Public Sector Agricultural Research Priorities for Sustainable Food Security: Perspectives from Plausible Scenarios

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Executive Summary

There is widespread agreement that our ability to deliver sustainable food security for all will be challenged in three dimensions – population growth, constrained natural resources and climate change.

This executive summary presents highlights on the current food security status and the results of recent assessments of the future of food security by FAO and the CGIAR. This is followed by an overview of present and recent past history of research expenditures by the public and private sectors. Finally, it presents recommendations for priority activities by the CGIAR and FAO to improve their strategic foresight activities.

The status of sustainable food security today

The latest FAO report on the State of Food Insecurity in the World (Food and Agriculture Organization of the United Nations 2012) estimates the number of under-nourished in the world at around 850 million persons (average over the period 2010-2012). The period of relatively steady decline since 1990 was interrupted after 2007 when food prices spiked and have remained at high levels since then.

The global numbers also belie significant regional differences both in the current levels and the overall trends since 1990. The largest concentrations of the undernourished are in South Asia (305 million), Sub Saharan Africa (234 million) and East Asia (167 million). In percentage terms, however, Sub-Saharan Africa outstrips all other regions with nearly 27 percent of its population estimated to be undernourished. South-East Asia as a region has made the most progress since 1990/92 with a 63 percent decline in the incidence of undernourishment. East Asia and Latin America are close to achieving a halving of the undernourishment index. South Asia has seen a drop of roughly 1/3 in the incidence of undernourishment. In Sub-Saharan Africa the decline has not even attained 20 percent. Note that Sub-Saharan Africa observed virtually stagnant growth throughout the 1990s.

The sources of food security challenges: drivers of change

All forward-looking scenarios start with some assessment of population and income growth, and where the growth takes place, as they are key demand drivers for food security. The IPCC's Fifth Assessment process includes new climate and socioeconomic scenarios (RCPs and SSPs).[1]

[1] Representative concentration pathways and shared socio-economic pathways.

Population will increase to over 9 billion persons from today's roughly 7.5 billion in the UN's medium variant scenario and closely matched in SSP2. In 2010, global average income is estimated to have been $8,400 per capita.[2] Under the worst scenario (SSP3), this would increase to only $11,500 by 2050; a truly miserable outcome should it obtain. For the middle of the road scenario (SSP2), average 2050 per capita income would be $18,857. For the two poorest regions – Sub-Saharan Africa and South Asia – the range in terms of potential outcomes is highest. Even in scenarios with considerable convergence, i.e. per capita growth rates much higher in the developing countries than in the high-income countries, income gaps remain large. In SSP3, high income countries have a per capita income of $65,175. One key feature of income growth for developing countries will be changes in dietary preferences and resulting impacts on overall agricultural demand.

Food security futures: FAO and CGIAR perspectives

Since the 1970s, FAO has regularly produced a number of reports on forward looking scenarios[3]. An important point to emphasize is that the AT reports in general and the 2012 update in particular ***do not*** include the productivity effects of climate change on agriculture. Hence, the results on production growth, yields, and other key variables do not reflect the mostly negative effects of climate change.

The headline finding from the 2012 *AT2050* report is that agricultural production would increase by some 60 percent between 2006 and 2050 to meet anticipated demand (in a baseline scenario). Population growth alone would account for 39 percentage points of the increase in demand, with the remaining 21 percent due to income growth and whatever structural changes in the diet are linked to income growth. Caloric intake improves at the global level from some 2,772 kcal/day/person in 2006 to 3,070 in 2050 (an increase of 12.8 percent), and significantly more in the poorest regions. With climate change effects considered, these outcomes would be less positive.

Yield growth accounts from some 80 percent of the overall production increase. Land use change is modest except in Latin America and sub-Saharan Africa. Global land use would increase by around 70 million hectares—an increase of 107 million hectares in developing countries and a decline of some 38 million hectares in developed countries.

The *Food Security, Farming, and Climate Change to 2050* report published by IFPRI in 2010 has results from a partial equilibrium model with extensive spatial detail that endogenizes country-level production, consumption, trade flows and prices. Unlike much of the 20th century, when real agricultural prices declined, this analysis suggests that real agricultural prices will increase substantially between now and 2050, as the result of growing incomes and population as well as the negative productivity effects of climate change. With high per capita income growth and perfect GHG emissions mitigation, calorie availability in developing countries would reach almost 85 percent of that in developed countries by 2050. With a pessimistic scenario that includes low income growth and more rapid population growth, however, calorie availability declines in *all* regions.

[2] Dollar amounts refer to constant 2007 prices and market exchange rates.
[3] These are the so-called AT20xx reports, where the AT means 'Agriculture Towards…'

In the optimistic scenario, the number of malnourished children in developing countries falls by over 45 percent between 2010 and 2050. With the pessimistic scenario, on the other hand, that number only decreases by about 2 percent. Trade flows can partially offset local climate change productivity effects, allowing regions of the world with positive (or less negative) effects to supply those with more negative effects.

Global trends in agricultural R&D spending

As the results discussed above demonstrate, population and income growth and climate change will put pressure on our ability to feed the world sustainably. Investments in agricultural productivity are essential to dealing with these challenges.

Following a decade of slowing growth at the end of the 20th century, global agricultural R&D spending by the public sector increased by 22 percent during the 2000–2008 period, from $26.1 to $31.7 billion in 2005 PPP prices. Accelerated R&D spending by China and India accounted for close to half of the global increase of $5.6 billion during 2000–2008. High-income countries were an exception to the global growth pattern of the 2000s. In fact, their growth rate in public agricultural R&D investment continued to slow. About one-third of the OECD countries spent less on public agricultural R&D in 2008 than they did in 2000. Although the CGIAR plays an important role in agricultural R&D in developing countries, it accounts for only a small share of global public agricultural R&D spending. In 2008, CGIAR spending as a share of total global public agricultural R&D spending amounted to a mere 1.5 percent (3.1 percent, if high-income countries are excluded).

Private investment in agriculture and food processing R&D increased from $12.9 billion in 1994 to $18.2 billion in 2008. About 45 percent of this amount was directed to R&D related to improving inputs used in agricultural production, with the remainder directed to areas related to food processing and product development.

What is missing from forward-looking scenario exercises?

Systematic planning for the future requires an assessment of *all* the key factors that could drive changes. Some changes cannot currently be modeled satisfactorily; in particular, sources of variability from climate change, under- and over-nutrition, and sustainability.

Satisfactory modeling of climate variability effects requires models that can incorporate variability explicitly and none of the global economic models currently do this. But even if they could, the climate modeling community is not able to generate estimates of the change in variability for the weather variables of most importance for agriculture. Climate change is also likely to increase the incidence and nature of threats from various agricultural pests. But today's crop models don't have many satisfactory methods of implementing changes in pest pressure. Even if they did, there are virtually no quantitative assessments of how climate change will affect the incidence of even the most common pests. These two lacunae deserve particular attention from the research community.

Malnutrition

Only a few of the global models report estimates of average daily per capita kilocalorie availability (see for example the results from the AT 2012 report and the IMPACT model results) and the basis for these numbers is somewhat shaky. There is little or no scenario work available that looks at changes in calorie consumption for different groups globally and nothing available on other nutrients that are key to childhood development, for example. And overnutrition is a growing problem in today's developing countries and the quantitative global modeling work has virtually nothing to contribute to the discussion.

Sustainability

Although virtually everyone agrees that sustainable food security is very important there is little agreement on which of the many potential dimensions of sustainability are most important to assess. Currently available global models can already assess some dimensions of sustainability – land use change, use of water, nutrient use, greenhouse gas emissions – but there has been no systematic effort to review these metrics, how the models implement them, and what key aspects of sustainability are missing.

Priorities for the CGIAR and FAO in scenario development and strategic foresight

It is clear that substantial resources are needed to sustain the detail of modeling and model improvements that are needed to meet the needs identified above and others. This suggests that cooperation across these two sets of institutions to take advantage of their expertise could result in better understanding for all. At the same time, neither of these institutions has some of the expertise badly needed to assess the coming food security challenges so cooperation should extend to a range of research organizations. We envision three types of joint activities.

Cooperative quantitative modeling

The FAO's ENVISAGE model is one of the world's leading global computable general equilibrium (CGE) models with detailed (from a CGE perspective) representation of agriculture. The feature of CGE models that is of particular importance is that they can explicitly deal both with the effects of agricultural investments and policy changes on other parts of the economy and with the effects of changes outside of agriculture on that sector. IFPRI's IMPACT suite of models, which includes a partial equilibrium, multi-market model with high spatial and product resolution, and soft links to a detailed hydrology model, a water supply-demand model, and the DSSAT suite of crop models, is one of the world's leading partial equilibrium model with highly developed links to biophysical modeling. Soft linking of these two modeling environments would allow better representation of plausible outcomes of potential public sector research activities, as well as a range of other potentially important public and private sector activities. Other CGIAR centers have expertise in certain kinds of biophysical models (e.g., ruminants at ILRI and agroforestry at ICRAF) as does FAO (e.g. Aquacrop). An effort to identify best-of-breed data and tools at these two institutions, integrate as appropriate, and share them as open source public goods would undoubtedly have high returns.

At the same time, other research centers have developed critical tools such as process-based crop modeling software that are essential to priority setting. Partnerships with these institutions will be essential to make most productive use of the resources devoted to CGIAR and FAO activities.

Cooperative use of institutional and outside substantive expertise

One of the strengths of the AT process at FAO is its extensive consultation with subject matter experts at FAO. The IMPACT suite has also had ad-hoc consultation with experts in the CGIAR centers. But scenario/foresight work at both institutions would benefit from a regular, systematic review process by internal and external subject matter experts of the inputs (e.g., biological potential in response to management and climate changes) and outputs (e.g., location-specific yields, planting and harvest dates, production levels).

Sustained cooperation with model intercomparison efforts

While both the IMPACT suite and ENVISAGE represent state of the art models for scenario/strategic foresight, there are several other global models produced by advanced research institutes that have dimensions not captured by these two models and internal expertise that results in model outcomes that can differ substantially. The AgMIP project (www.agmip.org) has intercomparison and improvement of agricultural models of all kinds as its *raison d'être*. Cooperation by FAO and the CGIAR with these other modeling efforts under the auspices of AgMIP will improve all the models involved in the comparison. A role model to consider is the Stanford-based Energy Modeling Forum (EMF) that has been active since the energy crises of the 1970s. Agriculture, like energy, is facing huge challenges over the next decades, with or without climate change. The ability to pool the best analysts from around the world will enhance the individual efforts of the research terms as well as provide policy makers—national and international—with improved analysis, which, not necessarily reflecting consensus, reflects more considered and insightful analysis.