. The y-axis shows the intersectoral productivity gap between agriculture and non-agriculture; the x-axis shows logged income per capita. Source: Data from the Groningen Growth and Development Centre, 10-Sector Database.

Heterogeneity in past transformation pathways can also be documented by looking at transformation in the structure of farming systems. Agricultural intensification pathways in Asia and Latin America have differed notably in the increase in the size of farms and in the number of active workers per hectare (Dorin *et al.*, 2013; World Bank 2009). Even under apparently similar ecological conditions, high levels of land productivity have been reached with a consistently high level of labor intensity in Asia, while the same level of land productivity relies on a much smaller workforce and larger farms in Latin America. These differences in past transformation pathways have led to contrasting current situations in the two regions, with different patterns of poverty distribution. However, labor-saving technologies are now spreading rapidly in Asian countries, particularly in the richer ones, which could

lead to a convergence between these contrasting cases or to a new type of pathway.

Considering the past and current impacts of agriculture on socioeconomic and environmental systems, it appears critical to ensure a proper understanding of the links between agriculture and the rest of the economy. This notion of “linkages” has long been core to the debate on the role of agricultural development for poverty reduction (World Bank, 2007). In addition to the consensus on the need to focus more analytical capacity on these linkages, there is also a need to study economic dynamics as a historical process: in each national situation, the complex social and economic processes of development need to be understood in order to assess how future agricultural development would interlink with the rest of the economy, and thus, what policies at a given point in time are likely to be most effective. Agricultural transformation thus needs to be addressed with “situational relativism” (Adelman and Morris, 1997) in light of the diverse initial conditions (such as small versus large farm sizes, geography and resource endowments, demographics). This understanding also requires due recognition of historical processes generated by the speed and nature of structural changes.

This focus on the diversity of processes, such as agricultural transformation patterns or structural transformation pathways, can help give greater insights into the fundamental processes that cause divergent outcomes—for example, in terms of per capita incomes or labor productivity, which lead to diverging levels of household welfare. Any historical perspective strongly suggests that the key drivers of differences in welfare levels are highly diverse, because differences in capital and labor availability and their changes over time cannot alone explain the widely diverging outcomes in economic performance. The real concern for policy is to determine how the structural transformation can be set in motion given that it is conditioned by myriad details. And despite the diversity in initial conditions, there are also important commonalities of the structural transformation across countries.

Agricultural systems are mainly linked to the rest of the economy through food supply chains, and urbanization has made supply chain linkages, primarily within the food sector, increasingly important. Reardon and Timmer (2014) identify five interlinked transformations of

the agri-food system: (1) urbanization; (2) diet change; (3) agri-food system transformation; (4) rural factor market transformation; and (5) intensification of farm technology. These transformations, which are interconnected in mutually causal ways in all directions, are now acknowledged as having the potential to bring about a rapid and complex transformation of an integrated system. Having an informed vision of these dynamic interrelationships can improve the capacity to act appropriately, through both private and public action (for instance, public investments in infrastructure, especially rural roads, communication systems, power grids, and irrigation are essential ingredients for virtually all five transformations). As the authors point out, significant interdependence now exists between the downstream (urbanization and diet change driving changes in food demand), the midstream/intermediation (processing), and upstream segments of the agri-food supply chain (the combination of rural factor and service markets and the farm segment). They conclude that “any food security strategy that focuses on one of these points of the triangle and neglects the others will fail in this new era of large urban markets, rural-urban linkages, and the need for the enabling of farm intensification and commercialization” (Reardon and Timmer, 2014, p. 9).

The research field that studies national-scale structural transformation of the economy places the dynamic nature of transformation pathways at the heart of its analytical framework. This is contrary to the farming-system approach described in the previous section, which focuses essentially on the image of a farming system at a given moment in time, through synchronic rather than diachronic analyses. In fact, the technical content of technological changes or system-scale innovations, which are core to the discussion on environmental performance in the former section, are not considered central in this second research field. Certainly, technological change at the farm level is considered a crucial element given its linkages to changes in labor productivity. It is more challenging to study how technological and farm-structure changes constitute constraints or opportunities for the different strategies that farmers can develop to move toward economic, social, and/or environmental sustainability (Bosc and Bélières, 2015). Among the strategies studied, rediversification at the farm or landscape scale or

reintegration between crop and livestock production are potential options for environmental sustainability, but they are more complex to represent in analyses of national-scale transformation pathways than specialization or monocropping strategies. Rediversification and reintegration strategies or specialization strategies have different impacts on changes in land, capital, and labor productivity at the farm scale. Their implementation also depends on what is happening in other segments of the supply chains (diversification in primary production and economies of scope in downstream collecting or processing industries versus specialization and economies of scale). Being able to account for the diversity of such strategies remains an analytical challenge.

12.4 A Cross-Cutting Lesson: Transformation Pathways Cannot Be Transposed from Past Experiences

Acknowledging the diversity of transformation pathways is the political project of the Sustainable Development Goals: universality and differentiation are central principles of the 2030 Agenda. This chapter goes beyond this political statement, as the two first sections present evidence that transformation pathways have always been diverse and will be diverse in the future, and at the same time share important common features. Although the two research fields presented here in separate sections have developed independently, they exhibit an important commonality: deciding on the right agricultural policy is going to be a highly knowledge-intensive task, because transformation pathways able to deliver social, economic, and environmental performance will be specific to each national context and cannot be transposed directly from past experiences or other national contexts, given the heterogeneity of past transformation pathways, unique national histories, and the multiplicity of possible future transformation options. This constitutes an important challenge for research and education institutions and for international cooperation.

How can the beneficial effects of agricultural policies on the rest of the economy and on the social and environmental sustainability of the agricultural sector be ensured? The answer cannot be simple. There will

be no “silver bullet” policy that perfectly addresses current and future challenges everywhere around the globe. In addition, win-win solutions are probably not going to come from a simple adjustment of existing systems.

Instead of putting together the pieces needed for successful transformation, countries will likely “muddle through” (Connors, 2005; Lindblom, 1959) and implement actions through second-best institutions (Rodrik, 2008). Yet research could contribute to a better understanding of each national context and its specific circumstances with respect to past and future structural transformation pathways at the level of the macroeconomic structure of the economy and the microeconomic level of the transformation of the structure of farming systems (Bosc and Bélières, 2015).

This is a challenge for research institutions. At the level of a specific country, it will require in-depth analysis of the historicity of the national social, economic, and political context, as well as past changes in farm structure. It also means analyzing the risks of path dependencies and potential bifurcations in future pathways in order to inform short-term investment or policy choices. At the regional or global scale, it means defining comparative analyses across national situations, though without attempting to transfer solutions from one context to the other. The objective of a cross-country comparison is to open up the range of potential solutions in each national context, to develop a common framework for assessing the potential to conjointly achieve economic, social, and environmental sustainability, and to draw lessons about what drives or blocks transformation processes.

Feeding national policy debates with such research results would usefully contribute to the dialogue among the different stakeholders in the agricultural sector and potential investors or donors: identifying the investments most likely to drive a country toward a sustainability pathway—including objectives for climate change adaptation and mitigation, poverty and inequality reduction, and food security—is an increasingly pressing concern for the donor community among others.

12.5 A Critical Analytical Challenge: Linking Farming-System Scale with National-Scale Transformation

The first two sections of this chapter show that past and future transformation pathways need to be analyzed at both scales (national-scale structural transformation of the economy and farming-system-scale transformation of agronomic characteristics), using both approaches in parallel. This is for two reasons. First, there is a need to explore the relative relevance, feasibility, and performance of possible transformation strategies for each specific national context, and changes in farm structure need to be analyzed in parallel to macroeconomic changes. Second, in order to explore solutions that can reach conjointly social, environmental, and economic sustainability objectives, different strategies for changes at farming-system scale need to be analyzed in the framework of regional- and national-scale cross-sector transformation scenarios.

Linkages between scales already exist in the agronomic approach (national-scale nutrient cycle balances, for instance, can be approached through flows of feed or nitrogen), as well as in the macroeconomic approach (changes in labor productivity are linked to technological change at the micro-scale and measured at the macro-scale). More complex links need to be represented: for instance, how changes in technologies or practices in farming systems influence the evolution of farm structures and the distribution of different farm types in a given region or country, and thus contribute to or interact with structural transformation pathways in the region's economy. This analytical framework should also take into account change drivers linked to competition for resources (such as land and other natural resources, for which access can be organized in markets or not) or product market competition between different types of farms. These factors can be major drivers for the transformation of the whole sector and depend on the different types of strategies developed at the farming-system scale—for instance in the case of a diversification strategy. Another example involves industrial strategies for the collecting, processing, or retailing segment of the supply chain. These strategies can constrain or enable strategies developed at the farming-system scale, and thus need to be

considered when linking farm-scale transformation with changes in the agricultural sector and the rest of the economy. For instance, depending on their capacity to deal not only with economies of scale but also economies of scope, downstream industries will enable or prevent diversification strategies at the farming-system scale and thus positively or negatively affect the capacity of these systems to reach environmental sustainability. Industrial strategies will also greatly determine the extent of linkages between the farming sector and the rest of the economy.

12.6 Conclusion

Drawing on two different fields of research into the notion of transformation pathways, this chapter suggests that, despite differences in their research objects, there is a critical research frontier to be explored at the interface between the two fields: the long-term transformation of farming systems to ensure environmental sustainability, and national-scale structural transformation of the economy, including the role of the agricultural sector. Both fields suggest that a better understanding of specific national circumstances and of the diversity of past transformation pathways is necessary to identify possible options for the transformational shift to future sustainability. To provide national-scale policy dialogue with relevant research results, it seems crucial to develop an analytical framework that takes into account both the national scale and the farming-system scale, as well as agronomic balances and socioeconomic structural change processes at both scales. The variables of structural farm changes (in land, capital, or labor intensity, and in the organization and social forms of farming systems) and the linkage between strategies at both the farming-system and industrial scales appear to play a particularly crucial role in this analytical approach. To ensure progress on this highly complex research frontier means having the capacity to conduct interdisciplinary work with diverse epistemic communities that have so far not worked together. It also implies linking in-depth country-scale analysis of historical processes in a diversity of national contexts with cross-country

comparisons. This is not only a conceptual challenge for individual researchers, but also an organizational challenge for research institutions.

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