11th Hugh Bunting Memorial Lecture

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Climate change and agriculture: risks and opportunities to food and farming systems in the tropics

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(Summary of presentation prepared by Andrew Bennett)

Introduction

Professor Wheeler started by outlining the contributions made by Hugh Bunting to understanding the impact of climate on agriculture, and the international reputation that Reading University has for its work on climate change and agriculture.

He indicated that in his lecture he would cover the challenges, the evidence, the impacts and possible opportunities, and ways forward to cope with climate change and achieve food security in developing countries.

The Challenge

The global population is set to rise from 7.5bn to 8.3bn by 2030. While current global food production is estimated as 3.6bn tonnes (equivalent to 2,700 calories per person per day), some 850m people are undernourished, 1bn experience micro-nutrient deficiencies and 1.4bn are over-weight. But with rising population, greater spending power, diversifying diets and urban growth, it is estimated that food production will need to grow by 50 percent. However, it is also predicted that the world will be between 0.3-0.7˚C warmer by 2030.

The UK produces about 50 percent of its food, with the remainder imported from over 170 countries. The average distance travelled by imported foods continues to increase in many countries, including those in Africa and south Asia.

The Evidence

The production of cereals in sub-Saharan Africa is closely correlated with rainfall, and natural variation in weather, such as El Nino/La Nina, has a major impact on rainfall across the tropics. There is still insufficient evidence to conclude that climate change has influenced the frequency or intensity of the El Nino events or average rainfall.

However there is consistent and compelling evidence of a rise of about 1˚C in global temperatures, starting in the early 1900s and increasing most rapidly since the 1960s.

The *Intergovernmental Panel on Climate Change (IPCC) Assessment Report* in 2014 concluded that *"Human influence on the climate system is clear"* and *"warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia"*. It went on to conclude that *"climate change will impact on all four dimensions of food security*".

FAO has stated that *"food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life"*.

There are four dimensions to food security:

- **Food availability:** the availability of sufficient quantities of food of appropriate quality. Supplied through domestic production or imports.
- **Food access:** access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet.
- **Food utilisation:** utilisation of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met.
- **Stability of the food system:** To be food secure, a population, household or individual must have access to adequate food at all times.

While there has been a significant increase in the numbers of publications on climate change and food security since 2005, the current evidence base for climate change impacts on global food security is heavily skewed towards food availability, with serious gaps on the broader aspects of food security.

There are an increasing number of ingenious experiments to assess the impact of higher carbon dioxide concentration. These indicate that higher CO_2 levels and warmer temperatures:

- Enhanced growth for C3 crops;
- Lengthened the potential growing season;
- Increased crop water use efficiency.

However higher temperatures also would:

- Shorten growing season for current varieties;
- Present new threats from pests and diseases;
- Result in frequent exposure to extreme weather conditions.

Research has shown that crop productivity is highly vulnerable to variations in climate. In rice, a single hot day above 32˚C at flowering can reduce the numbers of grains set per head, with a total loss of yield if temperatures exceed 40˚C.

Elevated CO_2 levels can also affect seed and grain quality, leading to significant reductions in zinc, iron and protein, but possible higher phytate contents in C3 crops such as wheat, rice, field peas and soya beans. The picture is less clear with C4 crops such as maize and sorghum, but phytates can impact adversely on the nutritional value of foods by rendering important minerals less available.

Given current agricultural practices, the *World Bank Development Review 2010* predicted that, while productivity could rise in the temperate and cool regions, there could be 20-50 percent reduction in yields across the tropics and developing countries of the world. This will exacerbate food insecurity in the areas currently vulnerable to hunger and under-nutrition. These projections are summarised in Figure 1.

The Global Hunger Index is designed to comprehensively measure and track hunger globally, by country and by region. Calculated each year by the International Food Policy Research Institute (IFPRI), it provides insights into the drivers of hunger. Figure 1 contains a summary of the 2012 Global Hunger Index.

A meta-analysis of 52 publications on climate change impacts across Africa and Asia has summarised the likely percentage reductions in yields as:

- Across Africa: wheat -17%; maize -5%; sorghum -15% and millet -10%;
- Across south Asia: maize -16% and sorghum -11 %;
- There are no detectable changes in rice production.

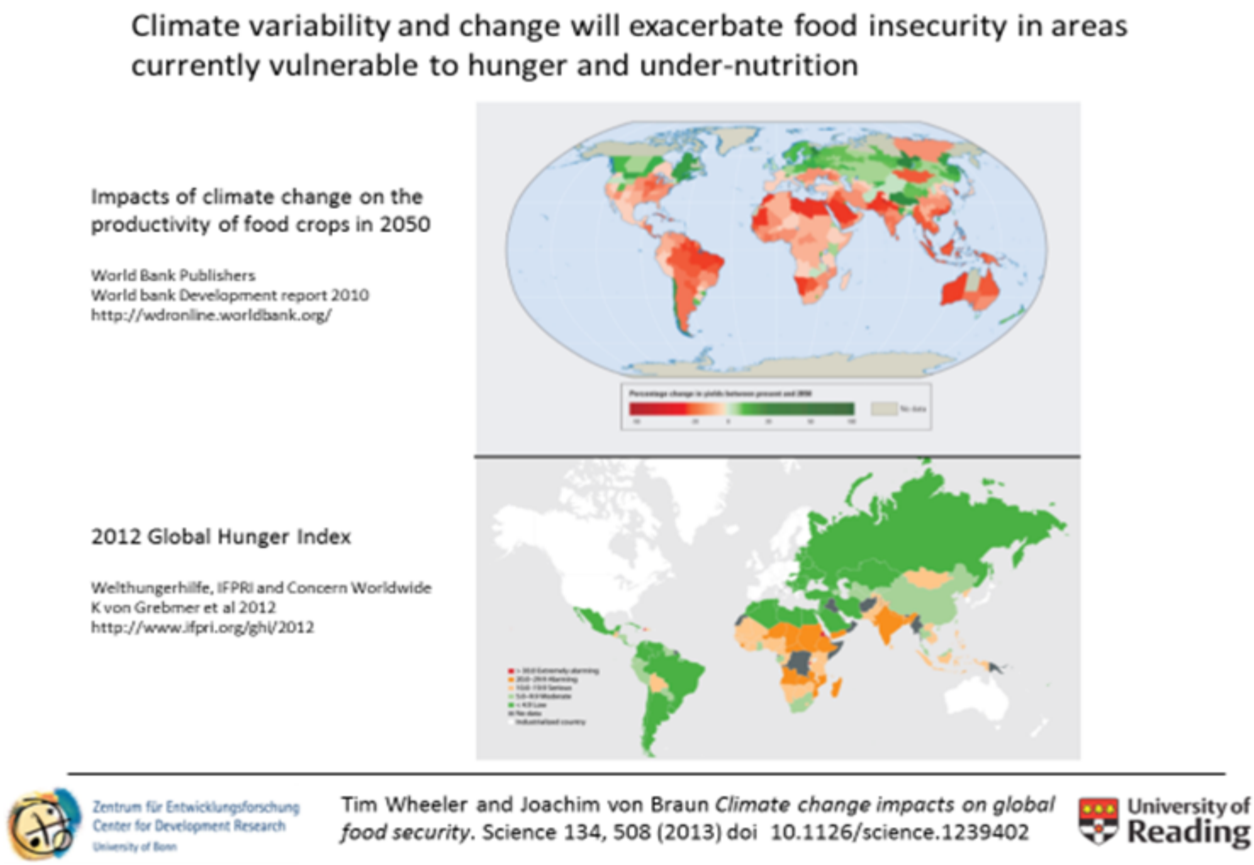

Figure 1. Impacts of climate change on the productivity of food crops in 2015; and the 2012 Global Hunger Index.

A World Food Programme Report estimates that climate change will:

- increase the numbers of people at risk of hunger by 5-20 percent by the year 2050;
- about 65 percent of this global total is projected to occur in Africa;
- in sub-Saharan Africa, 10 million more children could be malnourished.

Predictive models are increasing in their sophistication and accuracy.

Emissions come not only from crop production but elsewhere within the farming and food processing sector. The IPCC attributes agriculture, forestry and land use with 24 percent of global greenhouse gas emissions – some 12 gigatonnes of CO_2 equivalent in 2010. Of this total, 38 percent is from N_20 derived from soil management; 32 percent is from methane produced from enteric fermentation; 12 percent is from biomass burning; 11 percent is from rice production; and 7 percent is from manure management.

Opportunities and Responses

FAO advocates the need for climate-smart agricultural systems, which are designed to improve food security and rural livelihoods, and support climate change adaptation and mitigation efforts. The UK Royal Society calls for *"sustainable intensification – where yields are increased without adverse environmental impact and without the cultivation of more land"*.

There is clearly a need to develop more climate-resilient crop varieties. Paddy loss due to inundation in Bangladesh and India amounts to an estimated loss of about 4m tons of rice per year, enough to feed 30m people. The International Rice Research Institute (IRRI) has developed and released six flood-tolerant 'scuba' rice varieties, which are able to withstand 17 days of complete submergence. They are now being grown by over 5m farmers.

Biplob Sarker, a rice farmer from Bangladesh, said: "I gave up hope of getting any yield from my land as paddy seedlings remained submerged for 17 days. But to my surprise, the seedlings grew green again after the flood. I still can't believe I have got 18 maunds (672kg) of paddy from there".

The International Maize and Wheat Improvement Centre (CIMMYT), working with the Africa Agricultural Technology Foundation and other partners, has developed new African drought-tolerant maize varieties, which are becoming available to farmers. The long-term goal is to make drought-tolerant maize available royalty-free to small-scale farmers through African seed companies. These new varieties could increase production by 2m tons, which would be enough to feed 14-21m people.

Livestock insurance could also help the downward slide of vulnerable populations, allowing humanitarian resources to be focussed on the needy. The International Livestock Research Institute (ILRI) is working with partners to develop remote sensing technologies that can be used to assess the state of grazing resources, with payments to farmers when and where forage scarcity is predicted to cause livestock deaths.

Improving access to data through initiatives such as the *Global Open Data for Agriculture and Nutrition (GODAN)*, and other multilateral programmes, aim to help poor countries cope with the impacts of climate change.

The Climate and Knowledge Development Network aims to help decision-makers in developing countries to design and deliver climate-compatible development. It has created several fora in which interdisciplinary and transnational groups develop ideas on issues such as 'humans v mosquitoes'; 'disaster preparedness'; 'coastal resilience'; and supply chains.

Conclusions

Professor Wheeler ended his lecture with the following conclusions:

- Changes in CO_2, and in the means and variability of climate, present new risks to food and farming systems across the tropics;
- Under climate change, farms will be prone to environmental stresses not observed in today's climate, with increases in volatility of production due to extreme weather;
- The evidence base on climate change, food security and agricultural trade is still patchy, with a strong focus on food crop production;
- Broad-scale impacts on production are well-understood, with many threats expected to impact developing country agriculture;
- Adaptation and investment will be needed in order to maintain global food supplies to meet future demands for food;
- Better technology and knowledge to address climate change risks to crops will be vital for food and farming systems in the tropics.

Question and Answers

In the lively questions, comments and answers session, the following points were made:

- There were several traditional strategies aimed at coping with drought, such as the growing of gourds for storing water for livestock.
- In many parts of the world where yield levels remained well below potential, much more could be done to improve yields and cope with uncertain weather, through better and more timely agronomy.
- There was not much information on the impacts of climate change on tree and horticultural crops – though it was known that unfavourable weather at flowering could have a major impact on yields of such crops as oil palm.
- The adoption of 'conservation agriculture practices' which use less energy, do not disturb soil unnecessarily, increase soil organic matter and water retention – and possibly reduce N_20 emissions – should be more widely used and supported.

References

Parry M, Evans A, Rosegrant MW, Wheeler T, 2009. *Climate change and hunger: responding to the challenge*. International Food Policy Research Institute (IFPRI), Washington DC.

Wheeler T, Von Braun J, 2013. Climate change impacts on global food security. *Science*, **341**(6145), 508-513.

Porter JR, Xie L, Challinor AJ, Cochrane K, Howden SM, Iqbal MM, Lobell DB, Travasso MI, 2014. *Chapter 7: Food security and food production systems*. IPCC, Cambridge University Press.