

Q&A sessions

Moderators: Dr Denis Blight AO (Tuesday)
Professor Shaun Coffey (Wednesday)
Panels: The conference speakers on each day

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Q&A sessions*

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Tuesday

Moderator (*Denis Blight*) My name is Denis Blight. I'm the Chief Executive of the Crawford Fund, and was the CEO of CABI preceding Trevor Nicholls. After I'd left, Trevor invited me to write a history of CABI which turned 100 years old in 2011. One story I came across included a quotation from the Reverend J.G. Gibb. He said, in about 1842:

All of God's creatures have a purpose; all of God's creatures have a virtue, except for the weevil. That it has virtues there can be no doubt; it is just that they are deeply hidden.

CABI actually unveiled one of the virtues of weevils. Asked to find the pollinator for the oil palm, CABI's identification research discovered that it was a weevil. When oil palm was first introduced to SE Asia it was introduced without the weevil, but based on CABI's research the weevil was transported safely, with all appropriate tests, to Malaysia and a booming industry resulted. This booming industry has latterly been blamed for many other ills in the region, so I'm wondering if this actually was a weevil or an evil! Now let us begin this Q&A session.

Q. (*Peter Carrbery, CSIRO, to Jonathan Foley*) Thanks for the nice presentation. You presented five scenarios as essentially solutions to future food demand and I hope I'm not misquoting you but it was somewhere around your third scenario that I think you said: 'It's simply a matter of deploying currently known practices'. Yes, that's true, if you ignore the social, cultural, institutional, political constraints. Should you not present those scenarios with some likelihood term or probability of being able to overcome those constraints along with the simple biophysical perspective?

A. (*Jonathan Foley, University of Minnesota*) Yes, that's a very good observation. You're absolutely right. What I was trying to point out is that there are biophysical realities which, although people like to ignore them much of the time, tell us that, yes, we can actually deliver twice as many calories by 2050 and dramatically reduce CO₂, methane emissions, biodiversity losses and all those things, as I mentioned — and it's just a 'simple' matter of reorganising human civilisation. Obviously it's not simple, and so, you know, there's a bit of tongue in cheek here. In my 20 minutes I was outlining the broad opportunities. I think the point also is that a lot of the narratives we're currently using, about what

*The Q&A sessions were recorded and transcribed for inclusion in these Proceedings.



Denis Blight (left) and six of the panel (Jonathan Foley, Frank Rijsberman, Shenggen Fan, Christine Padoch, Xuemei Bai and Trevor Nicholls) listen to a question from Prof. Andrew Campbell, live videoed in the audience. The other Tuesday speakers were also on hand to answer questions (not in picture).

we need to do first, are still incorrect and not really informed by biology or physics either. A number of us are pointing out that soil nutrition is a very big area that deserves more attention than it's getting; or that water efficiency and productivity is a dramatically important area; or that genetically modified crops may not be needed in fact for food security but are useful for farmer income. And so I think the science, even though it does make it look like everything else is easy, gives us a road map to where we should be putting our priorities.

Also at the end I showed maps that tell you, if you really want to try and tackle climate change in agriculture, here are some starting points based on, again, the biology and the physics. So I agree, yes, I've given short shrift to all the economics and policy issues, because of the time constraint. I realise those are not simple issues, but I hope that science — the biology and the physics — can help point the way.

Moderator (*Denis Blight*) Does any other panel member want to comment on that question?

A. (*Frank Rijsberman, CGIAR*) I used to work at IWMI, the International Water Management Institute, and there many people used to point out that it was 'simply' a matter of introducing well known technologies. They kind of overlooked the fact that farmers often didn't use those technologies, for very good reasons. So you know, adoption of known technologies is one of the most intractable and complicated issues. That's just a little aside.

Moderator (*Denis Blight*) It's a bit like adoption of policies. Shenggen, you outlined a series of policies for governments to adopt. Is it as simple as that?

A. (*Shenggen Fan, IFPRI*) Well this is a research topic by itself! I think the capacity to demand policy research is also very critical. So policymakers, politicians, need to understand, need to appreciate different policy options.

Moderator (*Denis Blight*) You've had some success in working, for example, with China where we've seen quite radical change in policies, I think it's fair to say?

A. (*Shenggen Fan, IFPRI*) Well in addition to China we also had some impact in Vietnam, in Bangladesh, in Ethiopia. In Vietnam the program actually was partly supported by AusAID.

Moderator (*Denis Blight*) Trevor, I think you also referred to the adoption question in your presentation.

A. (*Trevor Nicholls, CABI*) Yes that's right, getting adoption of new methods is not an easy matter. Part of it is communication but another part of it is giving people a real reason why they should adopt them — not because they are a good thing but really communicating what the benefits will be, in terms that are relevant to people. We've certainly found with our plant clinics and 'Plantwise' that we needed top-down *and* bottom-up communication to attract users. We needed local champions on the ground but we also needed to work at a senior political level to have those clinics accepted as part of national policy and part of the broader plant-health system. Otherwise they're just another interesting intervention by NGOs or donors or someone like that. You have to achieve a broad integration into the system and an ownership by the national system to make the adoption happen.

Moderator (*Denis Blight*) Why don't we just leave it all to the market? I mean what makes us think that governments and policy makers are any wiser than the market? My experience is that government intervention can often be counter-productive. So the sort of policy solutions that Shenggen Fan and all of you are recommending, really, when adopted by government, get translated into legislation, get translated into meeting the sort of political balance required in their country, and end up being so compromised that nothing happens. Wouldn't it be better just to leave it all alone?

A. (*Frank Rijsberman, CGIAR*) Sometimes the policy advice that Shenggen Fan would give is to actually create conditions in which the market can really function. If you don't have conditions under which you can have private seed companies then there won't be a market in which you have seed companies. And actually getting the seed companies to be a viable alternative to government extension is of course a key area of our work. To think through the value chain, how farmers can be connected to the market is a key part of that as well. But isn't that part of the policy advice that we should be providing.

Moderator (*Denis Blight*) John Kerin do you want to comment on the competence of governments?

A. (*Hon. John Kerin AM, the Crawford Fund*) Well governments muddle through. If you look at Australia's position with respect to markets, we see that markets do work but it often takes a long time for them to work. What you need to analyse is market failure, market power and market behaviour; and the confounding factor is, of course, that you can't have really freely acting markets unless there's perfect knowledge.

Moderator (*Denis Blight*) Daniel Rodriguez you had a question which is related to this discussion on adopting technologies. I think you gave the example of IRR1: the contrasting figures we saw for IRR1 inside the gate and rice grown outside the gate of IRR1.

Q. (*Daniel Rodriguez, Queensland Alliance for Agriculture & Food Innovation, the University of Queensland*) My question has almost been answered already, but still I was impressed by these differences you had in production of rice between the experiment station at IRR1 and outside the station, outside the gate. One was 28 t/year; the other was 8 t/year. I was wondering: what causes that failure? It's related to what we're talking about now, it's a very complex problem. We have a number of technologies, and we know they might work, but how are they going to be adopted? And I was wondering what sort of effort you guys at CGIAR are dedicating to the development of the different agendas: for example, the breeding or the innovation systems, the development of the innovation platforms that are needed to really develop those connectivities between farmers, markets, businesses and to start the economic growth and economic activity in these places?

A. (*Frank Rijberman, CGIAR*) Well part of the answer to that question is that at IRR1 they're showing what is physically feasible but they're not trying to make money. At the low rice prices that we had until recently, I was living in Sri Lanka, and there was virtually no rice farmer who could afford to be a rice farmer. Most rice farmers were part-time rice farmers and making their money somewhere else. So under those conditions they had no incentive to try and optimise their yield. That's a key part of the situation.

It's also true that until recently in the CGIAR, while I was at IWMI, after seven years we had an external evaluation. A bunch of academics, some from Australia, came to evaluate IWMI's results in terms of the number of publications per scientist in high impact journals. That was, then, the primary way of evaluating researchers in the CGIAR, and it has since changed very significantly. The CGIAR research programs that we now have, and the views of our science council, will be held accountable for reaching development outcomes.

What are those development outcomes, and how can we move from research outputs to outcomes — which are somewhere in between research outputs and the final impacts? Well I always define them as the proxies for impacts that the investors can easily see to make it worth investing, but close enough to the research outputs that we can hold the researchers accountable for delivering them. It's not an easy task to come up with what those outcomes are: the partners, the countries and the CGIAR need to come to an agreement about the development outcomes that the CGIAR should deliver. But at least I can reassure you that that is now at the heart of the agenda. So five years from now when we have external evaluations we'll still count numbers of publications, but it will be more as a quality-control mechanism, and we'll be held accountable for delivering development outcomes. And very deliberately, in addition to the crop improvement programs, we now have challenge research programs like the one Dr Sanginga was speaking about earlier — the systems programs which

are focused on farming systems. There we try to integrate the varieties and the agronomy. The outcomes that we'll achieve there are definitely focused on reaching farmers at their scale, and demonstrating an impact, which is much closer to the kinds of things that Trevor was talking about before than what you're used to expecting from the CGIAR.

Moderator (*Denis Blight*) Do you want to comment on that Dr Sanginga, because you did make some point about that in your presentation?

A. (*Nteranya Sanginga, IITA*) Yes I would agree with Frank. And talking about adoption, I see this research as a platform where you have all the actors, whether in the private sector or the public sector, playing their roles and you will see adoption passing from a maximum of 20% up to 40% in some of the countries like Rwanda, Uganda.

Moderator (*Denis Blight*) And in your presentation you were saying that actually the gap gives reason for hope, because we can close that gap and increase food production?

A. (*Nteranya Sanginga, IITA*) Absolutely. Just remember that around 20 years ago we couldn't even talk to the private sector or talk even to the government. We were just doing this kind of linear research, and that's really changing tremendously now.

Q. (*Tony Fischer AM, the Crawford Fund*) Getting back to the subject of the seminar, one thing corporate and large-scale investors ought to offer is a very easy route to the adoption of the best technology. And this is the argument that people like Collier at Oxford University put forward, that the way to really move things in Africa is to get out of the road of the big investors. What does the panel think of that?

Moderator (*Denis Blight*) Dr Sanginga, the question is should governments (I think you mean governments?) get out of the road of the big investors because they're more likely to introduce the new technologies?

A. (*Nteranya Sanginga, IITA*) Well I believe, and I want to be frank here, that the government in Africa has a role to play. These kinds of policies in the 1970s and '80s from the World Bank about structural adjustment almost killed African agriculture. What we see now is that the new leadership in Africa is trying to reverse that, and in some situations suggesting even going to subsidies, calling for smart subsidies. We see that as necessary and very important.

Moderator (*Denis Blight*) Do you want to add to that, Shenggen Fan?

A. (*Shenggen Fan, IFPRI*) Yes, I truly believe that the private sector or even foreign investors can play a large role in Africa. However, the government needs to do its homework to provide an enabling environment, rural infrastructure extension system and, more importantly, regulations to make sure that smallholders, smallholder farmers, have the land rights so they will not be compromised when investors come. So truly explore the win-win opportunities. The government cannot get out of the way of investors; it has work to do first. That's actually related to one of the previous questions, what government

can do. Markets sometimes fail, so government's job, first, is to make sure to correct market failure. Second, it is also to make sure that certain policies and interventions have ideal design distribution outcomes to help the poor, because the market cannot help the poor and you need public intervention to do that.

Moderator (*Denis Blight*) Now, the next set of questions relate to return on investment in international agricultural research. The first question, from an unidentified person, is essentially the one asked by you, Frank: Is this all too good to be true? I'm looking for Ron Duncan in the audience. I'm not suggesting that he's the person that asked the question but he might help me here. Ron, is it too good to be true? Would you like to rephrase my question?

A. (*Ron Duncan, the Australian National University*) Thanks very much for putting me on the spot Denis! The internal rates of return that a lot of the analysis of impact leads to are extremely high, and one has to wonder whether all the costs are being counted and also whether the appropriate values are being put onto the benefits that are supposed to flow from these projects. But it is true that research is of a nature where single successful projects do have very large rates of return; and it's true there are a lot of 'dry wells' in research and that the really successful projects are needed to pay for the dry wells that researchers dwell in. So my belief is that we do have to be cautious about these high rates, but there's no doubt that there are very high rates of return associated with some research efforts.

Moderator (*Denis Blight*) Frank, you're the one that made the statement. I'll ask you to comment and then I'll ask Shenggen to comment on that.

A. (*Frank Rijberman, CGIAR*) Well if we were a private company and we did our marketing here, you might say: 'Oh you know these are your numbers, we don't believe you'. But in this case all these impact assessments we're quoting are carried out by ACIAR, independently. They have been carried out, I would say, time and again by the World Bank for convincing their own internal decision makers. It's true that when you look inside the box to see what generates these very high returns, it usually is a few very specific interventions, like the Cassava Mealybug. But in fact the Cassava Mealybug generated billions worth of returns, paying not just very high returns for the Cassava Mealybug research but also for all the other hundreds of not very high returning investments as well. So a few of these big hits generate the high rates of return for the system as a whole. And of course there is a fairly high variation; I think I showed that as well. Some studies have quite different rates of return. Impact assessment like this is difficult; it is relatively well-established for crop improvement; very much harder for policy research or for natural resources management.

Moderator (*Denis Blight*) Trevor might help me here, with a figure relating to the private sector. My recollection is that only one in seven private investment proposals work. Is that right?

A. (*Trevor Nicholls, CABI*) Venture capitalists will typically work on a ratio of one in ten. We are much more 'blue sky' than them: we would have only one in every couple of hundred projects, but those are such 'big bang' successes that they actually pay for the others. That's the story.

Moderator (*Denis Blight*) So why can't you run yourself as a business and make profits?

A. (*Shenggen Fan, IFPRI*) When I was a researcher, during my previous life, I did some impact assessment of IRRI research, and its impact on economic growth and poverty reduction in India and China. I remember, just for IRRI's investment every year, the return in China and India was about \$1 billion a year and the total investment of IRRI at that time was about \$30 million a year. Well obviously not everything succeeded, but just consider the semi-dwarf varieties — semi-dwarf wheat and rice adopted in China and India — that impact was tremendous. In terms of methodology, we didn't discount the future values to today's value or bring back the returns to today's value. I also did another study with Australian colleagues, to quantify again the impact of IRRI and the same research on benefits to the US. We call that benefit the hidden harvest, and that in itself got large amounts of money back from the investment. There is a publication on the IFPRI website called 'hidden harvest' where you can look at the methodology and the data — the concrete methods in calculating returns.

Moderator (*Denis Blight*) Many of these assessments come out of ACIAR so I'm going to ask Nick Austin to defend their reputation.

A. (*Nick Austin, ACIAR*) Thanks Denis for the opportunity to comment. The impact assessment program within ACIAR I think is a critical part of ACIAR's work, for a couple of key reasons. First, it is demonstrating the value of the investment, taking on board the comments of those who have spoken in relation to the numbers. I think that impact assessments are increasingly important, in the context of a growing aid program and growing investment from Australia into international agricultural research, and making the case for that investment. From an ACIAR perspective internally also, they're really important for informing decision-making in interpreting where the best returns or opportunities might lie. There's a healthy debate that goes on within ACIAR around the results of these programs. It might be opportune, in that regard, to mention an external review that our Minister, Senator Bob Carr, has commissioned which was announced last week and following on from the comments of Professor Ron Duncan who is a member of the external review panel. The review panel is chaired by Bill Farmer. The review is at the request of ACIAR. Dr Wendy Jarvie and Terry Enright round out the four member panel. They'll be doing their work between now and the end of December [2012] with fairly broad terms of reference about appropriateness, effectiveness and efficiency of ACIAR's operations and particularly in relation to the effectiveness of the impact assessment program. That series of evaluations now over many years I think will stand us in good stead internally. I mention that because there'll also be a call for public submissions to that review, and given the interest of this audience in that subject we look forward to the input into that review.

Moderator (*Denis Blight*) Are there questions from the floor on this subject of impact?

Q. (*Andrew Campbell, Charles Darwin University*) I agree completely with Nick about evaluating the impact of research. However, just a caution: it's very important to do the review at portfolio level, but if you start using it to drive

investment then inevitably your investment will track those areas where benefits can be more easily measured. Having experience in portfolio evaluation, we used to round down any benefits in wildlife habitat to zero, benefits for water quality to zero, social benefits to zero, because we weren't confident in the numbers. Once you do that then your investments will track those areas where you can get easy adoption numbers and translate them into easy production benefits, and the broader environmental and social issues will be discounted inevitably. So, again, this is just a caution against those evaluation techniques — but that doesn't mean it's not a good investment.

Moderator (*Denis Blight*) A question sent in earlier asks how we can learn to include the cost imposed on ecosystem services as a factor of production in agriculture? That will require us first to value those services; and how should we attempt this?

Q. (*Diana Gibbs, Murray-Darling Basin Authority*) That is my question. The MDBA is involved in water-use issues at the moment. I am very interested in what some people see as a trade-off between ecosystem services and agricultural production. I actually see them as being the same thing. I was very impressed by the number of speakers who have talked today about the need to integrate a whole lot of different skills and disciplines in these sorts of issues — which I quite agree with — but when we look at the traditional factors of production for agriculture how can we make sure that we include any loss of ecosystem services as another cost? That brings us to the need to actually consider ecosystem services and how do we value them?

A. (*Christine Padoch, CIFOR*) Yes, well we have actually done very little, so far, in understanding the value of all those systems. At CIFOR we're just starting really to look at it very seriously. We've been looking at those direct provisioning services of forests for families — you know, the fruits and the bush meat and all, for quite a while. But the idea of ecosystem services, and just what forests contribute, is a difficult area. We have the list and I read off the list of some of the services we want to look into: water and pollination and so forth. Some of that is known, but often only in very specific contexts, very separated really from these particular landscapes. I think looking at it much more broadly, and having a landscape view of it, is all important.

Also I think that we're still missing some of the social areas. For instance, how much do forests contribute? For half the year, people depend on those forests, and therefore you do have the labour in these areas, and the labour is supplied to agriculture. I think there's a whole series of areas to look into and to focus on, and this is something we're just starting.

Of course we have to be nuanced about it, and it's not all agriculture in all places at all times. I mean you can grow things in laboratories if you want, but we need to understand under what circumstances there will be elimination or degradation of these services, and who will bear the strongest and hardest impact, where and at what times. I think these are questions we really need to look at. So my answer to your question is that I think we need to make a start and learn to put it in context, and I would suggest we use a landscape approach.

A. (*Jonathan Foley, University of Minnesota*) Well I'd agree completely with what was just said, but I look at this question of ecosystem services as a massive market failure; I mean there's no other word for it. Markets are great if they get the right signals, but if they receive no signals they cannot work. And they're not getting three really fundamental signals. One is, what are the services that you know nature is providing and that have some kind of value? That's huge, whether it's physical climate regulation, flow regulation, water quality, pollination, all the rest, the things we've all talked about today — hugely important. We're beginning to recognise those.

The second, Christine just mentioned: the winners and losers. You know tropical deforestation certainly benefits a few, but many others who are not participating in that part of the market are the losers of that proposition, whether it's from what happens downstream for air quality, massive increases in malaria, what have you.

Third is the confusion of stocks and flows. I think a lot of people have this confusion when they think about economics. Economists like to measure flows but the real world likes to measure stocks, and that's where things get really tricky. We think about capital stocks, whether they're financial capital or human capital and natural capital. We're liquidating the natural capital of this planet and thinking it's profitable. That's insane. To liquidate the Ogallala Aquifer in the United States, or the topsoil of a region, or biodiversity, whatever. I mean the fact that we can consider that 'economic' shows just how insane we are. It's a massive market failure that needs to be remedied.

Q. (*Michele Barson, DAFF*) I'd just like to comment on the ecosystem services issue. I think there might be a much closer relationship between ecosystem services and agriculture than perhaps many people have been thinking about. Of course production of food and fibre is a provisioning ecosystem service in itself, and in the work that we've been doing over the last few years through Caring for our Country we've been encouraging farmers to improve the nature of the land management practices that they adopt for several reasons. One of them is to encourage production benefits which of course everybody is looking for, and the other is to encourage the improvement of soil condition to give benefits to the broader community through the quality of the ecosystem services that agricultural lands provide. I wonder whether any of the speakers have actually done any work or thought a great deal on the nature of and the benefits that agricultural land provides to the broader community?

Moderator (*Denis Blight*) Just before you answer that question can I go back to the earlier question. I heard that the Murray-Darling Basin Authority had actually tried to do some evaluation of ecosystem services and gave up because it was too hard? Is that right?

A. (*Diana Gibbs, MDBA*) It is certainly a very important political question for Australia. We did try; we've tried several studies and that was the basis of my question: I am looking for some guidance. I quite agree with Jonathan — you know we've been mining our natural resources, particularly during the drought, and we should include that as an externality in our production. Yes we tried to

value environment, or ecosystem services, but the work we did came up with such huge numbers, in the order of \$80 billion, and we were trying to compare that with the value of irrigated agriculture in the Basin and all the communities that depend on that; it just became meaningless. I'd be very happy to correspond with any of you about how we resolve this issue.

A. (*Jonathan Foley, University of Minnesota*) There are a number of groups now where economists and hydrologists and ecologists are collaborating to do that kind of work. One I'll just plug is something called the 'Natural Capital Project' which was started by Gretchen Daly out of Stanford. Our university's part of that, as are the Nature Conservancy and World Wildlife Fund, and that project's been pretty influential in trying to get really good science in that area, but I'm sure there are a lot of great Australian groups working in a similar area. So I can't answer that specific question.

For the other question, I guess really Christine could answer it better, but part of the question was about, maybe rephrasing it, as opposed to thinking of ecosystem services and agriculture as some kind of dichotomy that you're trading ecosystem services off for food production. I think what Christine showed, and she should say this but others have too, is that it isn't a dichotomy; that it's a continuum of portfolios managed through different kinds of things. And so if we think about agro-ecological approaches that are managing for more than one outcome, not just commodity throughput but also human wellbeing and the landscape wellbeing as a whole, that we could come up with some quite different kinds of situations that I think will be very beneficial.

Moderator (*Denis Blight*) It seems to me this is a pretty vital question; actually it is quite relevant to the research topic of land and resources, provided we express it in non-emotional terms, evidence-based. Shenggen?

A. (*Shenggen Fan, IFPRI*) In fact, yes, there is some work by economists to measure the value of the eco-services, using different scales: global, national and the micro level. But here I want to emphasise that this value also has huge distributional consequences. So if you put too much value, higher value, on eco-services by very rich people, that will in fact not support people, poor people who will not have access to food, will not have access to certain income opportunities. So we need to look at that trade-off.

A. (*Frank Rijsberman, CGIAR*) Well one thing is evaluating or valuing the ecosystem services, but that might be hard. There's also the practical approach of just taking them into account. A lot of dams were built for hydro- or for irrigation and did not take into account the wetland or the fishery values and so on. And it actually turns out that we might be able to put a value on all those other services. But actually optimising for different functions, there is a win-win if you just realise that some releases from dams can actually help sustain part of the fisheries or can maintain ecosystem values. Even though we can't put a dollar value on them it's quite possible to manage, or re-engineer if you like, management schemes of dams to get higher total value.

Moderator (*Denis Blight*) OK. One question from the floor, then I'll go to Trevor then I'm going to move on to another topic.

Q. (*Campbell Davies, CSIRO*) It's just a comment on the original question. I think if you're trying to value those things in the context of an economic optimisation, which is essentially what was done, as I understand it, in the Murray-Darling Basin, then it will lead you to difficulties because there'll be disputes about the dollar values put on individual components of the system. There are approaches that are more about identifying the values or objectives — the things that people want from those services — and ways of analysing those in a broader systems context that allow you to identify integrated management strategies and the like, which I'd suggest would be a more productive path to go down than trying essentially to do an economic optimisation on a complex system.

Moderator (*Denis Blight*) I see a couple of hands coming up, so clearly this is a question of broader interest so I will dwell on it. Christine, first.

A. (*Christine Padoch, CIFOR*) I just wanted to add, there are schemes where payment is made for environmental services. They don't value everything but they value certain things and then people who are up-river make payments to maintain the forests or agriculture of whoever is down-river: urban areas or whatever. On a broader level, I'm an anthropologist you know, and I thought economists could come up with a magic number for the value of eco-services, and I've been sorely disappointed that they don't or can't do this.

I would like to also argue for the landscape as a basis: looking at the various parts of landscapes as being integrated and feeding off each other and giving and rendering services to each other. That might be a particularly good way to tackle this, but one grand number is probably, unfortunately, not what we're going to come up with.

Moderator (*Denis Blight*) Jonathan?

A. (*Jonathan Foley, University of Minnesota*) Well just to reiterate this point, I wish people would not worry so much about the dollar valuation of ecosystem services, as Frank and Christine have said. I know economists don't like to say it but we make this stuff up. My point is, we can look at valuation in other terms than just dollars or Euros or whatever, and begin to think about this in terms of number of people who have benefited, number of people transitioning to a better life or to the number of cubic metres of water we're not mining out of a watershed. And those things are going to have tremendous real value. The problem with ecosystem services isn't the fact we can't put a dollar figure on it. That's a problem with the dollars, it's not a problem with the ecosystem.

Moderator (*Denis Blight*) We better move on to another subject now.

Q. (*Basant Maheshwari, University of Western Sydney*) My question is related to urbanisation. Peri-urban areas are quite important globally in terms of food production. Urbanisation involves having more hard surfaces, and that's impacting the water cycle. Yet on the other hand we need to house more people. Developers see this as an opportunity to make more money, big money, and farmers, also peri-urban farmers, want to sell the land because they can get a lot more money. And so my question is, is there any hope to preserve agriculture and continue producing food in the future in peri-urban areas?

Moderator (*Denis Blight*) I'm going to ask Xuemei Bai to answer that question first, but before that there was another question from Andrew Campbell on this same, or related to this, subject. Do you want to vocalise that now Andrew?

Q. (*Andrew Campbell, Charles Darwin University*) Just on that theme of integration. Many speakers have talked about the need for more integrated approaches and yet a lot of research investment is still siloed. And so how can we have a more integrated approach? I'm not aware of anywhere you would go for funding to do work across the urban–rural boundary or urban and agricultural planning. As a researcher, where would you go to get that sort of stuff funded? I'd welcome comments on that (as someone who used to run an outfit that tried to do integrated research and got abolished).

A. (*Xuemei Bai, the Australian National University*) Yes, I'll start from the second question. I would like to put the question back to the funders, who are sitting here actually. Because when we are trying to address something that is interactive, between urban and rural, that systematic kind of view, it's basically the business of nobody. So if you go to the urban centre they say, 'Oh that's agricultural business', and then the agricultural people they're only interested in how to improve their productivity. It's really hard to make the case that actually they are all connected, and that if the level of urbanisation increases there's a positive impact as well, as some of our data shows, in terms of green production, crop production and yield. But it is really very hard to make the case to look at both sectors together.

So I think this is a really good opportunity to put this case forward here, because we do have lots of international funders as well as national funders present.

Coming back to the first question, about increasing urbanisation and the need to preserve agricultural land and whether there is any hope. This is a big question to answer — and it is very hard to answer it. The Chinese governments have been trying very hard to preserve agricultural land, but they have so far been failing because there is a very strong fundamental driver that drives local government to sell the land so that they can get profit. Unless you can fully understand those sorts of underlying mechanisms and drivers, and why those sorts of things happen, it is really hard to do anything to preserve the agricultural land.

The Chinese governments have two policies, one to enhance urbanisation for the sake of economic growth and the other to preserve agricultural land. Those two policies they actually are fighting each other. It's all coming from the same government, and people don't recognise that there are these conflicting kinds of policies that are coming from the same government. So I suggest that we really need to start from a systematic approach: try to understand the linkage and then try to adopt more holistic and integrative approaches to preserve land as well as provide enough space for people to live in cities.

A. (*Andrew Noble, IWMI*) Can I just make a comment with regard to this interaction between urban and rural or agriculture? From a practical point of view, today, if you look at where people are living, they are living in the cities and they're consuming in the cities. The biggest challenge we have is that this

is where all the nutrients are being concentrated. I think one of the challenges we have as scientists and as society is how we close the nutrient loop between urban centres and getting those nutrients back to the agricultural lands whence they came. And I think it's clear that there needs to be considerably more research into the interaction between these two spheres, if we are going to address some of the critical water issues that we have and pollution issues that will eventuate with large cities.

Moderator (*Denis Blight*) Give me a practical example of what you might do. The nutrients in western societies end up in the sewerage system don't they?

A. (*Frank Rijsberman, CGIAR*) I thought Andrew was going to talk about a rather interesting group at IWMI working on peri-urban agriculture, because those nutrients where they end up is in the sewer. Next time you go to Africa or Pakistan and you have a salad in your hotel you'll be having those nutrients because people grow vegetables with raw sewage. It's a wonderful way of capturing some of those nutrients. It's not necessarily safe for your health but it's a very big deal in almost every city. Every city, however it grows, always has a peri-urban area, which might displace some of the more regular agriculture but it will always keep a band of pretty active agriculture around it.

Moderator (*Denis Blight*) I thought you were talking about something more radical than that though Andrew?

A. (*Andrew Noble, IWMI*) I think what we should be looking at is resource recovery business models that actually start to look at this waste or put an asset value to this waste. That could essentially address some of the challenges that you have with regard to food safety, as well as generate very large incomes. And I think it requires essentially a social change, a change of behaviour in how we see this waste.

Q. (*Eric Craswell, the Crawford Fund*) I just want to make some comments along the lines of Andrew's point. There used to be an organisation called IBSRAM* which worked on peri-urban agriculture and nutrient cycling in West Africa, particularly in Kumasi, Ghana. And if you think of China and some parts of India as being nutrient-rich areas, rural areas, and cities, in West Africa you've got all of this transport of nutrients in harvested product to the cities and the opportunity to return it into a nutrient-poor rural environment, where it has some real benefit economically.

At the other end of the scale, in the nutrient-rich countries, the cities accumulate nutrients to the point where they flow out into the fresh water systems and out into the oceans, cause red tides and so on. And I know Jonathan captured this issue of the use of nutrients in Asia as being prolific and in Africa as being very limited — that's been discussed. But I think within a country, the rural–urban divide in terms of nutrient availability is something else to consider. That's just a comment.

Q. (*Snow Barlow, the University of Melbourne*). This is more a fundamental question to all the panel but particularly to the economists. We've heard arguments for

* International Board for Soil Research & Management

the power of the market, and we can all agree with that at times, but for land — and you could include water — where you are looking at an irreversible change in terms of, let's say, good crop land around Shenzhen for instance (and there are many other examples), does economics work here or do you have to go to regulation? And this applies I think broadly to our use of land, water and air across the globe.

A. (*Shenggen Fan, IFPRI*) Well firstly I think that the land rights should be secured: who owns the land? who has the rights to access that land? More equitable access, smallholder access, to that piece of land is so critical. Then you need the market to work, on either rental markets or in the situation now where lots of land are undervalued or grabbed by local governments rather than by the foreign investors. The biggest land grabbing usually happens domestically, by the local governments, by the local community, or by chiefs. In Africa it's more by chiefs, though the whole village is supposed to own that land; usually it's the chief who makes a deal with a foreign investor or with other domestic investors. And in Vietnam, China, it's local government that converts the agricultural land into commercial land and gives a very small amount of compensation to farmers. So yes, the government has a very large role there, to regulate that, to make sure that everybody has access to land, to make sure that the market works, and that nobody can monopolise it. I actually believe that there are great opportunities for everybody to really maximise the benefits.

Moderator (*Denis Blight*) OK. Just backtracking briefly, Frank, can you put some numbers on the importance of recycling sewage, maybe just in the case of one country?

A. (*Frank Rijsberman, CGIAR*) Yes. By far the most challenging millennium development goal is the one on sanitation. A couple of billion people don't have access to decent sanitation. As a result, the second largest cause of death of children under five in developing countries is diarrhoea because we don't have a decent way of making that nutrient-loop closed and safe.

My primary program at the Gates Foundation was to reinvent the toilet, and to try and come up with a way to deal with waste which is safe and recovers the energy and the nutrients in it, and to try and find a way to return that to agriculture. Now wherever you have a city you have a sewage plant. And as I first saw in the Punjab where they built a sewer in 1969, the farmers were using that water. Farmers value the water, but of course it's not a safe practice. In Pakistan 23% of all the vegetables are grown with undiluted sewage, and the rest with diluted sewage.

Q. (*Margaret Hartley, the Crawford Fund/ATSE*) Just apropos of that last comment about the sanitation, I'm wondering if any of the research agencies are looking at the role of biochar as a means of burning sewage and generating energy but then generating a stable carbon with the nutrients embodied, particularly the P and K, to put back in a useful form and create stable carbon sequestration? I think it's a great opportunity that isn't being given enough attention at the global level.

A. (*Frank Rijsberman, CGIAR*) That was my previous job at the Gates Foundation. We funded several projects like that.

A. (*Shenggen Fan, IFPRI*) We have not discussed much about biogas production. Biogas production can really help to convert the waste, including human waste, to nutrients to energy. That we probably have not paid much attention to; maybe your toilet can help do that.

I want to come back to the urbanisation issues, the integration between rural and urban areas in terms of food systems, under the new CGIAR, IFPRI is leading a program to leverage agriculture for nutrition and health outcomes. By 2030 or 2040 the majority of the people on this planet will be in urban centres, say in China, India. China's urbanisation will be probably 60% or 70% and knowing how to provide healthy, nutritious, safe food for urbanised populations will be critical. The poor people will also become more urbanised. So we do use an integrated approach for tackling that issue.

Q. (*Felicity Schonk, Scholar, the University of Sydney*) I just wanted to ask, I know it's not strictly an agriculture-related question, but I mean the whole premise of all these problems is the fact that we do have these massive projections for population increase over the next 40 or so years. Why is it — and I'm putting this question out there to anyone — why is it that measures looking at the problem itself, which is our massively growing population — why are they so unpopular? Why is it so? I mean that is something that isn't really discussed much.

A. (*Jonathan Foley, University of Minnesota*) Well I think others can speak to this as well, but as I was pointing out in my presentation, population is not the problem for future food security at all. It's actually the 4 billion people who are trying to emulate our western diets, who are already here in the world. Two-thirds of the problem of future food demand comes from the increasing waistlines of people who look like you and me, pretty much, and a whole bunch of other people who are trying to do what we do. That's a very big problem. I think it's kind of unfair to point to the developing world and say population is the problem; it's not.

There are 2 billion heading our way, but populations grow for two reasons: one is that there are some people in the world who are having very large families still. But the good-news part of population growth is, there's a whole bunch of people who are finally getting to live as long as we get to live. In India, population growth is driven primarily by longevity; people are finally moving from living 40 years to now living to 75. That's a good thing. So I think we have to be very careful about saying population is the problem. I don't think that it is. I think that it's a symptom of a much larger systemic problem.

You know we had a population bomb that we largely diffused, fortunately, but there's a consumption bomb that nobody's talking about. And we have a modulating feedback on population called the demographic transition. It largely worked; should have worked earlier. There's still a lot of work to do on family planning — no question. But the consumption bomb — the richer people get the richer they want to be — there's no end in sight. So I think we have to be a little bit careful looking at the balance of those two things together.

Q. (*Terry Enright, Crawford Fund*) This question is unrelated to what we were just talking about. It's in relation to food pricing. The spike in food prices in 2007–08

caused some massive problems, but my hypothesis is that food prices have to go up. If you want to maintain production in the developed world, which is where most of the traded grain for instance comes from, these prices have to go up. We've kept food prices artificially low by increasing efficiency of production for probably three decades. So what are the implications of higher food prices? Because I think if we're going to feed 9 billion people we're going to have to have a lot higher food prices to do it.

A. (*Shenggen Fan, IFPRI*) What we are afraid of is high price volatility and the spikes. Say today the food price is high, tomorrow it goes down. Volatility hurts both consumers and producers. Higher food prices could provide an opportunity for smallholders in Africa, in south Asia, to increase their income. However, right now they do not have access to seed, to agricultural services, to markets, and so they will not be able to convert that opportunity to reality. Therefore, right now the higher food prices and price volatility will hurt both poor consumers and producers. What we need to do is convert the higher food prices to certain opportunities for smallholders. Obviously Australian farmers or American farmers, Brazilian farmers, would be very happy to see higher food prices, but what I'm concerned about is the poor hungry people in developing countries.

Q. (*John Angus, CSIRO*) I noticed a difference in emphasis about the direction of research. On the one hand Dr Sanginga made a point that there was a lot more need for agronomic and crop management research; and I think it was Frank who emphasised genetic and genomic research. Is there an imbalance in the research investment between genetics and crop management in the CGIAR system?

Moderator (*Denis Blight*) Yes another question as well, I'll take that and then we'll get the panel to respond, and to make final statements.

Q. (*Jenny Goldie, ACT Peak Oil*) Most of the speeches have been very good but just about everyone has ignored the question of rising oil prices. The International Monetary Fund says that the price of oil by the end of the decade will be about \$180 a barrel. This is going to possibly cause economic disruption generally but agriculture as we know it is heavily dependent on fuel. A farmer in Australia can spend \$150,000 a year on diesel alone, just getting a crop in and transported. So if we can anticipate possibly a doubling of oil prices by the end of the decade, what are the implications for agriculture? I mean, to me they seem to be huge and yet everyone's ignoring it.

A. (*Frank Rijsberman, CGIAR*) I pointed out two revolutions that I think are going to influence the work of the CGIAR: one is in the life sciences, and glamorous, and I think it will attract new scientists to agriculture because there is tremendous scope for doing exciting and interesting work. The second that I mentioned is what I called the IT revolution, but in fact a lot of that is, well, from mobile phones for extension to precision agriculture — which is another way of saying crop management. It's agronomy for the 21st century, which will have a lot more to do with using that kind of technology, and forms of extension that base themselves on opportunities for new sensors — opportunities for all kinds of exciting stuff.

Within the 15 programs that we have, about seven focus on crop improvement. There are three, one of them that Sanginga described, that are focused on farming systems and one on policy and several on natural resources management. I can't claim that we always get the balance right, but I certainly think that the old CGIAR which was mainly focused on crop improvement has been recalibrated to be much more balanced today.

A. (*Shenggen Fan, IFPRI*) Yes, if the oil price doubles then agriculture and food production will be affected tremendously. Yes indeed, we are very worried about it. That possibility keeps lots of food or agricultural economists awake in the evening. The reason is, when the oil price goes up the food price goes up. You know the correlation of the figures. I showed you the high correlation between oil prices and food prices, for two reasons. One is biofuel production, right now, because of the subsidies, because of the biofuel mandate in Europe and US that really initiated the biofuel industry, the biofuel industry was established because of government support. As oil prices continue to rise, then even without government subsidies and without mandate, biofuel production will become economically profitable. What does that mean? That means food prices will continue to rise. Yes, some farmers who have large pieces of land will benefit. What happens to the poor — the poor who spend 60%, 70% of their income on food? If food prices double could you imagine what will be the impact on their children, on their household members? So we do need to think of government interventions to make sure that higher oil fuel prices will not translate into higher food prices. And there is volatility as well. When the oil price is very volatile, it means food prices will also be volatile.

Moderator (*Denis Blight*) Jonathan, would you like to make a final comment?

A. (*Jonathan Foley, University of Minnesota*) As a final thought ... I've come out of this meeting with a renewed sense of optimism, seeing evidence at this event of the incredible array of work happening in a diversity of areas. I think we're seeing a breakdown of dichotomies between agriculture and the environment; between crop genetics and crop management; between forests and surrounding landscapes; between urban and rural interests. We're beginning to recognise that these things are a continuum across a lot of different sectors, which is very, very encouraging. I've also seen that that creates a lot of opportunities for leveraging a very big global problem.

We have talked today about some of the biggest challenges civilisation has ever faced and yet we've seen more solutions than challenges. We've seen many more new opportunities, by bringing together different disciplines, than we've ever had before. And so I feel that while we're seeing some of the greatest challenges that any generations have ever faced in our entire existence we have come up with potential solutions, and that makes me very happy and hopeful today.

Moderator (*Denis Blight*) Thank you very much, and I think that's a good point on which to finish the conference. Thank you all very much for your participation.



Dr Derek Byerlee, Professor Jonathan Foley and Dr Frank Rijsberman during the Wednesday breakfast Q&A.

Wednesday

On Wednesday at the breakfast, Dr Frank Rijsberman, Professor Jonathan Foley and Dr Derek Byerlee reprised the keynote addresses they had given on Tuesday, and then formed the panel for the Q&A.

Moderator (*Shaun Coffey*) I'd like to move into the questions and answers straight away and I invite any members of the House of Representatives or the Senate to take this opportunity to ask the first questions.

Q. (*Senator the Hon. Ian Macdonald*) Good morning. Thanks very much to the Crawford Fund for the breakfast and for the information. My name's Ian Macdonald. I'm a Senator based in North Queensland and my passion, in my long period in Federal Parliament, has been the sustainable development of the plentiful water and good mosaic of good soils across the top of Australia. Most of them didn't appear in the slides, I might say.

My question really is about a disconnect, or a contradiction, in Australia. We feed about 60 million people around the world. We can double that from what we have in Australia. But our farming sector seems to be failing all of the time; the age of the farming community is getting older and older; parents are telling their children not to come onto the land, with a couple of exceptions. Australian farmers are not doing particularly well financially and it's a real concern. We have the ability but it's not being achieved in Australia and I just wonder if any of the speakers have a solution or some way that we can help to encourage people to develop Australia's potential to feed the world.

A. (*Frank Rijsberman, CGIAR*) In many ways the increase in food prices is a mixed blessing. If you are poor, including a poor farmer, and you spend a very large part of your budget on food, then the increase in food prices is, no doubt, a bad thing. But if you're a farmer in Australia, and for some larger farmers in the world where we live, those increased food prices will provide new opportunities, new opportunities for investment, new opportunities for agriculture.

Q. (*John Anderson AO, the Crawford Fund*) The issue of energy security, as Jeremy Grantham points out, the incredible rise in global population centred around, you know, 1800, has really been both facilitated and made possible by cheaper oil and everything that springs from that energy source. Any comments on the implications of probably the end of cheap oil not being far away and the enormous dependence we now have, a quite hopeless dependence really, upon energy to feed ourselves in the future, and what that might look like?

A. (*Frank Rijsberman, CGIAR*) One of my colleagues was asked and answered that question yesterday, so if you'll allow me I'll just summarise his answer. And that is, agriculture has indeed depended on cheap energy and uses energy in many ways. So higher energy prices will cause the cost of producing food to go up. But of course also higher energy prices will mean even greater attraction to invest in biofuels, competing with land that produces food. So, yes, if the oil prices doubled, that would have a major impact on agriculture; it will be an additional challenge for sure. An opportunity for those who produce biofuels probably, but definitely an important challenge for those that want to provide a food secure world.

A. (*Derek Byerlee*) I would also like to comment on the energy and biofuels. I think one of the real surprises in looking at the larger land acquisitions in Africa is how important investment in biofuels has been. And that's partly because African countries have essentially duty-free status in Europe and the US, so that gives them a particular advantage in biofuel production. But certainly, with higher energy prices, that's going to be a major competitor for land, and the real question is, when do we move to the second generation biofuels, which are cellulosic rather than using maize grain or sugar? And even if we moved to the second generation biofuels, which are still going to use land, to what extent is there going to be competition for crops? I think there are some real issues out there, and that if you have high energy prices it's really going to drive this land scarcity issue even more.

A. (*Jonathan Foley, University of Minnesota*) Just to follow up on some of this, one of things that we were talking a lot about yesterday is the ratio of benefits to cost in agricultural systems: how many calories are provided to the world divided by the amount of water, the amount of land, etcetera. But when you look at this in terms of energy, especially petroleum or fossil energy, we see there are tremendous opportunities here; that it's not all bad news; that there are massive opportunities to improve efficiency or to substitute renewable energy sources for non-renewable. So while the peak oil kind of situation or the end of cheap oil is staring us in the face, it is a tremendous challenge; but I think agriculture has a lot of innovation upside to solve that kind of problem, pretty dramatically in fact, probably more than outpacing the changes in petroleum prices. But it's required some very big changes structurally in how agriculture relates to the energy sector.

Q. (*Tony Peacock, Cooperative Research Centres Association*) We had the World Food Programme out a few years ago and Australia did it a big favour by guaranteeing funding for four or five years ahead rather than year by year. Are we doing enough in the CGIAR system with our donor status, and is it enough,

and is there more that we can do that, maybe, wouldn't cost us a lot of money, but would give you more certainty?

A. (*Frank Rijsberman, CGIAR*) Thank you for that question, which plays right into the key parts of the reform. Australia is a very strong partner in the CGIAR, but all the donors together have discussed their normal donor practice. Normally they tell us sometime in October how much they're going to support us for this year, and indeed for 2012, quite a bit of our support is still uncertain. A new reform that I haven't talked much about has brought all the donors together in the CGIAR Fund, just like the senate has been united in the CGIAR Consortium. And the idea is that donors will pool their funds and, if at all possible, will make multi-year commitments.

I'm very proud to say that some donors, like my own country the Netherlands, have just recently decided to indeed pool all their project level funding together, put it into a bigger bucket and make a four-year commitment. If a few more donors are able to do this, and not all of them can, that would be a tremendous help in providing more stability and more opportunity to plan, even with the same level of resources.

Q. (*John Evans, the Australian National University*) My question is to Professor Foley. You made the statement towards the end of your talk about being able to do more with less. But I guess I'd like to have a slight elaboration on that because my understanding would be that generally with agriculture where we run the risk of the most polluting types of fertiliser use, reducing fertiliser inputs there will probably not result in more yield and generally the yield increase is going to be coming from places which are low input.

A. (*Jonathan Foley, University of Minnesota*) Thank you for the opportunity to elaborate on this. What we're finding is again and again and again when you look at the productivity of agriculture in relation to the resource consumption, whether it's per hectare of land, per unit of water, per unit of nitrogen, per unit of phosphate, per unit of energy, that there are about a hundred-fold differences between the most efficient — I didn't say the most productive — the most efficient farmers (that is, looking at how many calories you get per kilogram of nitrogen or per hectare of land or per kilogram of water) versus the least efficient. There's, again, you know, a factor of a hundred difference in efficiency between the best and worst farmers in the world.

For fertilisers, for example, we find the world is in a 'Goldilocks' problem. That is, half the world has too much fertiliser to put on the ground — China, India, the United States in particular. Most of the world has too little fertiliser being used, whether it's organic or chemical inputs. Most of Africa would be in that category. And there are very few who are getting it just right; I think Australia and Western Europe probably come the closest. So, again, there are massive opportunities to grow more, actually, with less fertiliser and less water. It's just a question of being more optimal rather than necessarily just dumping stuff on where it's not being useful.

There are huge, huge opportunities there, and they're much bigger than we think. In just closing these yield gaps whilst still reducing nutrient outflow to

rivers, there's 30% to 40% more food production possible, right there, which is more than all the crop improvement in the last 30 years has given us. It's possible through just changes in land management, and water management as well, as Frank alluded to. Huge opportunities to be more efficient with the land, water and nutrients we already have.

Q. (*Basiita Rose Komugisha, Uganda, James Cook University*) Thank you very much for your presentations. I would like to echo in another way the Senator's question. When I look through this room or the conference we had yesterday, there is a generational gap. We see very old people and the very young. We don't see the middle people in agriculture. I thought it was just in Uganda but it seems like it's the trend. And it's not really a question, but I'm thinking we should think together how are we going to push forward to encourage a certain group of people to come up to do the production, the research to feed the 9 billion people we are talking about. We need to be more aggressive and more eloquent in the way we bring it up. Because as young people when we look at the old people, they are saying they are failing. It's discouraging to go to such a sector that is filled with complaints. So, what strategies do we have in place to have a number of people come up and take the full production issue forward?

A. (*Frank Rijsberman, CGIAR*) Excellent question, and I think it's a key challenge that we face. I mean there are, everywhere, societies like the Crawford Fund, who indeed have been very good at keeping the flame alight, even at a time when agriculture almost fell off the agenda. And yes, let's face it, agriculture wasn't the sexy subject. You know, the number of students in agriculture dropped and dropped. Now I think, partly, having food security back on the top of the agenda, being better funded, having exciting projects happening — they all will help. And I also tried to show you that it's one of the most exciting areas in research. That is on the research side. I hope that the price side will also help attract more people who think of farming as a good livelihood. I lived in Sri Lanka and, you know, Sri Lanka is a rice growing country. But there are almost no full-time rice farmers left. They couldn't afford to be a full-time rice farmer; they called themselves hobby farmers, while their real income came from somewhere else. Now, better pricing will help create better business in agriculture. So we'll need all of that.

A. (*Jonathan Foley, University of Minnesota*) I teach for a living; that's my first and real profession at university, so I'm particularly interested in your comment. But our students have been telling us the same thing, that especially in agriculture at the university the faculty are much more likely to be over 60, white and male than in any other field. And they're finding that it's not really that attractive. There are students, for example, who are interested in the food system, but fewer and fewer people who are declaring majors in agricultural science or economics, because they don't really connect with that faculty. There's a generational divide, as you said so well.

It would be interesting to talk the recalcitrants of our faculty into changing the way they talk about these things, or into even being willing to talk about organics or food systems or local food or urban agriculture. I think we've been blaming the students for so long, but perhaps we on the faculty need to look at ourselves

and say, 'Wait a minute. Maybe we need to change the way we talk about these issues so they are more appealing to younger people and also middle-aged people, to bring us all together to solve these problems, to open these doors a bit wider. It would be tremendously beneficial.' And that requires quite a bit of change and that's the hard thing at universities, but it will have to happen.

A. (*Frank Rijsberman, CGIAR*) I should have said straight away, yes, we recognise it as a challenge. Totally valid question. I've just visited seven CG centres in the last few months and I was surprised how many young people, how many young scientists, how many new post-docs that are in those centres. A very different situation from some ten years ago. So I think in a way the reprioritisation of agriculture in the last four or five years is already beginning to have that impact.

A. (*Derek Byerlee*) Thank you, very good question. Going back to the land issue, one of the things that really strikes me in Africa, particularly eastern and southern Africa, is that the farm size is declining for the average farmer, yet you have these big investors coming in, taking over large areas of land. That just doesn't make sense. A number of countries, particularly Malawi and Zambia, have set up programs to try to make land available to young farmers. I think the Malawi program has been particularly successful. It's not just making the land available, because they need access to finance and there's also been some very good efforts at developing business skills and new industries for some of these young farmers. I'd be happy to talk to you about it. I think it is a real challenge in South Africa — this emerging young entrepreneurial farmer, a smallholder but a commercial smallholder. And I think it's land plus the other assets.

Q. (*Andrew Campbell, Charles Darwin University*) I agree with Jonathan's analysis about the gap between the best and the average. We certainly have that here in Australia, and then an even bigger gap between the average and the tail. This suggests to me that if there's a hundred-fold difference between the most efficient and the least efficient, then it's not really a research question because we obviously know how to do it. It's an extension challenge, and yet we've hardly talked about extension, planning, incentives, education — which ties into the point from the lady from Uganda. In Australia, in the last week, New South Wales has abolished all its Catchment Management Authorities; we've seen states massively disinvest in agricultural extension. It strikes me that we could waste a lot of money on research if we're not actually trying to get it onto the ground.

A. (*Frank Rijsberman, CGIAR*) Another excellent question. I didn't use the word 'extension' but I think I spoke about delivery, for instance, or our farming systems programs. There is a very deep understanding in organisations like our own that it's no longer good enough to, if you like, come up with new knowledge and publish about it. The new CGIAR is about delivering outcomes with its partners — development outcomes. Yes, there will still be research programs where the staff will be held accountable for coming up with new plans. Dr Sanginga, for instance, at IITA*, his key challenge in the humid tropics is to come up with farming systems that actually help close the yield gap.

* IITA, the International Institute of Tropical Agriculture

We probably don't talk about extension because extension in the old way is dead. There are new ways of extension, some of which involve informing farmers and connecting farmers to markets, and others involve helping to create a viable seed industry in Africa. This is not necessarily the big companies that are more interested in working with commercial farmers, but having local, small African seed companies linking their research to farmers, getting the seed to where it's needed. I think that question is very high on the agenda.

A. (*Jonathan Foley, University of Minnesota*) I'd just briefly like to add to that: in the United States my university was founded at the same time as the Moral Act, 150 years ago. During the height of the bloodiest war in American history, our Civil War, we still invented this land grant university concept which is replicated around the world. But we're now in the 21st century, and needing to reboot extension, as we have noted. Probably it needed to end so that something else could come in its place with half the world now living in urban centres, with nine billion people on the way. We're not going to service people very well by driving pick-up trucks to farmers one at a time; it's just too big. But we have a billion people on Facebook right now. This is extraordinary. (And, you know, it makes me very upset to learn there are more people playing Farmville in the world than actually learning how to farm on the internet. That's crazy.)

We can harness these mobile phones and social media technologies and others to amplify what has been known as extension, to a new 21st century model. We heard some great examples of that yesterday, and we need to do a lot more work there. Not just to farmers, but to consumers, to producers, to the Fortune 500 companies, to major investment corporations. These are also huge levers that didn't exist maybe in the earlier days of agriculture and that are now profoundly important actors in the system. We have to reach everybody, not just individual land holders. That's a whole different paradigm.

Q. (*Joe O'Reagain, Fitzroy Basin Association, Central Queensland*) My question's for Frank. With regard to plateaus in cereal crop yields, what are the plant physiological limits? Have we hit a wall with regard to harvest index? Secondly, will the promotion of high yielding crop varieties to the developing world inadvertently put further pressure on already depleted soil nutrients and therefore further drive the issues we've got with fertiliser, as raised yesterday?

A. (*Frank Rijsberman, CGIAR*) The plateauing of yields might be because we are running into physical limits in places like Nebraska. Farmers in Europe and North America and in Australia are pretty efficient already. It's the yield gap in Africa and Asia, where we are very far away from those physical limits, that offer a lot of opportunity, and which need to focus more on extension, on connecting farmers to markets, and also on managing nutrients. Indeed why should we say that in Africa they should have farming systems that don't rely on regular fertiliser that everybody else uses? Clearly we are going to have to use other inputs if we are going to manage fertility as part of that effort to close the yield gap. Yet at the same time CGIAR is a research organisation, and it has people that say, 'What can we do to break through that physiological yield gap?' They are focusing on theory — just like the team at the ANU which said,

'Hey, we'll change the way plants use their photosynthesis process, make that more efficient'. Theorising, they say, 'We'll make C4 rice'. Other folks say, 'We can introduce extra characteristics'. There's all kinds of ideals which at the top level of yield will make a difference, but in the longer term, in the immediate term, when we say we can make an increase it is more about applying non-technologies to get farmers that aren't doing as well as here to do better.

A. (*Derek Byerlee*) I think we don't want to take this plateauing of yields too literally. Tony Fischer is sitting over there; I've been working with him on a book with ACIAR looking at yields and yield gaps, and there's really quite a lot of potential in most countries, particularly in the low and middle income countries, where there are very significant yield gaps. It gets back to a lot of these issues of efficient management of inputs, extension, and so on.

A. (*Jonathan Foley, University of Minnesota*) One of the things that's quite interesting is if you look at these yield patterns, rice and wheat are the ones that seem to have the most pronounced yield plateaus where yields are already high. Those crops receive relatively little investment; we've relied on the public sector to invest in them — only through, let's say, the CG system. They've been ignored by investors in the private sector. On the other hand, maize and soybean yields are not plateauing at all, or nearly as much. That's where the private sector has invested a huge amount of money. Unfortunately those crops are not as fundamental to food security. I think this shows that we need to redouble our investment in the public sphere, so that we level the playing field between the crops that really feed the poor in most of the world versus those that are feeding biofuels and animals.

And so we see the effects of investment and the differential public versus private investment paying off. But now we have about a 20-year period to catch up on so we need to redouble this investment in the public sector for crop improvement, not just leave it to the private sector alone. We've seen what that will do and it's not very helpful.

Q. (*Snow Barlow, the University of Melbourne*) A question to Derek, on the land sector. You mentioned yesterday that Australian land that is available is probably a little cheap or more attractive. Where does Australia sit on the scale of attractiveness for international development and investment?

A. (*Derek Byerlee*) There is an annual report on farm land values around the world. They rated Australia very highly in terms of attractiveness and investment in farmland, partly because Australia's regarded as a low risk country. One country I've been involved in is Ukraine. You cannot buy and sell land in the Ukraine, still. Twenty years after the transition, it's still all on a rental basis. But here you have some of the most fertile soils in the world. Companies are coming in and renting at about \$35/ha. That gives you some idea of the differences in the opportunities in terms of land prices. These will yield 4 t, 5 t, 6 t wheat crops if you manage them well. Big differences in opportunities.

Q. (*Elizabeth Finkel, Cosmos Magazine*) Jonathan, you articulated ways we could solve the problem; you said physics and biology show it's possible. And one of the things you highlighted was that 40% of the food we produce is not actually

used for food for people. And then you talked about the 4 billion people who will be looking at the same menus that we've been looking at and wanting to order steak and so on. My question is, what levers can you pull to influence the demands of those 4 billion?

A. (*Jonathan Foley, University of Minnesota*) That's an extremely good question. I wish I had the answer to that; it is one of the greatest challenges. Right now, though, what we're finding is quite extraordinary. For 20–30 years we've been told one narrative, that the only way to get to food security is by improving crop genetics and just leave it at that. We're finding that that's not enough. The yields are plateauing, the investments have not been sufficient and the time lag between what research is doing and what yields actually do in the real world is too long. We're finding that other levers, like diets, like biofuels, etcetera, are becoming maybe even more important to solving hunger than just crop breeding, though we'll need all of these things.

So first it's just an awareness of this issue. Second, we need you to write about this in your magazine and tell people about it. In my country most people have no idea that it takes 33 kg of grain to make 1 kg of extra beef in American feedlot operations. They're horrified when they hear this. We have politicians who are enforcing a biofuels mandate to make ethanol out of corn, even though we have this drought in North America that has hit corn production, causing prices to sky rocket, with the lowest corn stocks in history. This is extraordinarily bad policy from a food security point of view. Again, I think talking about this in the political and public spheres is very very important.

So I think, though this may be naive, that the first stage is just to be aware of this situation and to communicate these kinds of issues and to redouble our efforts. The good news is that a lot of these things we might need to do for diets and biofuels might be good for us. Eating less red meat might be good for a lot of us around the world, in terms of cardiovascular health or waistlines, etcetera. Producing more grass-fed beef, which, you know, most countries already do other than the US. Having more, maybe not vegetarian diets exclusively, but more vegetarian mixtures in our diets is probably good for our health and so on.

Hopefully we can reform what the western diet is already doing through a health lens but also maybe through the food security lens. And then, secondly, really see the developing countries and transitional economies leapfrog over the mistakes of our past and maybe settle on diets that are better for them and the world in the long run. However, it's an enormous challenge and one that won't be solved overnight.

Moderator (*Shaun Coffey*) Thank you very much ladies and gentlemen. We'll need to bring things to a conclusion there. If I might just reflect on a couple of things in terms of the conference. We've heard an enormous amount over the last day and a bit and particularly this morning. There's a couple of things that struck me as having not been commented upon yet, but I think they are significant outcomes in the last couple of days too. It's been really great in this

conference to see that we're finally recognising the role of women in agriculture and particularly in smallholder agriculture, and it's now becoming an accepted norm, as opposed to something that we've really not consciously recognised and acknowledged the way we have in this conference.

The second thing: a lot of the discussion this morning has been about the generational renewal that's needed in communities such as this. I think it's really nice, reflecting on having attended quite a number of these conferences, to see a lot more younger members of the community, the agricultural science community and the food community here today. And I guess there's one thing that's come out a lot from what we've talked about, and it is that when you look at all of the initiatives about, and all that we can do, there is a tremendous amount of optimism around and I think that's been particularly good.

Thank you.