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Strategic foresight for agriculture: Past ghosts, present challenges, and future opportunities

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ABSTRACT

Strategic foresight is systematic means to explore plausible futures. In the agricultural context, strategic foresight allows decision-makers to explore how alternative investments in agriculture research may function given anticipated futures associated with a variety of drivers ranging from climate change to increasing wealth to a changing policy environment. This paper presents an overview and context for six recently published articles in Global Food Security that comprise a virtual special issue on agricultural futures. Each of the papers takes a distinct perspective and addresses key issues from how past trends drive future outcomes to specific commodity systems to issues around employment and rural transformation. While each of the included papers stands on its own merits, the collection presents a unique opportunity to unpack the role of investment in agriculture research from a variety of perspectives. Collectively, the special issue offers insights to support current and future investment planning to better target desired outcomes associated with long-term agricultural research.

1. Introduction

Since agriculture first appeared in the Fertile Crescent some 10,000 years ago, humankind has been working to make it better. Early farmers quickly learned that different crops had different properties, and that a variety of tools could help improve agricultural outcomes under different conditions. In the present day, our interconnected agricultural systems are still the foundation of the global food system, and the latest technologies from improved crop varieties to digital agro-advisory systems provide modern farmers with a range of solutions that would have been unimaginable even a few decades ago.

Whether talking about an ancestral farmer in the Fertile Crescent, a large-scale farmer in North America, or a small-scale farmer in sub-Saharan Africa, farmers have long recognized the need to develop their craft on an ongoing basis. Agricultural research and innovation, both informal and formal, have arguably been the "secret sauce" that has allowed economies to diversify, grow, and sustain the Earth's population over decades and even millennia.

As we have seen recently, however, whether examining the chronic impact of climate change on agriculture (Ruane et al., 2018), the acute vulnerability associated with climate variability (Perez et al., 2019), or the near instantaneous disruption of global food systems because of Covid-19 (Barrett, 2020), many challenges remain even as new challenges emerge. This is, to a large degree, due to the fact that agriculture is both a complicated activity and, in a food systems context, part of a complex system (Reilly et al., 2010). Furthermore, agriculture, the food system, and the drivers that affect both, are constantly evolving so the solutions that worked to solve a particular problem in a particular moment (e.g., the Green Revolution with the goals of bringing higher productivity to millions of small-scale farmers in developing countries) are not stationary in time.

In many ways, the Green Revolution is our "ghost of agriculture past" in the sense that it continues to influence us to this day. While the green revolution assured food security for billions of people, there were also numerous (and many of them unanticipated) social and environmental costs associated therewith. Calls for a Green Revolution 2.0 (Llewellyn, 2018) suggest that with better foresight we might be able to avoid many of the unanticipated costs associated with GR1.0. As our understanding of agricultural development and future food systems evolves, so too does our perspective on priorities, considering more crops (Hunter, 2019), healthy diets derived from sustainable food systems (Willett et al., 2019), and food system sustainability itself (Bene et al., 2020).

As farmers have done, agricultural researchers as well have clearly stepped up to address pressing challenges, both present and future. Yet,

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simultaneously, many of us remain entrenched in the dogma of past success. It is no small task to think about expanding agricultural research priorities to include not only clear and present challenges, but also a recognition of the future trends in climate, climate variability, technology, global connectivity, disease transmission, and other major changes in drivers of food systems. Given this complexity, how can we generate insights regarding the best options to "future proof" not only agriculture (Kissoudis et al., 2016), but the food system itself?

In a nutshell, the answer is foresight. Foresight comes naturally to all of us as we think about how to prepare for the next day, week, or year. Systematic strategic foresight approaches, both qualitative and quantitative, help us move beyond predictions based on prior data and to pull back the curtains on "plausible futures" that can support decision-making on a larger scale (Wiebe et al., 2018). In an agriculture development context, scenarios describing alternative plausible futures are, in many ways, the independent variables, and through scenarios, we can test what might happen given expected changes (e.g., climate change) and our possible responses (i.e., a new policy, a new technology, etc.). In this way, strategic foresight analysis is anticipatory in the sense that it allows us to test how different strategies today might help us respond to the challenges we are likely to face in the future.

Given the increasing complexity and uncertainty associated with the global food system, the corresponding dependencies on international trade, the desire to reduce greenhouse gas emissions and to "eat within planetary boundaries" (Springmann et al., 2018), the ability to consider multiple alternatives becomes increasingly important. Foresight approaches, whether quantitative models, qualitative participatory processes, or some combination thereof, allow us to explore a large number of scenarios and evaluate the outcomes for specificity, desirability, plausibility, return on investment, equity, and more.

An important strength of foresight approaches, particularly quantitative models, is their ability to help us systematically understand how agriculture systems might respond differentially over space and time relative to different pressures or interventions. The fact that the drivers affecting agriculture and food systems are themselves varying in space and time again suggests that "one size fits all" or "set and forget" solutions are no longer viable. This compound uncertainty presents a particularly significant conundrum when we try to understand how we can improve the performance of the food system through outcome-driven investment in agricultural research.

Using foresight to help understand the relationship between research outcomes and agriculture and food system futures is the theme of this special issue. One of the key challenges in food systems research is that a focus on any single sub-component of the broader food system may yield insights regarding opportunities and challenges within a relatively narrow context and without consideration of potential links and trade-offs with other elements of the system. At the same time, broader, more sweeping analyses of food systems often overlook how different components of the system respond differently to various perturbations and stimuli. When it comes to food systems, there are no universal frameworks for understanding their structure and function. This is equally true whether examining the present state of food systems or attempting to project their future characteristics.

Some of these challenges can be overcome by using quantitative strategic foresight analysis with parameterized scenarios describing multiple plausible futures. Using a common lens (i.e., IMPACT or GLOBE) in different contexts allows for exploration of pros and cons of different scenarios across different system components. This is the approach we take with this collection, where the authors explore a panorama of potential agriculture futures under conditions of climate change and in relation to several different investment paradigms.

The authors in this special issue highlight a series of evaluations of trends in agriculture, drawing on insights from a wide range of disciplinary and geographic expertise and experience. The work is supported by many years of earlier research using partial and general equilibrium models to understand trends in agricultural and food systems. The papers presented here build on an analysis using the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) and the global dynamic computable general equilibrium (CGE) model GLOBE (Rosegrant et al., 2017). That analysis evaluated the impacts of a series of scenarios representing broad policy options related to investment in agricultural productivity, natural resource management, and infrastructure. This special issue shares insights generated by the team of authors, building on the earlier work via a series of studies covering specific commodities and regions, as well as crosscutting themes such as employment, gender, and agriculture trends more broadly.

2. Learning from the ghosts of agriculture past

The motivation for developing a varied set of foresight analyses based largely on a common approach allows the exploration of a complex, multifaceted set of issues from a shared perspective. Among the papers presented in this special issue, Brooks and Place (2019 - this issue) highlight the historical importance of some of the major drivers of related to productivity growth, expansion of trade, and alignment of agricultural and environmental policy. They elaborate that observed trends in agriculture are, quite often, the product of drivers that may be either long-term (e.g., productivity gains driving prices down through increased supply), or short-term (e.g., fluctuations due to weather shocks or major policy changes). In either case, these drivers are usually happening simultaneously and often involve complex tradeoffs and decision-making at the supra-national level. It thus become crucial to examine these interlinkages carefully if we wish to address expected challenges in an anticipatory fashion. Brooks and Place (2019) press upon us the importance of keeping the past in mind as we work on refining our models that point an eye toward the future.

Looking to the past is useful beyond thinking about parameterizing models. As with Brooks and Place, Spielman and Pandya-Lorch (2009) meticulously make the case that both the specific emphasis and outcomes of agricultural interventions have continuously evolved over time. This has been in response to the success of certain historical investments in shaping supply, as well as relative to the changing demand patterns that have come with changing socioeconomic conditions and dietary preferences. It is our ability to look back and unpack past trends that helps inform our approach to understanding future trends, choices and outcomes.

3. From the past into our agriculture present

Agriculture is, of course, integral to the global food system. If the Covid-19 pandemic of 2020 has taught us anything, it is that the food system is more tightly coupled to many other sectors than we might have previously realized (Bene, 2020). Worldwide, it has become clear that agriculture and food systems are woven inextricably into the fabric of both developing and developed countries alike. The massive mobilization of resources to address the economic and food security issues that quickly emerged alongside the spread of Covid-19 and its direct health impacts have, whether intended or not, shaped both the contemporary food system as well as thinking about food system resilience more broadly. This, just like investment in agriculture research, will likely "cast shadows forward to 2050 and beyond" (Pardey et al., 2016).

At the same time, it is not just chronic shocks like climate change and acute shocks like Covid-19 that are influencing expectations associated with agriculture research investment. As Pardey et al. (2016) illustrate, the sources of investment are changing and, increasingly, resources to support agriculture research are coming from the private sector and from Low- and Middle-Income countries. If past shadows of public sector research in high-income countries have brought us to where we are today, how will new drivers, along with a shift in the origins and priorities associated with investment in agriculture research in low- and middle-income countries be casting their shadows forward into the future?

4. Anticipating our agricultural future

Of the many drivers that are influencing agricultural processes today, many are compound in nature in the sense that multiple implications may arise from the same phenomena. In the case of climate change, for example, it is well established that both increases in temperature and fundamental changes in precipitation variability are affecting agriculture in multiple different ways. Given the impossibility that any foresight model or process can completely disentangle the nuance of future trends, can we actually use foresight to help better focus agricultural research? Absolutely. First, structured models allow for the exploration of alternative possible futures in an explicit way; that is, the models can provide insights as to what could happen in future agriculture systems under specific assumptions, all other things being equal (e.g., without specific technological or policy interventions). All discussions about the future make implicit assumptions about future conditions or behaviors. The real value proposition of quantitative foresight models, however is that they allow for the exploration of consistently expressed and comparable plausible futures.

In many instances, insights can be gained from simply comparing across different regional, economic and climate scenarios, independent of additional investment in technology and policy. Kruseman et al. (2020 - this issue) argue that global simulation models can provide large-scale perspectives on future food system interactions, but need to be complemented with more focused analyses to better reflect the complexities of rural transformation and how they will influence the uptake of new technologies and other results stemming from present-day agricultural research. Focusing on major cereals systems, including rice in Asia and Africa, wheat in MENA, and maize in both Africa and Latin America, Kruseman et al. (2020) explore how transformation in both rural and urban areas is highly heterogeneous and likely to influence agricultural outcomes for many years to come, driving changes in production as well as increased demand for these key commodities. These insights clearly underscore the need for research and agriculture investment approaches that are tailored to the different dynamics associated with different rural transformation contexts.

The drivers that are influencing future demand for cereals are also influencing long-term demand for other commodities. For instance, in an examination of the potential for sustainable livestock production in South Asia and Sub-Saharan Africa, Enahoro et al. (2019 – this issue) note that demand for livestock products will increase by nearly 100% between 2010 and 2050, offering nutritional gains as well as posing environmental challenges. They note, however, that there are significant opportunities to reduce greenhouse gas intensities associated with livestock production. While Kruseman et al. (2020) highlight the potential inequities that arise with farm consolidation and increasing farm size in low- and middle-income countries, Enahoro et al. (2019) note that for livestock production, many producers are indeed smallholders and that investments that support livestock production (directly or indirectly) can help address equity concerns.

Just as with livestock, the demand for fish is expected to increase with growth in population and income. In Africa, fish currently provides an average of nearly 20% of dietary protein, along with a number of micronutrients critical for human development (Chan et al., 2019 - this issue). At the same time, as Chan et al. (2019) illustrate, development of aquaculture in Africa lags substantially behind many other parts of the world. Their foresight modeling shows that fish-friendly investment approaches have the potential to substantially boost aquaculture production and per capita fish intake, which is especially important considering that supply of fish from capture fisheries is not expected to grow. Thus, in a manner similar to observations regarding livestock by Enahoro et al. (2019), Chan et al. (2019) suggest that rising African demand for fish is expected to offer important opportunities for fish sector entrepreneurs given an appropriate policy environment.

Though rural transformation and other agri-entrepreneurial activities align with the optimistic sentiment regarding the potential of agriculture as a motor of economic growth in many of the lower- and middle-income countries (Binswanger-Mkhize et al., 2011), issues of food security remain a fundamental consideration in many parts of the world. In this issue, Petsakos et al. (2019 – this issue) note how root, tuber, and banana (RT&B) crops will remain important staples for food security for many years to come. They also note that, in spite of their natural climate resilience, RT&B crops have historically been somewhat on the periphery of major investments in agriculture development. They conclude that investment in RT&B crops has the potential to alleviate food security in many localities around the world and, likewise, that investment could also drive commercial market transformation, increasing both incomes and employment associated with this sector.

Income and employment, especially employment that lowers burdensome tasks for women, are oft-cited goals of investment in agricultural research. In looking at employment in Sub-Saharan Africa, Frija et al. (2020 – this issue) note there are many factors, ranging from barriers to land access to low labor productivity to low public investment, that serve to dampen the potential of agriculture to contribute in these areas. At the same time, Frija et al. (2020) argue that investments that improve agriculture performance, including closing yield gaps and improving extension services, have the potential to not only improve productivity, but also employment and, specifically, employment for women. Using foresight analysis for fourteen countries in Africa, they show how targeted investments, especially in improved market systems, have the potential to generate substantial increases in female employment by 2050.

5. Conclusion

If a careful reflection on our agricultural past, present and future tells us anything, it is that there are no one-size-fits-all solutions. The papers in this special issue highlight the importance of locally contextualized solutions. In spite of the highly varying local, regional and national contexts surrounding agriculture research for development, however, the foresight analyses included herein also show us the importance of understanding the potential impacts of broader macro-level drivers that will shape the future of agriculture and food systems. Understanding these trajectories is particularly important in lower- and middle-income countries as decisions now will affect these countries for many years to come.

Strategic foresight approaches, whether quantitative or qualitative, provide us with a valuable opportunity to peer into the future and explore how different investment decisions today may influence the future of agriculture and food systems. As we continue to increase our understanding of what has worked in what context with rigorous ex-post analysis, strategic foresight helps create a virtuous circle, taking past understanding and exploring both future business-as-usual and alternative scenarios. With this understanding, we can then circle back to the present, and work to create policies and investment strategies today that maximize the potential for desirable future outcomes and limit the possibility that we continue to be adversely haunted by the ghosts of agriculture past.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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