FutureDirections international

INDEPENDENT STRATEGIC ANALYSIS OF AUSTRALIA'S GLOBAL INTERESTS

Workshop Report

2 February 2012

The role of science, technology and innovation in solving global food crises: Workshop Summary

Purpose

The fifth workshop series, hosted by Future Directions International's Global Food and Water Crises Research Programme, examined the role of science, technology and innovation in averting any future food crises. In November 2011, meetings took place in Sydney, Canberra and Perth.

The meetings sought to answer the following question:

"What role can Science, Technology and Innovation play in increasing food yields and overcoming food shortages or oversupply?"

Further workshops are to take place, which will examine the role that education and training can play in overcoming future food and water crises and the potential for conflict. A final series of workshops will consider how Australia will be affected by the global crisis and what role it might play in ameliorating this situation.

The results of the November workshops are summarised in this document. The Key Points highlight the major conclusions. A final paper will be published on FDI's website.

The list of attendees is below. They represent a variety of backgrounds. This paper captures their responses and the discussions were indicative of the complex nature of global food security.

Attendees

All workshops

- Major General John Hartley AO (Retd), CEO and Institute Director, Future Directions International, Workshop Chairman.
- Alyson Clarke, FDI Executive Officer.
- Gary Kleyn, Manager, FDI Global Food and Water Crises Research Programme.

Sydney Workshop

- Dr Ingrid Appelqvist, senior research scientist and government liaison, food and nutritional sciences, CSIRO.
- Dr Jayashree Arcot, Associate Professor of Nutrition, Food Science and Technology Group, School of Chemical Engineering, Faculty of Engineering, UNSW
- Peter Arkle, Head of Corporate Affairs - Australasia, Syngenta International.
- Les Copeland, Professor, Faculty of Agriculture, Food and Natural Resources, University of Sydney.
- Veronique Droulez, Marketing Manager Nutrition, Meat and Livestock Australia.
- Dr Samsul Huda, Associate Professor, School of Natural Sciences, University of Western Sydney. Project manager Food Security and Climate Change in the Asia-Pacific Region: Evaluating Mismatch between Crop Development and Water Availability.
- Mick Keogh, CEO Australian Farm Institute.
- John Lloyd, CEO Horticulture Australia Ltd.
- Tim Siegenbeek van Heukelom, PhD Candidate, Centre for International Security Studies, School of Political and Social Sciences, University of Sydney.

Canberra Workshop

- Julie Bird, Senior Research Manager, Rural Industries Research and Development Corporation.
- Dr Denis Blight, Executive Director, Crawford Fund.
- Julian Cribb, author The Coming Famine.
- Simon Gould, Planning Coordinator, Soils for Life, Outcomes Australia.
- Dr Simon Hearn, principal advisor, ACIAR

Perth Workshop

- David Archibald
- Rudi Appels, Professor, Centre for Comparative Genomics, Murdoch University.
- Rob Delane, Director General, DAFWA
- Dr Ian Fairnie, president, Agribusiness Alumni Association.
- Kevin Goss, adviser, Future Farm Industries CRC.
- Paul McKenzie, Agrarian Management.
- Peter Zurzolo, CEO Future Farm Industries CRC.

Key points

1. Science, research and innovation must continue across all parts of the food supply chain.
2. Farmers, food distributors and health practitioners must work closer together.
3. The Study of Soil should be the new focus for researches as this has been neglected in the past few years.
4. Genetically modified technology and climate change have been two areas of research that have received a lot of recent attention, at the expense of wider research aims, particularly in relation to water and soil research.

Introduction

Science, technology and innovation can be applied to food supply and demand all along the supply chain, or as those in the industry say, from farm to fork.

To simplify this somewhat, this paper considers the role of science, technology and innovation in three areas. The first is the role it plays in growing the food, the second considers the logistical elements and the third considers nutrition. Much of the discussion at the workshops ranged across all three of these areas. Participants expressed different priorities along the food supply chain, with some stressing the need for on-farm research, while others believed it was more meaningful to focus on logistics, distribution or health and nutrition. For this reason the final part of this paper considers what can be done to bring the different stakeholders closer together.

1. Growing food

The workshops considered the different inputs required in growing food and discussed ways in which science, technology and innovation have played their roles in the past; they considered methods that will allow them to continue to do so in the future. Inputs such as soil, microbiology, water, plant technology, energy and fertiliser costs, the role of urban farming and the variable climate were all considered in this part of the food supply chain.

I.Water

Water and the understanding of the role it plays in food production were seen by many workshop participants as crucial, in seeking to achieve a reduction in food deficient regions. Water availability and use can be considered in connection with dryland farming, as well as irrigated farming. Both have their own unique challenges and opportunities. Irrigation was at the core of the green revolution and is also part of the current constraints because of the exhaustion and pollution of natural resources.

Irrigation does, and will continue to play an important part in global food production. In some regions, the over-use and over-allocation of water has induced salinity and had a negative impact on the soil structure. More will need to be done in ensuring water use and allocation is sustainable. Failure to do so will compromise future food supply.

At the same time there have been major technological advances in water use efficiency, with greater food production achieved with diminishing water use. New plant varieties, which can produce their yield with lower water inputs, or the development of pipe infrastructure where previously inefficient canal systems previously existed, are examples of this.

In this regard, Paul McKenzie said the key issue for research for any farmer anywhere around the world, is the business of transferring moisture into a product. “So we need to start at that basic level: How can we get maximum use of every millilitre of available moisture in the soil. To me this is one of the areas where we are doing and can continue to do a lot of research,” he said.

One participant said that further innovation will have to be technological and institutional, resolving water sharing issues between nations and conflicting demands for water. Sharing river water resources in areas such as the Mekong in Asia, the Nile in Africa and the Tigris and Euphrates in the Middle East, will become increasingly important.

II.Soil-Carbon, microbiology

Understanding the role of soil in providing healthy food will be fundamental in dealing with food security. Workshop participants said that a better understanding of soil and improvements to soil health will be required in the future.

Mr McKenzie: "It all comes from the soil. We cannot control the rain, so understanding the soil capabilities is our key, not only to better productivity but also to better conservation of soil. Productivity of the soil is increasingly compromised across much of the world. Understanding soil is the key to finding out what we can produce."

Professor Rudi Appels said researchers need to have a good understanding of soil constraints. The soils can only produce so much food.

Julian Cribb believes the next agricultural revolution will occur because of advancements in soil knowledge.

"The complexity of what goes in the soil is amazing. The next agricultural revolution resides in what is called microbiology ... and understanding how to regenerate the life in the soil, so that you can unlock nutrients," Mr Cribb said.

"This is a branch of science that worldwide is dead in the water, because we are hardly training any soil biologists. Yet this is where organic farming and high technology farming comes together. We need an understanding of the complexity of the life in the soil and how to generate a more productive environment.

"You can push a plant so far, like with grain you can get 60 per cent of the plant weight in grain, but once you go beyond that the plant will not be able to stand up, so we have got to look at other ways.

"Australia for its own sake needs to make an investment in soil microbiology. With the use of herbicides you can kill the soil and the fertility. Fertilisers are destroying access to micronutrients and the soil is losing its full range of nutrients that we need for a healthy diet."

Simon Gould said that, in the past, Australian scientists had a greater focus on soil quality than currently, something that needs to be addressed if Australia is to increase its soil productivity. He said increasing carbon levels in the soil would lead to greater water retention.

One view was that there was not a shortage of researchers but that they had moved into other areas of research, such as climate change.

The point was made that climate change research is getting all the attention and the funding, at the expense of soil research.

Rob Delane feels that the attention should not be on trying to improve the quality of all soils but rather focus attention on the soils that are currently being used for agricultural production, to try to maintain their productive level.

“If you think about it in terms of optimising the world’s food supply then the first thing you try to do is not lose any of those valuable soils,“ he said. “The world’s food supply does not come evenly across the soils and Australia’s soils are some of the least productive in the world. So if you own the world and you are solely responsible for the food supplies of your people, then you will work out where the most critical food supply areas are and you would do everything you could, not to lose any food capacity from there.”

“It is about protecting the food supply area that you have got rather than trying to turn the soil into what we believe it was like before our forefathers came. There are huge areas close to where the food is needed where land is being lost.”

Mr McKenzie said that in the end it was all about converting rain to grain and converting feedstock to meat. “I think the source of all life is water; while everyone looks skywards, the time is well and truly due for us to look down and understand how much water is able to be stored in soils in whatever environment around the world.”

Mr Delane believes Western Australian farmers have developed best practice farming, retaining stubble and using non-tilling farming methods. This expertise and knowledge is building up the soil quality and could be used in other countries.

Kevin Goss says that the challenge of building up organic matter in soils to improve production is that it is slow to build up and quickly lost. Australian long-term trials have shown that organic carbon in soils builds up in the pasture phase of crop: pasture rotations, with no apparent difference between annual or perennial plants. Building up organic soil matter is something that requires careful, sustained management, to avoid depletion events like mechanical cultivation (an issue with herbicide resistant weeds) and soil erosion. Australian expertise in farming systems development, including permanent soil cover with drought adapted perennial pastures and forage shrubs, could also be applied in other countries.

The interrelatedness of healthy soils and healthy food is something that appears to be little appreciated, particularly within the health community. Yet, as Dr Simon Hearn pointed out, crop rotation, social science and nutrition are totally inter-related.

Despite this, government subsidies and support from non-government organisations are often geared toward supporting mono-cropping, which can damage the long-term viability of the agricultural sector in that region.

“We need to breed the vegetable varieties that improve the soils of the individual countries. In Africa you see the amount of mono-cropping of maize, a crop which is very exhaustive on the soil, and by only introducing some legumes into this

environment it will improve soil and nutrition," Dr Hearn said. "It is about education, and that is an early deliverable. It is a researchable issue how to introduce legumes into tropical climates."

III.GM/Plant Technology, Plant Breeding

For some workshop participants, the main focus of research and innovation should be on the development of plant breeding and plant technology, including the use and exploration of genetically modified food. There is still enormous scope to increase plant yields, often by applying research already completed but left dormant on the shelves. A more commonly held view was that plant research had to coincide with further research into other inputs, such as soil and water.

Professor Appels said the Australian Export Grain Innovation Centre, which focuses on increasing the competiveness of the Australian grains industry, is one mechanism that appears to be improving the adoption of new research in Western Australia.

Mr McKenzie said a big concern should be the increasing lack of food diversity, a point which was also expressed by others. Having fewer crops means greater risk in the event of unfavourable conditions, or during outbreaks of new crop diseases. Narrowing the genetic base to produce higher yields has been the focus over the past few decades. Now is the time to try to increase the range of crop varieties and thereby improving food security. That said, what farmers will grow will continue to be driven by consumer preferences. More understanding of indigenous crops will be important in attempts to increase sustainable food security in different countries.

In increasing crop yields, the important thing is to ensure that the plant is making better use of the soil. China and France are seen as standouts in crop research at the moment. Both are said to be way ahead of other countries in crop development, using genetically modified technology, and also in making it profitable, by means of involving the private sector. One participant said that Australia used to occupy a fairly respected position in food research but that it is now struggling to catch up again.

Clearly it will be profit, or the promise of profit, that will motivate the adoption of new technologies and plant varieties.

While Genetically Modified Organisms (GMOs) have a place in research, an opinion expressed at the workshops was that they are taking all the attention and are viewed as the big solution, instead of just part of the solution, in shoring up food security.

"I think the science has been robbed by GMOs. The GMO technique has convinced people that it is a silver bullet, so it has sucked resources and science from everything else it has detracted science funding from other areas, which are equally or more important," Mr Cribb said.

However, the point was made that GMO research is now providing the standard tools for general plant breeding and genetic research world-wide. GMO and its related biotechnologies, and climate change are two areas of research that have received attention. The view expressed was that there is a need to complement this research with commitments to water and soil research.

IV. Input costs-diesel, fertiliser

Research into inputs by farmers, such as energy savings and fertiliser efficiencies, will become increasingly important for future farmers. There are a number of reasons why this will become more important than in the past, some of which are considered in this report. The first is that there is a view that energy and fertiliser costs will continue to increase if the globe reaches “peak oil” and “peak phosphate”, as suggested by some roundtable participants. The expectation that these input costs will continue to rise, opens the way for new technology. Second, fertilisers have reached their limit in lifting yields in many parts of the world. The rate of return for each fertiliser input has diminished, or has become negative. Yet in other places fertiliser is still underutilised.

Finally, environmental legislation has been, and continues to be, introduced in many parts of the world restricting the use of fertilisers, as well as energy inputs to run farm machinery. As regulation increases, farmers will need to justify and/or change their behaviours. Consumer expectations also need to be considered, with consumers demanding organic products; although this market is still relatively small.

Energy costs continue to go up, driving up food prices. Fertiliser may have to come from other sources if oil prices continue to rise. Mr Delane believes farmers need to maximise their resource use. “There is an enormous amount of resources wasted as a result of poor decision making, either because they don’t have all the information or they don’t apply the information well,” he said. “So there is an enormous amount of dieseline and fertiliser wasted in Western Australia each year because of inadequate decision-making, based on the amount of moisture and other conditions. If you go to the very high input areas of the world, like the EU and parts of the US, food could be produced much more efficiently in some of those areas.”

He said that Australia needs to be able to turn knowledge into innovation.

V. Urban farming

As farming land gets lost because of urban encroachment or as a result of landscape degradation, some researchers are turning their focus to the urban landscape, finding ways that cities can become more self-sufficient. The result could mean lower food prices and also has security benefits. Urban centres are largely vulnerable to outside shocks and can be easily cut off from their food sources should the transport infrastructure be damaged. One example of work being done in this area is by Dutch architectural firm van Bergen Kolpa Architecten, which plans to build a

4,000 acre park in the middle of the Netherlands most populous area, the Randstand. [1]

VI. Climate change

One uncertainty in future planning is the climate and future weather conditions. If the weather variables widen, it makes it more difficult to apply the correct research.

Professor Les Copeland believes one externality that researchers do not have their handle on is climate change.

"I think other technologies, such as producing breeds and better quality products, are in the pipeline, but I think the uncertainty of climate change is really the biggest worry. That is a major risk of food production."

That said, Professor Copeland said that as long as the efforts on breeding and quality continue, the research will deliver beneficial outcomes. He believes that we can be confident that farmers will be able to produce enough food out to 2050, based on past successes in discovering and adopting technology in agriculture.

John Lloyd agreed: "It will mean you will require a greater selection of tools to allow for the different scenarios."

2. Logistics: getting food to plates from the farm

Perhaps the most complex area of research relates to logistics and the efficiency of bringing food to the plate of consumers. This part of the food supply chain holds significant opportunities in areas of research and gains in efficiencies. It is during the time that food spends in transit that significant challenges occur. Governance, management and education all play a role in either hindering or encouraging the distribution of food. Food wastage and losses are significant around the world for varying reasons, while corruption adds to increases in food prices.

More needs to be done to stop the wastage of food, by improving storage and trying to protect food stocks from rodents and birds.

The quantity of food lost during storage or in transit in India is said to be equivalent to total Australian production. A lot of food is stolen, apart from the quantity eaten by rats.

Opportunities for Australia include developing new storage facilities and food tracking systems for places like India, as well as developing rail and road infrastructure.

[1] For more on the dutch plans visit: http://www.smartplanet.com/blog/design-architecture/dutch-architecture-firm-rethinks-the-urban-farm/825. Accessed 30 January 2012

David Archibald made the point that price would sort out the wastage to some extent – the higher the food price, the greater the incentive to reduce wastage or losses. If oil prices go up by 50-60 per cent it will raise food prices and so less will be wasted.

The point was made that it was important, through education programmes, to get the whole population thinking about how to reduce wastage.

Peter Zurzolo said that besides wastage, infrastructure, or the lack of it, is seen as an impediment to getting cheaper food. It is often due to inefficient transport connections to the countryside and can increase the cost of getting that product much more than can be saved by improvements that are introduced in the plant. The inefficiency in getting the food to the consumer is having an impact on food prices and there are lots of barriers right through the supply chain. When food losses are high, it increases the cost of the remaining food.

Dr Denis Blight said that 50 per cent of the cost of producing food comes post-harvest. He believes that situation should influence where to target research.

“Should the research be targeted at the post harvest sector? There are potential profitability benefits for farmers if those post harvest costs are reduced and the final price of the food is not reduced.” Input costs for farmers are also going up.

The problems that exist in India, for example, are the same as they have been for the past 20 years, and, according to Dr Jayashree Arcot, a lot of it relates to post harvest management systems.

“India can feed its population. There is no problem. The issue there is distribution, getting the food to the people,” she said. “So there is a lot to be done with the distribution cycle there. Education should focus on that part of food security as well.”

In many countries the problem is a lack of roads, refrigeration and electricity or other sources of energy.

3. Nutrition and diet

In the area of agricultural research, an area of study that is often over-looked relates to health and nutrition and how it relates to food consumption. For this reason, FDI included health and nutritional experts in the workshops, recognising that more collaboration is needed between health practitioners and farmers. This point was emphasised by those taking part in the workshops.

Depleting the nutrients from the soils through bad management appears to have ramifications for the health of food and, by extension, on the health of humans. One example cited was the link between the incidence of cancers and the deficiency of selenium in the soil, which means that many of the vegetables in shops are selenium

deficient. While this is only one microbiological aspect of our soils, it can have a significant impact on health.

Encouraging healthy living, particularly among the 5-6 million obese Australians, requires effective policy settings and investment. Mandating the non-use of particular foods or controlling consumption rates is not possible.

Just adding multivitamin supplements to food does not appear to be working, because people do not always want that food. To improve nutrition it is important to give people food that they are familiar with and that they will actually enjoy eating.

Veronique Droulez: “There has been a huge change in the way that we eat and that has not necessarily been good for us. So we have to think about what people are eating, what are some of the problems that they are having, how can we help them and are we susceptible to that.”

Dr Ingrid Appelqvist said more investigation is needed on the transformation of raw foods into food on the plate. “There is a lot that needs to be done in developing the right types of manufactured foods that will be of benefit to all of the different countries, because then you can start looking at some of the nutritional needs. I think than we can solve many of the problems we have today.”

“For example, we cut a cow up and then make best use of it. The best parts we keep and manufactures can add all sorts of things. It’s a partnership between the growers and manufacturers to work together. It is about growers and manufacturers working together to enhance the nutrition of food, for example, by adding extra fibre.”

Research in genetic technology and nanotechnology could hold the potential for a new green revolution.

One future possibility is that people will be able to order personalised food. They will have the ability to self monitor their health daily, using scans and other methods, which then gives the person the shopping list of food items that they require to meet any food deficiencies. Ms Droulez believes one area of research yet to be explored is the development of a matrix that integrates food with nutrition, so that people not only get enough food but they are also getting enough nutrients.

“What is really lacking in the whole agriculture area is a matrix, which can say this food is actually going to meet people’s food and nutrient needs - which is what health is all about,” she said.

“We will have to develop innovations in that area to inform decision-making and avoid adverse consequences. You need a certain amount of nutrients in your body to be healthy but that information is not being integrated into agriculture, so funding decisions are now being made based on climate change and CO2 emissions, which has nothing to do with nutrition. There is no matrix right now to bridge that gap.”

As countries are becoming urbanised, they are adopting western diets and the associated problems. Supermarkets are part of the problem, but can also provide the solutions.

Professor Arcot said there was an opportunity for three sectors to come together: agriculture, food and health.

“I believe the mistakes that occurred in the last green revolution should not happen again. Production of food was given a lot of importance and in the process nutrient degradation went unnoticed. There are some indications in literature that some micronutrient deficiencies seen today are due to effects of the green revolution. The effects are now being seen in those countries where the green revolution occurred. The three sectors have to talk to each other to ensure this does not happen again,” she said.

Julian Cribb suggests that health and nutrition education is needed in schools, as well as through the mass media on television programmes such as Master Chef. The message also had to be passed on to the health departments “because the health department is presiding over the biggest budget blowouts in all of the western democracies as a result of ill health.” The health departments have a strong interest in reducing their budget expenditure increases, which often result from health problems caused by bad eating habits among the population

Cross supply chain integration and support (governance)

For significant inroads to be made in ensuring the food supply-demand gap is met and the estimated one billion people living in hunger get adequate food and nutrition, better communication and coordination is needed. Critical to the success of alleviating the plight of the world’s hungry, it is also the most difficult task to achieve. Overcoming ‘silo’ thinking within government or university departments is one issue. Another is seeking to ensure that along the food supply chain, the different organisations are communicating their needs adequately, while also working together. Over and above this is the issue of governance, within both the private and public sectors. Finally, cooperation at local, state, national and international levels is required, an elusive condition that is hard, if not impossible, to either obtain or maintain.

Many at the workshop expressed the view that the imperfect distribution of food to those in need was not due to a lack of research, but rather to a shortfall in the implementation of the research. Poverty is also a major factor. People need to be able to afford the food as well.

On this, Mr McKenzie made the observation that there is a whole lot of low hanging fruit that does not necessarily require new innovation. “Many things we know about that can be applied to other countries,” he said.

Mr Hearn concurred: “The agricultural capacity is enormous on the basis of current knowledge. It’s not necessarily new research but we can adapt all sorts of technology in agriculture to sub-Saharan Africa. So it is adaptive technology as opposed to brand new research and it can increase capacity enormously.”

“The first thing that needs be done in Africa is to develop a political framework. Africa seems to be stabilising a little and there are some encouraging signs. If you get the right political stability it’s an enormous start in any industry, but particularly in agriculture.”

Ms Appelqvist said: “We have a heck of a lot of technology sitting on the shelf. If I went down the supermarket technology shelf it would be packed from the floor to the rafters, there are tonnes and tonnes of stuff but it’s not taken up and adopted for many reasons. One of them is that the sector along the food chain is very fragmented, so it can be difficult for companies to access the technology. The other point is that it can be difficult to implement the technology because it requires technical expertise and some changes to infrastructure.

Ms Droulez added: “We all work in silos. Research and marketing are not working together and similarly agriculture and health are not working together. Agriculture does everything about producing enough calories or enough proteins, and nutrients are about nutrition. Marketing is all about what the consumer wants and technology is all about how we can produce more.”

“There is recognition that we must all work together, but until we have a common language or a common process, how do we talk together? “For starters we have very different languages: Efficiency is a good word in agriculture, but in public health it is about making more money to the detriment of someone who loses out.”

Another point mentioned by a number of workshop participants, was the ability to work with other economic sectors to achieve outcomes for food distribution.

Mr Delane believes that infrastructure development by, for example, the mining sector could have a greater impact on food security in Africa than any improvements in biology, because it will enable the biology and other things to actually work.

“There is a real potential synergy here of linking the infrastructure, health and other priorities, things that mining companies contribute towards, as beachheads for agriculture,” Mr Delane said.

“There is an opportunity for it to be better than just random acts of progress. There are massive mining companies around the world that are trying to develop into Africa. They are putting into place whole bits of infrastructure, road, port, town, health, education so there is synergy to work together.”

He also feels that mining companies could act as a conduit to get to government departments and facilitate the distribution of food.

Conclusion

For research and development in agriculture to become a priority, the government needs to view it as nationally important.

Tim Siegenbeek van Heukelom said it is important to perceive food security as a security measure, to tap into resources that are used for national security and national interest and that are currently prioritised for other objectives. “As soon as we can securitise the food issue, there might be more resources available to do things,” he said.

John Lloyd feels that governments were hugely concerned with events in 2007 and now see increasing food prices and increased food insecurity directly relating to geopolitical instability. Ensuring food security with our neighbouring countries is a better mechanism than delaying and then needing to apply direct military involvement in the future. The Australian Government is already showing signs of understanding the importance of food security as part of national security. On the same point, Mr Cribb said food security is not a small issue. “This is defence spending. Everything we spend on food security goes toward making a more stable and peaceful world, and that is the bit that many are not getting at the moment,” Mr Cribb said.

While the global population is expected to reach nine billion people by mid-century, there is reason for optimism.

As one participant said, over the past 40 years global food production has risen significantly. People are notoriously bad at predicting the role of technology. From time to time innovations happen that can be complete game changers; they are hard to predict, but when they happen it can seem so obvious. The game changers can lift production levels to new plateaus.

Australia can play a role in ensuring the right regulatory frameworks are put in place in other countries, which allow the best technology to be adopted.

The general feeling was that the science and technology are largely in hand. The key is to give farmers access to that technology, through proper regulatory and policy frameworks. The political structure and leadership is important to deliver outcomes.

There is already evidence that countries are working together to tackle the global issues. Organisations such as the United Nations and groups such as the G20, are placing food security on their agenda.

Yet as Professor Copeland said to the workshop, decisions need to be based on evidence but it seems that, increasingly, countries are basing their decisions on populist view points.

“It’s a wonderful potential future for the agriculture sector,” Professor Copeland said. “Farmers will be able to produce enough food for the world in 2050. I think the

real challenge is to have good government and policy settings for informed decision-making. I think if there are good market signals and impediments like trade barriers are removed, there will be plenty of incentives for research to proceed and that will in itself lead to adoption.

Australia will be an important developer and exporter of technology and capacity building, rather than a major world food supplier.

One example of what can be done to share ideas, developed by Mr Cribb, is to set up a virtual information sharing portal, where farmers around the world can share ideas and learn from other farmers' mistakes. Given the quick way that farmers in the developing world have picked up on new technology, such as mobile phones and computers, this sharing by using virtual means of information communication provides enormous opportunities, for both the developed and developing countries.

Summing up what many said, Mr Lloyd said it was about getting across to the different government departments and calibrating the science and policy settings as required.

"Three areas of research are: First, growing food; recognising climate change; being able to produce higher nutrient food on less arable land. Second is logistics: transportation, storage, taking the food from the farm to the consumer. The third issue is the whole question of nutrition and diet: how we educate people to eat food more effectively," Mr Lloyd said.

To do that collaboration is required rather than competition, and using commercial means to achieve the desired outcomes of equitable food distribution.

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Any opinions or views expressed in this paper are those of the individual author, unless stated to be those of Future Directions International.

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