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Editorial

The challenge of global food sustainability

Introduction

The demand for food is forecast to grow by at least 50% over the next four decades, driven by population growth and rising affluence in many of the same regions whose populations are growing the most. With the continued competition for land, this means that the productivity per unit of land area similarly needs to grow to ensure adequate food supplies, but this needs to be achieved against a background of climate change, and the realisation that food production is itself a major contributor to greenhouse gas emissions and the loss of biodiversity. Even today there is a significant proportion of the world's people who are malnourished or even starving, and as the demand for food increases, there is a risk that food distribution could become even more unequal.

The reviews in this edition were commissioned as part of the UK's Government Office for Science Foresight Project on Global Food and Farming Futures, which will report in early 2011.[1] The project addresses the threefold challenge of feeding a future global population of 9 billion people in ways which are sustainable and equitable [1]. The reviews in this edition focus on issues other than production *per se*. They have contributed towards the evidence base which underlies the exploration of the policy options to address these challenges, and the authors are drawn from a broad range of disciplines.

The importance of trade policy

Although only a small proportion of global food production is traded internationally, it is extremely important in balancing supply and demand in countries whose consumption exceeds their production, and in providing a net income for countries which can produce a surplus. As was seen clearly in the price spike of 2008, one of the first reactions was for some countries to limit or ban exports, to protect their own population from shortage through either unavailability or unaffordability. This has led to concerns that with increasing global demand and extreme climatic events, this could lead to more riots over access to food. Even greater concern has been expressed that as agriculture uses around 70% of the world's fresh water, and climate change is predicted to significantly shift rainfall patterns, conflicts could also emerge over the supply of water. The analysis by Allouche [2], however, finds little past evidence for outright warfare over food or water, although competition between communities has frequently occurred. Whilst this may be seen as giving comfort, the analysis also notes that those most affected tend to be the poorest and most vulnerable, and advocates policies to mitigate this threat.

The nature of trade policies in relation to climate change is explored further by Huang et al. [3]. These authors note that climate change is likely to increase the importance of global trade in ensuring adequate food for all, as the areas suitable for highly productive agriculture will change. They argue that as agriculture is both a source of greenhouse gas emissions, as well as a sink for carbon capture, global standards on emissions will be essential to prevent one region protecting its income or food supply to the detriment of the health of the planet as a whole.

Minimising greenhouse gas emissions from productive agriculture

The greatest single component of greenhouse gas emissions from agriculture arises from the production and use of fertiliser, whether as synthetic nitrogen or as manure. However, fertiliser is absolutely vital to food production, with around half of the nitrogen which makes up human protein originating from it. Dawson's [4] analysis leads to a proposal that nitrogen fixation is so fundamental that a strategic reserve of methane is needed to proved energy and hydrogen, at least until alternative sources of energy become plentiful. On the other hand, Dawson proposes that within this century the easily accessible sources of phosphate are likely to become exhausted and new recycling methods for phosphate will be needed as an absolute requirement for plant productivity.

Having recognised that productivity will require fertiliser, and hence inevitably there will be ongoing emissions of greenhouse gases from agriculture, the subsequent two reviews look at the remaining opportunities to reduce net GHG emissions across the food system, without jeopardising food security. Garnett [5] concludes that whilst efficiency gains can be made across the food chain, major reduction can only come from reducing emissions from animal husbandry, and that this may involve significant reduction in meat consumption. In starting from the other side of the equation, however, Lal [6] concludes that there is substantial scope to reduce atmospheric carbon dioxide by increasing the levels of organic carbon stored in soil, through a combination of minimum tillage and increased use of cover crops. The additional advantage of this approach would be that in many areas the productivity of the soil would also be increased.

The need for globally-accepted sustainability metrics and policies

Reconciling the conflicting demands on land – for food, energy and for environmental protection – has been called a "trilemma"

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[7]. Harvey and Pilgrim [8] argue that making this reconciliation will require an holistic analysis, the establishment of clear metrics and strategic political intervention to drive innovation and improvement. However, at the simplest level the solution requires a drive to sustainable intensification rather than expansion of cultivated land, although what "sustainable intensification" means is likely to differ from area to area rather than there being a single, global solution. From the specific perspective of biofuels, Murphy et al. [9] reinforce the need for credible and certified schemes to regulate the use of biofuels that contribute positively to the overall carbon balance, and which can respond to the inherently uncertain demand for biofuels compared to other renewable sources of energy.

A similar call for additional research to develop science-based systems, based on sound metrics, to preserve biodiversity is also made by Phalan et al. [10]. These authors note that while there is much debate on whether land for conservation should be separated from productive agriculture, or whether the same land can serve both ends, there is very little hard evidence on the relative merits. Considering what is available, the authors argue for a combination of sustainable intensification, and where that is insufficient to preserve biodiversity, for explicit conservation.

The opportunities from improving soil science and long-range weather forecasting

There is a remarkable consensus of view, from organic to intensive agriculture, of the importance of soil health to both the environment and long-term food production. However, it is equally remarkable how relatively neglected soil science has become, but as Powlson et al. [11] clearly point out there is great opportunity to increase agriculture sustainability through the application of knowledge in this area of science.

At a time where the climate is changing, the ability to predict long-range weather patterns, in order to inform the adaptation and planting of the most productive crops and managing pests and pathogens, is of clear value. However, as Davey and Brookshaw's review [12] discusses, the benefits available from existing forecasts have not been fully used, and beyond that, there is the potential to develop improved systems specifically targeted towards agriculture.

The need for hunger metrics

In addition to simple lack of calories, more than two billion people in the world suffer from a lack of micronutrients, while in other places over-consumption of particular foods, especially refined cereals, has given rise to metabolic disease. Zhao and Shewry [13] review the potential for using biotechnology to biofortify crops or to remove allergens, and conclude that there is great scope for improving the nutritional value and health benefits of crops. However, although doing this through conventional breeding is uncontroversial, the use of GM technology remains anything but, and whether biofortification through this mechanism will become widely accepted remains unclear.

Whilst other reviews in this issue have argued for the establishment of metrics to drive improved sustainability, Masset [14] considers the extent to which hunger indices have been used to fight hunger. His conclusion is that the multiplicity of metrics has led to some policy confusion which has hindered progress. Masset proposes new indices to measure both the commitment to reduce hunger and hunger itself.

The opportunities and constraints of intellectual property rights

A commonly expressed concern is the extent to which intellectual property has shifted power to a few private companies in food and agriculture. Blakeney [15] evaluates the basis for this concern, and concludes that whilst there are risks, intellectual property can also provide commercial incentivisation for the investment in innovation that will be required to feed the world sustainably.

Conclusions

The challenge faced by the world is to feed its growing population sustainably and equitably. Market forces and appropriate investment in science and industry will arguably ensure that the richest majority of the population will be fed. However, much more fundamental challenge remains in ensuring sustainability. Agriculture is an inherent balance between energy inputs and outputs, and carbon capture and greenhouse gas emissions, and the reviews in this edition provide cogent arguments that much better metrics are needed, and that these need to be supported by policies to ensure the move to sustainable intensification. Although not the major focus of this edition, similar conclusions are reached on ensuring equitability.

While we can now envisage a world where population and consumption cease to rise, there are no simple answers, and the policy decisions we make and the science we choose to carry out over the next few decades will determine whether all the people living in this world have access to adequate food.

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