CELEBRATING AGRICULTURE FOR DEVELOPMENT

Outcomes, impacts and the way ahead

The Crawford Fund 2022 ANNUAL CONFERENCE

Parliament House
Canberra ACT Australia
and online

15–16 August 2022

Editor **Ann Milligan**

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The Crawford Fund

The Crawford Fund was established by the Australian Academy of Technological Sciences and Engineering (ATSE) in June 1987. Named in honour of the late Sir John Crawford, the Fund commemorates his outstanding services to international agricultural research.

The Fund seeks to increase Australia's engagement in international agricultural research and development, which is designed to benefit developing countries' farmers, environments and economies, and to foster mutual understanding. We raise awareness of the benefits – for both Australia and developing countries – of investment and involvement in work for food and nutrition security and the many other impacts of agricultural research.

Our training and mentoring programs build capacity with practical, highly focused training by Australians and partners across a variety of topics in agricultural research and management in Australia and the developing world.

With support from the Australian Centre for International Agricultural Research (ACIAR), the Crawford Fund offers a growing set of programs, scholarships, scholar activities, and student awards, to encourage passionate next generation 'nextgen' students, researchers and farmers in their studies and careers in agriculture for development. We also deliver opportunities through our partnership with the Researchers in Agriculture for International Development (RAID) Network.

The Fund promotes and supports international R&D activities in which Australian research organisations and companies, including ACIAR, are active participants. It supports the work of the CGIAR Consortium and other international research centres. Through collaboration and training, we can achieve more productive and sustainable agriculture, less poverty and hunger, and a more secure world.

The annual conference is a key part of the Fund's public awareness campaign, and each conference addresses a key issue related to food security and the importance and potential of international agricultural research.

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Foreword and Welcome

The Hon. John Anderson AC

Chair, The Crawford Fund

The Crawford Fund, the speakers and the delegates at this 2022 conference acknowledge that the meeting is held on the traditional lands of the Ngunnawal nation, and we pay our respects to Elders past, present and emerging.

It is my pleasure to welcome everyone to our annual conference, in which this year we are 'Celebrating agriculture for development: outcomes, impacts and the way ahead'. The title reflects this special year for the Crawford Fund, being its 35th anniversary. The year 2022 is similarly special for the Australian Centre for International Agricultural Research, ACIAR, which is celebrating 40 years of operation.

We are very pleased that this year again we have delegates attending in-person, here in Canberra, as well as online across Australia and in 20 countries overseas. They include around 50 conference scholars* who are also involved in the unique learning, networking and mentoring activities the Crawford Fund has developed as part of our suite of NextGen projects to encourage the Next Generation.

'Outcomes, impacts and the way ahead' in the conference title refers to challenges that now face international agriculture and food security, partly because of COVID-19, the 2022 conflict between Russia and Ukraine, and climate change – three Cs. Apart from the disruptions produced by COVID-19, the war in Ukraine has reduced exports of grain and oil seeds to countries that were already grappling with food scarcity, and this year's floods and droughts have devastated crop and livestock production systems in areas across the world.

The world has experienced similar challenges in the past. In the 1950s, there were significant food shortages and famines. Agricultural science responded in the form of the Green Revolution in the 1950s and 1960s, aiming to feed the global population which at that time was only 2–3 billion. The Green Revolution, driven by Normal Borlaug and M.S. Swaminathan, may have had limitations but it demonstrated the power of science and foresight in bringing global attention and collaboration to address a global issue. In a similar way, a few years later Sir John Crawford played a significant role in helping establish ACIAR, as well as contributing to the international work of the World Bank and CGIAR. His work is honoured at the start of every annual Crawford Fund conference by the delivery of the Sir John Crawford Memorial Address. We look forward to the publication of his biography in early 2023.

Ever since the 1980s, ACIAR and the Crawford Fund have been contributing to Australia's international agricultural research and development (R&D), to help the world's almost 8 billion people today to have access to food and improved food security. Our Crawford Fund conference speakers this year celebrate some of the achievements of agricultural R&D over the last 35–40 years, some of the benefits arising from investment in international agricultural research, and some of the future challenges. I am confident that well-targeted agricultural and nutritional R&D can continue to overcome food insecurity challenges and deliver better nutrition and economic development outcomes for many of the world's poor.

Delegates to this conference include members of the Researchers in Agriculture for International Development Network (RAID). Two of them – Jessica Fearnley and David Gale – are our designated 'keynote listeners' this year, and their report on the event is on the Crawford Fund website**. Thank you to them.

Sincere thanks also to the many supporters of our conference, listed on the next pages. Many of these people and organisations also are involved in the Crawford Fund's training and NextGen activities. We truly appreciate their ongoing collaboration.

The Hon. John Anderson AC
Chair, The Crawford Fund

* Conference scholars are asterisked in the Participants list.

** https://www.crawfordfund.org/news/2022-keynote-listeners-report/

Acknowledgements

The Crawford Fund sincerely thanks the Chairs of the conference sessions, and the sponsors and supporters of this year's conference and of the scholar program.

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The Crawford Fund Board, coordinators and staff, with the conference scholars, in front of the tapestry that is the focal point of the Great Hall at Parliament House, Canberra. 15 August 2022.

2022 SIR JOHN CRAWFORD MEMORIAL ADDRESS

Food and nutrition security in the Pacific and the road ahead for small islands and developing states

Dr Audrey Aumua

CEO, Fred Hollows Foundation New Zealand,
and Member of ACIAR Policy Advisory Council

Thank you to the Crawford Fund for the very privileged invitation to present the 2022 Sir John Crawford Memorial Address. I am delighted to be here in this place in this building – the heart of your democracy.

It is an auspicious time, on the cusp of a new beginning, now that the pandemic clouds and tumult of the past several years have started to clear. We might be forgiven for feeling almost giddy, as it has been so long since many of us have been able to connect physically.

As we step forward into the bright future for agriculture this evening, I would first like to congratulate the Crawford Fund, which this year is celebrating its 35th Anniversary. Thirty-five years of progress as a reliable partner in building a brighter future in Agriculture, globally promoting the vision for a better world through collaboration and training. Your efforts have indeed been felt in the Pacific. I should also mention that this year is also ACIAR's 40th birthday, and I was pleased to be able to join that celebration earlier this year.

These important milestones tell you that Australia has for many years made a significant contribution to the global landscape of agriculture.

Trying to summarise all the challenges and achievements in agriculture, for a region as vast as the Pacific, is an almost insurmountable task. The peoples and nations that make up our Ocean Continent are as unique and diverse as the stars in the sky. However, I believe there are a few commonalities which can help guide us.

Tonight I want to speak about five of these. They are five issues to discuss and kindle a fire for; they are five challenges that could turn discussion into action; and they are five signposts that can help us map our way to a more sustainable future.

1. We see ourselves as a Blue Continent region

You will never know how far you must travel unless you know where you are starting from; so to begin, I want to focus on taking a small snapshot look at the state of agriculture in the Pacific today.

Along with the beauty of the Pacific comes the harsh reality of environmental changes, biodiversity loss, cyclones, natural disasters, pandemics, and economic pressures and shocks.

Most recently, the eruption of the Hunga Tonga-Hunga Ha'apai volcano, one of the largest ever recorded, spewed ash and adversity throughout the islands of Tonga, requiring rebuilding of entire communities, and destroying the entire agricultural and crop sector of Tongatapu. A few minutes of volcanic activity destroyed decades of development. And let's not forget 2016's devastating Cyclone Winston from which Fiji is still rebuilding. The journey to recovery from the impact of Winston is likely to take many years. And, of course, many other increasingly powerful cyclones have been wreaking havoc across the Pacific since then.

There is the ongoing impact of COVID-19, from which we are still slowly emerging, that has left communities and economies across the region completely ravaged.

And now we are even feeling the impact of issues happening half-way around the world as the war in Ukraine has helped trigger rapid inflation of basic goods – from fuel to grain, including agricultural inputs.

What we have learnt and understood more clearly through the COVID-19 and Ukraine disruptions is how dependent, and therefore vulnerable, our agriculture sector is on external inputs and the fossil fuel industry.

Hanging over all of that is a more rapidly changing climate, leading to sea-level rise, droughts, infectious diseases, unsustainable development, food and nutrition challenges, and threats to livelihoods and our traditional ways of life.

These challenges go hand-in-hand with agriculture challenges, and the difficulties farmers often have in getting safe, nutritious food into markets, due to disasters and hazards and competition from cheap imported food – which is slowly becoming a catastrophe of a different kind.

The climate emergency alone has negatively impacted agriculture and has led to declining availability of arable land and declining crop yields.

Our region today is constantly fighting a rearguard action against these continual threats. There is often little time to make long-term plans because of the constant disruptions of the environment, and many governments' immediate actions, needed to save lives today, are not always sustainable. Long-term planning is unattainable for many of our small island nations.

Pacific communities' relationship with nature is changing: forests are being felled, biodiversity is being lost, and the tiny and precious amount of land that our small island states in the Pacific do have is often not managed with a view towards future generations.

Although our starting point looks bleak, it's not one that can't be managed.

We as a region are learning to embrace science, technology, innovation, tradition and flexibility to ensure our small nations achieve big ambitions. We must be proactive in anticipating what is coming. The Pacific needs to become global leaders in adaptation. We have the resources in place: organisations like The Pacific Community (our regional scientific organisation) which is already working to pool our knowledge, expand our scientific expertise, and help up prepare for the future.

We must tap into the big thoughts of our small populations to blend tradition with modernisation if we are to thrive in a post-COVID-19, politically dynamic and climate-driven world.

2. Sustainable nutrition

In my second point, I want to spend a few moments talking about the importance of the relationship between nutrition, health and sustainable livelihoods.

Today, Pacific communities are drowning in an ever-encroaching sea of cheap, imported food that often has lower nutritional value than traditional foods. Though growing urban populations and changing diets will require some food imports, research has shown the substantial increases in imported non-traditional foods have been linked to an increase in non-communicable diseases (NCDs), including diabetes – a condition that requires good nutrition to be managed. Today the Pacific is globally known for having the highest rates of mortality due to NCDs and some of the highest rates of obesity in the world.

We have the challenge of both poor nutrition and malnutrition in our children, with some countries having high levels of stunting in our adolescents; and of increasing concern is anaemia in our younger women. This is a double-edged sword for many communities that require good nutrition to manage these conditions.

The truth is that Pacific food production is still currently insufficient to supply the amounts of fruits and non-starchy vegetables required for good human health. Nutrition security has to be at the heart of many of our efforts, and there is ample room for new ideas in thinking about how to embed local production and nutrition-behaviour-change through school feeding.

In regional food production, we must ensure every aspect of getting a plant or animal from the farm to the table is viable – from the seed to the crop to market and, of course, down to the very building blocks of this food: its genetic resources.

I am heartened that we do have a long-time ally and deep expertise in these food building blocks – genetics and seeds in the Centre for Pacific Crops and Trees, CePaCT. A key area of their work is improving planting material, where they conserve and make available different food crops and genetic material; and, more importantly, exploring food options for different and future climatic conditions. There is no doubt the Pacific will indeed need different varieties of food as we face further climatic conditions such as drought, and we will need food that is more salt-tolerant as we face sea-level rise.

I am really so delighted to see that CePaCT's leader, Logo Waqainabete, who is also the Head of The Pacific Community's Land Resources Division and Genetic Resources Programme, is here with us tonight. For more than 10 years, Logo has ensured the Pacific has a fruitful, robust base of agricultural crops and trees. This year CePaCT won the 2022 Island Innovation award for Innovative Island Research. Well done to you, Logo!!

The importance of regional food systems has been brought home, thanks to COVID-19, as many economies closed and markets have become difficult to access over the past two years. Add in the impacts of globalisation and the war in Ukraine recently, and the vulnerability of

Pacific agriculture has become obvious. But the Pacific is not blind to this vulnerability and is already taking steps to meet these challenges.

Last year, The Pacific Community led a series of online food systems dialogues in the lead-up to the inaugural UN International Food Systems Summit. The Pacific dialogues not only led to the regional representation and supported a coordinated regional voice at the International Summit, but also laid the groundwork for The Pacific Community's flagship Food Systems Programme. The initiative is a prime example of governments, community groups, NGOs, research agencies, and business and development partners coming together to act now for a future of hardy and resilient food systems that will feed our communities. I thank the many partners involved in supporting this.

An exciting initiative underway that will have region-wide impact is an integrated program managed also by The Pacific Community on the coconut. In the Pacific we call the coconut the 'Tree of Life' because every part of the coconut – the entire tree from top to bottom – is used to sustain human life. It has to be the most useful tree in the world. However, it is under threat: the rhinoceros beetle is a major pest to the coconut and has, to date, devastated coconut growth and production in many small islands.

A coconut risk-management and mitigation manual, released earlier this year, covers risks from seed to consumption, including climate change, planting, pests and diseases, policy, technology, post-harvest, marketing and, essentially, cultural habits. The coconut and its fruits are an ingrained part of Pacific culture, and this targeted initiative will go a long way in ensuring this culture, and the livelihoods it supports, will remain strong.

I want to acknowledge the work of ACIAR and DFAT for their scientific support in this area.

Every step we take towards ensuring the Pacific has a sustainable, regionally based healthy food system, will be a step towards better and more secure livelihoods that are nutritionally safer for all.

3. The blue–green economy

There is arguably no region on earth in which the connections between the green and blue economies are so intertwined. This relationship is my third signpost.

Agriculture is the green of the blue–green economy, but we cannot leave out the blue – the ocean – and the food and nutrition it provides. Agriculture and fishing are not just sources of food: they are vital for livelihoods. Across the countries of the Pacific, 50–70% of people depend on agriculture and fishing for their livelihoods. For most small island nations or large island nations we have the necessity of farmers who fish, and fishers that farm. That reality must shape our approach to Pacific agriculture.

The blue–green Pacific economy is facing both slow shocks – such as deteriorating water quality and availability, deterioration of coastal ecosystems, degraded soils, and loss of plant genetic diversity – and rapid shocks such as extreme climate events, as well as extreme natural events, and increases in invasive plant pests and animal diseases. We have economic

disruption from the pandemic and now other global events such as the Russian invasion of Ukraine.

It is important to remember that these shocks are cumulative, and the climate-related ones are forecast to be more frequent and more extreme. The blue–green economy means evolving not only our food systems but also our relationship with food, so that we can capture and emancipate a very powerful means to realise the climate-resilient societies and climate-resilient food systems that the Pacific needs.

Consider for a moment the challenge faced by atoll nations such as Kiribati. With limited soil, a narrow biodiversity base, and access to fresh water difficult, we see mostly fishers that farm, and the changing climate is slowly swallowing the scarce amount of land that is available. What they require are new ways to integrate ridge and reef systems, and investment in multi-sectoral disciplines that support local communities.

A real concern in the region related to food sources in the blue economy is, of course, fish which are the region's greatest source of nutrition. Our fish are being impacted by ocean warming and are migrating away from their historic territories, and the result has been that the fishermen's livelihoods and therefore the availability of our traditional sources of protein have been disrupted.

The time is right to better support these nations with our resources and our technology to find new ways to feed their communities. Land Resources teams in the region, for example, are working with their partners on adapting the new Foodcube technology for atoll nations: a trial in Tuvalu is being investigated, on whether gardens could be established using only on-island resources, and trials will be extended to Kiribati and urban Fiji, paired with training on how to use the technology.

We must be careful, however, that these new technologies, in addition to the current technologies and coastal food systems in place, do not damage delicate coastal fisheries. Land-based agriculture should complement or support sea-based food harvesting, just as sea-based harvesting should complement land-based farming.

A good example of this is the research work done by the Government of Fiji into a bacterium fertiliser, made from local resources, which supports soil health and crop productivity while protecting coastal ecosystems and fisheries from hazardous runoff possible with conventional inputs.

These components of the food system will clearly be key to realising blue–green economies in the Pacific, and we must ensure they are progressive and adaptable so that they can serve the different needs and environments of the region's volcanic nations, as well as its atoll nations.

4. Traditional knowledge and technology

My fourth point is on the critical importance of weaving traditional knowledge with modern science and technology.

A blue–green technology for a blue–green economy must be driven by new thinking and new tools for our new times, but the old agricultural knowledge, traditions and culture that have

fed Pacific people and supported them and their communities for generations cannot be left aside. This weaving of tradition and technology is the only way forward for a Pacific that has been swept up into the tides of rapid world transformation and modernisation.

Sadly, many of our traditional knowledge and customs in the Pacific are being lost to modernisation, but we are increasingly discovering that they may hold the key for our agricultural future. For centuries, Pacific peoples have survived on our small, remote islands through intimate knowledge of not only the surrounding seas but also the generous land. Our island countries are small, and their lands and soils are not always rich – particularly in atoll nations – but our communities have always found a way to feed their citizens.

Though traditional knowledge and customs are vital for the future of Pacific agriculture, it is also true that this sector cannot realise progress without merging them with modern science and technology. The pace of science is continuing to accelerate worldwide as a result of globalisation and knowledge interconnectivity. But too often our region has been left out of the international research efforts, like the European exploration maps of old where blank spaces represent the Pacific – 'There be dragons'.

How can we ensure that the deep and invaluable knowledge locked in the Pacific can become a part of the global knowledge base?

One answer is to ensure that Pacific researchers and scientists are publishing in more peer-reviewed journals and other science-based outlets. We need the Pacific to become part of the conversation: the uniqueness of our agricultural challenges can and should lead to unique scientific breakthroughs.

One of these breakthroughs is in plant health. Plant health on farms and in agroforestry projects is vital for our communities: our native and farmed species are under growing threats, and without plant health there simply will not be enough food to feed our communities. There has been a focus on plant health in the region for several years now, and farmers have been trained through plant health clinics. This training is now widely available and now also online.

A new app was recently introduced for farmers to diagnose plant disease and other issues, and to get help from experts when needed, to stop a scourge that could destroy their entire crop. And in April this year, regional partners teamed up with Manaaki Whenua (Landcare Research in New Zealand) to open a new molecular laboratory in Fiji that will offer a pathogen diagnostic and genotyping service to the region.

It is a start, but these breakthroughs will not happen if our small island nations do not collaborate and receive support from our large regional partners. So I ask, as science and research progresses in the Pacific, why is our aid lagging and why are our agricultural models outdated?

There is currently a lack of investment in scaling, and most importantly we need a broader regional research agenda that not only provides support but builds capacity for agricultural research in the region, so the Pacific peoples can innovate using their knowledge and skills.

The good news is that the Australian Government has started to recognise the problem and this year ACIAR has partnered with The Pacific Community on a Pacific Regional Research Agenda. The agenda is currently under development and will be presented to the annual Pacific Heads of Agriculture and Forestry meeting, due to take place in Fiji in November. I trust you will join us to ensure this vital initiative gets off the ground and plays an important role in the Pacific's agriculture future.

Although this may sound like a new initiative, ACIAR has long been a solid and trusted partner in the region. For some time ACIAR has been working with various research partners to build and strengthen core research capacity, assisting many of them to build core scientific and technical management capacity. The goal ultimately has to be that we work together collectively to strengthen coordinated research mechanisms across the region as well as build the human resource capability in research – a topic close to the heart of the Crawford Fund.

The science and technology communities need to work hand-in-hand with traditional knowledge practitioners in finding unique and relevant solutions to our unique and relevant agriculture challenges, but we need those solutions to travel beyond the lab and beyond the village. We need solutions that are as extensive and adaptable as the Pacific region itself; that are not reductionist in approach but recognise and work with whole systems.

5. My fifth signpost – 'It Takes a Village' – is about inclusive and comprehensive action

Our efforts, solutions and advances must be available and relevant in all Pacific island countries, and for all their peoples. We cannot prosper agriculturally now and in the future without bringing gender and under-served communities into the conversation. Welcoming and supporting all is the only path to success.

Women already make a large contribution to Pacific economies. In places such as the Solomon Islands, women are responsible for 90% of the activity in Honiara Central Market. In Samoa, 80% of the private sector comprises microbusinesses, and women are estimated to head over 40% of them.

Clearly the Pacific cannot find success in agriculture, or with any sustainable development initiative, without including women, youth and other under-served communities: they drive the economies and provide much of our food. Their workdays are often 'double workdays' as they combine responsibilities for home and family with their economic activities.

Attitudes and cultures towards the contributions of women and youth are shifting, but in order to shift into a plentiful post-COVID-19 agricultural future, we need to do more to ensure they are empowered and recognised for their invaluable contributions.

There are some fantastic examples already in place: DFAT is funding the *Building Prosperity for Women Producers, Processors, and Women Owned Businesses through Organic Value Chains* project that is managed by the POETCom initiative. The project is working in Palau, Republic of Marshall Islands, Kiribati and Pohnpei to help women participate in organic value chains and, importantly, in decision-making processes. Women are gaining increased financial independence and benefiting from organic value chains which are helping to increase food security. The project will help increase gender equitable policies and practice in four countries.

Furthermore, the *Pacific Women Lead* initiative, again funded by DFAT, will see a greater focus on women in the Pacific leading on key agricultural initiatives.

In Fiji in the village of Nadroumai on Fiji's largest island, Viti Levu, women have taken the reins of an agroforestry project that has prospered in the wake of COVID-19. They have planted trees to improve biodiversity and help stem the impacts of climate change in their village, and this in turn has led to a plant nursery, where seedlings are sold to benefit the community.

The project and its collective knowledge is also being passed onto the next generation: many of the village daughters came home from the tourist resorts in which they worked due to COVID-19 shutdowns. The Nadroumai women taught their daughters their growing methods, and young girls are now interested in their work, carrying on tradition while also bringing their own education and knowledge back to benefit their families and the community. When we pass these traditions to youth, everyone benefits.

These stories tell us that women can lead in our post-COVID agriculture future, and we need to foster and support more examples like Nadroumai and the Women Producers project in Micronesia, throughout the Pacific.

Pulling it all together

The five elements I have highlighted this evening are all essential for the future of agriculture in the Pacific. But I want to emphasise that these and other efforts should not be looked at as a menu of choices. We cannot decide to deal with one area and leave the rest for another time. They are all interconnected. Failure to fund and invest in any one area will inevitably bring down all the rest.

A holistic and integrated approach to all investments is essential for sustainability.

The diversity of the Pacific means that 'one agriculture' – meaning using the same model for every country – will be challenging, but our approach to agriculture throughout the region cannot be successful without putting the One Health approach into practice.

Some of the projects I have mentioned tonight are already doing this, but it is clear we need more: more education, more knowledge, more collaboration, more bold ideas, and more resources from our partners in Australia and beyond.

We have momentum now. Spirits are high, as the fever of agriculture and development in the Pacific is reigniting post-COVID. Old projects are back online, with new projects sprouting quickly. Our region is big. I THINK WE NEED TO THINK BIG!

While we work to regrow our agricultural communities in the next few years post-COVID, let's think about what we can achieve in five years, in ten years, and even the next 30 years. Let's commit to our farmers in the Pacific ploughing only healthy soil in 2050: soil that is rich in tradition, watered by knowledge and technology and bound together by community. We can support our region by thinking about climate-resilient food systems, climate-smart agricultural production. It is possible, but only if we collectively make comprehensive consistent investments. And not only with *your* knowledge and *our* collective knowledge and resources, but with *your* ideas, *your* ambition and *your* commitment.

Recognition of the roles of women and youth is now being integrated into the narrative of our agriculture traditions and our progress. New projects, technology-based but grounded in traditional knowledge, are taking shape. The Pacific is increasingly being heard on the world stage. This is the time, the opportunity to re-imagine and renew our call for agricultural resilience throughout the region and to recognise and support the role agriculture can play in regenerating our ecosystems and economies.

So I urge you, and all of us, to not let these many opportunities pass: the opportunities to not only revive but also to re-imagine and rejuvenate agriculture and food systems in the Pacific. The potential in our region is boundless, and with your collaboration we can start building the farms and markets of tomorrow, today. DFAT's *Partnerships for Recovery — Australia's COVID-19 Development Response* is a good step forward.

We can turn the Pacific's thorny and increasing rooted challenges into an opportunity. Thriving agriculture seeds One Health, and One Health seeds a radiant future for this region.

Finally, I thank you most sincerely for listening this evening. I am indeed looking forward to a future where we are all fed and all valued.

In fact, I think we have already taken the first step. We have already put shovel to soil, dropped in that seed of collaboration and innovation and watered it. Now I think we just need to help it sprout and grow.

Dr Aumua oversees the work of The Fred Hollows Foundation NZ which has a mission to end avoidable blindness and vision impairment in the Pacific. She took up this role in January 2021 after serving as the Deputy Director General of The Pacific Community SPC based in Suva for 6 years. The Pacific Community, being the largest regional science and development organisation in the region, is the host of the largest scientific agriculture and livelihoods program in the Pacific, including the Centre for Pacific Crops and Trees which is responsible for conserving the region's genetic resources. A key focus of Dr Aumua's work previously had been to shape many of the Pacific region's programs around food and nutrition security to the impacts of disasters and climate change. Pacific food systems – in particular, coastal food systems – have been a key interest. Dr Aumua's background is in the areas of public health and nutrition, and policy, and non-communicable diseases, and she has worked both as an academic and as a practitioner. Dr Aumua has been a member of the ACIAR policy board for three years, bringing both policy and sustainable development knowledge in land resources and nutrition to the work of ACIAR. Dr Aumua has extensive experience in research, policy development and management in New Zealand and Australia, Samoa, Fiji, Solomon Islands, Vanuatu, Tonga and Papua New Guinea. She has worked in regional development and held a variety of regional leadership roles across the Pacific.

OPENING ADDRESS

Celebrating agriculture for development

The Hon John Anderson AC

Chair, The Crawford Fund

The speakers and delegates at this conference acknowledge that it is being held on the traditional lands of the people of the Ngunnawal nation. We pay our respects to Elders past, present and emerging.

This year is special both for the Crawford Fund and for the Australian Centre for International Agricultural Research, ACIAR, in that we are both celebrating anniversaries – 35 years and 40 years, respectively.

Professor Derek Tribe (founder of the Crawford Fund) and Sir John Crawford (in whose name the Fund was established) both recognised the vital role that agricultural research and development (R&D) could play in supplying the world with food, having witnessed famines, widespread malnutrition and hunger, and the undeveloped state of many economies. Sir John Crawford was also the driving force behind the founding of ACIAR and, to a significant extent, the CGIAR. When the Crawford Fund began work in 1987, the 'Green Revolution' was well underway, driven by Norman Borlaug based at the International Maize and Wheat Improvement Center in Mexico (CIMMYT) for wheat and maize, and by M.S. Swaminathan at the International Rice Research Institute (IRRI) in the Philippines for the rice-dependent countries of South and East Asia. At that time, there was a growing awareness that agricultural R&D could also help lift people out of poverty and raise the GDP of the world's poorest countries. Although the proportion of hungry people (about 1 in 9) has not changed significantly since 1987, agricultural production driven by R&D and other innovations has enabled us to feed approximately 3 billion more people. This is compelling evidence of the importance of the continuing success of many scientists and farmers in agricultural research.

In the 1980s, it was also recognised that improved and sustainable management of the natural resource base and environment that underpins agricultural production needed significantly more attention. That led to the formation of several more international centres with specific foci: for water, the International Water Management Institute (IWMI); for forestry and agroforestry, the Center for International Forestry Research (CIFOR) and the World Agroforestry Centre; for biodiversity, Bioversity International.

Similarly, the important roles of animal and fish protein in diets were recognised, resulting in the International Livestock Research Institute (ILRI), and WorldFish; for policy, the International Food Policy Research Institute (IFPRI) was formed; the World Vegetable Center (WorldVeg) and the International Potato Center (CIP) were set up to work on vegetables and potatoes. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) was formed for R&D on so-called 'poor people's food', and the International Center for Agricultural

John Anderson giving the opening address of the 2022 conference, in the Great Hall of Parliament House, Canberra.

Research in the Dry Areas (ICARDA) began working on food for dry areas. Australians have had pivotal roles on the boards or staff of these international organisations and others. Many of these centres have displays at this conference.

The Crawford Fund highly values its working relationship with ACIAR and the international centres, and with organisations such as the Asia Pacific Association of Agricultural Research Institutes (which is also represented here today) and with the Australian universities and federal and state institutions involved in international agricultural research. We have always tried to take stock of the impact of our work which depends on collaboration with them and with universities and agriculture departments at home and abroad.

Our founding Director, Derek Tribe, coined the phrase 'doing well by doing good' to encapsulate the benefits arising from our investment in agricultural R&D. This year, we want to celebrate some of the positive outcomes arising from our 35 years of doing well by doing good, and from ACIAR's 40 years. Consequently, the conference focuses on a range of good-news success stories.

These include the positive benefit–cost ratios arising both in recipient countries and, I stress, in Australia, from Australian and international investment in international agricultural research. The benefits span on-farm productivity and profitability, food and nutrition security, gender equity, environment and natural resources, capacity development, biosecurity and 'soft power' (a term used by diplomats) outcomes.

Over the last 12 months, the Crawford Fund has commissioned two major studies of the benefits arising from investment in international agricultural research – both the economic

benefits and other less tangible but equally important benefits. We will be releasing these two reports later this year. The results back up other international studies and make compelling reading. They include:

- up to 10-fold monetary returns on investment to farmers;
- significant numbers of individuals trained across diverse subject areas;
- improved nutrition and natural resource management practices;
- improved roles and outcomes for women; and
- the development of networks across countries that enhance our collective capacity to respond to threats and challenges.

Furthermore,

- Australia's investment in the international centres has given us access to new varieties and cultivars that have enabled our farmers to increase yields and remain internationally competitive!

These are all worth celebrating. They represent the collective work of ACIAR, the Crawford Fund and many individual researchers. Such achievements are often overlooked politically and by the general public, despite our best efforts to publicise 'good news stories'. Through this conference and the subsequent release of the reports and a planned series of activities, we hope to further rectify this.

Today's speakers are asked to look to the future, while recognising that we are in an era confronted by the 3 Cs – COVID-19, climate change and conflict.

From a political perspective, in these days of great self-doubt and loss of confidence in the west, it is all too easy to overlook the enormous strides that have been made. It seems vitally important, to me, to remember that the significant achievements in food security have been made possible by two major realities – realities that are too easily forgotten or misunderstood. The first has been what is known as the 'liberal global order' – the rules-based international system that has prevailed since the end of the Second World War which made it possible to mount the major international cooperation for food security, in which Australia has played such an honourable role. It hardly needs stating that there is now a genuine and frightening tussle for a new more autocratic global order, which seems, to me, to be threatening progress towards a fair and free world. Indeed, I am not certain what would happen to climate policy should the current global architecture be turned on its head.

The second great reality is that we have had an abundance of cheap energy, and the technologies and fertilisers that have accompanied that. The nexus between the production of ammonia, steel, concrete and cheap diesel and electricity on the one hand, and plentiful food on the other, is I fear very poorly understood, including by many policy makers.

The road to a lower emissions future is already involving difficult and contentious policy options that go to the very heart of global food production – think of Sri Lanka and the Netherlands. We should also note that serious geopolitical issues tend to take precedence over other significant issues – including food security and climate change. My point is that in

an environment where there is a very low level of understanding of the mechanics of feeding the world, it is vitally important that we avoid catastrophism as much as possible, in favour of cool calm reason soundly based on high quality science and research.

Agriculture and agricultural research, when understood properly, are already part of the solution, and outstanding organisations like the Crawford Fund and ACIAR play significant roles. More can be done if there is greater support, as today's speakers will no doubt reinforce.

John Anderson has been a long-serving member of the Board of the Crawford Fund, and has been Chair of the Board since 2017. He was recently appointed companion of the order of Australia (AC) in the Queen's Birthday 2022 Honours List for eminent service to rural and regional development, to leadership in international agricultural research and food security, to social commentary, and through contributions to not-for-profit organisations. John Anderson is the former Deputy Prime Minister and Leader of the National Party of Australia (1999–2005); Minister for Primary Industries and Energy (1996–1998); Minister for Transport and Regional Development (1998–2005); and served on the Expenditure Review (Budget) Committee, National Security Committee and Standing Environment Committee while in Cabinet. He was the member for Gwydir, New South Wales, from 1989 to his retirement in 2005. John has returned to farming, and is also active in the not-for-profit sector.

MINISTERIAL ADDRESS

Senator the Hon. Murray Watt

Minister for Agriculture, Fisheries and Forestry

It is a privilege to be able to speak to you all today. The Crawford Fund does some amazing work in support of international agricultural research and development. Even more amazing is that you have been doing it for 35 years now! And I congratulate you on reaching that milestone.

On the topic of milestones I want to give a special 'shoutout' as well to the Australian Centre for International Agricultural Research on their 40th anniversary of providing world-leading solutions in agricultural research.

I want to start by giving you a quick snapshot of where Australia's agriculture sector is at, right now.

State of the sector

It is fair to say that Australia's farmers are in a favourable position at the moment. With a third year of above average rainfall expected, conditions are currently generating significant financial returns after many years of hardship. The value of agricultural production is forecast to be $80.4 billion, the second highest on record, while the value of agricultural exports is forecast to be the highest on record, at $64.9 billion.

However, what I have seen and heard, since taking on this role, is that farmers know the good times don't last. There are some serious challenges ahead of us, and we need to work collaboratively to ensure this industry is resilient and innovative enough to see them through.

Biosecurity

We have all seen the headlines about Indonesia's foot-and-mouth disease (FMD) outbreak, while they also try to manage an incursion of lumpy skin disease (LSD). The Albanese Government has been working closely with the Government of Indonesia in response to the outbreak.

We have been addressing the outbreak with a three-pronged approach. We have committed funding, resources, training and support to Indonesia to help them as they combat these serious diseases. This includes $14 million in immediate funding to manage the increased threat of foot-and-mouth disease and lumpy skin disease. An additional $10 million for FMD vaccination and further support has also just been announced. ABARES have estimated an outbreak of FMD could cost Australia up to $80 billion over ten years.

These outbreaks have 'brought home', to many people, biosecurity risks and what they could mean for our own agricultural sector if we were to have such an incursion here. One of the

reasons we have acted so strongly is to protect food security and the impact an outbreak would have on our exports.

I couldn't be prouder of the response from our biosecurity teams and the Australian public. Sanitation mats, shoe cleaning and declaring goods at the border are not easy things to navigate, especially after a long flight, but Australians have wholeheartedly supported these measures to protect our farmers.

Of course, FMD is not the only biosecurity challenge we face. Our work there is never finished, and we need to remain vigilant to the threats of pests and disease to our food production.

Global factors

Russia's invasion of Ukraine is putting enormous pressure on grain prices around the world. While our farmers in our export-focused market are currently seeing strong prices for their goods, the reasons for these prices are tragic.

Although Russia and Ukraine are not major trading partners for Australia, flow-on effects from the war are raising prices of fertiliser, fuel, freight and commodities to impact producers and consumers alike. World fertiliser prices are at their highest level since 2008, which will lead to reduced use on all farm types.

This squeeze on fertiliser will drop production across the globe, impacting on food security and keeping food prices high in the short to medium term.

Workforce

Access to farm labour and imported machinery will also continue to present challenges for many businesses and consumers.

The inability of many farmers to attract and retain the workforce they need over a number of years has a direct impact on food security and prices. We are prioritising workforce shortages to ensure producers have the on-farm support they need, through strengthening the Pacific Labour Scheme. There is also much more that we can do to attract and retain Australian workers in regional areas.

I'll be working closely with my Cabinet colleagues to ensure that regions benefit from greatly increased emphasis on local jobs and skills. This begins with the Jobs and Skills Summit being held here next month and the industry roundtables we are conducting in the lead-up.

Each of these issues is contributing to a growing concern across the world – the Crawford Fund is very focused on food security.

Food security

Australia is deeply concerned at the alarming levels of hunger globally, including in our region.

Around the world, the mounting pressures are hitting the poorest and most vulnerable people the hardest – women, children, people with disability and those that are displaced – impacting on livelihoods, income and food security.

Countries need equitable, sustainable, and resilient agri-food systems that can withstand and recover from external shocks. But it is important to do that in a socially inclusive and gender-responsive manner – otherwise the risks of destabilisation and conflict will increase.

Delivering food security also requires us to take serious action on what is arguably the biggest challenge we face – climate change. ABARES latest modelling, from 2021, estimates that changes in seasonal conditions over the last 20 years have reduced annual average farm profits by 23%, or around $29,200 per farm. Agriculture is disproportionately exposed and vulnerable to adverse natural hazards, so investment in climate-smart agriculture is important to drive long-term sustainable growth and build climate resilience.

This will also increase the appeal of Australian produce in global markets.

That is why we are supporting our growers to overcome climate impacts and become more resilient to external shocks while innovating, adapting, and sharing our nation's expertise in sustainable production.

In the meantime, through our international development program, we are helping communities in our region to meet the growing food security challenge. This includes through our long-standing partnership with the World Food Programme (WFP). In 2021–22, we provided over $157 million to that specific programme. Most recently, this included $22 million for emergency food assistance to help the WFP meet the daily nutritional needs of three million people in Sri Lanka.

All countries need to maintain open, transparent and predictable trade in agricultural products in the face of the current food security crisis. Australia is promoting this through our leadership in international standard-setting bodies such as the World Organisation for Animal Health (OIE), the Codex Alimentarius Commission (Codex) and the International Plant Protection Convention (IPPC), where we are advocating for policies and standards that facilitate international trade in safe food.

We are encouraging countries to align their requirements with these policies and standards to better harmonise requirements, which in turn facilitates trade and mitigates against unnecessary barriers that impede food security and are not based on principles of sound science and risk.

In addition, we are funding important research through ACIAR, to sustainably increase agricultural productivity and enhance livelihoods in our region.

Conclusion

We are conscious of the leading role we play in ensuring food security in our region. Australia must lift our efforts to support countries as they navigate the environmental and economic challenges of the day. Not only is this a humanitarian issue, it is also a diplomatic and economic one as well.

We can improve relations with our neighbours in the Pacific and help nations throughout Asia deal with rising threats of pest and disease which are largely being borne by climate change.

It is imperative we all work together to achieve our common goals – including governments, industry and business.

Murray Watt was elected as a Senator for Queensland in 2016. He is the Albanese Government's Minister for Agriculture, Fisheries and Forestry and Minister for Emergency Management. Murray is Brisbane born and bred, and has strong family ties to regional Queensland, with both sides of his family having a long history in farming and teaching. For over 20 years, Murray's working life has been spent as an advocate for others, as a lawyer, a public servant and as Chief of Staff to former Premier Anna Bligh. Murray also served one term as a Queensland State MP and Assistant Minister in health and economic portfolios. Since his election in 2016, Murray has played a key role in Senate Estimates and a range of Senate Committees including the Rural and Regional Affairs Committee. As a Senator and Shadow Minister, he led a number of Senate inquiries into issues including regional development, energy and resources, emergency management and health care.

KEYNOTE

Science for nourishing the world, sustainably

Professor Andrew Campbell

CEO, Australian Centre for International Agricultural Research (ACIAR)

In this talk I am going to cover some of the things we have learned and then come back to the present day and think about 'Where to from here?'.

Some very far-sighted people in the early 1980s persuaded the then Prime Minister, Malcolm Fraser, leading up to the 1981 Commonwealth Heads of Government meeting in Melbourne, that Australia needed to share its agricultural science expertise. That is what the ACIAR Act says, and in my view it is as relevant today, or more relevant today, as it ever was.

ACIAR is a Commonwealth statutory authority. I report direct to the Foreign Minister. I have had an excellent meeting with Minister Wong, and she completely understands the value of science partnerships as a strategic component of Australia's development aid program.

We have an eminent Commission and Policy Advisory Council, and the ACIAR ten-year strategy – which I'd encourage you to read – sets out an ambitious agenda. Because we are halfway through that ten-year strategy, we recently had an independent mid-term review chaired by Dr Wendy Craik and eminent colleagues. The review essentially says that, COVID-19 notwithstanding, the strategy is still fit for purpose. However, the review found some areas that need more emphasis over the remaining five years, and I shall come back to that. Meanwhile, though I cannot cover everything that has happened in the last 40 years, I can show you that ACIAR has had a really significant impact.

Figure 1. Some of ACIAR's (not necessarily greatest) hits.

Figure 1 shows some of ACIAR's projects, to give you an idea of the breadth of our work. It includes social science, it includes hard-nosed agronomy, it includes fisheries work, policy work, community-based work. And that is just a tiny snapshot.

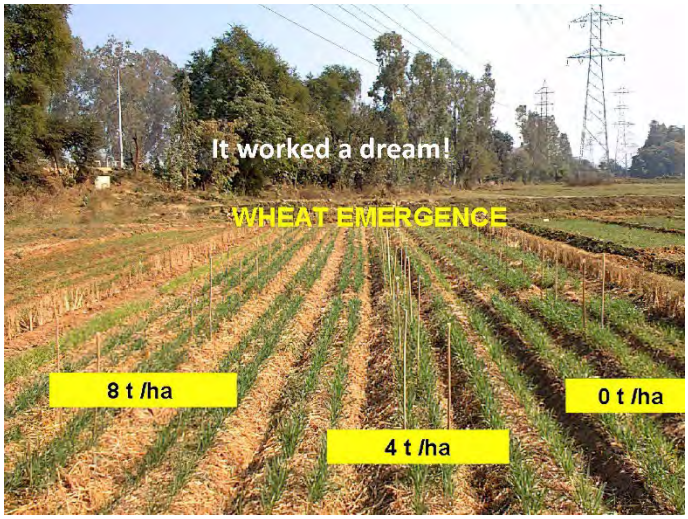

Figure 2. Wheat emergence through various weights of stubble trash, 2004. *Photo: John Blackwell.*

One example is the way Australia's expertise in conservation agriculture has made a very significant impact in the Middle East, in North Africa and in India, in figuring out how to sow wheat into heavy rice stubbles, and how to use direct drilling. You can see the different levels of trash there in Figure 2, and that there is very good wheat emergence.

Figure 3. Fishway under construction at Xayaburi Dam on the Mekong River.

In the Mekong Basin, 60% of protein consumed by humans comes from fish, and all the fish need to be able to swim upstream to breed and then get back down again. And yet humans have put structures that block those streams all over the place for irrigation and now for massive hydro-electric schemes. Our challenge was to add a fish ladder at Xayaburi Dam on the Mekong River, where the fish ladder itself (Figure 3) has more concrete in it than the Melbourne Cricket Ground! Fabulous work by a Charles Sturt University team led by Prof Lee Baumgartner, funded by ACIAR and DFAT, is figuring out how to design and monitor these fish ladders to suit diverse structures. We are now writing new manuals for civil engineers in Lao on how to build fishways.

We have been involved in fantastic anthropological work in Papua New Guinea, on farm-family teams, led by Prof Barbara Pamphilon at the University of Canberra and NARI (the National Agricultural Research Institute). Farm financial planning and financial literacy, banking and savings, and treating the senior woman of the family with the senior man as equals and helping them to learn and plan as a team. Reducing domestic violence, improving livelihoods and incomes, improving the proportion that's left over for the education of kids and for health, empowering women.

We have been involved in developing a new community-based national seed system for Timor-Leste, dramatically increasing yields of staple crops (Figure 4). About 60% of all households in the country were involved in this high-impact work – which is funded by AusAID partnering with ACIAR.

Figure 4. Seeds of Life, Timor-Leste, a community-based new national seed system for staple crops.

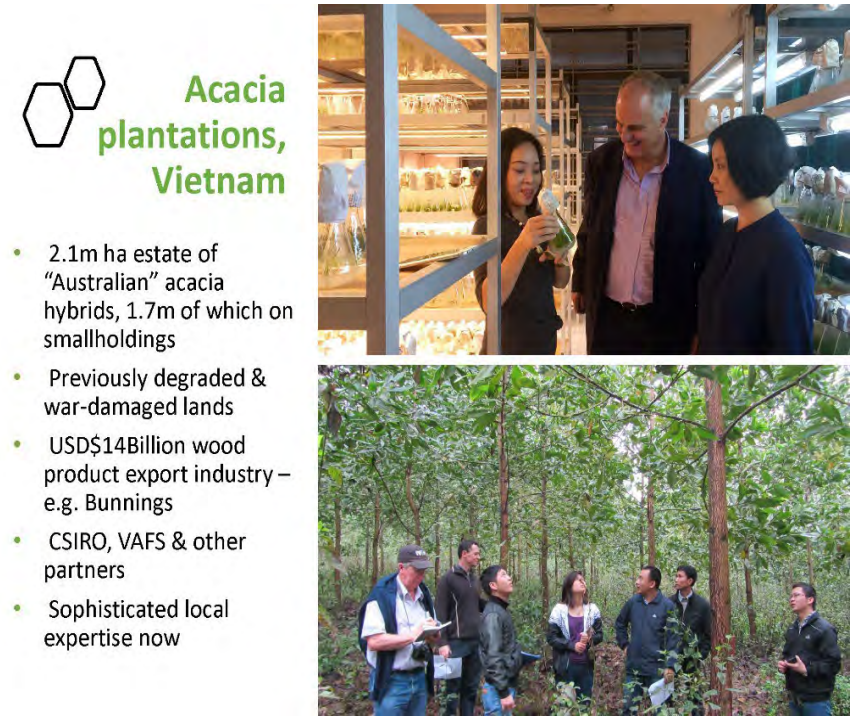

Figure 5. Acacia plantations in Vietnam provide wood for export.

Blast fishing in the Philippines is a, shall we say, 'once-off' operation. It's very effective, once – and then you are left with a destroyed reef. How do you accelerate the coral reef regenerating? Prof Peter Harrison and his team at Southern Cross University have figured out a way to accelerate coral larvae reattachment to the reef. It is so effective in the Philippines that it is now being taken to scale on the Great Barrier Reef here in Australia.

As a forester it gives me a lot of pleasure that in the outdoor furniture section of Bunnings hardware stores you will see acacia-wood furniture. It comes from Vietnam, out of ACIAR projects (see Figure 5) using clonal propagation. Leading eucalypt and acacia clonal propagation labs in the world are in Hanoi, with scientists trained in Australia on ACIAR scholarships, at CSIRO and Vietnamese Academy of Forest Science (VAFS) for example. By productive revegetation of formerly degraded and war-damaged lands, this is now a US$14 billion industry for Vietnam.

In Bangladesh, CIMMYT had predicted the possibility of wheat blast fungal disease spreading through seed, from Latin America to South Asia. Sure enough, it turned up in February 2016. Dr Eric Huttner (our crops program manager) had spotted the possibility very early on. ACIAR funded a workshop that got people together in July 2016, and later in 2016 I was in Mexico City with the Bangladesh Minister for Agriculture. She was completely up to speed with the risk and the need for a quick response. Being there with CIMMYT we were able to get a big screening exercise going, to find and breed resistant varieties. Luckily, there turned out to be some resistance within the breeding pipeline that CIMMYT and BARI (Bangladesh Agriculture

Research Institute) had underway. There is an excellent precision phenotyping platform in Bangladesh. They can look at 4000 lines per annum. There are several promising lines and one of those – BARI Gom33, which has the bonus of being high in zinc – was released by the end of 2017 and has been sown on 10% of the area planted to wheat in Bangladesh this year: about 30,000 hectares.

That is a really important story because it has several ingredients. If we didn't have the collaborative international architecture of research infrastructure through the CGIAR, via CIMMYT, the gene bank, and the long-term breeding programs, we wouldn't have been able to screen quickly for resistance. If we didn't have very good research collaborations in Bangladesh, with good leadership, we wouldn't have been able to get it into the field so quickly – and we also had sufficiently agile funding to be able to arrange the workshop and get the key people around the table very early on. To go from spotting a problem in 2016 to having resistant wheat on 10% of the planted area by 2022 is a terrific success, with huge implications for food security in Bangladesh.

What we have learned

We have learned along the way that long-term partnerships deliver; that they build trust and reciprocity and social capital. We have learned that while you can maintain a mature partnership over Zoom, it is very hard to develop a new one that way. You can't beat face to face contact time in the field.

Good leadership here and in our partner countries is characteristic of the best investments.

From our perspective, getting the right people around the table, including the private sector and people along the value chain, is essential. If your research is targeting policy, then make sure the policy people are in the room, getting a shared understanding of what you are trying to achieve here, and then make sure that the actual project – or the investment – you have designed is appropriate to that problem and that you understand how you are going to achieve impact. ACIAR was not set up to fund 'blue sky research' but, rather, to fund research that makes a difference on the ground. Therefore, we need to know how that is going to happen and then we need sufficient time and resources to actually do the job.

Many of our more successful longer-term investments are those that have been running for multiple phases, such as Seeds of Life for, I think, 16 years. ACIAR has a program now on peatland fire in Indonesia and I have suggested the researchers need to be thinking about it as a 20-year investment, because the idea that you could fix an issue as complex as peatland fire in a three-year project is naïve.

If you really want to make a difference in the long term, science and policy capability has to be built locally. We have fabulous collaborators across our whole portfolio in our partner countries, many of them trained in Australia, and many others trained in Japan, Russia, the US and elsewhere. Developing that collaborative capability with Australia has been fantastic.

And it is important to keep following the story, to keep going back and looking at adoption, tracking uptake, understanding impediments, evaluating impact … those are factors that definitely help inform future investment.

Why invest in innovation?

To my mind, there are three reasons to invest in innovation. One is to invent new stuff and generate new knowledge. Another is to make sure that, in the words of my old mentor Prof Peter Cullen, *'at least we should be making new mistakes'*. ACIAR has been doing a lot of that. Figure 6 shows the two volumes of issue number 100 in the ACIAR Impact Assessment Series. They are a retrospective look at benefit:cost analyses.

Figure 6. Tracking and evaluating ACIAR's impact. Volume 1: Quantifying returns on investment. Volume 2: A qualitative comparative analysis.

Focusing on the quantitative, our modest investment has generated measured benefits worth at least $64 billion. This is based on looking at a sample of about 10% of the portfolio going back over those 40 years, where we had good data. Of that 10%, there's a weighted benefit-to-cost ratio – allowing for the scale, the respective size of different projects – of 42 to 1, with a median of 22 to 1 benefit-to-cost ratio. We could argue to the Departments of Finance and Treasury that our work is a pretty solid way of investing ODA (overseas development assistance) funds. This gives a big 'bang for the buck' in partner countries – and, by the way, the benefits back to Australia are also positive, even though we are investing ODA funds overseas.

The Crawford Fund's 'Doing Well By Doing Good' report, which will be out later this year, will bring some aspects of that investment to life, and ACIAR is also producing a book for a popular audience which tells some of the human and other stories of our investments over 40 years.

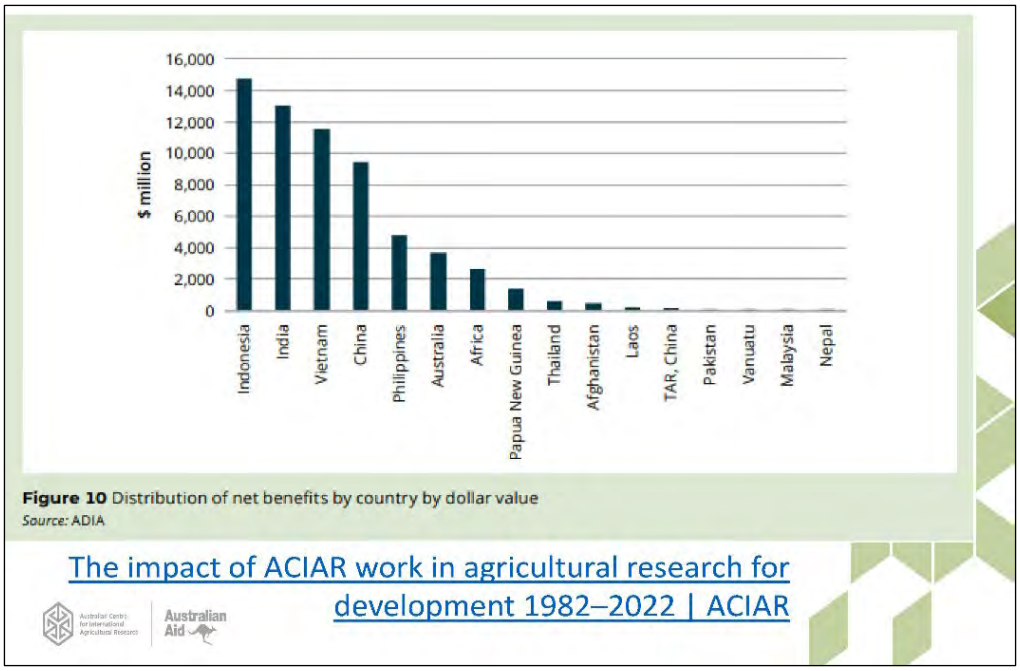

Figure 7. https://www.aciar.gov.au/publication/technical-publications/impact-assessment-100_1982-2022

Based on that 10% sample, Figure 7 shows the distribution of some of those benefits to date. The biggest benefits measured so far were in Indonesia, India, Vietnam, China, the Philippines. I would expect the shape of that chart to change as some of the programs in places like Lao and Cambodia mature. Obviously the population size is so small in the Pacific that when you plot these sorts of numbers, you need a different scale on the graph.

The current food security crisis

The world is now in another food security crisis, reflecting the three Cs: climate, COVID-19 and conflict (Figure 8). We are seeing people hungry and starving – not just in low-income countries but also in medium and high-income countries. After very promising trends of recent decades, there's certainly been a sharp uptick in severe food insecurity.

The International Food Policy Research Institute (IFPRI) in Washington is one of the CGIAR centres, and one of the top food security think-tanks in the world. Incidentally, it has long and deep connections to Australia: Sir John Crawford, Prof Ross Garnaut and Prof Kym Anderson have all chaired IFPRI over long periods, and Dr Derek Byerlee is on the board at the moment.

There is some excellent information on the IFPRI website about the current crises and solutions. Figure 9 is a slide from Dr Johan Swinnen, the Director General of IFPRI, and the link will take you to a slide deck from an extremely interesting IFPRI policy seminar. The green line is food, the blue line is fuel and the orange line is fertiliser, and the bars are GDP growth in low-income countries.

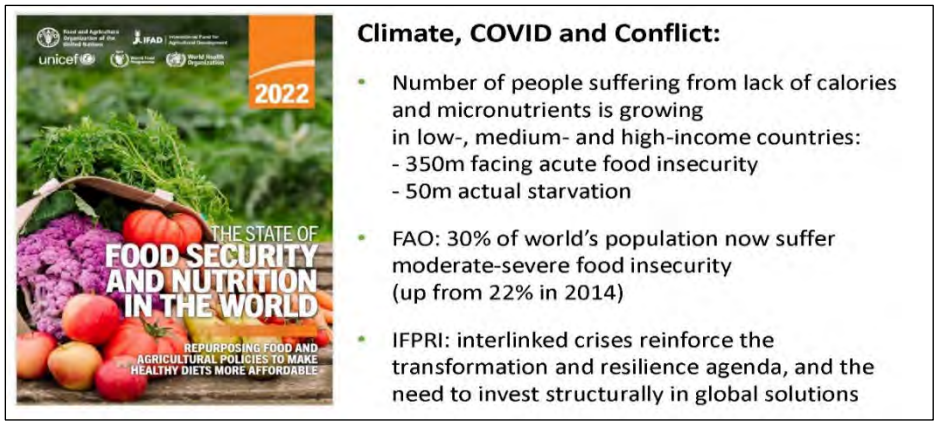

Figure 8. The current food security crisis.

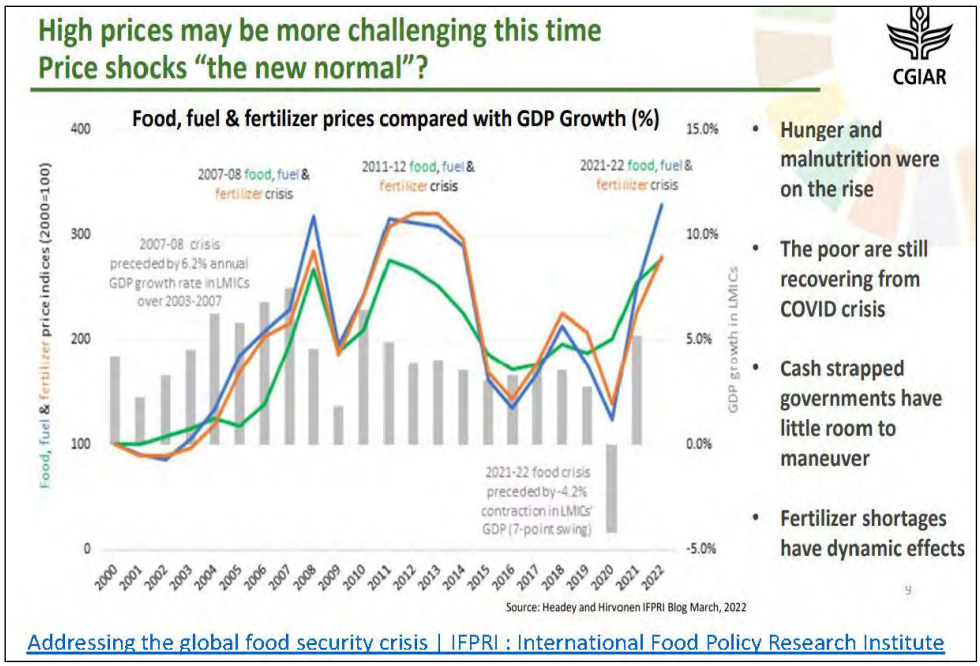

Figure 9. https://www.ifpri.org/event/addressing-food-security-crisis-caused-war-ukraine-research-and-policy-responses

A difference between the current situation and the 2007–08 food price spike is that previous food price spike came at a time when GDP had been growing by an average of 6% per year in those countries; now the spike is coming off the back of negative GDP growth. Cash-strapped governments have little or no room to manoeuvre in this current situation, compared to the 2007–08 situation, and those fertiliser shortages are having dramatic effect. In other words, this is not the same as previous crises. Yes, we were doing very well in reducing the proportion of undernourished people, but suddenly those curves have turned around (Figure 10). The links to the broader security issues are very clear, with people on the move.

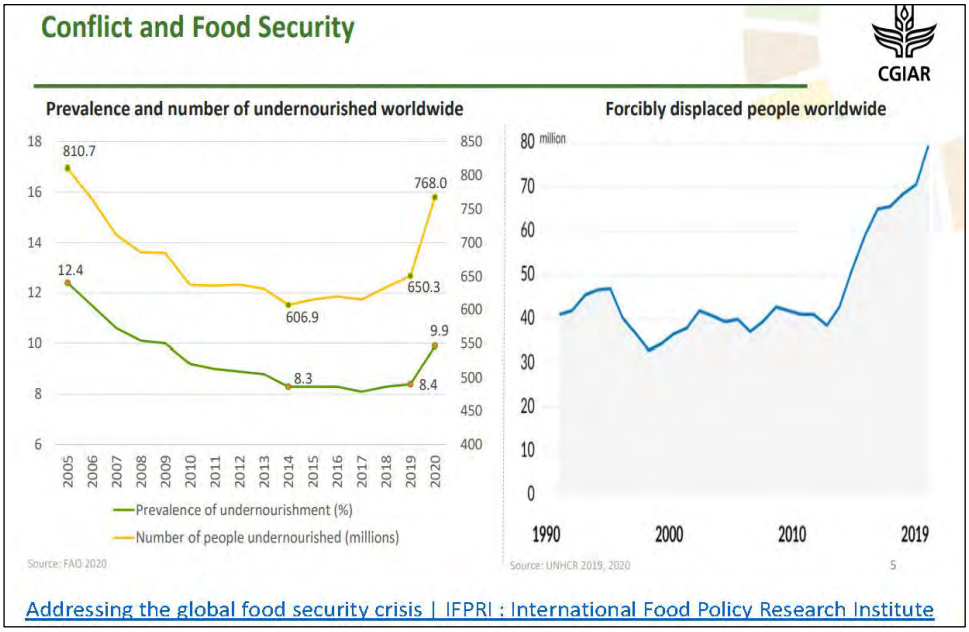

Figure 10. (Link as in Figure 9.)

Agri-food systems are connected to almost everything else. They drive a huge proportion of the Sustainable Development Goals. It is very hard to separate food security from water security, energy security, biosecurity and health security. All these feed into national, regional and global security – conflict and migration.

Noting that COVID-19 is the sixth zoonotic pandemic since 1980, the next one is likely to happen within a decade. It may be worse than COVID-19. It's about habitat fragmentation, the intersection between bush foods and wet markets, and things that spill over from animals to humans. These interactions demand a One Health approach. The world is not set up for that.

All those issues are connected with and amplified by climate change: not just the direct effects of climate change, but the decarbonisation agenda and the adaptation agenda.

The implication of that is that ACIAR cannot just keep doing what we were doing in the past. Yes, successful crop-specific agronomic research like the wheat blast disease example is still essential, but it is not sufficient to tackle these intersecting issues.

Figure 11 outlines the policy agenda, based on work by IFPRI, FAO, UNEP and UNDP, and ACIAR's own work here in the Pacific, in particular on COVID-19 impacts and responses. We need to avoid food export bans, and in particular we must stop using valuable land and water for biofuels and subsidising that.

In the medium term there is a lot of scope to reorient social protection measures, so they bolster local food production and food security. A 'no-brainer' is to target food loss and waste. Eastern Australia is struggling to complete the Murray-Darling Basin Plan, with the river system needing to reduce extraction by an extra 650 GL of water. Well, the food that is

Figure 11. Imperatives – policy agenda.

wasted in Australia represents about 2500 GL of water, which gives you an idea of the potential gains here. In the long-term policy agenda (Figure 11), the world is currently spending about US$540 billion on agricultural subsidies and generally doing it very badly. There is huge scope for redirection there, into much more productive forms of support. IFPRI estimates that 87% of those current subsidies are inefficient, inequitable, price distorting or adversely affecting human health or the environment, and that only 35 cents in the dollar actually reaches farmers.

Our agricultural innovation system needs updating. As I said earlier, all the big challenges for agriculture – climate, water, food, nutrition, energy, gender, resource competition, biosecurity, One Health, social licence – are cross-sectoral, and they have very significant public-policy and public-good dimensions. But the way we are organised – such as in R&D corporations in Australia or as CGIAR centres, as well as much of Australia's research and government agencies and policies – is commodity-focused, production-focused, farm-based, agri-centric. The connections across to the health system, and across to the energy system and so on, that need to be there, are missing.

When we think about an innovation architecture for the 21st century, it should look very different from the 20th century. This current food crisis will not be our last. We can't just keep responding to each event as an isolated instance. We have to think about how we bring together food, water, energy, health and climate, in our heads and in our institutions, along whole value chains and across whole regions (Figure 12). As IFPRI has done in its prognosis, we need to think not only about solving problems in the short term, but also to make sure we are aware of the long and medium terms as well, and ensure we look at those structural issues.

Figure 12. Ways forward.

Innovation system architecture for the 21st century needs better integration of research, technology development, private sector value chains, finance, extension, education and governance.

In relation to governance, at a water workshop I attended in Chiang Mai, discussing water sharing in the Mekong between the six countries involved, one of the facilitators asked delegates to define 'governance'. A provincial water utility officer spoke up and said: *'Well, in my mind, it's how society shares power, benefit and risk'*. What an elegant definition!

How does society share power, benefit and risk? We need to think about that in the way we organise our research and our policy, and those things need to come together. The CGIAR is tackling this, through the One CGIAR reform to try and develop a cohesive, coherent policy agenda across a whole group of independent and essentially commodity-based centres – an heroic reform, that still has a long way to go, but we are thoroughly engaged in it.

In our bilateral work at ACIAR we are trying to think about 'partnerships' – not as a noun but as 'partnering', as a verb: to change the nature of our partnerships from static agreements to active processes. ACIAR will be managing partnerships in a genuine 'how and why' way. The 'what' can be in a schedule to the agreement, but the agreement itself is about how we are going to work together.

To do all that, we'll need a new cadre of professionals. I hope that I am looking at a large number of them in this room! We are going to need 21st century professionals who can think in joined-up ways across these issues without losing disciplinary depth.

In responding to our mid-term review, we are looking at reallocating around 30% of our bilateral portfolio into more transformational research initiatives; trying to halve our

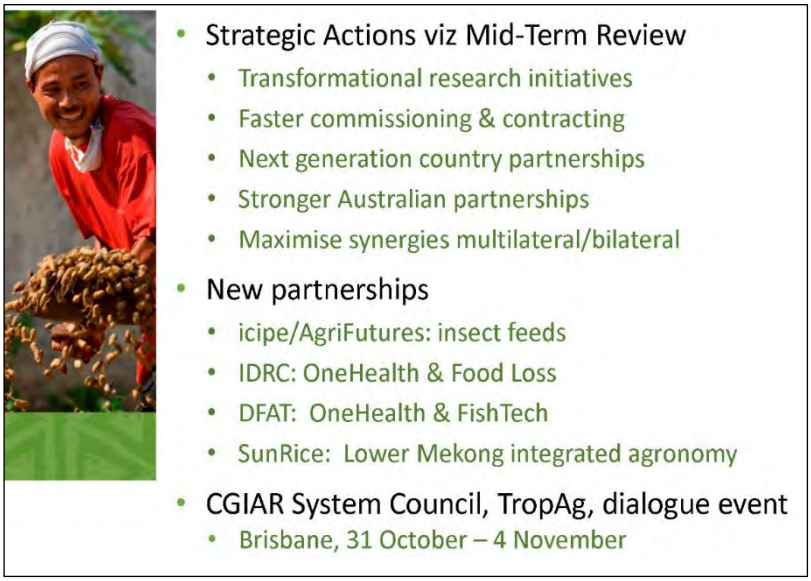

Figure 13. ACIAR strategic directions.

commissioning and contracting time; and as I've mentioned, work on the evolution of country partnerships (Figure 13).

We want to work more strategically with our good friends in DFAT, CSIRO, the Australian innovation sector, DAFF (Dept of Agriculture, Fisheries and Forestry) and the Department of Climate Change, Energy, the Environment and Water. We are trying to see how we can get synergies across our bilateral investments and our multilateral investments, in the CGIAR and more broadly. Some of these partnerships are already in place and with a lot of scope to build on, including very exciting private sector work, notably in Vietnam with SunRice, and also on pepper and coffee, with the McCormick company.

In early November, for the first time in 50 years, Australia is hosting a meeting of the CGIAR System Council, in Brisbane, back-to-back with the TropAg conference. There will be a meeting of our Commission and our Policy Advisory Council, and a food systems dialogue event running through that. It will be one of the largest face-to-face gatherings of food security research and policy experts in the world this year.

In summary, I think there is no more noble pursuit to be involved in than this work. It is a sacred trust to be investing public funds strategically to feed the world. If the younger people in the audience want to choose a career that that will give you very proud things to reflect on when you are old and grey, then I can think of few better areas to be going into.

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Andrew Campbell is the Chief Executive of the Australian Centre for International Agricultural Research (ACIAR), appointed by the Minister for Foreign Affairs in 2016, and re-appointed in 2021. At ACIAR he has overseen the development of a 10-Year Strategy 2018–27 that has consolidated the research portfolio around six high-level development objectives, overhauled capacity building with substantial investments in new programs and alumni, improved capabilities across the country office network, and transformed outreach, particularly online. Among influential roles in sustainable agriculture and research management in Australia for over thirty years, Andrew Campbell was Australia's first National Landcare Facilitator, and was CEO of Land & Water Australia for seven years from 2000. He is Patron of Landcare in Victoria, succeeding the late Joan Kirner in 2015. Professor Campbell represents Australia on the System Council of the CGIAR, and in 2021 was Chair of the Global Research Alliance on Agricultural Greenhouse Gases. He is an elected Fellow of the Australian Academy for Technology and Engineering, a Professorial Fellow at the ANU Fenner School, and a Fellow of the Australian Institute for Company Directors. He is a Councillor, ACT Division in the Institute for Public Administration Australia and a Director of the Peter Cullen Water and Environment Trust. Andrew Campbell has written widely on landcare, sustainability and the science–policy interface. He trained in forestry at the University of Melbourne, and then in agricultural knowledge systems at Wageningen University in The Netherlands. Andrew Campbell is still involved in landcare work on his farm in south-eastern Australia, where his family has been farming since the 1860s.

Science for nourishing the world, sustainably – Q&A

Chair: Dr Cate Rogers

Q: Peter Wynn, Charles Sturt University

Thanks, Andrew, for that excellent talk. You mentioned the supply of fish for protein for developing countries, but given the carbon footprint of the ruminant species – of goats, sheep, cattle, etc. – do you think the supply of meat from these species still has a place in the food basket for these developing countries too?

A: Andrew Campbell

The livestock debate and the methane debate is very frustrating, really, because often people lump all livestock farming together, though there is a very big difference between a Kansas feedlot and a smallholder with a handful of livestock that for them are as much capital as they are income. The grass-fed smallholder livestock operations in developing countries are very different from an industrialised feedlot for McDonald's somewhere in the midwest of the US, but people often conflate the two.

That said, methane is an incredibly important story and the focus on methane is not going to go away. So I think it is very good that MLA (Meat and Livestock Australia) and others have got out in front and set themselves ambitious targets.

There is some very exciting science – asparagopsis and so on: methane-reducing feeds and potential genomic tools – that can be used in the gut microbiome. There is a very important research agenda there. There is also a very important research agenda around the full life cycle in more intensive operations – a circular economy approach, where you are actually producing energy rather than consuming it, and where you are catching methane and so on.

But to 'badmouth' livestock and ruminants in smallholder agriculture in developing countries, in my view, is just completely misguided and misinformed.

Q: Faruq Isu, Pinion Advisory, a conference scholar

I am originally from Bangladesh, and my question relates to that. How difficult is it to set up a research program, particularly in developing nations, given certain policies around that? They can be quite difficult. And do we reach out or do they reach out, when there's the need or scope?

A: Andrew Campbell

For setting up new research, challenging research programs, in a developing country context, I think it is a matter of being creative in finding the right alliances within that particular context. If you know you are up against a policy barrier or an institutional barrier, it is often not very smart to try and tackle that head-on before you have established some evidence base and credibility elsewhere by working around those blockages and strategically developing alliances with relevant interest groups, industry groups and so on.

Unless your research program is completely misconceived, you should be able to envisage some beneficiaries. Try and get them around the table, and involve champions other than the scientists. To have scientists barracking for science is important, but to be super-influential politically you do better by finding those other stakeholders and forming alliances with them. And then hasten slowly. Make sure you have a story to tell before you start trying to knock on doors. Happy to talk further about that over coffee later today.

Q: Alison Bentley, CYMMIT

Andrew, you talk about the importance of resources and timescales to get the job done. How do you reconcile that with funding cycles that are becoming more fragmented and more short-term oriented?

A: Andrew Campbell

It's a very good point, Alison. One of the drivers behind the One CGIAR reform process, was a recognition among the donors that there needed to be longer-term funding cycles and more and longer-term security. But a lot of organisations that are investing aid monies or development aid monies still only have an annual budget from our own governments. It is really hard as a public servant to enter into a funding agreement that is multi-year and long-term when you are making assumptions about and beyond the forward estimates about how much money you might have.

Committing the taxpayer, our taxpayers, to things that go beyond those forward estimates is very difficult. Nevertheless, we try and give as much assurance as we can that we are not stopping funding in the near future. I know my colleagues in Germany and in Norway and in Sweden and in Canada and in the US, and elsewhere, are in the same boat.

But we are trying to come up with an architecture that gives us the confidence and gives the system the confidence to know that there will be resources available in the longer term. There will also be short-term injections. The head of USAID was in East Africa recently, and I expect that will lead to a big chunk of American investment within weeks, and maybe some of that will come into the CG system, obviously not for long-term research but to pay for things that help starving people right now. Yes, you have certainly identified a very important issue, that we need to figure out ways of giving as much funding surety as we can within the constraints of the way in which our budget works. That might be different for other donors like the Gates Foundation that is literally spending their own money, but it is very hard when you are investing public funds.

Q: Joel Fitzgibbon, The Crawford Fund

Despite spending I think nine years in the portfolio, my appreciation and understanding of the processes within ACIAR are not as advanced as most in the room, so I apologise if my question is founded in a little bit of ignorance. First and foremost, ACIAR's mission is food security, but you mentioned climate change on the way through. My question is about mitigation and, in particular, about natural resource carbon capture. I saw you had a fairly large forestry plantation project in Vietnam. To what extent do you or your advisory board factor in mitigation opportunities when you are making decisions about projects? And to what extent,

if any, are you able to leverage projects like that plantation where there must be significant carbon credit opportunities? And how do you capture those opportunities, and do you leverage that into other projects? Or indeed, does that bring down the investment hurdle in some way when you're thinking about a project?

A: Andrew Campbell

Joel, ACIAR has a climate change program. One of the big issues with the climate change program is helping our partner countries to figure out where they sit in relation to what their leaders committed to in Paris, and what that means for the LULUCF (Land Use, Land-Use Change and Forestry) and agriculture sectors.

The carbon market was aptly described by our Climate Change Research Program Manager [Dr Veronica Doerr] yesterday as the 'Wild West'. I get asked by farmers in Australia, 'Should I sell my carbon?'. And I say, 'No way! You'd be mad in the current situation. I'm certainly not selling mine. You've got "subprime carbon" all over the shop; you've got carbon grifters everywhere, … . Until we get the governance right to manage this emerging opportunity, then you're far better off just understanding your own footprint, understanding your emissions, understanding your sequestration opportunities, and implementing those that give you co-benefits – i.e. that make sense by themselves without selling carbon.'

If you are doing anything just for a carbon play, in my view you are likely to get your fingers burnt. But that said, we have projects from Fiji to Vietnam to Indonesia to help governments, firms and communities figure out where the opportunities are and where they might be able to put up a credible bid for the green climate funds, for example, that are available, in ways that deliver the co-benefits that justify the project.

I agree with Veronica. It is definitely the 'Wild West' at the moment, and we haven't got the governance right, either in Australia or overseas.

Chair

We need to stop this session now. Thank you, Andrew, for the wonderful presentation. And thank you everybody for the excellent Q&A session.

OVERVIEW

Agri-food R&D: re-examining the rewards and the risks

Professor Philip Pardey

GEMS Informatics Center
College of Food, Agricultural and Natural Resource Sciences, University of Minnesota

It is a delight to be back in Australia and to be here at the Crawford Fund annual conference, this year celebrating the 35th anniversary for the Crawford Fund and the 40th for ACIAR. My brief is to reflect on the impacts of international and national agricultural research, through the lens of a sceptical hard-nosed economist.

I am going to benchmark my remarks by looking at the evolving investment scene in food and agriculture R&D worldwide. I will show that this scene has changed dramatically over the past decades and looks very different now from how it was when the CGIAR was formed in the early 1970s. This investment benchmarking can help us understand the risks and the new headwinds that we face going forward, and reflect on those risks compared with those that prevailed when the CGIAR was formed from its antecedent agencies that came on line in the 1960s. I am really worried about what I see, having looked at these data for many years over my career, relative to what needs to be done. And I hope we can collectively galvanise a different trajectory from the one evident in the data that I am presenting today.

Global agri-food production and R&D investment trends

Before going into the R&D story, I will benchmark what the world of agricultural production looks like today relative to what it looked like when the CGIAR was formed. The good news is that we have almost increased the value of agricultural output in real terms four-fold, from

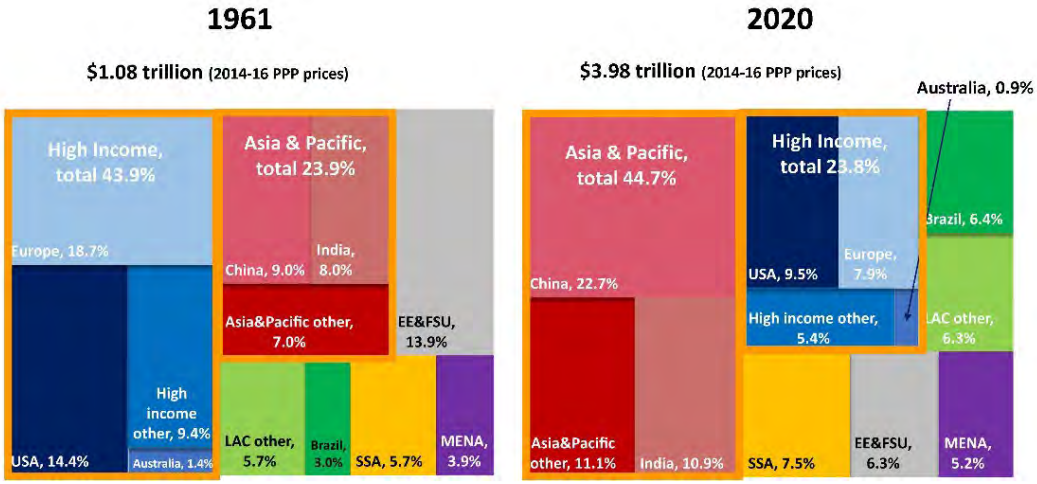


Figure 1. Where agriculture happens across the world, 1961 vs 2020. *Source*: FAO 2022.

about $1 trillion in 1961 to nearly $4 trillion today (Figure 1). That fourfold increase is a greater increase in the value of output than the increase in population; thus, the world has increased the value of agricultural production per capita globally over this period.

Now look at where in the world that production takes place (Figure 1). We have had a huge geographical shift in the location of production. Formerly, the rich countries accounted for around 44% of that total agricultural production, and today their market share has dropped below a quarter. The Asia–Pacific region is the flipside of that story. They have gone from around 24% of the total to 45% of the total. So, the geography of production – and the implications of that with respect to the impacts of markets and climate on agriculture – are now very different from how they were 60 years ago.

Australia, notwithstanding its significant increase in agricultural output, has not increased its output as fast as the rest of the world. Consequently, Australia has lost about a third of its market share over this period. If you look at other countries, such as Brazil, they have nearly doubled their market share (Figure 1). This has very significant implications in terms of the types of technologies, institutions and policy instruments that will be required to foster agricultural growth in the years ahead. …

***Editor's note**: Since this presentation at the Crawford Fund conference, Professor Pardey has been encouraged to submit a policy piece to a major international journal, reporting on and drawing lessons from his team's newly collated data in relation to 'Global agri-food production and trends in R&D investment', and 'Investment in the CGIAR'. Therefore, content related to those two sections of his talk (and Figures 2–6 and 13) are omitted from this record of his conference presentation. Pending prospective publication of that material, the full record of Professor Pardey's conference paper will then be published on the Crawford website.*

Summary of the messages of the omitted sections:

> Over the past four decades there have been unprecedented structural shifts in the geography, research orientation, and public–private performance of agri-food R&D worldwide. These kinds of large structural differences need to be reflected in innovation opportunities and institutional instruments in ways that recognise the investment needs and environments facing different countries in different regions of the world. Currently new funding is often directed to newly important issues including health, nutrition and environmental concerns, at the expense of continued funding for research aimed at sustaining productivity growth in agriculture. However, Prof Pardey considers the funding scene with respect to food and agriculture R&D is amenable to policy change. He says these R&D investment trends are not 'set in stone'; we can change these trajectories.

The remainder of the record of Professor Pardey's conference talk continues below.

Does agricultural research pay?

For this talk I was asked to present an up-to-date sense of the evidence regarding the returns of investment in agri-food R&D. For this I will draw on a recent study conducted by myself and colleagues, with funding from the Bill and Melinda Gates Foundation and under the auspices of the SOAR Foundation (Supporters of Agricultural Research, in Washington, DC, which has a mission highly aligned with that of the Crawford Fund).

For this study we were asked to tackle the question 'Does agricultural research pay?' and to also reflect on some related issues that I am often asked about. For example, questions often arise like 'Maybe we made the easy gains back in the early days of the CGIAR (or back in the mid-fifties for, say, national agricultural research) such that research is much more costly now, but the benefits haven't grown commensurately?', or 'Has the return on investment declined over time?', implying 'Perhaps agri-food R&D spending in general is not as good an investment now, or perhaps investment in the CGIAR no longer provides as good a payoff as investments made during its founding years?', or finally 'How do the R&D investment trends I just described square with the economic evidence about the impact of these investments?'.

To undertake our study and address these questions, we conducted a hard-nosed data-driven assessment of the published evidence over the past 50+ years regarding the economic returns to investments in research performed by the CGIAR (and national agencies).

- A hard-nosed, data-driven assessment of the past payoffs to CGIAR research investments
- To do so we
  - Compiled all available ROI evidence for National (and CGIAR-related) R&D
    - 430 (115) published studies, 2,600 (363) ROI estimates , spanning 1958-2015
  - Standardized ROIs into comparable benefit-cost ratio (BCR) estimates
  - Conducted a formal meta review of the ROIs
  - Benchmarked that ROI evidence against other relevant information
    - Identified 9 studies of CG-related R&D with payoffs in excess of one billion
    - Assessed value of TFP growth attributable to R&D for 1961–2020.

Figure 7. What we did.

Figure 7 summarises what we did. Specifically, we compiled evidence from hundreds of studies, including those published in journals, books and elsewhere, that reported estimates of the return-on-investment (ROI) to research conducted by the CGIAR and national research systems, and then standardised the different types of ROI estimates into comparable benefit–cost ratios (BCR) estimates. We then undertook a formal meta-review of the evidence and benchmarked that ROI evidence against other information related to the payoffs to research,

including an assessment of the plausible share of the growth in agricultural TFP (total factor productivity – that is, the ratio of aggregate agricultural outputs to inputs) attributable to the associated R&D spending.

Figure 8 summarises what we found. It includes a graph of the counts of the standardised returns to research (i.e. benefit–cost ratios) evidence related to CGIAR research, ranging from low benefit–cost ratios on the left to high benefit–cost ratios on the right. Many of the studies reported BCRs in the 2–7 range, indicative of a payback of $2–$7 (in present value terms) for every dollar invested in research conducted by the CGIAR (often in partnership with research conducted by national agencies). Notably there are a number of estimates at the high end of the distribution, indicative of research with very large payoffs (more than $47 of benefits for every dollar of spending). That is just the nature of R&D. It is a risky endeavour so that some research yields modest to no returns and some research pays off 'big time'. The pertinent question is, overall, is the investment in a portfolio of R&D such that the investment overall yields sufficient return to justify that investment?

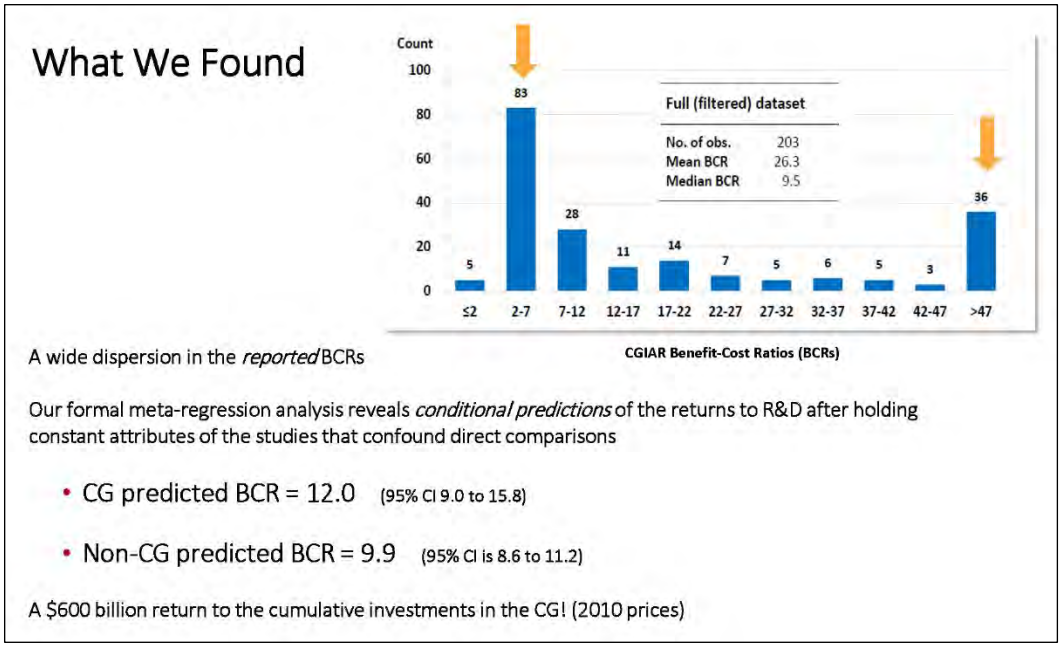


Figure 8. What we found

One way to summarise the ROI evidence is to take the mean (or better still in this instance the median) of the distribution as an indication of the payoffs on balance (i.e. averaging across the low and high payoff research). However, the studies from which these ROI estimates were drawn differ markedly in terms of the types of research being evaluated, when and where and by whom that research was undertaken, and, critically, the technical evaluation details as to how each of the studies was carried out. To improve the comparability of the studies we used regression procedures to undertake a formal meta-evaluation of the evidence from which we produced conditional predictions of the BCRs that hold constant all the potentially confounding factors that would mean one study is not directly comparable to another.

The good news is that, despite being sceptical economists, we got an incredibly robust result from our meta-analysis. Specifically, after due allowance for the confidence intervals (CI) around the conditional point estimates of the BCR on average, we found that investments in both CGIAR and in national research agencies are returning about ten dollars for every dollar of investment. That is a very big return. It indicates that the CGIAR, overall, returned globally $600 billion of economic value back to society from the $6 billion in cumulative investments made in the system over the past decades. That's a really big number from one institutional organisation, which constitutes a fairly small share of the world's total R&D expenditure on food and agriculture.

Figure 9 highlights some other important nuances that arose from our analysis. For most if not all agriculture R&D there are long lags, often multiple years or decades, before the returns to the investment in the research are fully realised. Thus, reaping the full potential from agricultural research requires very far-sighted and sustained investment. As I mentioned, these BCRs are especially high. In fact, investments in food and agriculture R&D appear to be more profitable to society than many other areas of government spending. Also, importantly, there is a natural built-in equity bias with respect to investments in food and agriculture R&D. Low-income people spend a much higher proportion of their income on food consumption – 60% or 70% – as compared with high-income people who spend about 10 to 15%. So, the equitable impact of investments in agricultural R&D that tend to lower the price of food pivots towards low-income people, who benefit more than richer people particularly when the R&D work is focused on food staples.

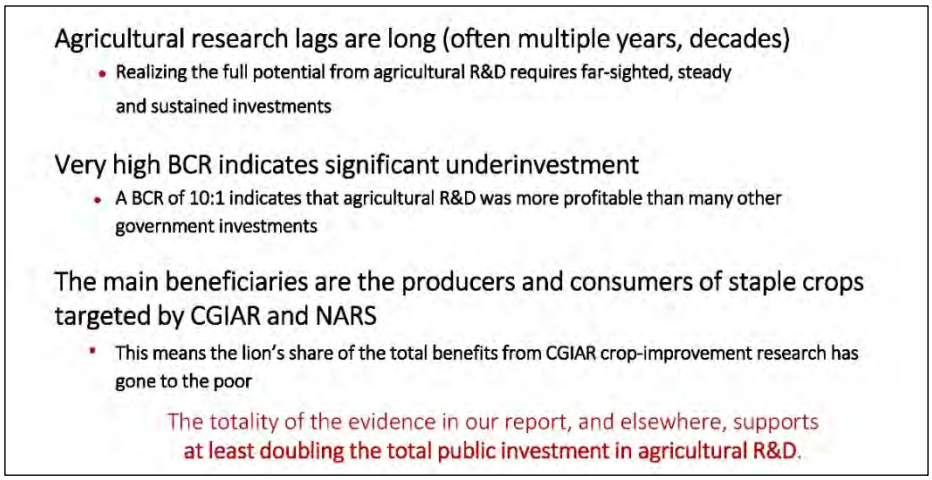


Figure 9. Aspects of the findings.

Our conclusion, from looking across the totality of evidence, including our own work and that of others, is that the economic evidence justifies at least a doubling of the total investment in food and agriculture R&D. From an economist's perspective, a benefit–cost ratio of 10 to 1 indicates that you have grossly under-invested. The optimal benefit–cost ratio is 1:1 – which means that the last (marginal) dollar you invest gives back a return of the margin of a dollar. So ideally you keep investing in R&D up to the point where the marginal benefit equals the

marginal cost. That is a core principle of economics. And when you are producing a lot of benefits relative to a smaller total cost, in principle you need to keep investing into that space until you drive that return down. Therefore, the hard economic evidence, let alone all the equity and other impacts arising from research conducted by the CGIAR and national research agencies, points to a substantial underinvestment in agri-food R&D.

Some new insights on crop production

The impacts of investment in agricultural R&D are multifaceted. I'd like to briefly step back from the ROI evidence a little to highlight some new insights from some new research. Hopefully the insights that are arising from some of the current work we are doing may help you to see the agricultural world (and the importance of R&D) in a different way than in the past. Some of this research is in a publication pipeline; some is still a work in progress.

One strand of research is seeking to understand in much more depth the *long-run* processes and implications of the genetic gain in crop development, focusing first on wheat production in the US because this is where we have been able to compile very long-run data (Figure 10).

	1919	2019
Top 5 varieties (area)	88.1%	24.3%
New varieties (<5 yrs)	1.3%	35.9%
Average age (yrs)	36.4	9.3
Varieties /million acres	0.83	9.2

Consequences of Scientific Selection

Increased

- Spatio-temporal varietal diversity
- Yields
- Output
- Crop resilience

Reduced

- Cropped area

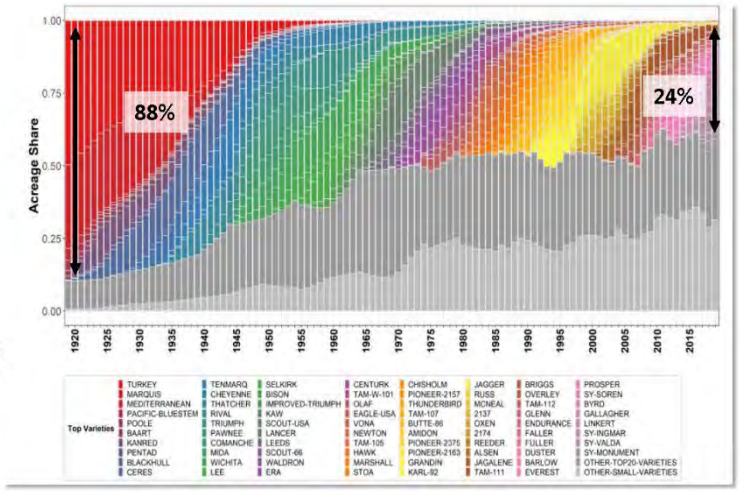


Figure 10. Genetic gain in US wheat, 1918–2019.

The graph shows changes in the farmed area share of each wheat variety year by year from 1918 to 2019. The coloured parts of the graph indicate the respective area shares of the top five varieties, from then (being 1918) to now (being 2019). A century ago, just five varieties accounted for 88% of the entire wheat production in the US, while now the area share of top five varieties has shrunk to just 24%. The darker grey area plus the coloured area indicate the area shares of the top 20 varieties, and the lighter grey area shows the area shares of the minor varieties. The shifting spectrum of these colours reveals the waves of new varieties

sweeping across the cropped landscape over time: indicative of a persistent wave of innovation within the wheat sector over the past century. The number of new varieties (i.e. varieties less than 5 years old) that farmers sow in their fields has increased from barely 1% of total wheat acreage to 35% over the century. In addition, the average age of those varieties has dropped. And, importantly, there is increasing pattern of environmental niche-filling evident in these data – that is, a better matching of varieties to the spatial variation in local agro-ecologies, as evident by the increasing number of varieties per million acres. This has had all sorts of beneficial consequences. In the US there has been a 3.5 increase in yield associated with a doubling of output despite a major decline in the acreage sown to wheat. Having a much richer mosaic of varieties on the landscape, and changing them often, means there is a lot more resilience built into that system as it confronts new shocks from changes in climate, pest and disease pressures, and things of that nature.

We have also been thinking about the multi-peril risks faced by wheat (and other crop) producers. Crop breeders and farmers know they are facing not just one pest at a time; rather they must contend with a whole portfolio of pests. We have been developing a capability to spatially assess the (changing) strategic pest risk exposure of wheat, maize and other crop producers worldwide.

Just as there have been big geographical regional shifts *between* countries in the location of production over the past 60 years (see Figure 1), there have also been similar shifts *within* countries. Figures 11 and 12 draw together our on-going work regarding the movement of crops within countries and spatial differences in multiperil pest risk exposure, in this instance for maize producers in Brazil and the US. The darker reddish colours are indicative of locations exposed to more pest risk. The green shading indicates the location of maize production in 1920 for Figure 11, and 2015 and 2007 in Figure 12. We can estimate the geographical centre of production of maize in Brazil and the US, and we find it has moved considerably within

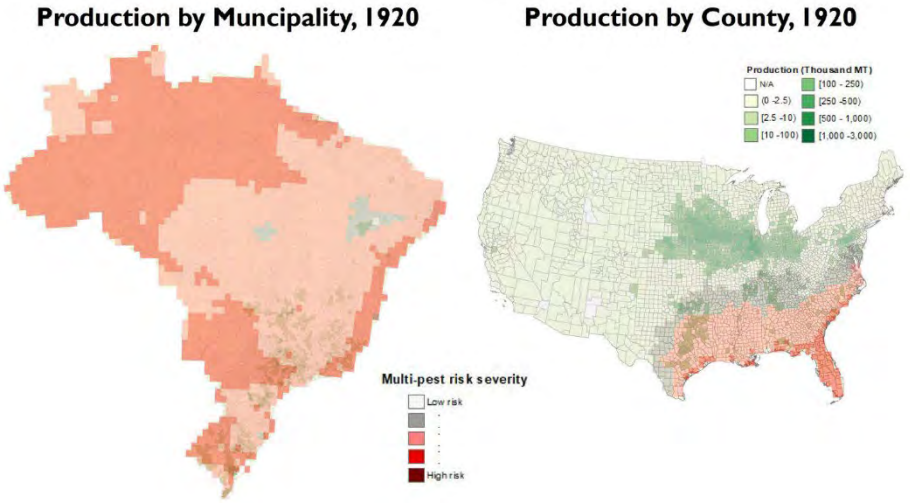


Figure 11. Maize pest geography

those countries over the past century: roughly 400 km in a north-westerly direction for Brazil and around 200 km in the same geographical direction for the US.

This is amazing. Although maize production in both countries has moved in the same geographical direction, it has moved in exactly the opposite agro-ecological directions. In Brazil, maize growing is moving close to the equator and in the US it is moving further away from the equator. Moreover, we have overlaid these maps with long-run climate data (Figure 12), and we find that the average corn plant in Brazil is now grown in a climatology that is 2.4 degrees centigrade warmer, while in the US it is now grown in areas that are over 1 degree centigrade colder compared with the location of production in the early 20th century. In addition, we find that maize production in Brazil is now located in a much riskier climate and pest-risk environment than maize production in the US. Once you start moving the location of production, for market or other reasons, you have fundamental and possibly profound changes in the production risk implications facing agriculture. These are among the risks that lie ahead and are yet to be addressed.

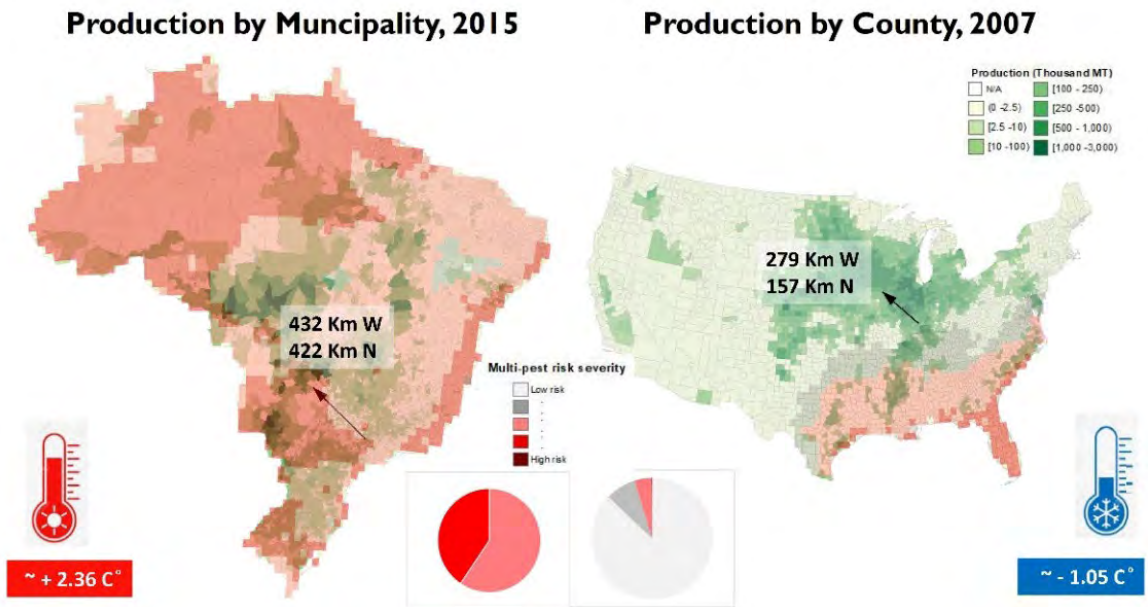


Figure 12. Maize movement and pest risk

If the current under-investment trends in agri-food research continue, we can expect further slowdowns and possible reductions in sectoral productivity growth in the future. That can have implications for the national competitiveness of those countries who fail to make the necessary investments in R&D, without which agricultural productivity growth is in peril.

Notably, the payoffs to investments in agri-food research are high, and, importantly, they show no signs of diminishing over time. From my vantage point, the multitude of risks facing the world's agri-food sector now and looking forward is larger than it was when the CGIAR and

its antecedents were founded in the 1960s and 1970s. That might be an arguable proposition, but it is my considered judgement.

That said, the worrying thing is that instead of doubling investments in agri-food R&D, we see that many of the trends are heading in the wrong direction.

Investments in food and agricultural R&D are still 'slow magic'; it takes considerable time to reap the full rewards from those investments, but the overall payoffs are large. The generally worrisome investment trends revealed in this talk, coupled with the payoff evidence I presented, calls for a revitalisation in the amount of investment and a rethinking about the cross-country and public–private innovation opportunities, both within and outside the agri-food sector required to spur sustainable productivity growth in the sector going forward.

Philip Pardey has been at the University of Minnesota since 2002. He is a Professor of Science and Technology Policy, in the Department of Applied Economics, and Director of Global Research Initiatives for the College of Food, Agricultural and Natural Resource Sciences (CFANS). He also directs the University's GEMS Informatics Center. GEMS brings together CFANS and the Minnesota Supercomputing Institute to develop and deploy computational systems that address complex problems to unlock innovation in the agri-food sector. Previously he was a senior research fellow at IFPRI (International Food Policy Research Institute), Washington, D.C., and ISNAR (International Service for National Agricultural Research), The Hague, Netherlands. Philip's career has focused on informing and enabling data-driven innovation and sustainable productivity growth in the food and agricultural sectors worldwide. He has authored more than 400 books, articles, and papers. He is a Fellow of the American Association for the Advancement of Science (AAAS) and of the Agricultural and Applied Economics Association, Distinguished Fellow and Past President of the Australasian Agricultural and Resource Economics Society, Distinguished Life Member of the International Association of Agricultural Economists, and winner of the Siehl Prize for Excellence in Agriculture.

PANEL

Agri-food R&D – re-examining the rewards and the risks

Dr Ravi Khetarpal[1], Dr Madaline Healey[2],
Ms Regina Bi Nukundj[3], Professor Philip Pardey[4]

Chair: Dr Sandro Demaio

1 Asia Pacific Association of Agricultural Research Institutions
2 University of the Sunshine Coast
3 Department of Agriculture and Livestock, Papua New Guinea
4 University of Minnesota

Q: Chair

In his paper just now, Philip Pardey has outlined some fairly strong returns, together with flatlining investment and confounding risks.

Dr Khetarpal, coming to you first. What is the 'magic sauce'? What elements in agricultural research do you think are critical to the success of high impact projects that you have seen?

A: Ravi Khetarpal

Good morning, everyone.
The factors which are leading to, or led to, the success of the collaborative projects in the Asia–Pacific region as we observed, are, firstly, the quality of collaboration with partners. Secondly, it is the ownership taken by the beneficiary countries. If we have ownership from day one, I think we have an easy go, and half the job is done.

The quality of collaboration – with the partners with whom we implement – matters. We are not the implementing agency; we are an association; we get others to implement. One example is an ACIAR project, which was funded by ACIAR and implemented by IFPRI, Washington. There it was the quality of the partnership, with how we collect the data, analyse the data, clean the data, and how to project it for future research investments. We incorporate it locally in South-East Asian countries. That played a very important role. So, the engagement of the partners and the technical implementation with us become very crucial, apart from the ownership by the country.

Another point which is becoming very important now is how we see the policy institutionalisation of the outputs of the project, if there is something related to policy. Or how we look at the scaling-up of what is a research output. We normally build capacity of individuals, but we fail at times in building capacity to scale-up. Capacity and scaling-up are entirely different domains, and most of the donor agencies only build individual capacity and that's all. So that is where many good projects stumble. If you have a capacity to scale-up also inbuilt in the whole funding process, that makes a winner.

Q: Chair

Thank you. So, partnership, and capacity to scale.
Dr Healey, Ravi's answer must really resonate with you. You have had experience as a volunteer and a trainer and now as a mentor. Can you tell us about impacts that you have seen and from your own involvement in some of these projects across the region?

A: Madaline Healey

Being a volunteer, a mentor and a trainer really speaks to the Crawford Fund's crop health capacity-building program. So that's exactly what I'm going to talk about here.

Across yesterday's RAID event and also this morning, we keep hearing about partnerships, collaboration, trust and communication.

In the Crawford Fund's program, trainers and mentors are all volunteers, and the impact of that is that everybody's very 'invested': everybody's there because they want success. They want to build up the capacity of young early career researchers here in Australia and also overseas. And that's where the collaboration comes together.

Volunteers go overseas; they work with local colleagues in Lao – where the program is mostly working – and they train other agricultural officers, other forestry officers, weed scientists, … . They engage and work with farmers as well. They say: 'What do you need and what can we do?'. And the program has so much success and so much impact because it's got this succession of volunteers and mentors and trainers coming in. We have people on the ground daily, weekly, having wins every month, having wins every year. And there's the support of these amazing and incredible people like Professor Deirdre Lemerle, who's in the room here, and Professor Lester Burgess.

There was talk yesterday [at the RAID event] about capacity-building and leaving legacies. And that's what the Crawford Fund's program is. It's a legacy. It's leaving a legacy for impact on the ground in helping with production; impact in terms of institutional training and scaling-out, slowly, in rural areas in Lao.

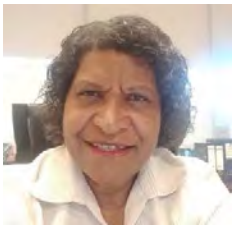
There is also the long-term impact, because you're working with unqualified people like myself who stumble into a volunteer position and then get to keep on going, and training, and developing research, and supporting people collaboratively. Because we're talking with everybody on the ground and saying, 'Hey, what do you need? What can we do to help? And how can we do it together?'.

And so that's really what the impact of the program is.

Q: Chair

Thank you.
Ms Bi Nukundj, I want to ask you a question about the translation of research and development into policy, because that's been an area that you've led in, and done some incredible work in PNG and through the FAO.

What do you see as the major opportunities or ingredients we need to have if we want to translate research into policy outcomes?



A: Regina Bi Nukundj

That's a great question. In a beneficiary country we have policies that guide us in whatever we do, and we have policy directives and national goals and development plans that cascade down from the global Sustainable Development Goals. And in whatever we do, we must translate to achieving those plans and targets.

In my experience, we have a lot of funding and money poured into doing research. The research projects' outcomes, the objectives of the research, are very good and the collaboration is very good. But to translate these research outcomes into information that can feed into evidence-based policy decisions or decision-making, there is a connectivity gap. From my observation, the connection is not there.

I would like to take this opportunity at this forum to say that it would be good to have policy officers being able to contribute during the design phase of the research programs, so that the research programs are also able to consider the policies in the beneficiary country, the sectoral and national overarching plans guiding the development in that country. So that the research is not done just as research and to obtain very good results, or just so it helps the research fellows in capacity-building for individual researchers in the country, but rather so that the research funding institution leaves behind a legacy.

Then the people, the government, from policy makers and decision makers, all the way through to stakeholders, the private sector and the farming communities that benefit will appreciate the money and support that is put into research. The beneficiary country will appreciate the researchers from Australia going in to work in collaboration, jointly working together with researchers in the country.

This suggestion is proposed to have that factored into the research design, so that at the end of the life of the projects we can have seminars, or a forum, where all the Australian Government funded projects can present their findings, their research outcomes and the impacts. This will be a forum where all stakeholders, from government officials to private sector, to farming community and development partners, can gather to share their research outcomes and gain from that work. The information shared can be used in developing policies and making decisions for the country.

Q: Chair

Thank you.
One more quick question to you, Dr Pardey. You mentioned that the last time we saw a significant increase in CGIAR contributions was during the 2008 food crisis. The world faces another food crisis with Ukraine at the moment. How do we galvanise that as an opportunity to increase funding for global agricultural research and make a small silver lining out of what is a significant threat and challenge to so many millions across the planet?

A: Philip Pardey

That is a tough one to answer. I think that the incentives are to throw some money at this problem really quickly, and move on. However, what might be more prudent is to couple increased investment with considered thinking (and action) to adjust the structures by which (international) agri-food research is financed.

A few years ago, colleagues and I wrote a piece on the changing (funding) fortunes of the CGIAR*, in which we speculated how different, perhaps, the trajectory of investments in the CGIAR might be if they were being funded by organisations like the National Science Foundation and the counterpart institutions here in Australia. And that maybe there is scope for opening up opportunities and dialogue with agencies *beyond* the economic development agencies – and even routing (some of) that international funding by way of domestic agricultural (research) agencies.

At the moment, in the US and here in Australia, the primary public-sector funding base for international research is coming out of foreign aid budgets, which tend to be rather volatile. Thus, there may be an institutional-design mismatch between the sources of funding and the strategies that are required to sustain this type of investment over the long term.

I think the other opportunity – one that we are actively exploring at the University of Minnesota – is to think much more creatively about public–private partnerships. The Twin Cities [Minneapolis and Saint Paul] probably has the largest cluster of Fortune 500 companies in food and agriculture 'in our backyard'. We have behemoths like Cargill, with $160 billion turnover or something like that, and General Mills, and Hormel, and Land O'Lakes, and others.

It's not easy but we are working on how to strategically engage with them, beyond just picking their pockets for sources of funding, and seeking to use data-driven strategies to partner with the private sector as a means of amplifying and accelerating the impact of R&D. Figuring out what the shared value proposition is, so as to encourage investment into this joint public–private space that yields both public and private goods, is an area where I am personally spending a lot of time – and where we are starting to gain a bit of traction.

*Alston J.M., Dehmer S., Pardey P.G. 2006. International initiatives in agricultural R&D: the changing fortunes of the CGIAR. Chapter 12 in P.G. Pardey, J.M. Alston and R.R. Piggott, eds, *Agricultural R&D in the Developing World: Too Little, Too Late?* Washington D.C.: International Food Policy Research Institute.

Chair

Thank you. I am sorry to rush our speakers and our panellists this morning. We did start late. Please give a big round of applause again for Dr Pardey, Dr Khertarpal, Dr Healey and Ms Bi Nukundj.

Dr Ravi Khetarpal is the Executive Secretary of Asia Pacific Association of Agricultural Research Institutions (APAARI) which has more than 80 members from the region. He facilitates and promotes networking, capacity-building, knowledge management, policy

issues and partnerships in the region, and also coordinates the development and implementation of global and regional projects on agriculture innovation systems, phytosanitary compliances, promotion of biopesticides, agribiotechnology and bioresources, agriculture science technology indicators and public private partnerships. He has served ICAR, India and CABI (South Asia) as Regional Director in the past. He was also a consultant for twelve FAO/World Bank/USDA Projects in Asian countries on biosecurity and compliances to SPS Agreement of the WTO and represented Asia as Developing Country Expert in SPS working Group of STDF/WTO. He recently chaired (2020–2022) the Tropical Agricultural Platform, a G-20 initiative of FAO, and is now chairing (2021–2024) the Global Forum of Agricultural Research and Innovation with the secretariat at FAO. He holds a PhD in Life Sciences (Plant Pathology) from University of Paris.

Dr Healey is a member of the RAID network, a Crawford Fund mentor in Laos and a former conference scholar. She studied a Bachelor of Agricultural Science before stepping into a PhD and then landing in Laos as a volunteer entomologist in the Crawford Fund program. Madaline works at the University of the Sunshine Coast on ACIAR projects in the Mekong countries focusing on integrated pest management, biological control and forest biosecurity. Her interests are trees, veggies and all things bug like. A short video on Madaline's time in Laos as a volunteer and then a mentor in our biosecurity work is here.

Regina Bi Nukundj is Chief Livestock Officer under the Food Security Branch at the Department of Agriculture and Livestock in Papua New Guinea. She holds a Master of Science Degree in Animal Production from James Cook University, Australia. She has worked for the Department of Agriculture and Livestock for 28 years now, being recruited straight into the department after graduating with Bachelor of Science Degree in Agriculture from University of Technology, Lae, Papua New Guinea. She has also worked in livestock production under food security and is now focusing her efforts as a policy planner in the sector and has served in various capacities in the department as Livestock extension officer from 1994 to 2006 before being transferred into HQ as Chief Livestock Development Officer from 2007 to 2018. Regina has acted as the focal point for PNG FAO and has been appointed as National Coordinator of various FAO Technical Corporation Projects under the food security programme from 2016 to 2019. She was appointed as Deputy Coordinator of PNG APEC Agriculture Coordination Team in 2017 preparing for hosting the 2018 APEC, and successfully hosted 11 sets of Food Security and Agriculture related meetings. During the PNG APEC host year, she initiated discussions on Promoting Women in Agriculture and Fisheries in APEC where it's been accepted as an important agenda in the following APEC meetings in 2019 (Chile) and 2020 (Malaysia). She coordinated an APEC project in 2019 to promote active participation of Women in APEC in Agriculture and Fisheries sectors, contributing to improve economic capabilities and improve food security. She has reviewed agriculture research projects, for ACIAR, of research conducted in PNG, and from June 2019 to April 2020 she was appointed as DAL's Acting Deputy Secretary of Policy and Planning, and coordinated the formulation of the National Agriculture Medium Term Development Plan 2020–2022, which was approved by the National Executive Council and launched by the Prime Minister and Minister of Agriculture.

Philip Pardey has been at the University of Minnesota since 2002. He is a Professor of Science and Technology Policy, in the Department of Applied Economics, and Director of Global Research Initiatives for the College of Food, Agricultural and Natural Resource Sciences (CFANS). He also directs the University's GEMS Informatics Center. GEMS brings together CFANS and the Minnesota Supercomputing Institute to develop and deploy computational systems that address complex problems to unlock innovation in the agri-food sector. Previously he was a senior research fellow at IFPRI (International Food Policy Research Institute), Washington, D.C., and ISNAR (International Service for National Agricultural Research), The Hague, Netherlands. Philip's career has focused on informing and enabling data-driven innovation and sustainable productivity growth in the food and agricultural sectors worldwide. He has authored more than 400 books, articles, and papers. He is a Fellow of the American Association for the Advancement of Science (AAAS) and of the Agricultural and Applied Economics Association, Distinguished Fellow and Past President of the Australasian Agricultural and Resource Economics Society, Distinguished Life Member of the International Association of Agricultural Economists, and winner of the Siehl Prize for Excellence in Agriculture.

OVERVIEW

Nexus gains to the environment and sustainability

Dr Jean Balié

CGIAR – Southeast Asia and the Pacific; and
International Rice Research Institute (IRRI)

Thank you for giving me the opportunity to be here with you today, representing the CGIAR and IRRI, and celebrating the 35th anniversary of the Crawford Fund and the 40th anniversary of ACIAR. It is an important milestone for us, given the very strong partnerships that CGIAR has with both the Crawford Fund and ACIAR, and we hope that this will continue into future years and decades.

This presentation will tell the story of what the CGIAR has been trying to achieve in previous decades – we have already heard a little of that today – and what we certainly need to continue doing for the future in transforming food systems and improving lives. I was asked to focus on the impact that the CGIAR has on natural resources and environmental issues and sustainability – that is, economic, social and environmental sustainability, of course. This is a very broad issue, and difficult to tackle entirely in 20 minutes. I will only be able to provide a few of the best examples of what we have been doing. I would invite you to look at more of the evidence that the CGIAR has provided over time that is available on our website to really understand what Professor Pardey was saying before, and the profound impacts that the CGIAR is really having. I was also asked to shed light very briefly on what is ahead of us, in terms of challenge, and to talk about what I call a necessary paradigm shift.

I think it is useful to start with the diagnostic and recall very briefly – with a specific focus on the Asia–Pacific region – the current challenges that our food systems face in the region. This is very well known to this audience, but it's worth recalling that these drivers are already affecting us through our food, our health, environmental resiliency, economic growth and other ways that are basically the result of a social–political construct. We need to realise that these challenges are, for the most part, anthropogenic. They are the result of the way we have been conducting our agricultural and rural affairs.

For many years we have grappled with different challenges that directly affected the way we feed the world (Figure 1). There are climate change effects that, if anything, are manifesting earlier than foreseen or anticipated, and Australia and many countries can confirm that. Biodiversity loss is putting our food system resilience at risk. There is food and nutrition insecurity and, as we have already heard, we are moving backwards in terms of both macro-nutrient deficiency and other nutritional aspects. This is certainly worrying, and it is in the context of growing inequalities and inequities, within countries and across countries.

When COVID-19 hit the world these challenges were already there, and it has exacerbated them, putting even more strain on an already fragile food system. COVID-19 has helped us fully realise that, besides being fragile, our food systems are interdependent. They are also

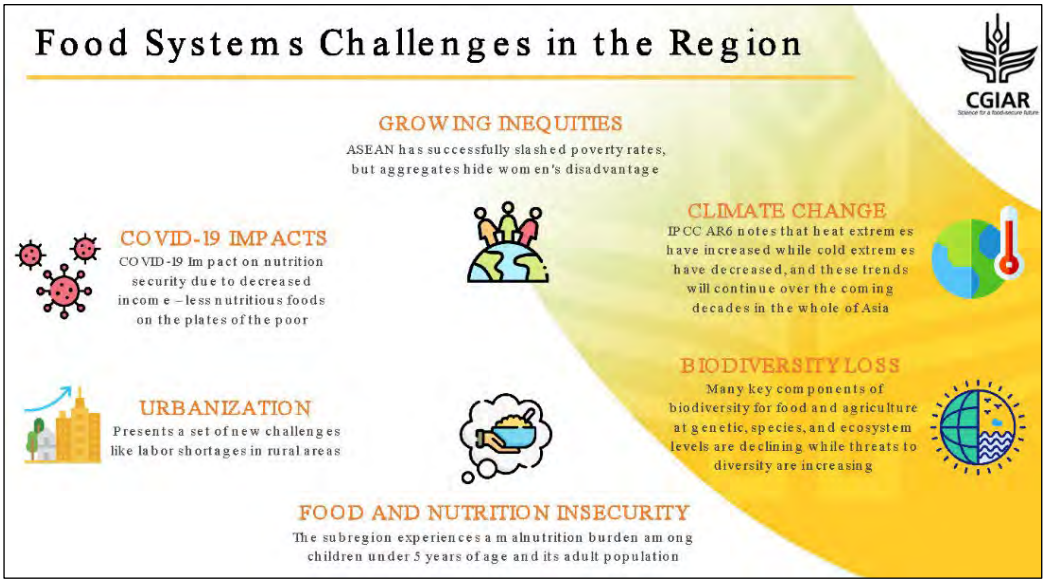


Figure 1.

dependent on outside shocks to other systems such as our health systems, and the energy sector, among others. The core of what the CGIAR is trying to do now is to understand all these intertwined mechanisms that drive the way food systems can evolve forward.

The One CGIAR is now operating with a different structure – a reformulation of the value proposition of the formerly-named CGIAR.

Our strategy is articulated around the five impact areas listed at the right-hand side of Figure 2: climate adaptation and mitigation; environmental health and biodiversity; gender

Figure 2.

equality, youth and social inclusion; poverty reduction, livelihoods and jobs; and nutrition, health and food security. These are the key challenges that we propose to address simultaneously with our programs: not all at the same level of intensity, of course, but certainly all with a primary focus on SDG Goal 2: zero hunger.

As you know and have already heard, for many years the CGIAR has been a key player in global food, land and water systems transformation research. Our reformulation emphasises that it is now time to talk about not just agriculture but also food – actually food, land and water systems transformation. That is a much more complex and more ambitious agenda.

The CGIAR is well known for its innovations – particularly technological innovations, as well as institutional innovations – that together with capacity development and policy work are the three main impact pathways through which we expect to deliver these transformative changes (Figure 3). Today's conference is an opportunity to recall that such changes are only possible if we work very closely with an array of partners, especially country partners, to make sure that we are able to scale these innovations and have long-lasting, impactful results.

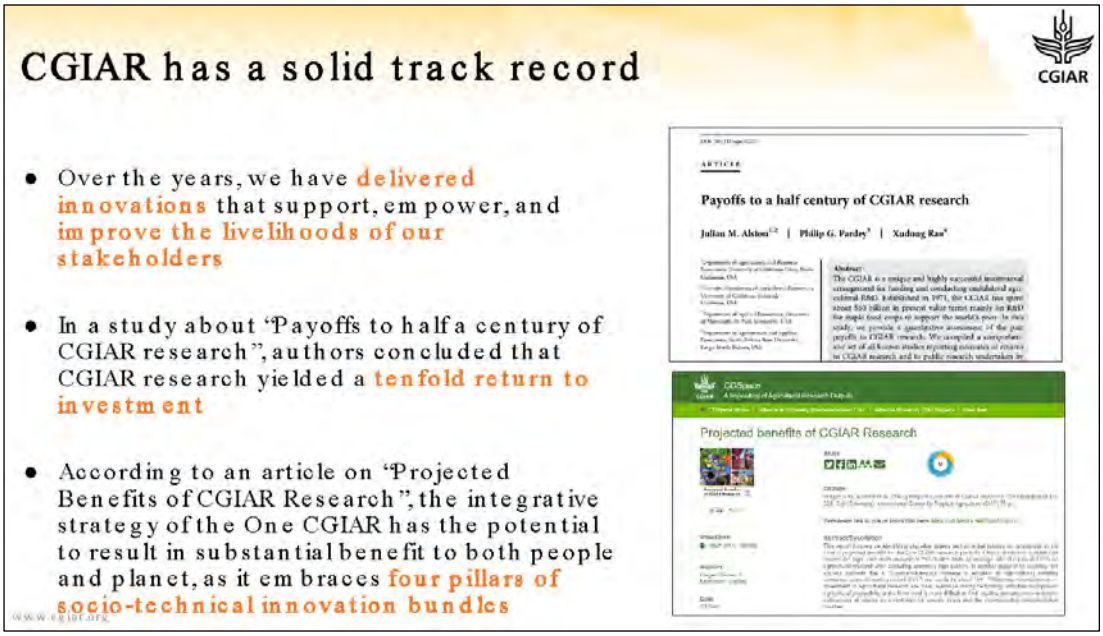


Figure 3.

Following what Professor Pardey has already told us, and the evidence provided, I would like to emphasise the pressing need for more funding for international agri-food research. I would also like to call for *better* funding, meaning we make sure that we talk not only about the *level* but also the *composition* of the financial support that is needed to further progress our international research capacity, for immediate and long-term benefits and economic, environmental and social sustainability.

We have used the study shown in Figure 3 ('Payoffs to a half century of CGIAR research', Alston, Pardey & Rao) to anchor our value proposition when we interact with funders and

countries. This helps us highlight that over the years the CGIAR has delivered innovations and more, that support, empower and improve the livelihoods of the people that we serve, and especially farmers.

We need, again, to build a case for agriculture. Still too many young people are *not* attracted to agriculture because the sector is not perceived as the way to fulfill the legitimate aspirations youth have, and that is a very difficult situation for many countries. We need to make the agriculture and food sector attractive again. That is one of the conditions for the agricultural sector to continue to be the engine of transformation and structural transformation of the various economies.

As Professor Pardey has already told us, we now have very robust evidence that the returns to investment in agriculture research are massive with a cost–benefit ratio of 1:10 or tenfold, and that evidence is certainly something that will help us grow the portfolio. We want to see that also as part of the new endeavour to develop long-term partnerships with a broader array of partners that are funding international agricultural research, and not only the top five funders that you have seen mentioned previously today.

Figure 3 also shows another study, 'Projected benefits of CGIAR research', that focuses on the effectiveness of the CGIAR's strategy. This is an example of research related to the area that I am in charge of at IRRI. These kinds of socio-technical innovations are providing bundles that are taken up by countries. For example, core CGIAR technologies such as genetic improvements and enhanced agronomic practices that are bringing additional benefits to countries; it also includes technology and systems that support these core contributions as well as additional functionality such as digital capabilities and financial instruments; we also focus on building institutions, which may benefit from capacity building and enhanced collaboration and foresight; and finally we are interested in the enabling environment for innovation uptake so that individuals and communities can derive advantages from better policy, stronger institutions, and broader inclusion.

The study found that these bundles are strategically integrated through sets of activities in the six CGIAR regions where we aim to achieve beneficial outcomes and impacts and that over time they have the potential to result in substantial benefits to both people and planet. I don't have time to elaborate on all their merits, but we certainly have this information available to all of you if you want to dig into it and learn more about the returns that investment – in genetics in particular – is actually providing in terms of public goods.

I will now give specific illustrations in relation to the five impact areas that I mentioned before. First, some examples that relate to climate adaptation and mitigation.

Our efforts and investment in terms of climate adaptation and mitigation

Over the years we have seen the growing importance of integrating climate change into everything we do. It is now more pressing than ever. This climate crisis is no longer looming. It is here, and it is already affecting the outcomes of agriculture. Food systems suffer directly and indirectly and increasingly from climate change (Figure 4). But agriculture and food systems are also among the main causes of climate change: food systems produce nearly one-

third of the world's greenhouse gas emissions. Fortunately, agriculture can also be part of the solution because it has the potential to act as a global carbon sink. This again is about investment and policy.

We need to bring together innovations, investments and policies, and make sure that this happens, and happens now. Maintaining agricultural systems and guaranteeing food and nutrition security depends on assisting the most vulnerable farmers, the ones that are unfortunately the most exposed to climate change effects. Some of the work that CGIAR has done is listed in Figure 4, just for the Asian region.

You are probably aware of the climate-smart varieties (Figure 4) that have been developed not only by IRRI, by CIMMYT and by other CGIAR centers to make sure that we have these varieties that farmers need for adapting to climate change effects including salinisation, fighting drought, and other stresses, and that we deliver them through efficient food systems. That research is related to helping farmers continue to do their business and maintain yields, which means incomes.

We also have other initiatives, and here I mention only one: the Asian Mega Deltas Initiative, which is about securing the future of some very specific areas upon which the livelihoods of farmers and communities depend (Figure 4). The Mekong Delta and also other deltas are the food baskets for many countries, and so this program, along with other programs on climate change, tries to harvest the collective knowledge we have created. And there is already knowledge and scientific evidence available to tell us what needs to be done. The next task is to mobilise investments and bring along policy makers to make sure that in, for example, Asian Mega Deltas, the 4.8 million people that are projected to benefit from these kinds of measures can finally get sustainable solutions for improving their livelihoods.

Figure 4.

Still on climate change and adaptation (Figure 5), there are vulnerable small-scale producers that need to adapt to climate change and that are also increasingly concerned about some of the effects of their own production systems.

In Vietnam, for example, we are trying to bring together solutions to address climate change at the farmer level, and at the same time mitigate it. Rice is the second most important emitter of methane after livestock. We now have practices that allow for reduction of the carbon footprint of rice fields. This is known as Alternate Wetting and Drying. It is a technology that is already available, that has been scaled in many countries. By controlling irrigation, we can significantly reduce methane emissions by an average of 48% and reduce water use by at least 30%. That's significant, and it goes together with a reduction in pumping costs, all without reducing yields. These are attractive solutions for farmers.

Another technology that illustrates the efforts we are currently putting in on climate change is what we call Direct Seeded Rice (Figure 5). This means planting rice seed into the field but avoiding the stage of transplanting. This is an innovation that can be adopted in many locations. And direct seeding can also reduce water use by 40%, and greenhouse gas emissions associated with rice cultivation, as I was saying, by at least 47%.

These are examples of the kinds of programs that we are trying to disseminate throughout Asia and also increasingly in Africa to show that we already have potential for reduction of the carbon footprint of the rice sector. In other areas, we are working closely with the livestock sector to make sure that we also provide integrated solutions there.

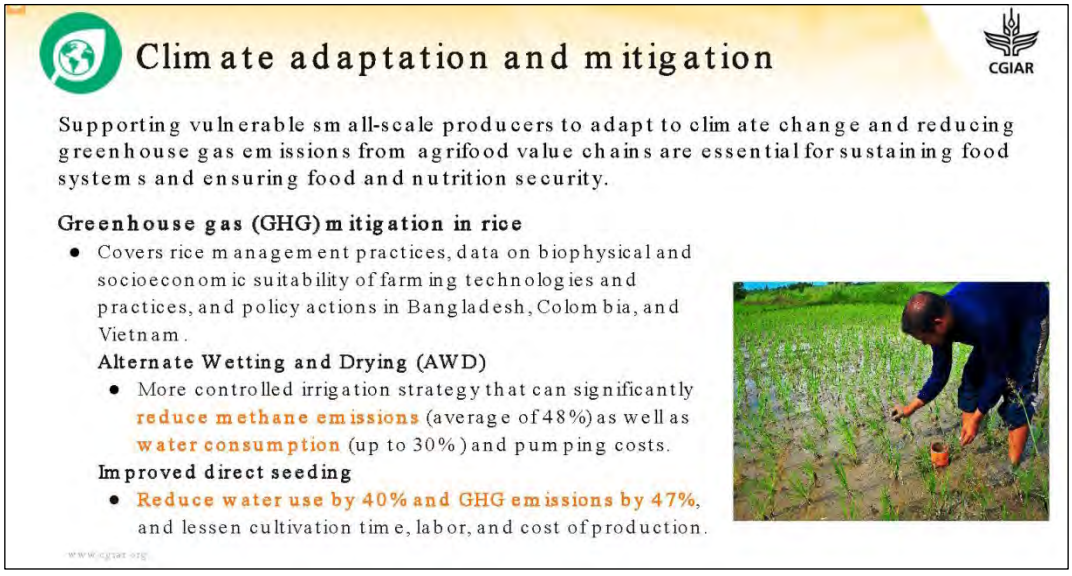


Figure 5.

Environmental health and biodiversity

Moving on to the second topic I was asked to discuss: environmental health and biodiversity. I think it is common knowledge that agriculture is the biggest driver of forest and biodiversity loss, unfortunately, and including diversity is crucial to a healthy diet and nutrition.

A third of the world's soils are degraded. Agriculture accounts for about 70% of global freshwater withdrawals (Figure 6). This certainly is not sustainable. The CGIAR has provided, and continues to provide, models to safely reuse wastewater and its nutrients, to treat and re-use septic waste and wastewater for irrigation, and create safe fertiliser pellets for crops, and briquettes that can be burned for energy. These models provide guidelines and pathways to change the way we do business and transform the current practices into more virtuous agricultural practices.

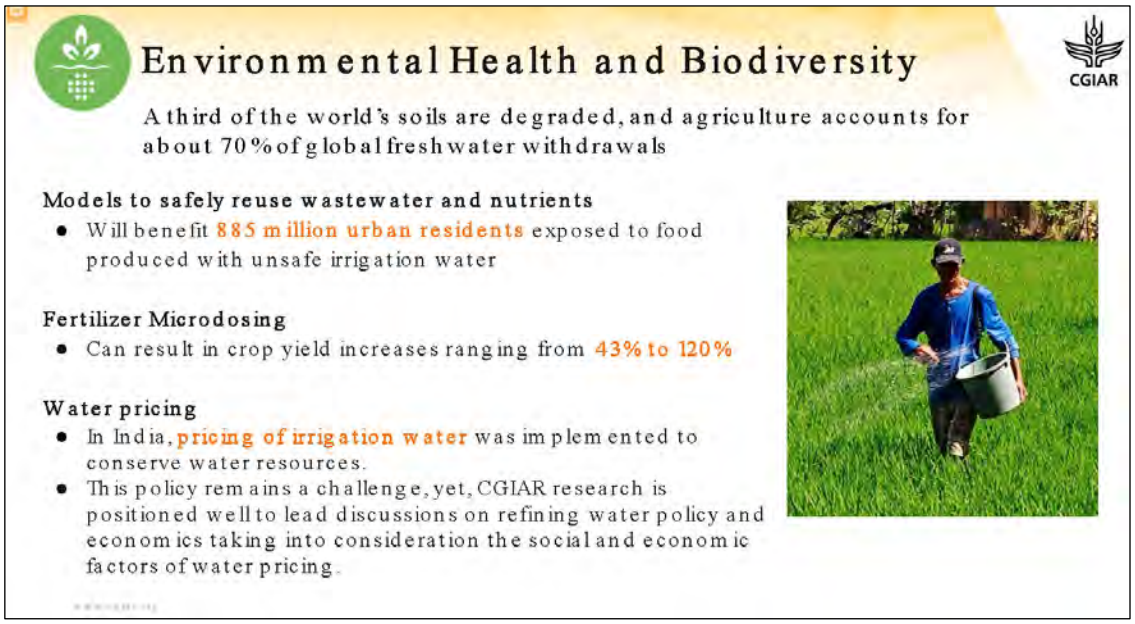


Figure 6.

Another example is fertiliser micro-dosing (Figure 6). It is about precision agriculture by which we increase fertiliser use efficiency, and reduce investment costs for farmers by a significant percentage that varies, depending on the locations, by between 15 and 40%. At the same time, crop yields increase by 43% to 120%. There are, of course, growing concerns about the depletion of water reserves, and we need to move to more efficient use of water throughout the agricultural sector.

The third point in Figure 6 is about a discussion that we have started in India about a policy on water pricing for irrigation water. Water can no longer be considered a free resource; it has to be priced. The CGIAR is starting conversations – which are often difficult and sensitive – to increase the awareness of policy-makers, trying to make sure that we gradually integrate or re-internalise the so-called negative environmental and social 'externalities' associated with water use in agriculture. Although it's very promising, it is also a challenge that we need to clearly communicate with the policy-makers.

I think this is a fundamental function of the CGIAR based on our 'vision', and we are looking forward to having these kinds of fundamental discussions.

Figure 7.

Gender equality, youth and social inclusion

In relation to Figure 7, I want to emphasise some of the points that I was making on the growing inequalities and recall that we have programs to address that, especially the gender dimension of our work. We cannot internalise one type of 'externalities' and not others. These kinds of inequities between gender and youth are part of the social aspects or market failures that we need to fully internalise in everything we do.

The Smart Valley approach is a good example that has been used in Africa and in Asia. Also very recently, the Women Producer Company initiative in Odisha, India, is bringing massive benefits to over 1200 members of these cooperatives, helping women to become entrepreneurs and agents of change. Through this project, we are making sure they can access the same level of knowledge and credits as their male counterparts, and that they are empowered to grow their businesses. This is something that we are certainly proud of.

Poverty reduction

Poverty reduction is the fourth impact area. In this audience, you are all aware of the very close correlation between poverty and food insecurity. Food insecurity is essentially an income and access issue. Lifting people out of poverty is certainly the fastest way to improve food security, but still more than 3 billion people cannot afford healthy diets; so it's not only about getting food, it's about getting *healthy* food. Twenty-five per cent of the world's population is living on less than $3.20 per day (Figure 8).

The world needs to be able to feed this growing population with healthy and affordable diets, and that basically means helping national food systems to transform in a way that can deliver

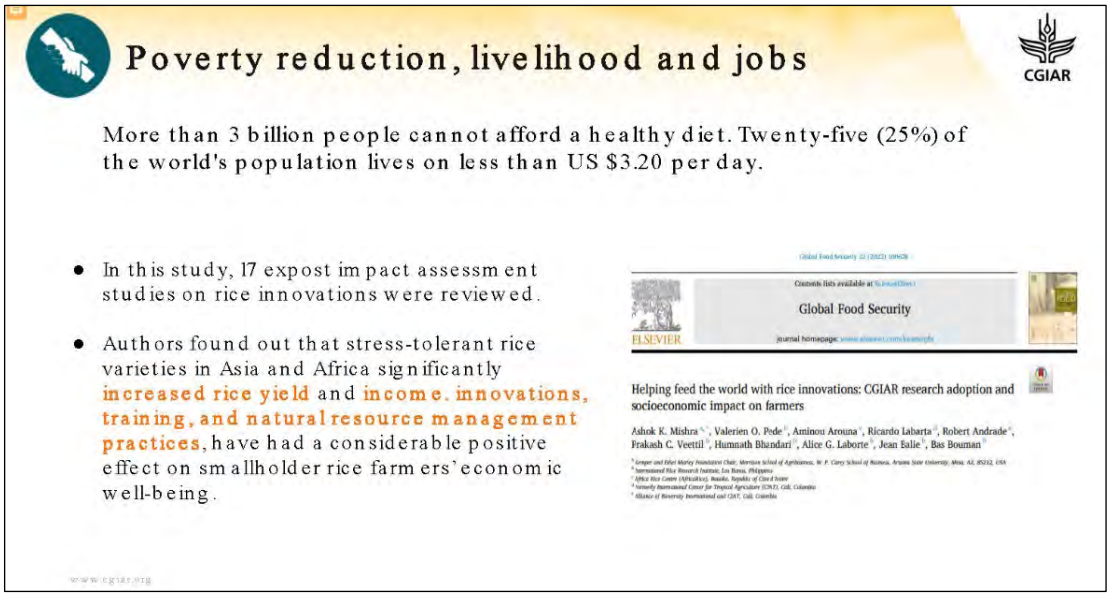


Figure 8.

healthy diets out of sustainable landscapes, within the planetary boundaries. This is something that the CGIAR is doing. It is described in one of the recent studies published in *Global Food Security* (Figure 8: 'Helping feed the world with rice innovations: CGIAR research adoption and socioeconomic impact on farmers'), which you might be interested to look at.

Nutrition and health

The CGIAR is known for its work on food security and nutrition. As I said in the introduction, unfortunately the number of people who are undernourished is now rising instead of falling, and that is a major source of concern, along with our concern about food safety and food quality. Figure 9 shows several examples of the benefits of research for development and its achievements, to address this challenge. Every CGIAR center has food and nutrition security at its core, as part of its DNA, and it is where the CGIAR's work has produced the most benefits throughout the years and where I think Professor Pardey would agree that the benefit–cost ratio is the highest.

In IRRI for example, we have a two-pronged approach. It is about improving the quality of grain, by fortification for example, so we deliver rice grain of enhanced quality with more iron and zinc content. And we also work on diversification of production and of diets. We aim to deliver healthy meals where rice continues to be the key staple with a number of other foodstuffs available on the same plate, having been produced in the same landscape or elsewhere in the local economy.

This is something that we are working hard to deliver throughout Asia, and governments have become very receptive to this thinking.

Figure 9.

The challenge for the future

Most issues that I have discussed so far are current challenges that are here to last. Now I want to highlight the need in the very near future to address what I think are the root causes of failing food systems. We all agree on the diagnostic; we have heard that several times today. But we do not yet all agree on the scale and the depth of the changes that are required.

I believe that there is a need for a paradigm shift, a conscious effort to transform the way we view and operate our food systems. We collectively need to shift from the agricultural productivity paradigm that characterised the Green Revolution, often based only on one metric: land productivity. We increasingly need to think in terms of food system efficiency as a new paradigm, making sure that we integrate other metrics to measure the contributions that the sector is making.

It also means thinking more in terms of food policies and food outcomes, and less in terms of agricultural policies, agricultural output. That is, focusing on food outcomes as opposed to agricultural output and so on. While the Green Revolution was characterised as producing cheap and abundant food, we now need to reinvent ourselves and promote a new 'green revolution' that would be around food system needs, with the goal of delivering nutritious, diversified food and sustainable ecosystems.

This means, of course, revising our metrics and making sure we can compare the benefits of various food systems across countries and within countries with comparable metrics.

Agricultural productivity paradigm	Food system efficiency paradigm	Possible implications of the evolution
Farm systems focused on agricultural production	Food systems focused on heathy and sustainable diets	Need to look beyond the agricultural sector. Involve several institutions beyond ministries of agriculture.
Agricultural supply/availability	Food demand, access, quality, safety, utilization	Shift from a primary focus on production/producer welfare to a primary focus on consumption/ consumer welfare.
Cheap & abundant staples	Nutritious & diversified foods	Higher prices are likely for consumers. They may require safety nets for the poorest households. Small farmers may get higher prices and become more competitive.
Calories, proteins	Macronutrients, micronutrients, & vitamins	Methods, tools and mechanisms to measure and monitor nutrition performance of food systems would need to adjust.
Crop productivity	Sustainable intensification, Total factor productivity	More complex management of the farm environment with multiple and sometimes competing performance indicators.
Mono-cropping	Farm diversification	Less control of agribusiness in the short term. Likely more diversified foods and biodiversity.
Economy of scale	Value addition, quality	Change in performance measurement with a focus on value addition per unit of labor as opposed to yield.
Land access	Land restitution	Possible negative consequences for marginal farmers relying on marginal land. Likely increase of land price and speculation on land markets.
Feeding people	**Nourishing people**	Change in quality and price of food.

Figure 10. A paradigm shift to food system transformation. *Source:* Balié (2020).

The table in Figure 10 results from the discussions we had at EAT Lancet, on the ways to think about future challenges and the fundamental issues that we need to courageously address in the near future. I am convinced that the CGIAR can help broker these kinds of discussions.

Figure 11 shows the partnerships needed to address these challenges. I emphasise the importance of the CGIAR working with national and other international partners, like NARES [national agricultural research and extension system], representatives from natural systems and all the CGIAR centers. This is critical to make sure that we progress these transformational changes that can have lasting effects.

The integration of centers into One CGIAR really puts partnerships at its core. It is about a demand-driven approach to our research that is driven by collaboration.

Figure 11.

Finally, I want to thank the Crawford Fund and ACIAR for all the support they have been providing us over the decades. The CGIAR, as I said, has a renewed focus on food systems, but it is also because we have this intellectual dialogue with the Crawford Fund, in this year and other years, that we are actually progressing this thinking; and so I want to finish by thanking you for that.

Figure 12.

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Jean Balié has over two decades of experience in leadership and expertise developing policies for agriculture, food, and rural development. Dr Balié is currently the Director General of the International Rice Research Institute, and the Regional Director for South East Asia and the Pacific of the CGIAR. As Director General of IRRI, he sets the global strategic direction of the institute and manages its affairs in accordance with the policies and decisions of the IRRI Board of Trustees. He joined IRRI in 2018 as Head of the Agri-Food Policy Platform and, before becoming Director General, served as Research Director – External Engagement and Deputy Director General for Research. Prior to IRRI, Dr Balié worked as a Policy Officer, Senior Economist, and Program Manager at the Food and Agriculture Organization of the United Nations (FAO). He earned his PhD in agricultural economics at the University of Göttingen in Germany, and has a Masters degree from Montpellier SupAgro, École Nationale Supérieure Agronomique de Toulouse (ENSAT) and the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM).

PANEL

Nexus gains to the environment and sustainability

Ms Logotonu Meleisea Waqainabete[1], Dr Anika Molesworth[2]

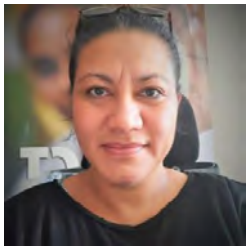
Chair: Dr Sandro Demaio

1 Land Resources Division, SPC, Centre for Pacific Crops and Trees (CePaCT)
2 Crawford Fund NSW Committee

Q: Chair

Following Dr Jean Balié's talk, we just want to finish off with a few questions.

Logo, Jean spoke comprehensively and passionately about the importance of diversification. One element of that is, of course, genetic conservation – your work. Could you explain a little bit about what you do and its role and importance in food and nutrition security in the Pacific?



A: Logotonu Waqainabete

I am very privileged to be looking after a very unique resource, the Pacific's regional gene bank, CePaCT (the Centre for Pacific Crops and Trees), that is hosted by the Pacific Community (SPC) and based in Suva, Fiji. We are not an international gene bank like the CGIAR centres, but we are an affiliated member through our collaboration with the Crop Trust and the International Plant Treaty and our key aim is to support the conservation, development and utilisation of the region's main plant genetic resources. Our crop mandate primarily focuses on plant genetic resources for food and agriculture. We also now incorporate forest trees, recognising the important contribution of these species to overall healthy ecosystems, linking to sustainable agriculture systems in the region. So, we now have a broad crop and tree mandate that we're dealing with. Of course, our ultimate aim, aligning to the aims of our organisation and our division that mainly looks after agriculture and forestry, is to contribute to improved food and nutrition security and resilience building.

Over the years, we have assembled around 56 crop and tree species where 66% of them originate from 16 countries in the Pacific region. We are still collecting, and still identifying and doing a lot of research with our members and also in partnerships with our universities and all other key stakeholders. That helps us not only to do research with a purely genetic focus, but also to look at systems approaches to make sure that the genetic resources that are in the gene bank are being rolled out for farmers to use, particularly in our member countries. It is a unique resource and, as I said, we have a lot of partnerships to make sure that the research that we do in the gene bank generates fit-for-purpose diversity that addresses the needs of the region around climate resilience and nutrition, which are very big issues that the region is facing, as Dr Audrey Aumua highlighted in the Sir John Crawford Memorial Address yesterday.

A quick example of the impact of research that we have been carrying out, with several partnerships and stakeholders, is the work that we do on taro. Our gene bank has the largest

collection of taro diversity globally. I am very happy to have met some of the key researchers that have had been pioneering this work over the last 20 years of the gene bank, and I am very grateful that myself and my team have inherited all this hard, hard work that has been going on in the past years.

The impact of the taro work is really shown in Samoa where, as you may have heard, there was a classic example of the taro leaf blight disease that wiped away a food security crop. For Samoa, taro is their number one staple (crop). It's also a main economic crop for Samoa although, of course, taro is also eaten and grown and in most other Pacific countries. I am Samoan, and I can vouch for the way people there had psychological stress when they didn't have taro to eat. This classic example and the research happened some 20 years ago. Fast forward to today, Samoa is once again planting, eating and exporting taro, simply because of the partnerships that were developed, the research that was carried out mostly in partnership with universities in Australia, and key funding support from DFAT and the partnership with ACIAR and other Australian universities like the University of Queensland. That really helped the research to develop new resistant taro breeding lines so that Samoa can grow taro again. That was a very successful program that I think is underestimated by many in our region. The success is not restricted to our region. We have also sent these taro breeding lines to Africa, the Caribbean, the Philippines and other Asian countries. And our colleagues in Ghana and Nigeria, where we send this material, tell us the lines are doing well and the farmers are picking them up. It is helping these countries manage taro leaf blight.

I think that is a good example of the research and the partnerships that we have developed and the investment that we have made.

Q: Chair

Thank you. That is an excellent example. To hear more, please speak to Logo during the break.

Anika, with your work in Australia and across the region, what are your one or two priorities that you think we need to have front of mind as we leave Canberra after this conference, in terms of getting the best outcomes for agriculture and the environment?

A: Anika Molesworth

I think for the large-scale transformative change which is required, which is being brought to light from these speakers, we need policies and strategies brought in line with the science, with the wealth of evidence which is being produced from scientists, from these people in the room. And for that we need more people to be educated, engaged and feel empowered. They need to be understanding what the research is showing, and how to utilise it, and to feel they too can do something with it.

I think that falls into the communications 'space': that is, how do we communicate science in a way where it's not just awareness but it's converted into activity, so that this information and evidence is applied practically on the ground? I think a challenge to set to the scientists in the room is: How can we connect scientists with artists, with people who can connect data to minds and hearts, so that we actually see change of mindset and behaviour?

Chair

That is a great call to action. Thank you, Anika.
We're going to have to stop here. Please give a big round of applause to these incredible experts. Thank you, Logo Waqainabete and Dr Anika Molesworth. There will be time in the break for you in the audience to ask more questions and to harvest more insights and wisdom.

Logotonu Meleisea Waqainabete, originally from Samoa, is responsible for the overall leadership and management of the Genetic Resources thematic area, including the renowned Pacific regional gene bank, CePaCT, of the Pacific Community (SPC). Prior to her current role, Logo was CePaCT's Assistant Curator for five years, later becoming Curator for six years. She has technical and management experience in gene banking and the conservation of ex-situ crop and tree collections of the Pacific. Prior to joining SPC, Logo worked in the Research and Quarantine Units of the Ministry of Agriculture, Samoa. Logo holds a Bachelor of Agriculture and a Post-Graduate Degree in Science (Biology) from the University of the South Pacific in both Samoa and Fiji. She is passionate about plants and their important contribution to meeting food requirements and healthy diets of Pacific people like herself. CePaCT and its genetic resources program is one of the four pillars of the Land Resources Division of SPC, and Logo hopes that through her pillar's work, people will continue to appreciate the value of science, technology and innovation to sustainable development.

Dr Anika Molesworth is a recognised thought-leader of agro-ecological systems resilience and international farming development. With a passion for rural communities and healthy ecosystems, she is committed to help create sustainable and vibrant rural landscapes now and for the future. She is a Founding Director of Farmers for Climate Action – a national network of over 5000 Australian farmers undertaking climate change action. In 2017, she presented at TEDxYouth@Sydney the talk "Farmers are key to a better future." She is also the author of the book, *Our Sunburnt Country*. Awards include 2015 Young Farmer of the Year, and 2017 Young Australian of the Year NSW Finalist.

A DIVERSITY OF BENEFITS

Nutrition-sensitive food systems: integrating nutrition programming into agriculture development

Jessica E. Raneri

Senior Nutrition Sensitive Agriculture Adviser to ACIAR and DFAT

Today I am going to talk to you about nutrition-sensitive food systems. Global malnutrition and food insecurity rates are still high, as we heard last night in the Sir John Crawford Memorial Address, and again today. There are now 2.3 billion people who experience moderate and severe food insecurity. Nearly a quarter of children under five are stunted and 3.1 billion people cannot afford a healthy diet. There is a huge financial cost associated with malnutrition. It is estimated at 3.5 trillion USD per year and that does not include the cost of over-nutrition. Clearly, our food system is failing.

There are different entry points to improve nutrition across the food system (Figure 1).

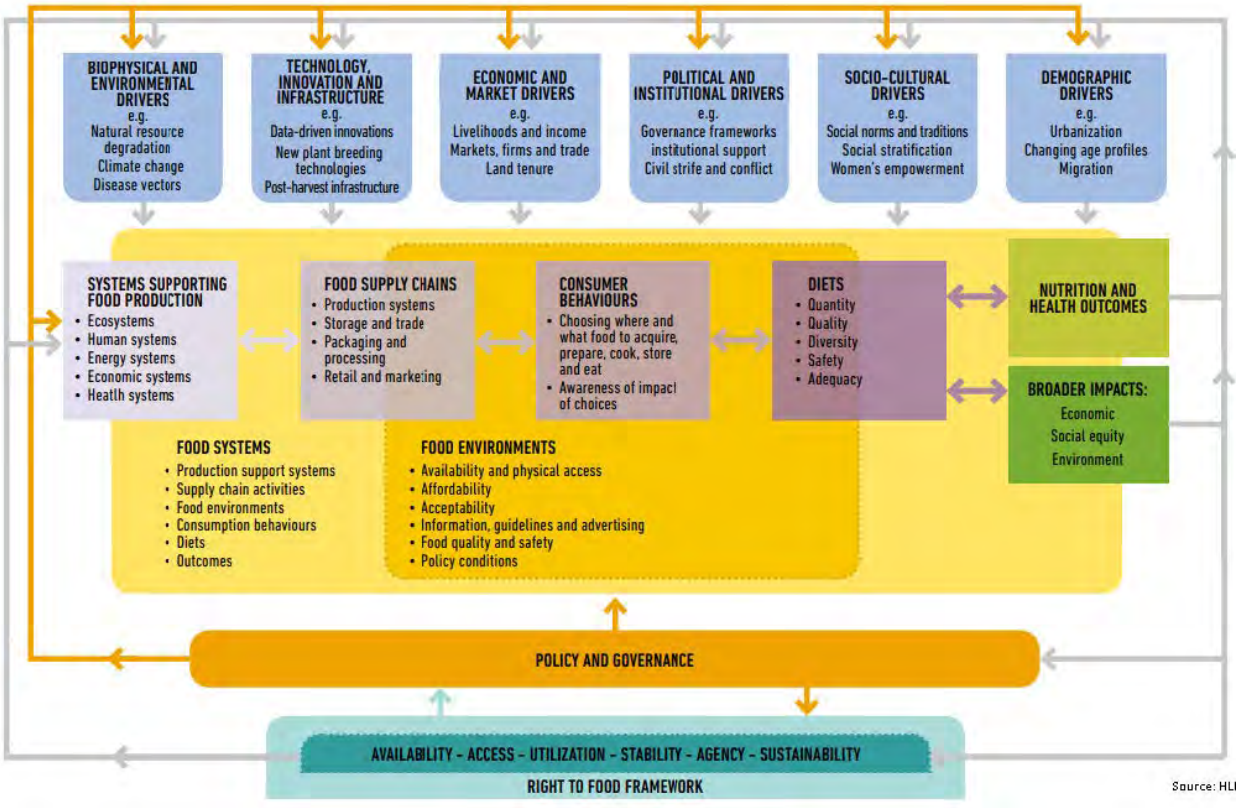


Figure 1. Various approaches or entry points to improving people's nutrition. *Source: HLPE 2020.*

Traditionally, agriculture projects have taken a supply-oriented approach, assuming that the consumers – the people who actually eat the food – will simply follow suit. Alternatively, taking a food-system approach means putting people at the centre of what we do, and understanding how consumer demand and consumers' capabilities and preferences can be leveraged to help improve nutrition outputs and outcomes across the food system.

We know that agriculture is the most direct way to improve nutrition of the rural poor, and it can do so through multiple pathways, including as a source of food, of income and of women's empowerment (Figure 2). The most direct pathway is by bolstering the availability of – and accessibility to – sufficient nutritious and safe food. Nutrition-sensitive approaches address the multiple underlying causes of malnutrition, including food insecurity (Figure 3), which is where agriculture is very important.

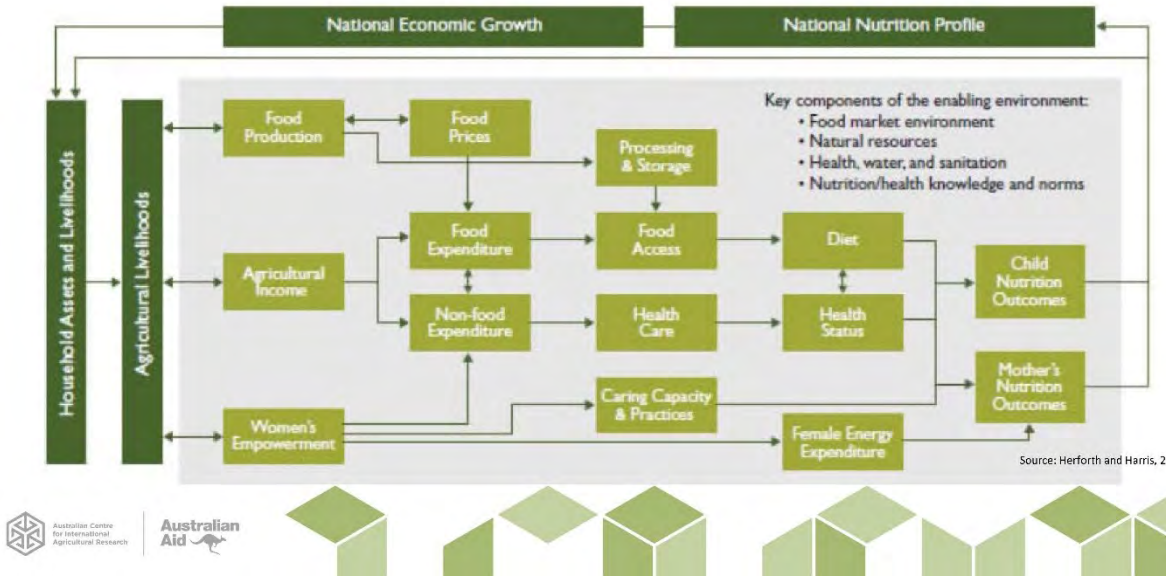


Figure 2. Conceptual framework for agriculture and nutrition.
Source: Herforth & Harris 2014.

In the past, global efforts to improve nutrition have focused on pastes, pills, powders, fortification and therapeutic foods, and these all have their place. What was missing was a food-based approach that put nutritionally rich foods and dietary diversity at the focus of program design. This is where Nutrition-sensitive agriculture (Figure 4) comes in.

Nutrition-sensitive agriculture

Nutrition-sensitive agriculture has the overall objective of enabling food systems to function more effectively to produce good nutritional outcomes. However, being a relatively new concept, this approach doesn't yet have a strong evidence-base. Various meta-reviews have found little impact of agriculture on nutrition, but not because agriculture cannot improve nutrition. Those reviews give various explanations as to why that evidence is missing.

For example, impact pathways were often insufficiently articulated, and studies tended to have weak design, and often lacked a whole-of-diet perspective and had made a poor choice of indicators. For a long time we were targeting women and children as they are some of the most nutritionally vulnerable populations. In reality, we need to take a more holistic approach to social inclusion and equity, because all marginalised people are likely to be less food- and

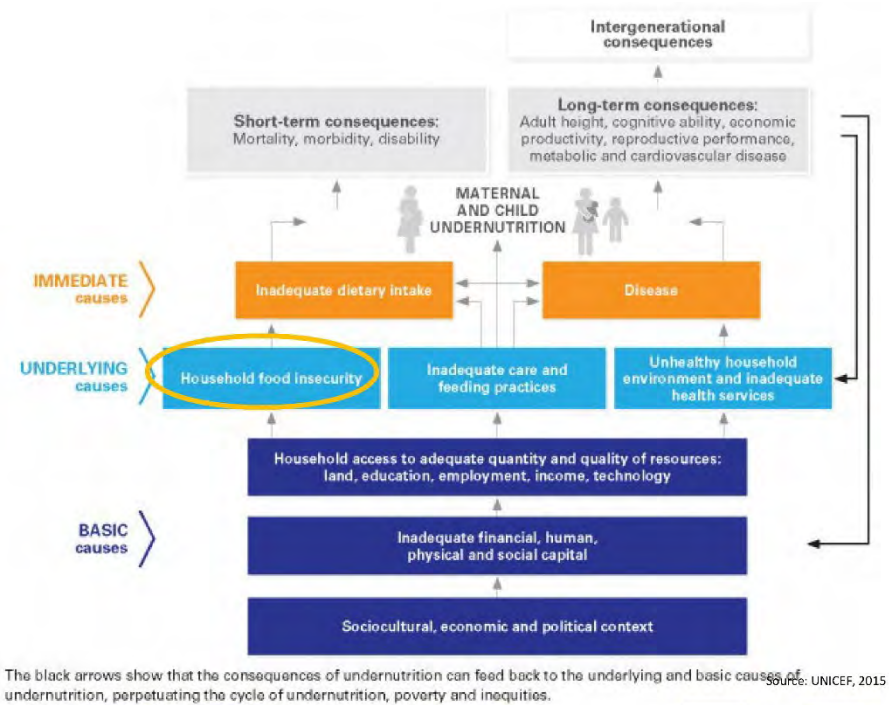


Figure 3. 'Nutrition-sensitive' approaches address the underlying determinants of malnutrition. *Adapted from UNICEF Conceptual framework, Wali* et al. *2019*.

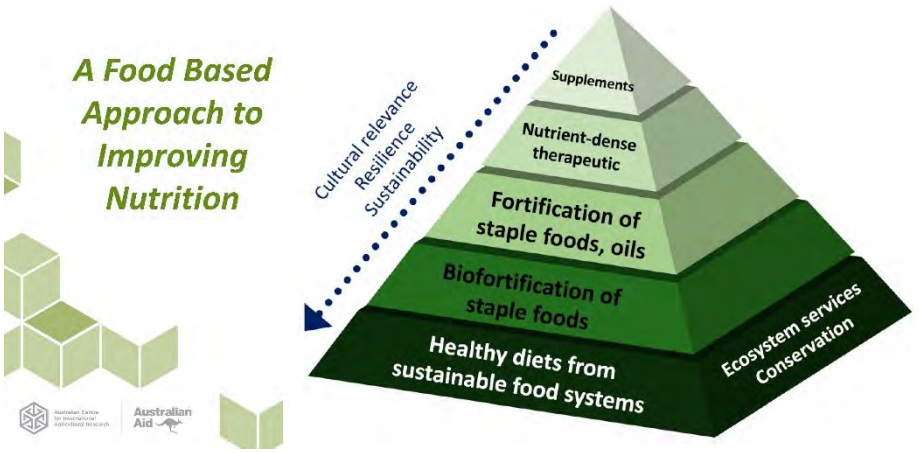


Figure 4. Nutrition-sensitive agriculture (NSA). *Raneri (unpublished).*

nutrition-secure. These include indigenous people, and people with diverse sexual orientation, gender identity, gender expression, sex characteristics and physical abilities. Yet most of the tools we have for measuring and improving nutrition have been designed and validated with women and children in mind.

So not only do we not have data or evidence on nutrition for those other vulnerable populations, but also we don't have validated tools or indicators to use to gather such data. There is a critical gap here, and a main contributor to the evidence gap has been the poor choice of indicator.

How we measure nutrition in Nutrition-sensitive agriculture

A growing body of research shows that the consumption of sufficient nutrient-rich foods is associated with lower rates of stunting in children. In many cases, when people think about nutrition, they think about these types of nutrition-status indicators: stunting, wasting, obesity and micronutrient deficiencies (Figure 5). However, these are high-level nutrition outcomes.

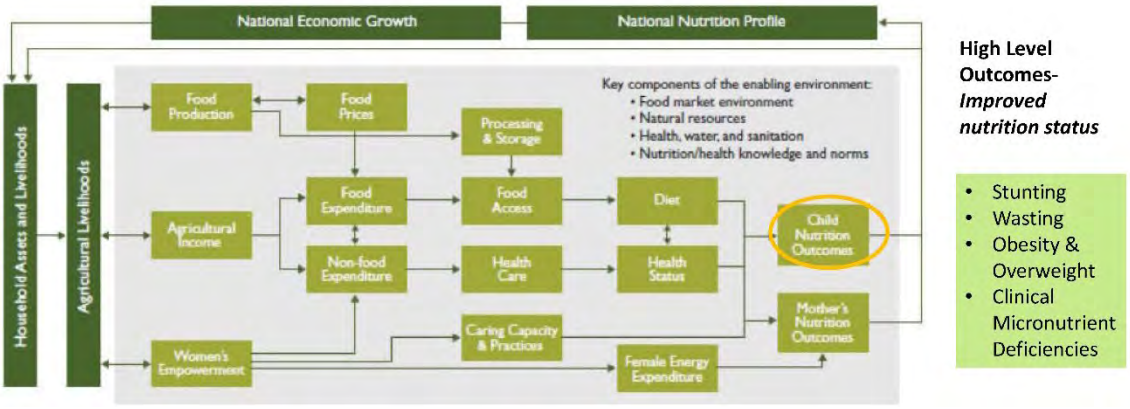


Figure 5. Nutrition outcome indicators. *Source: Adapted from Herforth and Harris 2014.*

They are complex and have multiple drivers such as poverty, health, education, and WASH (water, sanitation and hygiene). They can be extremely difficult to change, especially within an agriculture project that lasts for only a few years. There is even a discussion on whether stunting should even be considered as an indicator of nutrition or rather as a more generalised indicator of development.

Focusing on diet quality makes sense for agriculture projects (Figure 6). Agriculture produces the food we consume in our everyday diets. One in five deaths are associated with poor diet quality, and those suboptimal diets are characterised by a lack of whole grains, fruit, vegetables, nuts, seeds, milk and legumes, and these are foods that agriculture R&D projects can target, across the food system. You cannot have good nutrition status without first having a good quality diet.

There are two main impact pathways that are often considered, or stated, in agriculture projects aiming to improve nutrition: direct consumption pathway, and income pathway.

Often, production for direct consumption is assumed to be the most direct and easiest pathway: grow more, have more food available, eat more (Figure 6). It seems easy, but is not always easy, and especially not if it's assumed it will happen automatically. For example, in many cases, nutritious foods have a higher market value, and so households will choose simply to sell these foods instead of eating them.

Figure 6. Agriculture for direct consumption pathway. *Raneri (unpublished).*

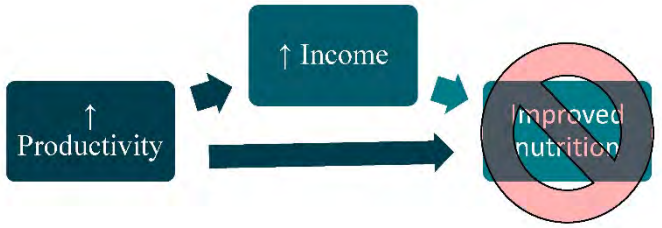


Figure 7. Agriculture for more income pathway. *Raneri (unpublished).*

It's a similar story with the income pathway (Figure 7): increased productivity leads to more income, and with that income they will buy more and better quality foods, leading to better nutrition. However, increasing income alone is also often insufficient to achieve nutrition impacts, and this has been observed in many developing countries where child malnutrition has increased despite reductions in poverty and increases in GDP. At household level, we see the income being spent on more of the same foods (such as staples) or on non-food items, and so the diet quality doesn't improve. Sometimes the income is spent on more desired but less healthy foods such as ultra-processed foods including instant noodles, and the diet quality actually deteriorates.

The lack of impact could also be a result of insufficient targeting. For example, income-generating activities often target men. However, we know that when such activities target and empower women they are more likely to result in the larger income being spent on acquiring better quality foods for the household.

What this all tells us is that we need to create incentives for households (Figure 8): incentives to eat what they produce, and also to allocate income on inputs to good nutrition (like food, or seedlings of nutritious foods to grow).

Figure 8. *Photos: JE Raneri.*

This is where nutrition education comes into play. Often, we think about nutrition education targeting women and telling them about food groups and micronutrients. We need to instil in both men and women the value of a costlier but more nutritious diet. If women aren't empowered to make decisions in their household and men don't value and understand the value of nutritious foods, then that knowledge cannot be utilised.

But we also need to improve the food environment. You can have all the knowledge about good nutrition, and even the income to spend on it, but if you only have the same two vegetables available at your local market or even no local market at all, and you are not able to buy seeds to diversify your home garden, then that knowledge is wasted.

At a minimum, projects should aim to do no harm (Figure 9). No single food or nutrient is a silver bullet, and sometimes focusing on just one can result in imbalances in the diet. We cannot assume that promoting a single food will lead to it being added to people's normal diet. Often, substitution occurs. For example, your project might be successful in leading

Figure 9. *Photo: JE Raneri.*

households to eat more pak choy, but if they are substituting that for aikiba there may be no positive impact on the diet. And if you only measure pak choy consumption, you won't have the full picture.

To make meaningful contributions to food and nutrition security, it's time to move beyond what are too often the end goals of agriculture projects: yield and income.

We know that smallholder farmers too often don't eat what they produce. They don't use profits to buy better foods, and they don't end up improving their diets. How can we as researchers, create the right incentives for households to change this (Figure 10)?

Figure 10. *Photo: JE Raneri.*

We need to simultaneously improve food environments while also improving capacity and knowledge on nutrition.

- The first step is building stakeholder understanding on the importance of taking a nutrition-sensitive approach and acknowledging that improving incomes alone will not solve malnutrition. So that's, hopefully, what we've done today.
- The second is to incorporate specific nutrition goals and action during project planning. Hopefully, you'll do that tomorrow.
- And finally, do yourselves a favour and get a nutritionist involved in your projects if you want to improve nutrition.

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Jessica Evelyn Raneri is currently Senior Nutrition Sensitive Agriculture Adviser to both The Australian Centre for International Agriculture Research (ACIAR) and to the Australian Department of Foreign Affairs and Trade (DFAT). She spent a decade working at Bioversity International as a nutrition researcher, leading research projects and programmes related to agrobiodiversity, sustainable diets, nutrition and systems research work mostly focused on sustainable local food systems, highlighting the role of local foods and agrobiodiversity for improving diet quality. Jessica's work is now focused on guiding research and development investments aiming to improve nutrition and health outcomes of agriculture and food system initiatives, both by supporting research design and implementation, and by providing evidence-based policy and programming recommendations for more resilient and sustainable food systems. Jessica is passionate about food and nutrition security data, including novel indicator development and testing, as well as supporting common indicator use to support global monitoring. She is a strong proponent and practitioner of participatory action research, whole-of-diet approaches, evidence-based policy and effective communication as key components of improved global public health and development. Jessica is passionate about school food environments. In a world where diets are rapidly degrading to be less diverse, healthy and nutritious, and youth are less engaged in agriculture – working with teachers, children and their families provides an opportunity to actively engage and nudge dietary choices, preferences and behaviours towards being more healthy and sustainable, whilst also supporting local rural agriculture-based livelihoods, and supporting local food systems. She is an executive team member for the Pacific School Food Network, and is interested in innovative solutions that both support smallholder farmers and improve the quality of school food environments. Jessica has worked in agriculture development in South America, sub-Saharan Africa, South Asia, South East Asia, and the Pacific. She is currently completing her PhD in Bio-Science Engineering (Food and Nutrition) with the University of Ghent, Belgium.

A DIVERSITY OF BENEFITS

Soft power and diplomacy

HE Robyn Mudie

First Assistant Secretary, Australian Government Dept of Foreign Affairs and Trade (DFAT)

Thank you to the Crawford Fund for inviting me to contribute to this conference today. It is a great opportunity. I have only recently concluded my term as Australia's ambassador to Vietnam, and Vietnam is a great case study of the benefits, the diverse benefits, that accrue from our contribution to their agricultural development – in fact, science-based contributions to their agricultural development.

My first diplomatic posting was to Vietnam from 1993 to 1995, so I have had the opportunity to see, with my own eyes, Vietnam's remarkable growth and development trajectory over a quarter of a century, and to get a real sense of the positive impact of Australia's support across many sectors, including agricultural development.

When I first arrived in Vietnam in 1993, the economic reform agenda 'Doi Moi' had been introduced only seven years earlier. The country was an emerging but still heavily socialist economy with 58% of people living in poverty and 50% in extreme poverty. By the time I returned as ambassador in 2019, Vietnam had improved the living standard of its people to a remarkable degree, reducing the poverty rate to just over 5% and extreme poverty to only 2%. It is now a truly market-oriented economy that is recognised as one of the success stories of the region and in fact is currently tracking towards 7.5% growth in 2022.

Australia sees our partnership with Vietnam through the broader lens of our engagement with the near region and in the context of our government's commitment to deepen engagement with South East Asia. Our engagement supports our ambitions for a strategic equilibrium in which no country is forced to choose sides and where all are free to make their own sovereign decisions. The priority we place on our relationship with Vietnam was clearly reflected in the early visit to the country by Foreign Minister Penny Wong in late June [2022], only weeks into the life of the new Albanese government. And as another indication of the importance of Australia's role in agricultural development, one of the very last functions I was privileged to host during my term as ambassador was for the ACIAR Commission, which visited only weeks before I left the country. That, to me, really sums up the priority we attach to supporting agricultural development in Vietnam.

Vietnam's economic prosperity and stability play directly into that of the Indo-Pacific, so Australia has an enduring and long-term interest in supporting the country's economic development as we work to stitch ourselves into the region's growth trajectory. Australia's support for agricultural development, agricultural research and, more recently, innovation in agriculture has made an important contribution to Vietnam's economic development story. This engagement is a great case study of the diverse benefits that can accrue from agriculture for development.

Fifty years of diplomatic relations and scientific interaction

The year 2023 marks 50 years of diplomatic relations between our two countries. Agricultural science was one of the first areas where we worked together in a development relationship. The government has invested in agricultural research for development from our DFAT aid program through the Australian Centre for International Agricultural Research (ACIAR) and most recently through the Aus4Innovation Program that CSIRO is leading.

ACIAR began its Vietnam program in 1993 with the aim of long-term improvements for smallholder farmers in Vietnam. It has made remarkable progress over the intervening decades and this is illustrated by the fact that, in 2017, ACIAR signed a new agreement with Vietnam's Ministry of Agriculture and Rural Development for a ten-year strategy, which is ambitious and forward looking. It covers building scientific capacity, empowering smallholder farmers, enhancing human nutrition, strengthening agricultural supply chains, dealing with climate change impacts, and the list goes on.

CSIRO also has had a long collaboration with Vietnam, including government ministries, universities and research institutes and the private sector. It has a strong focus on applied science and innovation, and a further strong focus on the agriculture and food sectors. In 2018, building on its long-standing history of collaboration, CSIRO entered into a Memorandum of Understanding with Vietnam's Ministry of Science and Technology to develop a more formal partnership between research and development institutions between Australia and Vietnam. In 2019 it entered into a further tripartite partnership with DFAT, CSIRO and the Vietnam Ministry of Science and Technology to co-invest and manage the four-year $16.5 million development program for innovation which is aimed at supporting the inclusive and sustainable development of Vietnam's innovation system, with a strong focus on the agriculture sector.

The core value of our science-based partnerships in Vietnam is that they have and continue to directly target the country's development needs in line with our own overarching development strategy.

Changes in the fifty years

Over the years, our programs have changed and adapted in line with Vietnam's development and growth trajectory and its needs. They have moved from a predominantly donor–recipient relationship to a much more equal partnership, and from a strong poverty-alleviation focus in the 1990s to the innovation-based approach we now have with both ACIAR and CSIRO. Our collaboration and support have evolved to address emerging issues, and so they remain relevant, valuable and valued in the contemporary environment.

As one small example, in recent years ACIAR has been assisting in Vietnam's need to address the challenges posed by climate change and in particular its impact on the livelihoods of smallholder farmers in the Mekong Delta. For instance, the issue of rising sea levels leading to salinity intrusion that is affecting agricultural production is being dealt with by various research collaborations and projects, such as those under FOCUS [Farmer Options for Crops Under Saline conditions]. These projects will help farmers become more resilient, and thus

secure more income, through the introduction of new systems and the improvement of farming practices to meet market demands. Earlier this year, I was privileged to visit one of these projects at Can Tho University in the Mekong Delta, and I saw a simple user-friendly technique and how it can help farmers manage their crops better by tracking salinity in soil and matching their crops to that.

Like ACIAR's work, CSIRO's Aus4Innovation Program is focused on current and emerging issues in the agriculture and food sectors, with a view to supporting Vietnam's ambitions to reach high income status by 2045. It takes a diverse approach, including further promoting science commercialisation to deepen connections between the research field and the market. It also pilots innovation platforms to connect research to markets to solve challenges in the agriculture and food sectors with technology-based solutions. And it introduces innovation partnership models looking at novel solutions and technologies from Australia, which can be used in Vietnam to address challenges in the agriculture sector. CSIRO's work also supports policy development and dissemination, including in the development of the Vietnam National Strategy for Science, Technology and Innovation (2021–2030), and the dissemination of the National Artificial Intelligence Strategy, which is very important given the high potential application of this emerging technology to the agricultural sector.

A number of elements have contributed to the success of Australia's support for Vietnam's agricultural development.

- Our consistent long-term commitment to working with the Vietnamese Government through ACIAR and CSIRO programs has underlined Australia's role as a responsive and trustworthy partner throughout Vietnam's development history.
- Our engagement is based on our strong, long-standing partnerships and relationships.
- Our cooperation with partners under ACIAR is built on broad links across government, academia and science-based organisations, and these in turn have laid the basis for further collaboration through CSIRO in science and innovation.
- We have stayed the course. We didn't leave Vietnam once poverty-alleviation lost its priority, and we are now looking to the future, which is a valuable aspect of our cooperation.
- We work on a 'level playing field' with Vietnam. We treat them as partners and equals and we do genuinely collaborate.
- We are also very flexible and adaptable to changing circumstances, and that was illustrated strongly during the pandemic when many ACIAR and CSIRO programs were able to be adapted into an online format.
- And finally, our success is based heavily on our continuous ability to deliver tangible and meaningful programs that are suited to need and fit for purpose.

The power of people-to-people links

Our support for agriculture and scientific research has not been created with the sole focus of creating soft power, but it is a valuable aspect of what we get out of our programs. At the heart of this soft power are the close people-to-people links that emerge from partnerships

across a diverse range of sectors, through scholarships, research partnerships and collaboration, and people-to-people links in the field. The basis of these relationships is in the practical, tangible and relevant collaborations that Australia brings to the table, all of which I saw with my own eyes during my term in Vietnam.

In April this year in particular, one example that springs to mind is my visit to Điện Biên Province in the north-west, where I saw the ACIAR project 'Intensification of beef cattle production to upland cropping systems in Northwest Vietnam', which essentially is introducing much more efficient food and cropping systems to the local community. Importantly, the main beneficiaries of this program are the women ethnic minority farmers in the area. I met some of the beneficiaries and saw for myself how meaningful Australia's contribution is, and the long-term benefits that will follow.

In summary, although soft power is not the core focus of what we, Australia, do in Vietnam with our agricultural support, it is a very meaningful benefit that does accrue. It builds a broader relationship with Vietnam which, as I described at the beginning, has broader interest for Australia in the region.

I was immensely proud to lead the ACIAR and CSIRO efforts in Vietnam, because I could see how directly they benefit the lives of people in that country.

Ms Mudie is a senior career officer with the Department of Foreign Affairs and Trade and was most recently Australian Ambassador to Vietnam (2019–2022). She has previously served overseas as Australian High Commissioner to Sri Lanka and Maldives (2012–2016); Deputy Permanent Representative to the United Nations (Geneva); First Secretary, UN Permanent Mission, New York; and Second Secretary, Hanoi. In Canberra Ms Mudie was the inaugural Executive Director of the DFAT Diplomatic Academy (2016–2018) and has served as Assistant Secretary, Public Diplomacy Branch; Assistant Secretary, Information Resources Branch; and Director, Strategic Policy Section. Ms Mudie holds a Master of Southeast Asian Studies from the University of Hull; Bachelor of Arts (Honours) from the University of Adelaide; and a Graduate Diploma (Foreign Affairs and Trade) from the Australian National University. Ms Mudie is a Vietnamese speaker who has studied Vietnamese at the RAAF School of Languages (1992), the Foreign Languages School, Hanoi (1993) and the Diplomatic Academy (2019).

A DIVERSITY OF BENEFITS

The social benefits of agricultural research

Dr Jenny Gordon

ACIAR Monitoring, Evaluation and Learning Advisory Panel; and
Asian Development Bank Institute Advisory Committee

This talk takes a historical approach, looking at why continued investment in agricultural R&D really matters, and also how it is evolving over time, and why it matters because of the resulting social benefits.

The key pathway is R&D, which raises agricultural productivity (value added per worker) and rural incomes, which means you need less labour for agricultural production, by definition. Therefore, you end up with surplus labour, which becomes available for doing something else.

The ideal is that the surplus labour moves into manufacturing and into services and other things that grow incomes and create a diversity of other income sources. That then promotes urbanisation, which is essential for supporting growing populations. The rural areas cannot simply expand agriculture to absorb a very large growing population, and the result is urban populations – which have both positive and negative aspects, in social terms – ultimately reducing food insecurity, but with less civil unrest as a result.

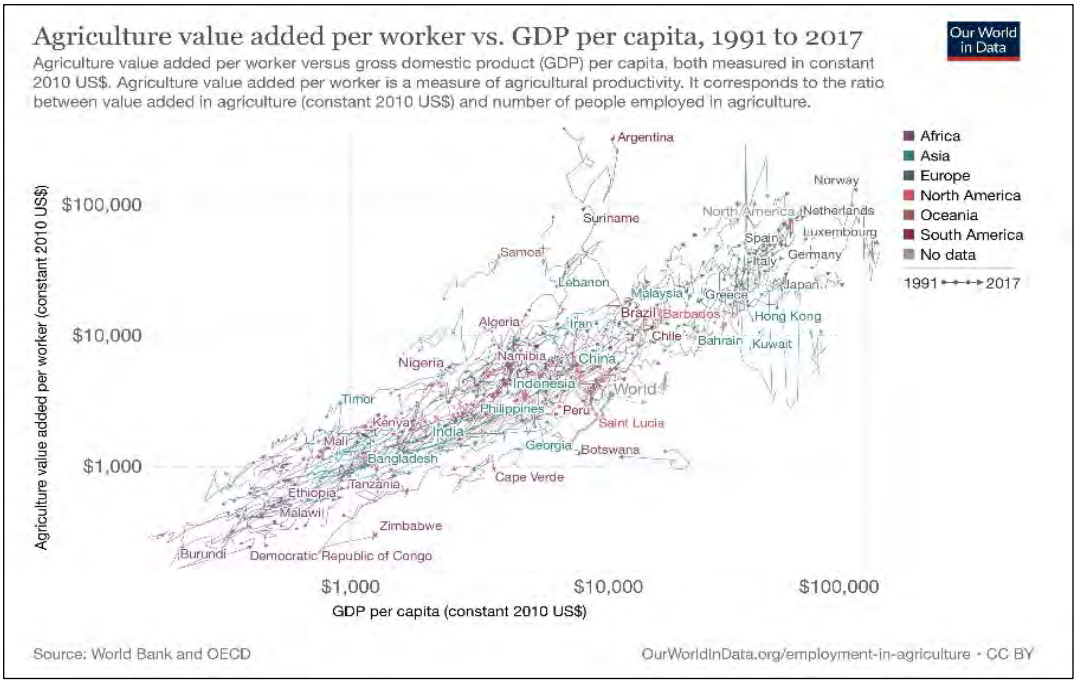


Figure 1.

Overall, agricultural R&D now is looking for better ways to protect the environment. It is valuing and raising the profile of indigenous knowledge in agriculture and in water management, and supporting greater gender equity and minority equity. That is essentially what this talk will show, in pictures.

Figure 1 is an amazing chart that tracks agricultural-value-added per worker versus GDP per capita over time from 1990 to 2017. There is a very clear pattern, showing that GDP per capita is very highly correlated to high agricultural-value-added per worker. It is a key component of income growth, and it is absolutely unavoidable that the share of labour in agriculture must fall to support this growth. The lines in the chart bounce around between countries, sometimes going backwards, sometimes forwards, but there is an interesting and overwhelming pattern. Agricultural productivity is, I think, causally related to GDP per capita in a very important way, and R&D has been the key factor behind that.

When there is high GDP per capita, the share of agriculture in employment falls (Figure 2). Much of that agricultural productivity is labour saving: you need fewer people on the land to produce the products. Nutrition has to be thought of not just as the farmer who grows their own food but also as the nutrition of urban populations and how to get nutritious food into those urban populations as well: otherwise, we are going to be failing. That brings us to the reasons why it is food systems that really matter, rather than just food production. The challenge is to get that nutritious food to the people who need to eat it.

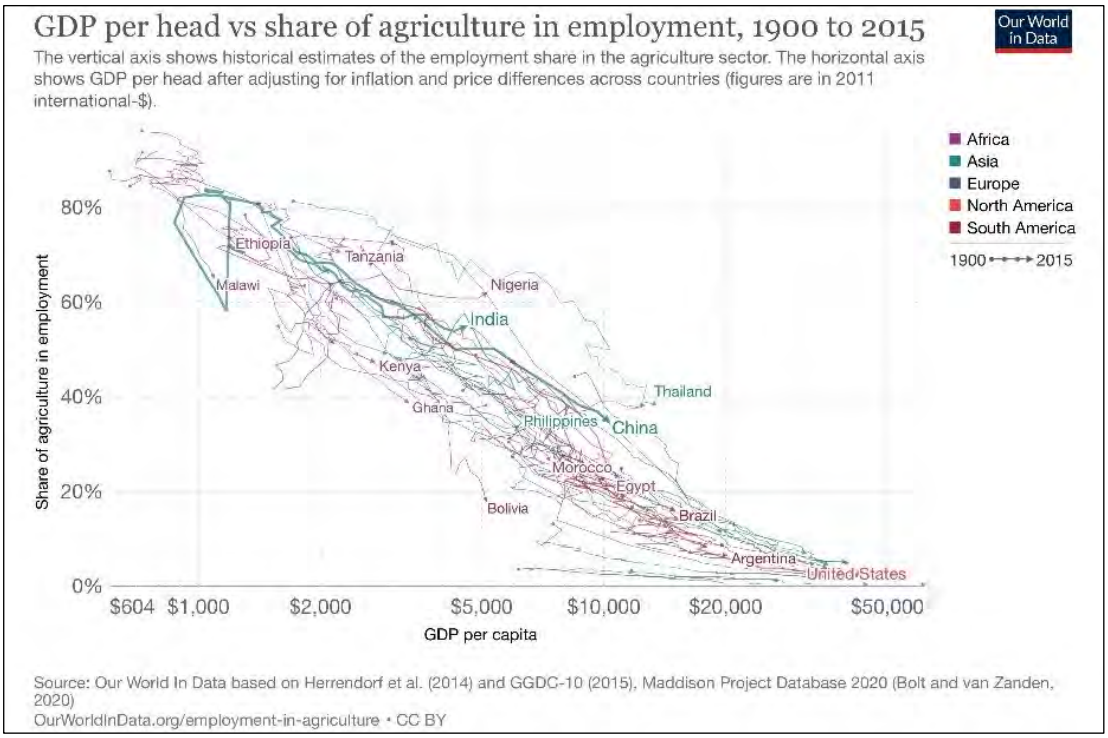


Figure 2.

Figure 3 plots the share of the population living in urban areas. Until 1800 there was not much urbanisation, and there was a lot of surplus, or underemployed, labour. If agricultural productivity is increasing, and labour has nowhere else to go and nothing else to do, they stay in rural areas. That is happening in India today where it is quite difficult to increase agricultural productivity if there are a lot of workers still working smaller and smaller plots of land. You can bring in new technologies, but you still need to be thinking about that broader system, and where that labour is going to go, where it is going to be absorbed, and what it is going to do.

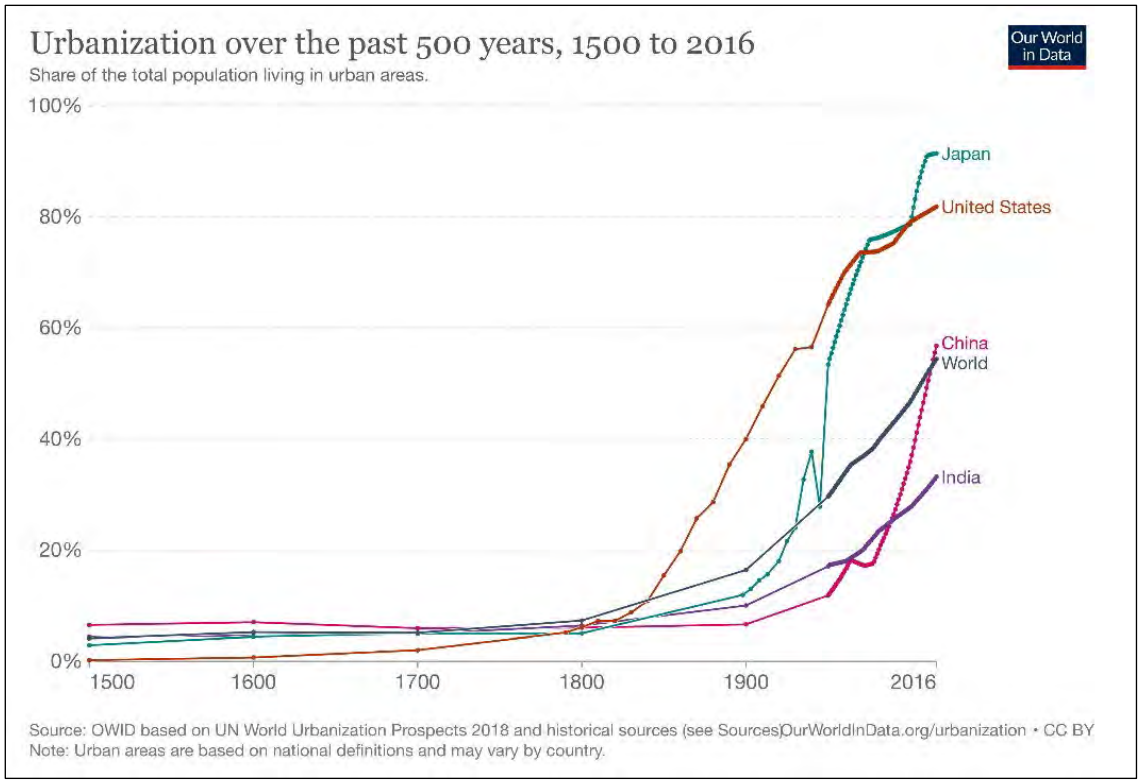


Figure 3.

Therefore, you cannot think about a food system without thinking about a political system, without thinking about industry policies and how those all fit together. The urbanisation in Japan is interesting (Figure 3). Japan still has lots of small plots growing food, but incredibly high productivity because a lot of the work is mechanised and they are using extremely good technology there.

Is urbanisation bad? The answer depends on your personal preferences. I was listening to the person who wrote *Sapiens: A brief history of humankind*, saying 'Well, actually, it's really terrible we ever had agriculture at all, because our diets are not nearly as diversified as when we were hunter gatherers.' However, I think most of us would agree that our lives are somewhat better than when we were hunter gatherers, and slightly less risky – for most or many of us, anyway.

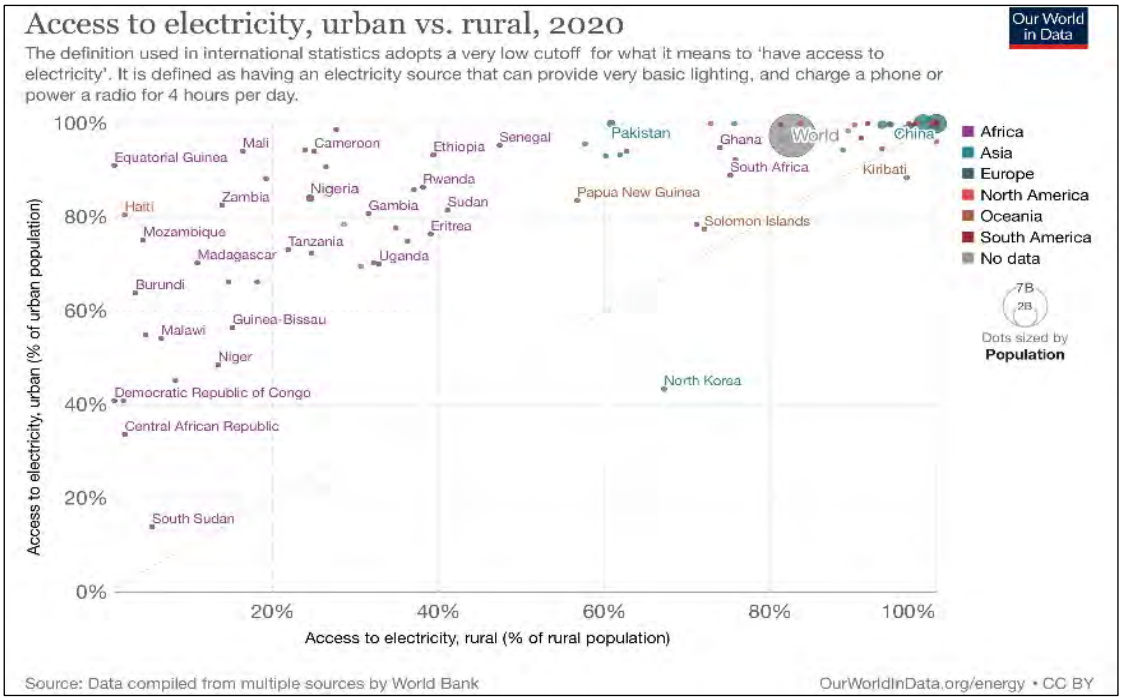


Figure 4.

Figure 4 plots access to electricity, urban versus rural in 2020, and it shows a pattern that is true for many services, such as access to education and to health services and similar benefits. There is a strong correlation between urbanisation and access to those services, largely because it is much more efficient to provide these services in urban areas than in rural areas. There is good justification for providing these services in urban areas, because there is a concentration of people there that need to be healthy, to have skills, to have something to do, to be valued. These services are an investment in human capital, and that is part of that broader system. Agricultural productivity is the starting point, but all these things flow from it.

We need to think about the whole system as it works together, and particularly about absorbing rural people into urban areas, in ways that can enhance their quality of life, even if they are living in slums: often being among the urban poor is actually less bad for people than being among the rural poor. We need to be very aware of that. Obviously, we want to reduce poverty in both urban and rural areas, and improve the quality of life.

Already this conference has acknowledged how COVID-19 has made situations worse – in food security, for instance – and how we've been heading in some wrong directions recently. Figure 5 shows the share of population experiencing moderate and severe food insecurity, by region. You can see in 2021 that COVID had increased food insecurity relative to 2019. The data in this chart are from before the Russian invasion of Ukraine, and I think things would be looking more dire now, with the difficulty of exporting grain and the disruptions to production in both Ukraine and Russia, which are both major grain producers.

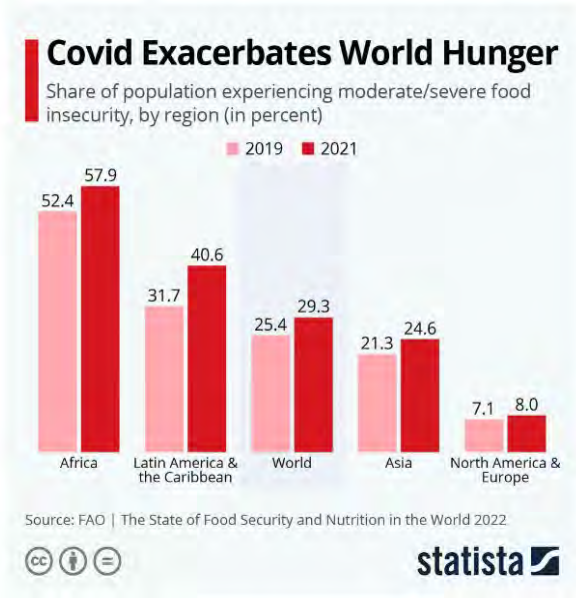


Figure 5.

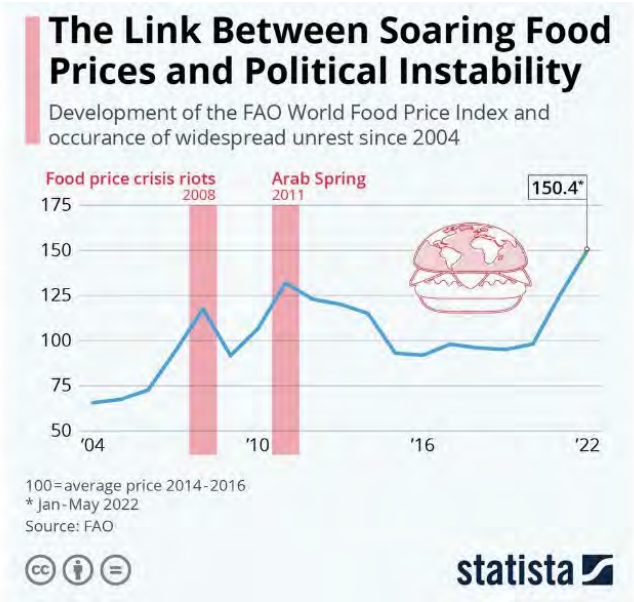


Figure 6.

The challenge in Figure 6 – an immediate challenge – is that link between soaring food prices and political instability. There are many reasons for food insecurity other than lack of agricultural productivity, but clearly food prices and political instability are highly correlated, so agricultural productivity does matter. Food security also depends on getting food to places, which then involves another system – transport. You cannot think about one without thinking about the other.

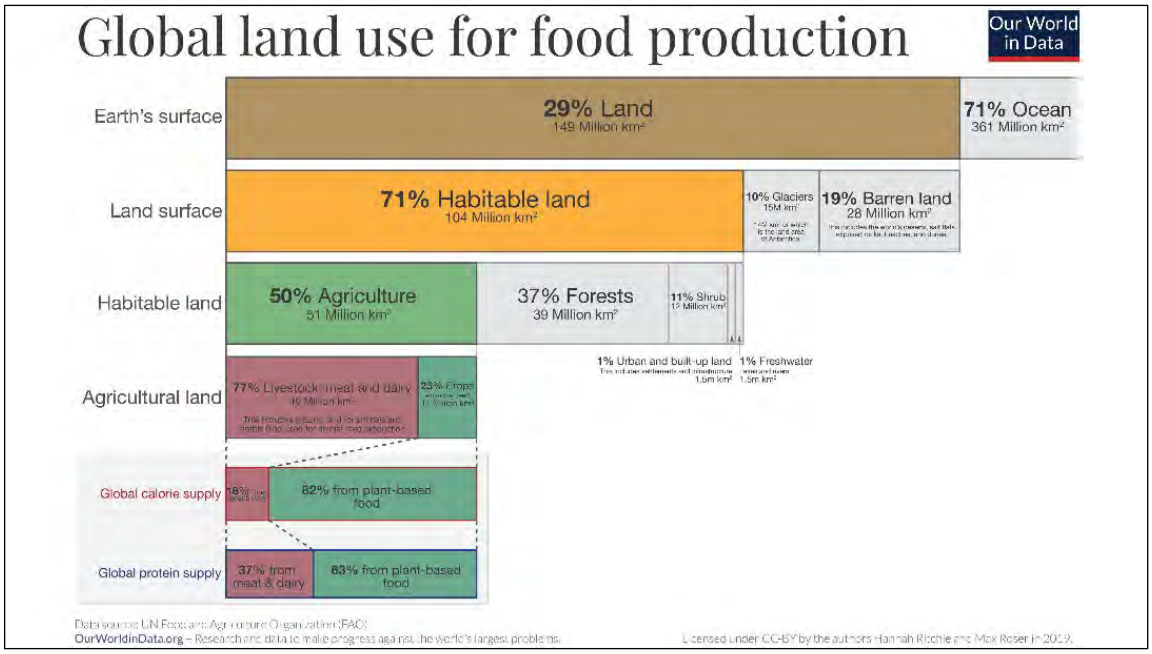


Figure 7.

Finally, Figure 7 explains why we must do agriculture well. In its work, ACIAR has been focusing not just on productivity and yield in actual farming and production, but also on the systems, such as the water systems. They are thinking about how to have more inclusive agricultural systems and food systems, and the environmental impacts as well.

Agriculture occupies 50% of habitable land, so if your agriculture is not looking after your environment, you really are not going to have a lot of habitable land in the future. We have been mining our environment since industrialisation, and that is leading to all sorts of challenges. We are going to have to start replacing the free environmental services we have had in the past with ones that we invest in ourselves. Doing that well is a research challenge.

Now is not the time to be satisfied with rather good agricultural productivity and think that we don't need to worry. Instead, we have a new set of problems that agricultural R&D is starting to tackle. For instance, how do we make a move away from monoculture?; how do we move to multiple plantings and diversify?; how do we use mangroves for multiple purposes, such as shrimp farming as well as protecting the coastal areas? These are just a few of the things we need to be thinking about for our research in the future.

We also need to use our scientific-based systems to enhance and understand the core reasons why indigenous knowledge is so valuable and how it can contribute to directing research in much more productive areas than would be researched otherwise. I think we are starting to see recognition of the value of that indigenous knowledge – not just in Australia, but all through countries that have surviving indigenous populations.

In summary, those are reasons why agricultural R&D matters for society, and why there are many social benefits from it.

Dr Jenny Gordon is an Honorary Professor at the Centre for Social Research and Methods, at the Australian National University. She is also a non-resident fellow at the Lowy Institute, one of Australia's leading think tanks on foreign policy. Jenny is a member of the Australian International Agricultural Research Centre's Monitoring, Evaluation and Learning Advisory Panel, and is on the Asian Development Bank Institute's Advisory Committee. Until recently Jenny was the Chief Economist at DFAT, joining DFAT in November 2019 from Nous Group, where she was the Chief Economist. Jenny spent 10 years with the Australian Productivity Commission as Principal Adviser (Research). Prior to this she was a partner at the Centre for International Economics (TheCIE). She has a PhD in Economics from Harvard University and started her professional career at the Reserve Bank of Australia.

A diversity of benefits – Q&A

Ms Jessica E. Raneri, HE Robyn Mudie, Dr Jenny Gordon

Chair: Ken Young

Q: David Gale

I am here today in my capacity as a member of RAID. My question is for Robyn.
I spent eighteen months at Can Tho University during my post-grad research and I was an Endeavour Scholarship recipient, so I have a sense of the soft diplomacy you are talking about. Thinking ahead, what do you think the next steps or the new approaches in this space are?

A: Robyn Mudie

Thanks very much for the question. Great to hear that you were at Can Tho. It was really inspiring to see that long-standing collaboration between Australia and Vietnam playing out in such a tangible way. I think the next steps in our science-based collaboration with Vietnam are the things that I mentioned that CSIRO is focusing on, and ACIAR as well, looking at high-tech agriculture and agricultural techniques.

Although not directly related to the agricultural focus, I did have the opportunity to go to Tram Chi National Park and to see CSIRO's work with artificial intelligence in monitoring and surveilling the wetlands and monitoring the patterns of migratory birds and water loss and other issues. The technology which is being embraced is an example of what Australia and Vietnam can do together and it has an adaptability into the agricultural sector.

One of the important things that we're doing with both ACIAR and CSIRO is looking at long-term sustainability of our engagement. The project that I mentioned in Điện Biên had strong support from the local government, and they were looking at taking on responsibility for the next phase of that project. That is where we should be aiming to put these activities into sustainable format for the future for Vietnam.

The science commercialisation I mentioned, which CSIRO is leading, is also very important, to make sure that all these tools of trade that we are giving them, and all the results of the collaboration, are going somewhere that will lead to sustainable results, connection to market and adaptability to the current circumstances. It's all about the future.

There is still a lot of work to be done in sustainable production for smallholder farmers, but the Vietnamese are very keen to partner with us. And I think that is where the soft power comes in, that we are seen to be partners for the future. We have been there in the past, we are here in the present, and we will be there for the long term – and that's really valuable.

Q: Helen Garnett, The Crawford Fund

You mentioned what was being done in Vietnam with regard to increasing salt and crops, and the tools. Last night in the Sir John Crawford Address we heard that salinity and issues like this are increasingly important in the Pacific Islands. I am always interested in how learnings in one country are being transferred across into implementation and sharing in other countries, and

so I am particularly interested in this case because I think the whole issue of increasing salt is really important. Vietnam is a very interesting country. Geographically it goes from the far north down to the south; it crosses a lot of temperature and agro-ecological zones. I would think there would be some learnings from that work to be shared, and I am keen to understand how that sharing is happening and who is doing it.

A: Robyn Mudie

I cannot answer in specifics because I haven't seen the detail of what ACIAR is doing, but I do know that our model of collaboration across many areas of agricultural development in Vietnam is one that ACIAR replicates across the region in many different countries, including in the Pacific. As I mentioned, that credibility and long-term engagement, and the ability to prove that what we have is useful for a particular country scenario and then to adapt it to the future and to adapt it to different challenges like salinity – that's where the 'value-add' really comes in, because we are a credible partner. We can approach a host government and talk to them about different challenges, and then take the results and show them the evidence of what we have achieved in other countries. I can't give you any specifics on whether the fantastic beetroot crops I saw at Can Tho University have been translated into the Pacific. But the essential idea was to take a new product, show the local population how to farm it, how to track the salinity, how to make it most productive, and how to build it into the market economy of that area. I would be surprised if we weren't taking that approach into other countries as well.

ACIAR is publishing an evaluation that looks at agricultural innovation platforms across a number of different examples, to try and draw out the lessons on what actually works, and then to embed them into future designs of programs. The challenge is, there are a lot of factors – such as the quality of leadership, the quality of the institutions that you are working with, etc. One challenge always is the sustainability of funding – being able to maintain resources to keep things going when the research part of the project finishes. Sometimes that means evolving from a research model to a different kind of model in terms of funding, which the development program at DFAT continues to look at.

There is a sense that you cannot just pluck one model that works somewhere and apply it somewhere else. It is not just that the R&D itself may be relevant in terms of the agro-ecology of the new place and the problem they are trying to solve; there is also their broader set of systems, and how you engage the decision makers. You need to build learning-based systems as well. The extent to which that learning is sustained and that other groups learn from those first groups is sometimes natural in an environment – and at other times you need to work very hard to create that flow. We are still learning a great deal about how to do this well.

Chair:

Sorry, we have run out of time. Please give another round of applause for our speakers.

BUILDING FOOD AND AGRICULTURE INNOVATION FOR THE FUTURE

Safeguarding future wheat

Dr Alison Bentley

CIMMYT Global Wheat Program; and
CEAT Agri-Innovation Fellow, Australian National University

The theme of this year's conference is 'Outcomes, impacts and the way ahead' for international agricultural research. Within this context, global wheat and safeguarding wheat for the future could not, arguably, be more relevant.

Wheat is eaten by 2.5 billion people globally (Figure 1). It is important that we also remember that 1.5 billion people who eat wheat around the world live in the global south. This is the region of the world where over 50% of the world's wheat is also grown, and it includes many of the most food insecure regions of the world. The recent impacts of the Ukraine–Russia conflict on global wheat have highlighted the multifaceted and multi-dimensional challenges that face our global wheat system, both in terms of securing our food security and for wheat as a geopolitical instrument.

At CIMMYT in Mexico we work to incorporate and accumulate genetic innovations to improve our wheat for the world. We also look to encompass and incorporate new innovations and new science and make them available to smallholder farmers. These innovations are not just innovations in science; they are also in the next generation of wheat and agricultural

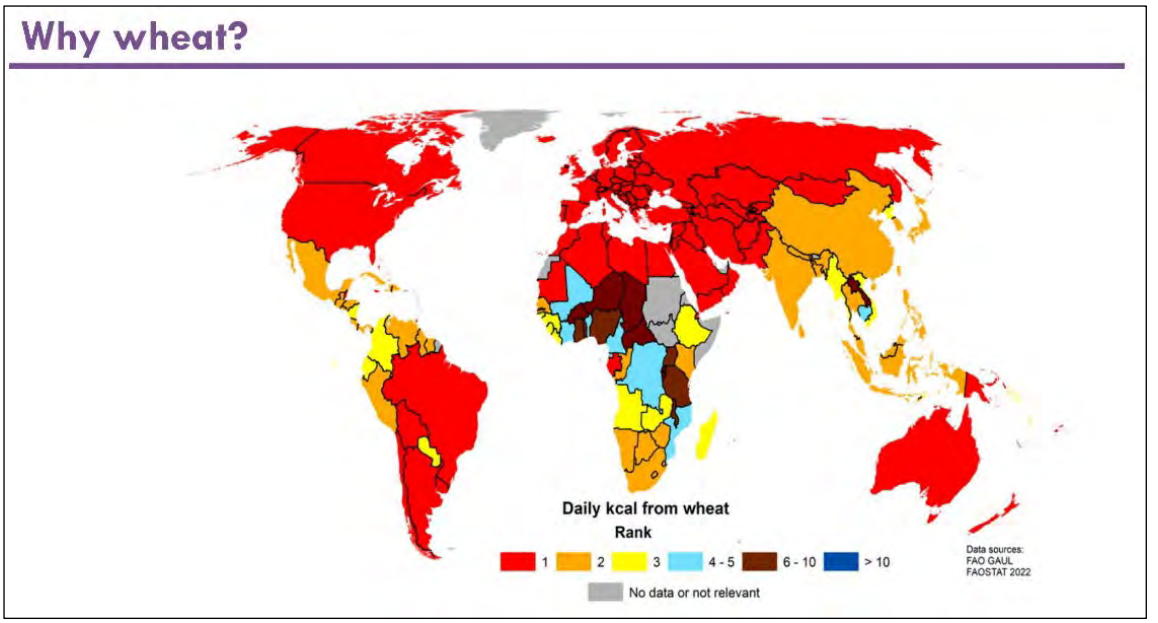


Figure 1. Wheat is eaten globally. (Map produced by Kai Sonder, CIMMYT.)

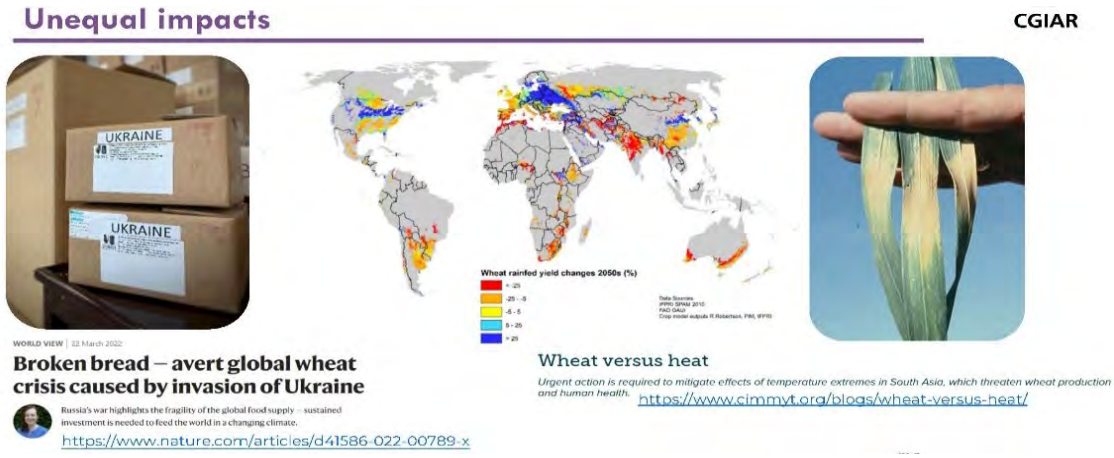


Figure 2. (Map produced by Kai Sonder, CIMMYT.)

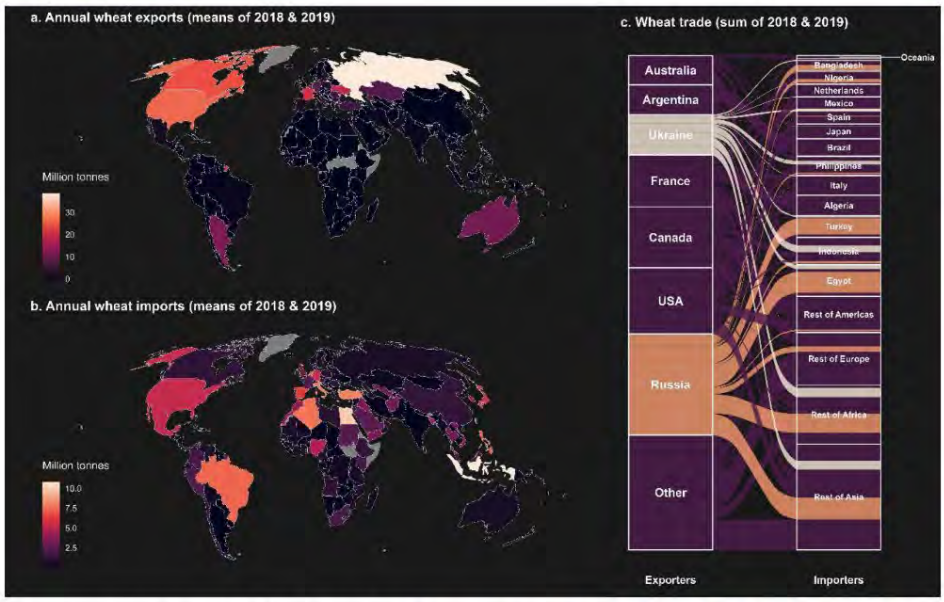
scientists. I myself was very fortunate to have my first experience of working in wheat in the international context as a Crawford Fund-sponsored scholar visiting the CIMMYT wheat program in Turkey in 2003.

Challenges to wheat production

We need to talk about unequal impacts (Figure 2; Bentley 2022a,b). We know that the current geopolitical challenges and the biophysical challenges that face wheat have great negative impacts, particularly in the global south. We have been highlighting the impacts of the Ukraine–Russia war on global wheat. They reveal inequalities that already existed due to much of the background to wheat production. We see huge impacts and huge vulnerabilities on food security in the global south as a result of this conflict. We can see this at the regional level; we can see it at the country level; and we can also see it at the level of the household. We know that, through gender inequality, females have greater responsibility for absorbing food shocks at the household level. Also, as wheat production changes and as the value of wheat production changes, there are significant gender implications on incomes and decision-making about agricultural and food production.

When we look at the biophysical challenges that face global wheat production, we can see from the forecasts of climate change that the effects are also likely to be most negatively felt in wheat-producing areas of the global south. We have recently highlighted the impacts of heatwaves in South Asia just before harvest, significantly reducing wheat yields; these had a real knock-on effect to wheat markets. We have also been highlighting that wheat requires rural populations, rural labour forces, to produce it, and that the impacts of heat and heat-related health disorders and health decline are very relevant when we think about how we adapt our crops to future climates. People need to be able to farm and produce cereals in these hotter, drier and more challenging environments. Therefore, we need to be thinking about some of these aspects of our research or breeding in a wider societal context.

Supply dependency



www.cgiar.org

Bentley *et al.* (2022) Nature Food https://doi.org/10.1038/s43016-022-00559-y

Figure 3. Ukraine, France, Canada, USA and Russia are major wheat producers.

We heard this morning, from Philip Pardey and others, about concentration: concentration in the spending of agricultural R&D; concentration in the funding of agricultural research for development. We also see the same thing when we look at the wheat market. The world relies on five major wheat-producing countries for most of its supply (Figure 3), and this has led to much of the vulnerability that we have seen in the market. Russia and the Ukraine are both in this group of the top five producers and exporters of wheat. We know from many examples that when we have this concentration, we introduce vulnerability into the system, and that is exactly what we have seen with the invasion of Ukraine. Many of the countries in the global south have for many years relied on Russia and the Ukraine and the other top three producers for cheap wheat. The availability of cheap wheat, readily available in a ship that sails across the world, has been underpinning a massive component of our food security.

Looking at these trends in supply dependency or the dependency on imported cheap cereals, we see that this is crucial to understanding the current vulnerabilities in Africa and Asia, which include many of the most food insecure countries of the world. This dependency on being able to buy and access cheap imports of cereals to underpin food security in some of these regions is projected to increase over time (Figure 4).

Proposals for practical action

At CIMMYT we have been proposing practical actions in response to the current wheat crisis (Figure 5). These range from short-term mitigation of the food security impacts of the current crisis, through to a longer-term view on what can be done to build greater resilience.

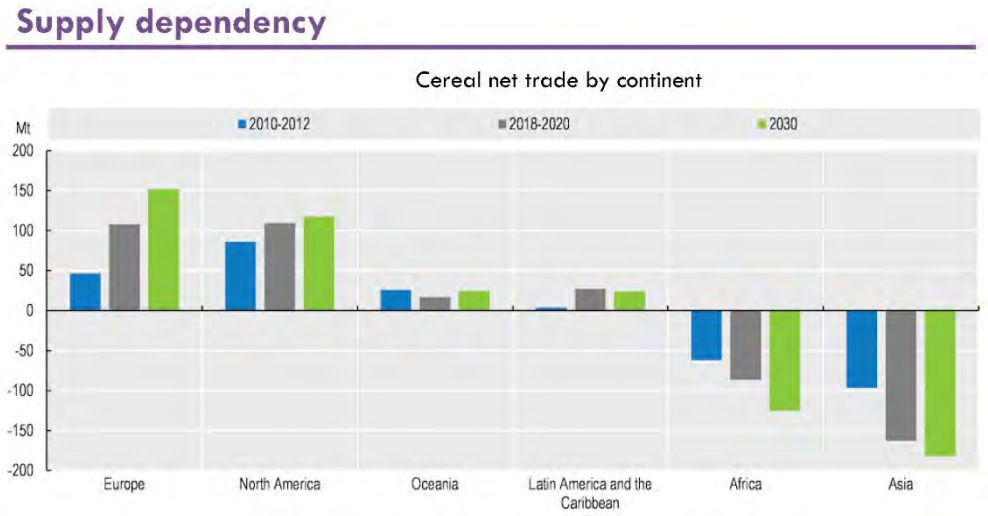


Figure 4. *Source:* OECD-FAO Agricultural Outlook OECD Agricultural Statistics 2021.

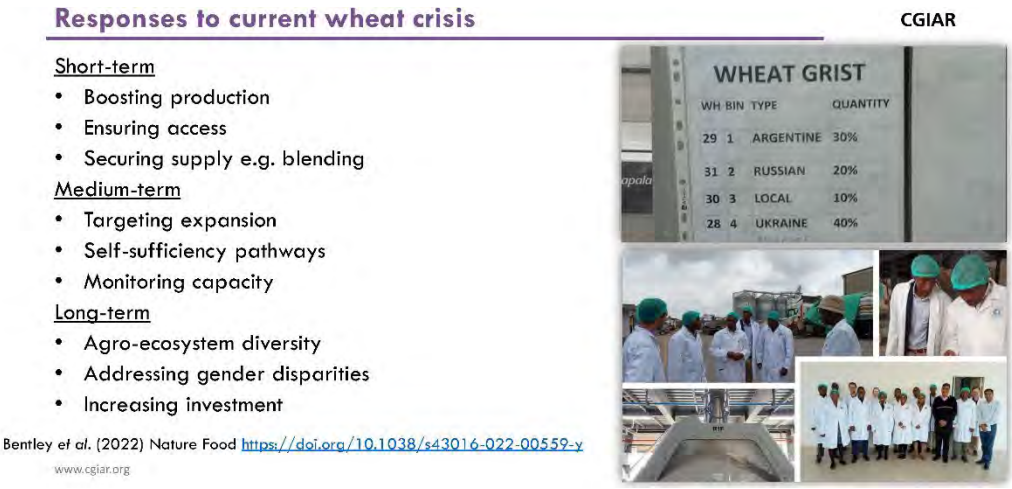


Figure 5.

In the short term, proposals include boosting production, market controls and ensuring access, as well as securing supply. Supply issues are very noticeable in East Africa, where no wheat imports into the port of Mombasa represents a significant food security threat. If you visit one of the largest mills in East Africa, you see on the wall the composition of the wheat grist – the wheat flour that sustains much of Africa's urban and peri-urban population, which is growing rapidly. It shows their current reliance on 60% of their wheat from Russia and the Ukraine. That absence represents a very significant deficit in the supply that is available now, today, to feed and to secure the livelihoods of those populations.

In the medium term, we suggest actions targeting expansion, supporting self-sufficiency pathways through bundled packages of plant breeding, agronomy and policy, as well as monitoring capacity. What if all the PCR machines that were requisitioned for COVID-19

testing were turned into a capability for genomics-based surveillance of pests and pathogens in crops and crop products that move across the world? There is great potential to scale-up the monitoring of crop production and the monitoring of biosecurity hazards as crops and commodities move across the world.

In the long term, there needs to be a focus on achieving agro-ecological expansion within the boundaries of the system. We also need to think about how to address gender disparities that we know exist in agricultural production systems. And there needs to be increasing investment, instead of investment that is 'firefighting' from one crisis to another; that is, sustaining investment in agricultural science as a foundational component of global food security.

CIMMYT global wheat improvement

At CIMMYT, we are very focused on the biological and genetic aspects of wheat improvement. We work on accelerating the generation of new genetics and making those available across the world. We also go 'upstream' from this, looking at the genetics that might be needed in the future as environments become hotter and drier, searching out the traits that need to be incorporated to build climate adaptation (Figure 6).

At the other end of the spectrum, CIMMYT has programs looking at the consumer and the farmer – trying to understand their changing demands so we can better design wheat genetics and biology to match those future needs. For that, we are using some innovative concepts such as video product concept testing, a method commonly used in the design of consumer goods. We are trying out the same testing approach for seed, to understand what people want now as well as what they are going to want in the future. We are examining consumer

Figure 6. Some aspects of work at CIMMYT.

demand, patterns of urbanisation, and how consumer demands are changing, and how, as geneticists, plant breeders and agronomists, we can satisfy these changing needs.

CEAT innovations In Australia

In my work with CEAT, the Centre for Entrepreneurial Agri-Technology at the Australian National University, through an Agri-Innovation Fellowship, we are also looking at innovations from different sectors. As we have already heard at this conference, many agricultural innovations have come from outside the agricultural innovation space.

For instance, we are considering ways to accelerate the rate of developing new seed varieties. Vaccines that used to take ten years to develop were available in a year for COVID-19 through, obviously, large investment, and also through parallelisation of many of the processes. A seed variety takes ten years to develop, so we are examining if any of the learnings from COVID-19 vaccine development can be applied to the development of seed varieties. What if seeds were vaccines? Could we make this possible? Are new innovations possible when we look at these processes and the building blocks of what we know has been achieved for COVID 19?

With CEAT we are also looking at the use of alternative financing and technology products to disseminate seed in places where no formal seed sectors exist. In countries such as Afghanistan, where wheat is a hugely important component of food security, it is very difficult to move seed and track the uptake of seed varieties because of the lack of a formal seed sector. Can we use blockchain technology to enable the movement of seed to farmers, and to reach the most inaccessible areas of those countries?

Supporting greater diversity in crop sciences

At CIMMYT we strongly believe in supporting the next generation and this really resonates with the work of the Crawford Fund and many of the activities in the CIMMYT program.

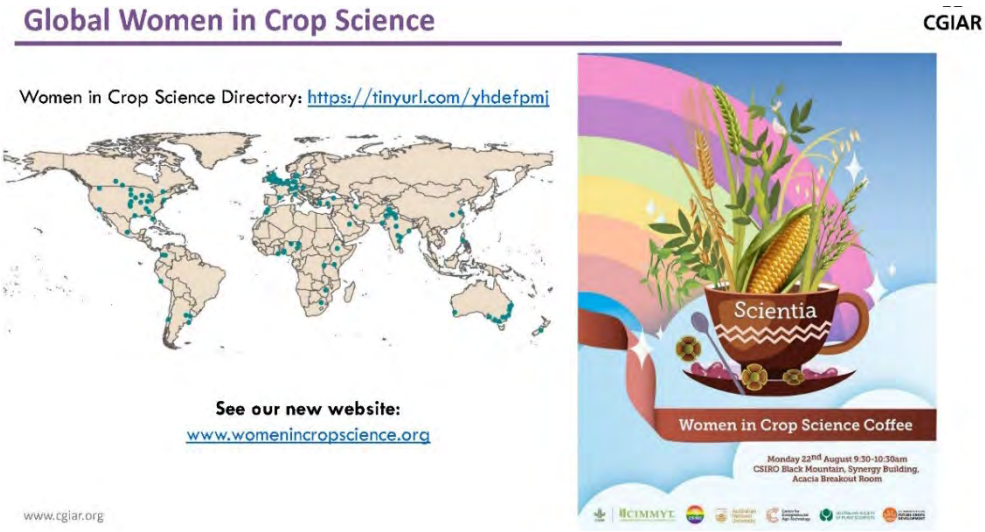


Figure 7. Global Women in Crop Science, www.womenincropscience.org

I want to highlight the coming together of the Global Women in Crop Science community (Figure 7), which has now developed a directory of women working across the crop sciences. I encourage people to join. We have launched a website and are trying to support the community in this space and build resources and a more equitable future.

The future for wheat

In summary, I believe that the future of wheat, and safeguarding wheat and the way ahead, involves collaboration, innovation and the coming together of diverse communities and ideas, to ensure future impact.

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Dr Alison Bentley is the Director of CIMMYT's Global Wheat Program, based in Mexico. Her research combines genetics and genomics to develop and deliver new tools and technology to improve plant breeding, crop production and adaptation to climate change. At CIMMYT, Alison leads a team of scientists using scientific approaches to develop improved wheat germplasm. This germplasm captures packages of traits providing productivity, resilience, and broad adaptation, supporting global wheat improvement and smallholder livelihoods. Prior to joining CIMMYT in November 2020, Alison worked in the UK, focused on translation of fundamental scientific breakthroughs into tangible impacts for the agri-food sector. She has a doctorate in agricultural science and PhD in agriculture from The University of Sydney, Australia.

RNA-based biopesticides for sustainable agriculture: BioClay™ technology

Professor Neena Mitter

Director, Centre for Horticultural Science, Queensland Alliance for Agriculture and Food Innovation; and
Director, ARC Industrial Transformational Research Hub for Sustainable Crop Protection, The University of Queensland

This talk is about RNA-based biopesticides for sustainable crop protection: the BioClay™ platform innovation, which is a specific innovation with a broader impact. We started working on RNA sprays for crop protection about ten years ago – an innovation that may have been an agricultural genesis for today's RNA-based vaccines for COVID-19.

We have been reminded – both by Dr Audrey Aumua yesterday, and again by today's speakers – about the significance of plant health for food and nutritional security. We do need pesticides to protect our plants from crop losses. However, there are issues, such as resistance, residues, runoff to our precious waterways and the significance of the blue–green economy, and also the issue of lack of specificity. We do not want to harm our beautiful butterflies and bees, yet new chemicals are hard to find. There are now also global imperatives, with the European Green Deal in 2020 setting a target of 50% reduction in pesticides by 2030.

Within that landscape, we need innovative tools to grow safe food. I am not saying we can find a silver bullet. However, we can look for integrated pest management strategies, and develop tools that resonate with sustainability and that show some responsibility towards the planet.

For me personally, a trigger to working on RNA-based crop sprays was the news in 2013 that 25 children in India died after consuming a community meal that had toxic pesticides. Things like that do happen, and we need to look for solutions.

When I started work on RNA sprays, there were already people working on RNA sprays for crop plants. However, there were problems: RNA is a very fragile molecule, highly unstable, and it gets washed off by rain, so the protection window was lasting maybe only 3 to 5 days. The challenge we took on was how to convert these RNA sprays into a system that is commercially viable for farmers, that is environmentally friendly and non-toxic to humans, is stable, sticks to the leaves but has no residue, is not washed off by rain, is easy to adopt, and protects for more than 3 to 5 days. In other words, a system that can be translated for adoption, and which can make a difference on the ground – all features that will make it more viable. And that is where the concept of BioClay was born. 'Bio' in BioClay™ is RNA, which is the biologically active ingredient, and the clay particles are the carriers of the RNA, in a way that provides the spray with all those advantages and features that we were looking for.

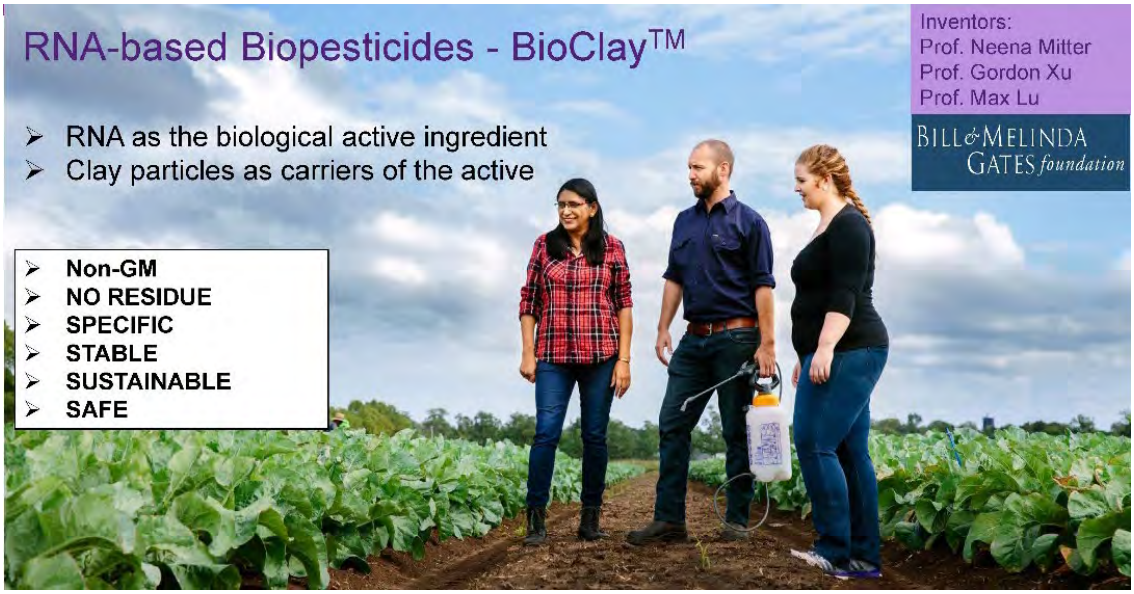

Figure 1. Prof Neena Mitter, Dr Karl Robinson and Dr Elizabeth Worrall.
Photo: The University of Queensland ©

This idea was first funded by the Bill and Melinda Gates Foundation (Figure 1). Later on, Nufarm Australia Ltd joined as an industry partner and we received funding from the Queensland Government followed by other multiple grants from Rural Development Corporations and the Australian Research Council. The team has published in *Nature Plants*, and the young leaders have gone from strength to strength, which resonates with the theme of this conference – that we need to support the flagbearers of tomorrow.

BioClay™ and progress so far

The clay, as I mentioned, is just an inert clay: it is just magnesium and iron, and the RNA is the biological active. The clay particles are positively charged; the RNA is negatively charged. You mix the two and you get BioClay™. The spray does not alter the plant genome, and the clay layers degrade naturally, leaving no residue. BioClay is stable enough for slow release of the dsRNA on the plant surface. The important point is that the RNA in this comes from the pest or pathogen itself, to kill the pest or pathogen. It is almost 'nature versus nature'. I will not go into the details of the science of the RNA interference technology.

Here is a brief snapshot of the progress we have made with BioClay over the years. We started working with vegetable crops. Figure 2 shows capsicum plants sprayed and unsprayed. It works! This was our first system, and we were very excited.

We then moved to other viruses. Zucchini yellow mosaic virus (Figure 2) was a learning curve for us when we transitioned from the lab to the field. I still remember the phone call from my post-doc saying, 'Neena, do you know how big zucchini grows in ten days in the field? They are really huge plants. I never thought it would grow like that. We need to optimise our dose and spray regimes.'

That experience highlighted that it is very important to bridge that gap between lab to field – and the engagement with growers and the engagement with industry partners – right up front, to have success.

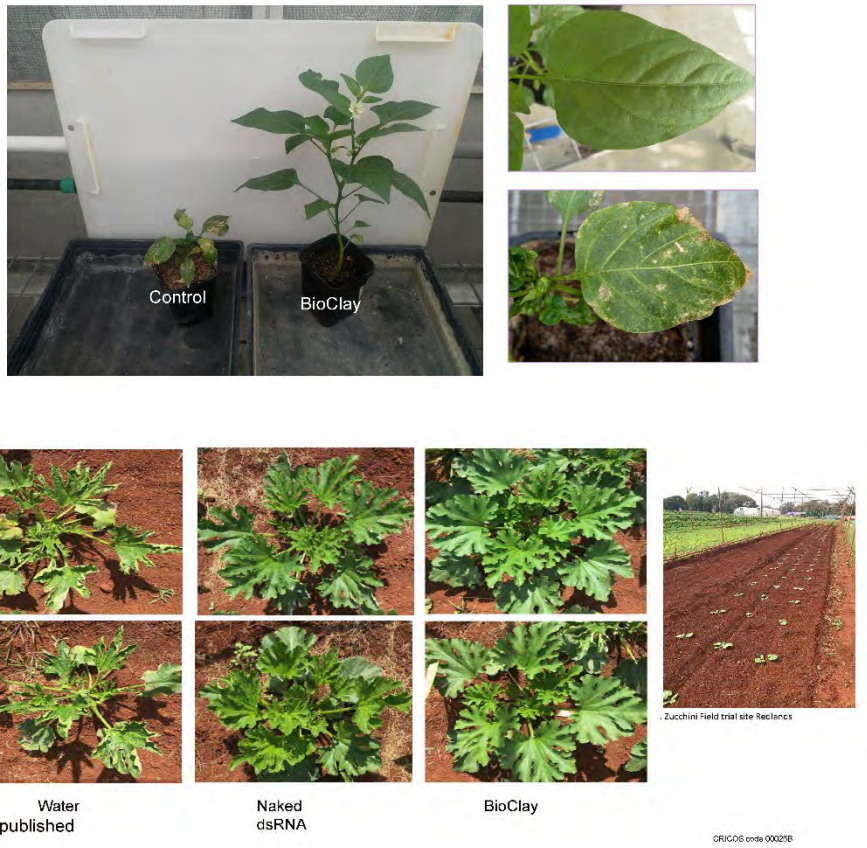

Figure 2. It works! *Top:* Tomato spotted wilt virus in Capsicum. *Below:* Zucchini yellow mosaic virus.

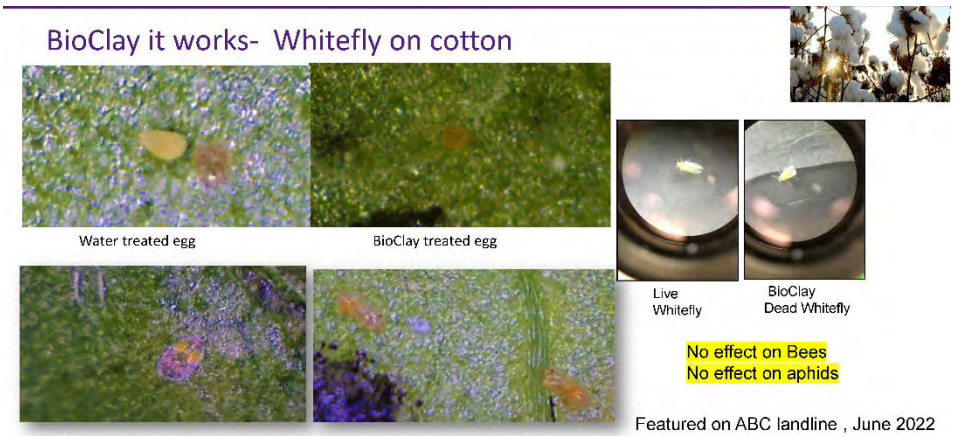

Figure 3. BioClay™ targeting silver leaf whitefly

We have now added work on insect pests, such as whiteflies on cotton (Figure 3). We find that BioClay can target not only the adult whiteflies but also multiple stages of the lifecycle of whitefly. This was research by a PhD student who was a Crawford Fund scholar in 2019, and he also has published in *Nature Plants*, and been named as inventor on patents, and the work was featured on ABC *Landline* in June 2022. This is another example of how important it is that we inspire young researchers to take up these innovative concepts, work through all the problems and challenges, and succeed ready to take on new challenges.

Figure 4.

We are also looking at fungi because fungal diseases are highly significant. We have an Australian Research Council Research Hub, and our team of three who started the work on BioClay is now a team of 50! (Figure 4). It is through collaboration, through partnerships, that the BioClay work has progressed the way it has, in partnership with Nufarm Australia Limited and multiple Rural Development Corporations such as Horticulture Innovation Australia, GRDC, CRDC, Wine Australia, and other academic and government partners across Australia and internationally. It also brings support from the Department of Agriculture and Fisheries, Queensland. For fungi, we are working on some of the key crops, based on industry feedback: *Sclerotinia* in canola, *Verticillium* in cotton, *Botrytis* in grapes, chickpea and strawberries, and

Figure 5. Chickpea

Fusarium in wheat. I can tell you (this is 'hot off the press'!) that we are getting early success with *Botrytis* on mature chickpea plants, where once again BioClay provides an extended window of protection (Figure 5).

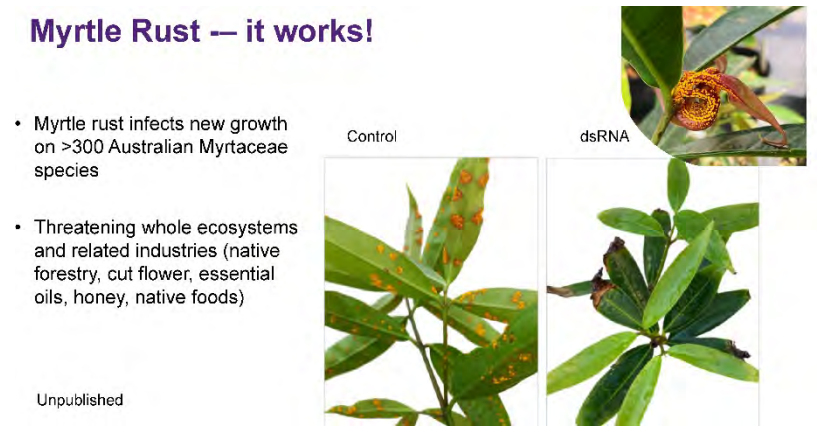

Figure 6.

This has also inspired some of the young girls in our team specifically to look at BioClay for tree crops. One of the senior postdoc researchers and her PhD student are looking at myrtle rust – a very significant issue for multiple Myrtaceae species, and we are getting some very nice early success (Figure 6), though there is still a long way to go.

The important part is that when we design this process, we believe in co-designing and co-creating it with industry partners. Our ARC Hub (Figure 7) does not just talk about science; it talks also about scaling-up as one of the themes for RNA and clay manufacturing; and it takes into account the registration and the regulatory components of the work. Most significantly, we have a team in the Hub to consider social licensing. An entire project team focuses on how we will engage with the growers; how we will engage with the consumers; what will be the adoption issues. That becomes part of this Hub's translational process as well.

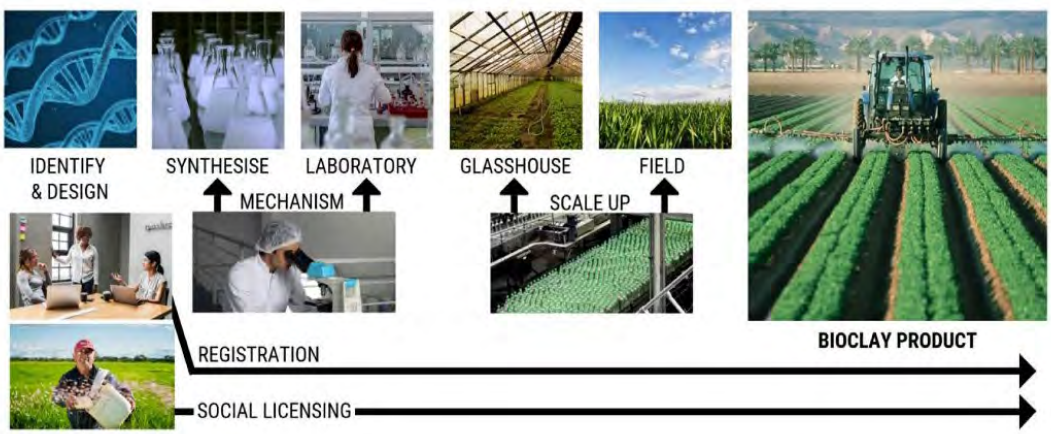

Figure 7. The Research Hub process.

On 8th October 2019 the Australian Parliament formally agreed with the Office of the Gene Technology Regulator's proposal that topically-applied dsRNA be exempt from GMO regulations

Gene Technology Amendment (2019 Measures No. 1) Regulations 2019

24 Schedule 1A (at the end of the table)

Add:

11 Introduction of RNA into an organism, if:

(a) the RNA cannot be translated into a polypeptide; and

(b) the introduction of the RNA cannot result in an alteration of the organism's genome sequence; and

(c) the introduction of the RNA cannot give rise to an infectious agent.

Figure 8.

In relation to GM regulation and policy, the Office of the Gene Technology Regulator has now passed legislation, that topical application of RNAi is non-GM (Figure 8). That is a big step. It means BioClay™ does not require any deregulation here. It is also the case in USA. We hope that Europe may decide similarly, sometime in the future.

For trade and markets, the decision is helpful, as it means short or nil withholding periods for produce for sale in domestic markets, and short or nil intervals before export (to satisfy standards imposed by overseas trading partners). It gives BioClay™ treatment the possibility to be used more widely, which has implications for value chains, and food security, and the future consumer as well (Figure 9), because the consumer of today is very conscious about provenance, looking at the credentials of food production. That will affect the cost-effectiveness, and the wider reach of the BioClay™ platform as well.

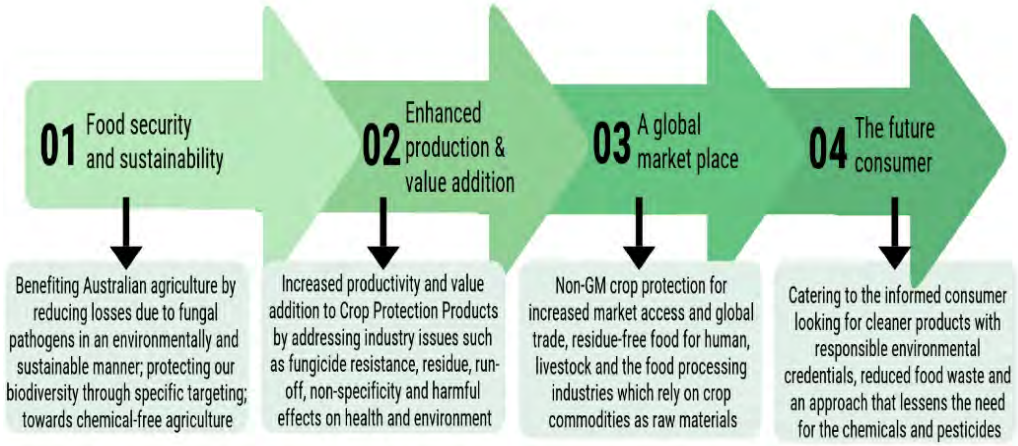

Figure 9.

We are looking at biosecurity issues. We are even investigating animal health with BioClay™ treatment – it appears to have a wider reach, which we can tailor (Figure 10). It may not work for everything, but at least we can try a range of applications and see which ones work. The key thing is that regulation, policy and public opinion are crucial in this area of research. There is still a way to go to develop BioClay as a product and make it a reality.

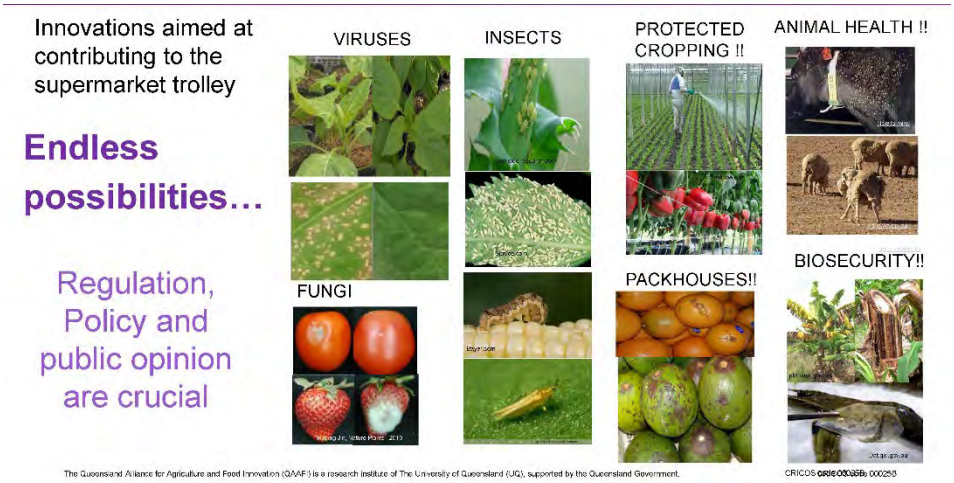

Figure 10.

Acknowledgements

Thanks to everyone who has now worked with us on the BioClay team. It takes a village to grow those innovations, and I am very proud that we have built that village.

Professor Neena Mitter is the Director of the Centre for Horticultural Science at QAAFI (Queensland Alliance of Agriculture and Food Innovation), at The University of Queensland (UQ), and the Director of the Australian Research Council Industrial Transformation Research Hub for Sustainable Crop Protection. Her career and passion for delivering real world outcomes have received recognitions such as Fellow of the Australian Academy of Technology and Engineering, 2021 Pravasi Fellow of the Indian National Academy of Agricultural Sciences, Australian Women in Technology Outstanding Life Sciences Award, and Gates Grand Challenges Explorations Award. Professor Mitter has over 120 publications and has supervised >20 PhD students. She is globally renowned for her leadership of innovative platforms: namely, 'Environmentally sustainable BioClay platform for crop protection' and 'Clonal propagation of avocado using plant stem cells'. These are ground-breaking platform technologies influencing agricultural production, environmental sustainability, and socio-economic dynamics of farming communities. Professor Mitter is also championing a UQ wide initiative on 'Protected Cropping for Tropics and Subtropics'. With increased scrutiny on use of chemicals as crop and animal disease control agents, Professor Mitter is focused is on developing clean technologies for the agriculture of tomorrow. As Chairperson of UQ Cultural Inclusion Council and Deputy Council member of the Australian Human Rights Commission Leadership Council on Cultural Diversity, Professor Mitter is at the forefront of diversity and inclusion initiatives.

Innovations for extension: a case study from Pakistan

Dr David McGill

Faculty of Veterinary and Agricultural Science, The University of Melbourne

I am very happy to be here and proud to be speaking to you on behalf of our wonderful team of researchers in Pakistan and Australia. It was about 15 years ago today, plus or minus a few days, when Peter Wynn, my boss at Wagga Wagga, came with me to Pakistan for the first time. We were scoping out a project there. Not long after that I went to work in Pakistan for two years, living in Lahore, and it was an amazing experience. It was the hardest thing I have ever done, being a risk-averse person, but it was awesome, and though I did not realise this at the time, it had a massive and profound impact on me and where I was at in my life, and on my understanding of research for development. Living there also was a critical step for our project, with important impacts on our understanding about the people that you work with in Pakistan, and the country itself. There is great complexity in the politics and the provinces and the different organisations that have roles in extension in Pakistan.

I hope to give you a few insights about what we did, and share a few lessons from some of our social researches that taught me and our Pakistani team a lot about extension and about innovations for extension.

Figure 1. Typical smallholder farming in Pakistan; our projects; and defining 'extension'. *Photo: Conor Ashleigh.*

We were lucky to have three projects follow one after the other (Figure 1). There has been real continuity and momentum in them because of that, and also because I and Peter Wynn and Hassan Warriach have all been working on those projects for the whole 15 years. It meant we did not need to spend the first year or two of each project trying to get all the knowledge out of one head into the next head. That made a big difference in what we did.

Our team was able to build on understanding the context of the smallholder farming system in Pakistan, where they had only a few animals. Although milk production was small, those animals and that milk supported quite large households, and were extremely important to 9 million smallholder farming families and to the livelihoods there (Figure 1). We knew that basic information when we began work.

When we started in our first project, we focused on on-farm challenges and on understanding the gaps in information in the local context, and on understanding what information was flowing and where it was flowing to. Then in our second project, we looked more at the extension system and what information was getting to the smallholders. The challenge that came out of that work, which was really highlighted by our Pakistani team there, was that although information was flowing – maybe not to everywhere – there were gaps, and in particular it was very difficult to engage with the smallholder farmers and build relationships, especially with women. There was an extra layer of social norms about whether women could come to meetings and have access to that information.

In our third project we were joined by the social research team from the University of Melbourne, and they added massive value – enabling us to expand on the knowledge we had already gained. The team had social research experience from Australia and elsewhere, and they helped us to understand extension and the extension system, really value-adding to what we were doing there.

For anyone who has not worked in extension, Figure 1 has a short definition. Extension is about understanding what the agricultural problems or issues are, and working with farmers to try to innovate or find a technology to try to address those issues.

Figure 2 gives a snapshot of the shifts in theoretical perspectives on extension that have happened over time. This is all from the theory. If you worked in extension in the 1980s or 1990s, maybe you are familiar with the technology-transfer approach. It is a very linear style of communication, with the scientists being the innovators and the farmers being the adopters. Since the year 2000, the approach is much more about an agriculture innovation system. It is much more participatory; it is about facilitated process; and there are more organisations involved. Instead of the government being in charge of it, the extension system is now much more pluralistic, with not only the scientists being innovators but also the farmers being involved in that innovation process as well.

In Pakistan, extension still uses a linear style of tech transfer. It is pluralistic – that is, there are lots of organisations involved, including non-government organisations (NGOs) as well as government, but the government has a more major role. Private NGOs are starting to do more, but it is still very much government-led.

Shifts in theoretical perspectives

Regarding supporting agricultural innovation. Source; Klerkx *et al.* (2012)

Characteristics	Transfer of technology / Diffusion of innovations	Agricultural innovation systems (AIS)
Era	1960s	From 2000s
General approach	Linear style of learning	Participatory approaches with facilitated learning
Organisations	Government lead	Multiple organisations; pluralistic
Mental model & activities	Supply technologies through pipeline	Co-develop innovation involving multi-actor processes and partnerships
Role of farmers	Adopters	Partners, innovators exerting demands
Role of scientists	Innovators	Partners, innovators responding to demands

Figure 2. Shifts in theoretical perspectives regarding supporting agricultural innovation. *Source:* Klerkx *et al.* 2012.

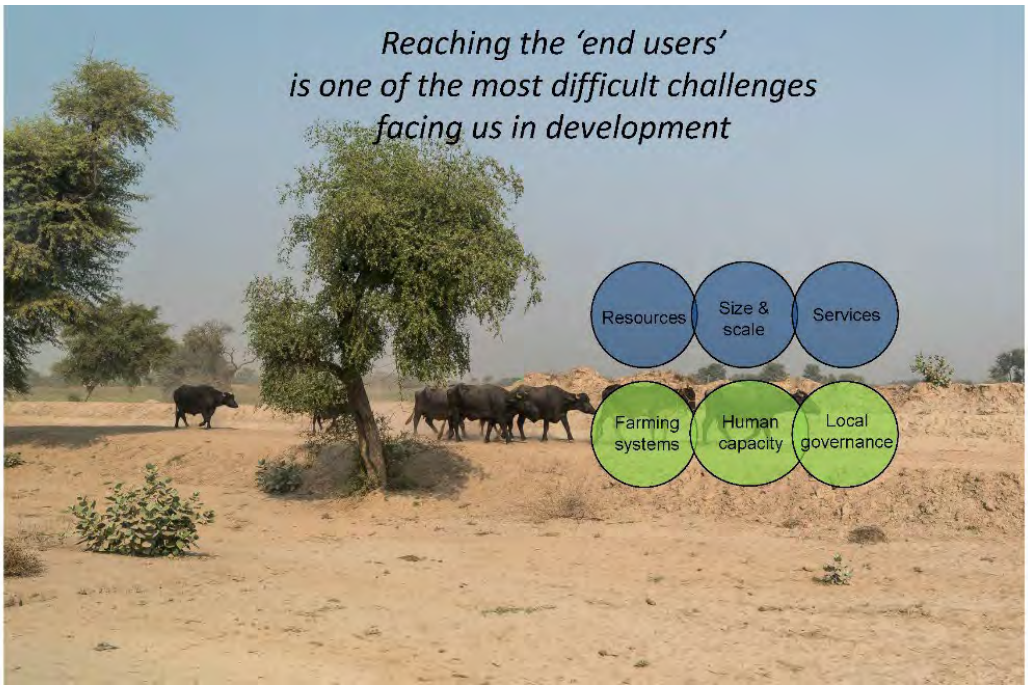

Figure 3. Some of the challenges and issues of working in the smallholder farming system in Pakistan. *Photo: David McGill.*

Figure 3 suggests the size and scale of some of the challenges you have to deal with and the issues that occur in the smallholder farming system in Pakistan. The climate is very hot – the photo shows animals dealing with that hot climate – and there are resources that differ across the country, across Pakistan. There are various sizes of farms and different scales of things happening, and there is also a range of services in all those different locations. On top of that, if you are trying to work within that system, you need an understanding of the variety of those farming systems, and the variety and the differences in human capacity across those different areas, and also of the local governance of the services that you can work with so as to be able to work with the smallholder farmers.

In the second phase of our project, our team used an approach called 'the Whole Family Extension Approach' (WFEA) (Figure 4). Our innovation was in getting the team to co-design and build the idea of working with farmers, and building and establishing relationships with farmers including women and if possible the whole family. The approach was mainly based on good extension principles and on having a combination of technical information, and ideas about social mobilisation, and training farm advisers to go out and build relationships with farmers. A critical component of this was that the WFEA explicitly stated that it was important to engage with both men and women farmers, and we made sure we were supporting both male and female farm advisers to be active where they could be.

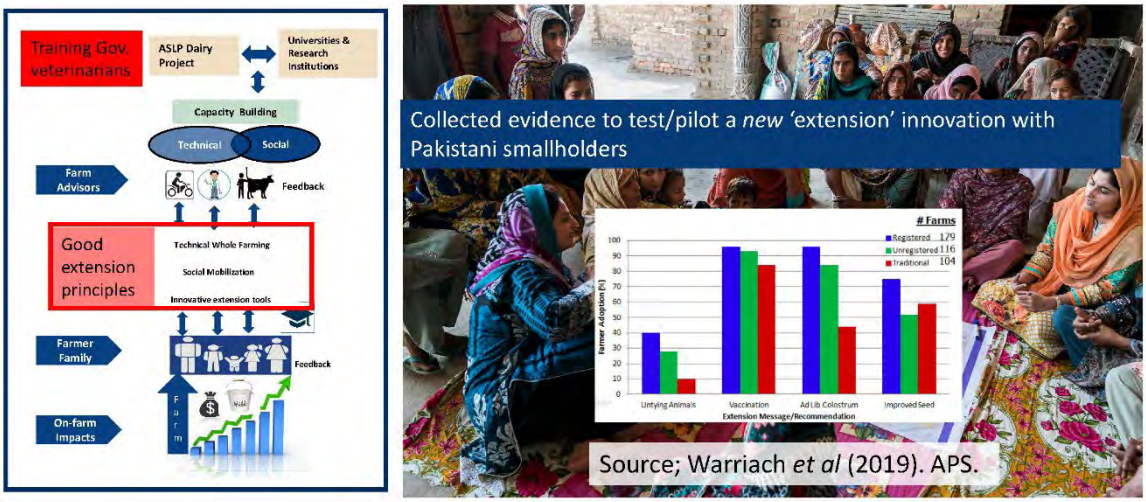

Figure 4. Our innovation: the Whole Family Extension Approach (WFEA).
Photo: Conor Ashleigh.

We applied this approach and tested it with the government organisations there – who were primarily veterinarians – but our team members were heavily involved in collecting impact and evaluation data to assess if the approach worked in Pakistan. And it worked! That was the outcome of the second phase of the project.

When we moved into the third phase with the social researchers, we worked with that WFEA that we had tested in the second phase, and we took it out to the whole Pakistan extension system, including all the organisations that wanted to be involved (Figure 5).

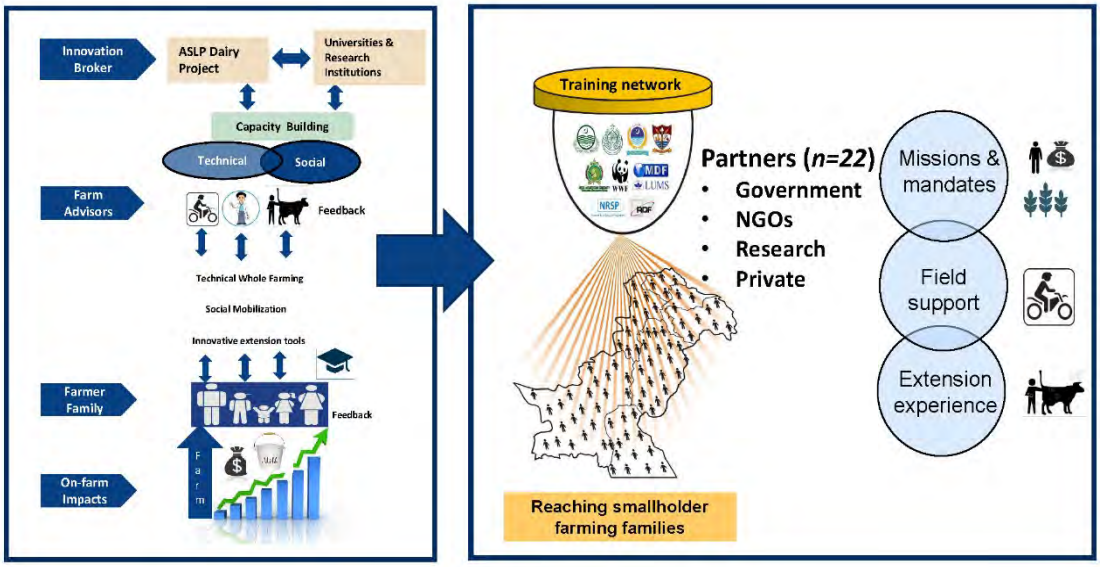

Figure 5. WFEA (left box) flowing to the Pakistan extension system (right box).

There were 22 different organisations, including some in the government, some NGOs, some private sector organisations and some research organisations, and we encouraged them to be part of the program. To work with all those different groups we needed to understand that, naturally, they had different missions, different mandates, different field support, and different extension experience. For example, an NGO might have great community-development experience. By contrast, the government groups, particularly in Pakistan, were mainly vets doing veterinary work, which is still a good part of the extension system. We wanted to get those people to learn from each other. I would like to highlight the social research team doing this work, led by the Rural Innovation Research Group at the University of Melbourne: Dr Margaret Ayre leading, with Professor Ruth Nettle advising, and Dr Kaitlyn Height doing a lot of the legwork.

Our major interventions were at the farm adviser level. The project team in Pakistan all put a lot of effort into training farm advisers, with Hassan as the local leader. We trained 50 farm advisers across those 22 organisations. The social research team emphasised the importance of working with the organisation managers as well, and of having a Community of Practice at the extension manager level. Rather than just training the farm advisers our group was also training the farm extension managers, so that they could be getting feedback about what was working in the field. Our team was doing field mentoring visits as well, and that feedback loop connected the organisation managers so that they knew what was happening and what was or wasn't working (Figure 6).

The Community of Practice and the training workshops were run to build learning networks and to support innovation (Figure 6). Our aim was not for our team to do the innovation themselves, but rather to support those other organisations to innovate, using the ideas and

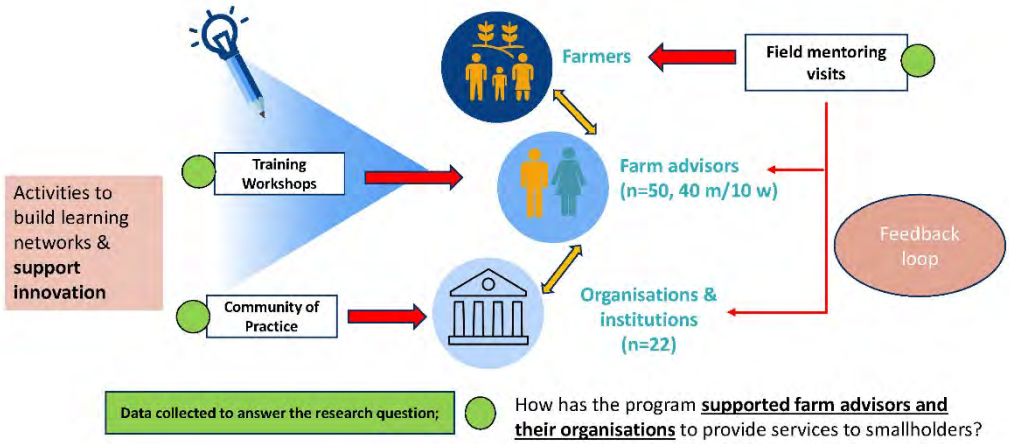

Figure 6. Project interventions, at three layers.

technology our team was sharing or brokering with them. A new publication has the qualitative results from this work (to be published in late 2022).

We collected a lot of data about impacts at all the different levels: farm adviser level, farmer level, and organisation level. Figure 7 summarises the qualitative results.

One of the key learnings for me was that via those networks at the farmer level and the farm adviser level and the organisation level and extension manager level, these people were able to get together and to learn from each other. That kind of collaboration is important and is needed to support our innovation. It takes the lessons that we learned into those other organisations for the future.

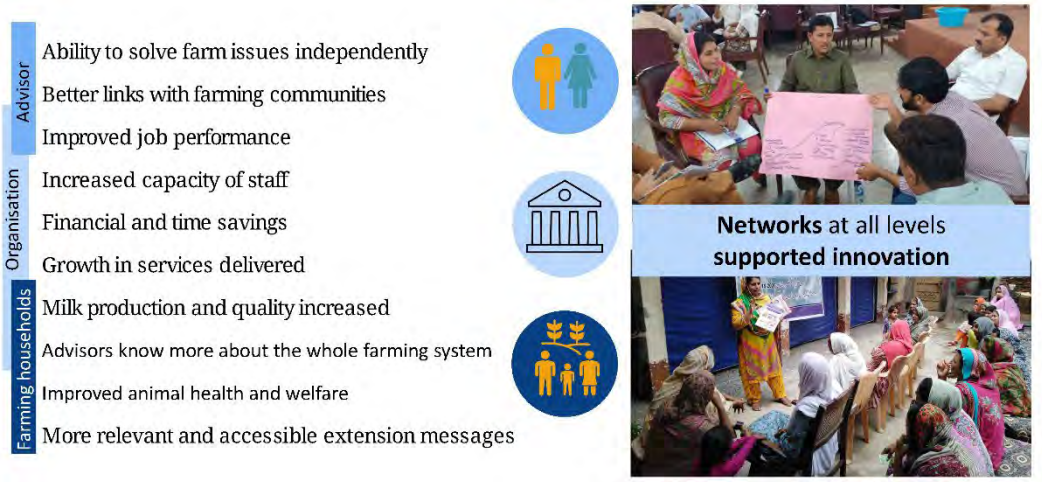

Figure 7. Qualitative results from case study data. *Photos: Conor Ashleigh.*

Thank you to ACIAR for funding these projects, and to our Pakistani team members, and to the smallholder farming families we work with.

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David McGill is Senior Research Fellow in the Faculty of Veterinary and Agricultural Sciences at the University of Melbourne. He is a founding member of the RAID network, and currently a Crawford Fund (VIC) committee member, and he has been part of the coordinating team for numerous Crawford conference scholars' days. He has been working in the international livestock research for development space for over 15 years. David was initially given an opportunity to work in Pakistan, managing a research project focused on dairy extension. This led to a three-year role based in Lahore coordinating research activities, data collection and capacity building of local employees and field officers. The success of this program led to additional funding, which built on the previous work and incorporated research using a farm systems approach for smallholder households and co-designed a whole-family approach to extension. His more recent project is evaluating how these new extension technologies and approaches can be integrated within the larger innovation system. Some videos which explain the work that David and his wonderful team in Pakistan have worked on can be found here.

Building food and agriculture innovation for the future – Q&A

Dr Alison Bentley, Professor Neena Mitter, Dr David McGill
Chair: Dr Gabrielle Vivian-Smith

Chair

Thank you to our three speakers Dr Alison Bentley, Professor Neena Mitter, Dr David McGill, who are now our panellists in this Q&A session. We have about ten minutes for questions.

Q: Ravi Khetarpal, APAARI

Thank you. First of all, those were amazing presentations by all the three speakers. I have a specific comment for Neena about the shelf life of the BioClay RNA spray which is going to be a biopesticide. I am keen to know if you have tried it in the IPM program, Integrated Pest Management, so far. Why am I saying that? Because we have a big project with biopesticide where we have found that if you do the spraying with a biopesticide which does not have a residue, then it reduces the MRL [maximum residue limit] value and you make your product exportable. So that is where I see the future of the BioClay there, where you have a potential for export, if that works out, and we will be happy to partner with you on that. Thank you.

A: Neena Mitter

Thank you, Ravi. In terms of your first comment about shelf stability, yes that's one of the very critical components. Our aim is that this BioClay or a concentrated suspension product should be shelf stable for at least one year. Also, we are looking at other guidelines, which the APVMA provides, which say it should be shelf stable at 40°C for eight weeks, and at 55°C for two weeks as well. These are the guidelines provided for transport of such pesticide products as well. So that is the target that we are working on.

In terms of compatibility with other products, I don't think BioClay will be the only solution. Some of the crops get ten sprays in the growing season, and really if we can reduce that number and translate some of the sprays with BioClay, then that's good. And you have made a very relevant point about the last few sprays or when the fruit is forming or when a product which is sold as fresh produce is forming and we can do the spray, then it gives us an extra value in terms of maximum residue limits. Those compatibility tests of the BioClay with other insecticides and pesticides are being done as well.

Q: Peter Wynn, Charles Sturt University

Alison, you do a lot of the breeding of your wheats at your central lab in Mexico. How much of your work is training geneticists, crop geneticists, in developing countries, and how much of the work is translated to directly happen in those countries, rather than you just sending seed out from your base?

A: Alison Bentley

It's a great question and very relevant to the partnership model for the seed system as a whole, going forward. So, so as you say, the CIMMYT wheat program has for the past 50 years

bred from Mexico, and it uses simulated selection environments in the Sonora Desert in north-western Mexico to simulate different environments around the world. We are now moving to a new model, where we send material much earlier to target environments all around the world, in South Asia and Africa in particular. We have just moved our African breeding pipeline to Kenya for exactly this reason, so that we can develop material that is appropriate in the environment that it is destined to be grown in, but also to provide greater opportunities for capacity development throughout all stages of variety development.

We do a lot of in-service training in Mexico, and we are also looking at how we decentralise that and offer it in the regions and make it appropriate in different parts the world where there are different challenges.

For both aspects – the capacity development as well as the development of germplasm, which is really a core value proposition of the CGIAR – we are looking at how we move these more to the regions, where they are destined to be useful and to be taken up. For both aspects, we are looking at new models, new partnerships and new ways of doing that which are less centralised than they have been in the past.

Q: Nicki Duncan, Charles Sturt University, a conference scholar

Dr McGill, it sounds like your project would have been the envy of many people here having the continuity of time for your project, also the human resources, and that maybe you have been able to build that social capital. You have worked at the different levels: with the farmers, the farm advisers and the institutions. So I wonder, have you been able to make any difference in policy over that time? Have you been able to make a sustainable change there?

A: David McGill

Thanks for that question. We did put in a real concerted effort over the last 12 months to ensure that those lessons about the different layers – particularly the farmer level, in the first project, the farm adviser level, in the second project, and then the organisational level – we made a point of getting those lessons to the policy people whom we had good engagement with, in terms of ag and livestock. We spent a lot of time in the last 12 months in Islamabad having wonderful conversations with the crew up there, and we also had good engagement from two or three of the key livestock experts in Pakistan to make that happen. And Margaret Ayre, from the social research team, and Kaitlyn as well, had strong input in putting together workshops where we (arguably) forced the policy people to sit down with the information and go through the top 10 or the top 20 recommendations that we had at the different layers, and put them into lists for ones to tackle in the short term and others in the long term. And that really forced those conversations to happen.

Maybe the best thing about that was that we asked Dr Muhammad Afzal to talk with us or look at the workshop. He was the CEO of the organisation we worked with at the start. He said, 'Don't call it a policy group. Don't call it a policy group.' He said, 'Call it a "science-into-action" group.' So that's what we did, and we made a point of that: 'science-into-action'. We made that happen and made the policy people engage with the information that was put in front of them – and it really did work. That was something that Anna Okello from ACIAR said

to us: 'You've been there for 15 years, nearly. Make sure you have those policy level discussions'.

The continuity in our projects – you don't see that very much. I guess we were super lucky, but also it kind of goes back to that original experience, that lived experience in Pakistan that gave me a true love for just going out there and doing it. Living there gives you a chance to understand the complexities of the situation in a country like that.

If you're running a project or you want to be on a project, go and live in-country for three days, three years, whatever. It's going to make a big difference to your understanding.

Q:

Alison, I was just reflecting on the presentation by Jean Balié, of IRRI, this morning, which was about productivity and the contribution to a changing climate. We heard about emissions reductions, etc. And then I was thinking about your presentation, which was quite strongly focused on productivity growth, and through that addressing some of the crisis and then a very strong equity lens as well. Incredibly important. Can you just describe how the program, the global program, also takes into account some of the drivers around climate?

A: Alison Bentley

Yes, very happy to do that. Obviously, productivity for wheat and for staple crops remains a crucial component of the alleviation of hunger. And as was pointed out, SDG2: Zero hunger, is an ambition that is getting further away rather than closer to being achieved. I think that sets the context, that we need to have that productivity and that's the baseline provision.

In terms of growing resilience, that also needs to be a focus area. There are challenges in doing this, in building resilience while maintaining that productivity, particularly in the face of expanding pest and pathogen burdens around the world. Within the global wheat program, our focus is on baseline productivity plus the package of diseases, acknowledging that most of the farmers that we serve don't have access to agrochemical inputs. That is, having productivity, having your package of disease and then trying to build greater resilience to water and heat into that, which is a very complex thing to do genetically, biologically and agronomically. It is important to be able to provide that rounded package. That's where the science comes in.

There is a lot of science that will say, 'There's a new gene for heat.' And we think, 'That's exciting, but we've got to accumulate that with 100s of other things that we need to keep stable.' That's the constant challenge, along with the need for longer-term investment and the time lag in research into breeding, into a farmer's field.

Packaging those things is a priority and it's a very difficult and ever-moving target as the world moves, I think, as we see wheat and other cereals move, and the climate changing, and as we reach tipping points for certain cereals and we need to transition to other cereals, which is a big part of the conversation. What are the traits that we need to expand? What are the traits that that we need in other crops as they become more and more important?

And then obviously, from the consumer's perspective, as we make crops more nutritious with enhanced grain iron, grain zinc, all these things add to the complexity of providing this full package in our cereal crops.

Q: Tabita Tan, Charles Sturt University, a conference scholar

A question for Neena, in several parts. Thank you for that really exciting talk on your innovation. You mentioned, at the end, the importance of public opinion on this. I just want to find out what the public opinion is on the use of BioClay, and if there's any resistance to that. If so, how can it be overcome? And what impact does the direction of public opinion have on the uptake of this technology by industry?

A: Neena Mitter

Thank you for asking that question. It is important and actually sits at the very core of the adoption of any platform for that matter, and more so of innovations. When we started this journey, even to talk about RNA took a bit of time because the moment you mentioned nucleic acid or gene, the conversation immediately went to GM. So it took us a while to cultivate that conversation about how this system does not involve any change in the genome of the plant; and yes, it is very much a concept that can work. During the course of the 'journey', attitudes changed when the project really started succeeding.

We have been engaged with the growers right from the beginning: any trial that we do, we do a workshop, we bring them in, we show them that it is working – and that changed a bit of the conversation as well. When RNA became a familiar term, that changed the conversation as well. In fact, over recent months, I am now getting queries asking me whether BioClay can be certified as an organic product. This is not my call. That is an organic certification with protocols.

For me, this is an exciting and innovative platform using a biological active to control pests and diseases. Public perceptions are important, but it is looking quite positive at this stage. We are going through the engagement process and going through a survey. The first year's task has been to bring the growers 'on board', and we have also been talking with retailers, and then the consumers, as that chain becomes more visible. So yeah, early steps, but looking very positive at this stage.

Q: Niamh Walsh, Curtin University, a conference scholar

My question is for Dr Bentley and Professor Mitter. Do you believe it's possible in the long term, with adequate investment in research and development, that modern agriculture can move fully or mostly away from chemical use, with products such as your BioClay and with large-scale organic fertiliser being developed? Or has the combination of feeding a growing population and modern agricultural techniques made it impossible to ever move away from mass chemical use in food production?

A: Neena Mitter

We are hearing these words like 'chemical-free agriculture' as some of the targets in some conversations. Any tool, any technique, is a journey that we need to undertake. What we need

to do is a bit of 'responsible agriculture' as I call it, by developing those arsenals and tools, as I was saying, by reducing the use of chemical pesticides. But also not only reducing the use. There are new chemicals – green chemistries – that can develop as well. It's not as if agriculture has to use things that are not 'chemical'. That should depend upon the use case. It can depend upon that green chemistry, which could be very useful and still sustainable, and can have all the beneficial features. This is what we need to watch, if we start thinking of a chemical-free agriculture.

Overall, I'm not sure how the scenario will play out for various applications, because it's not just pesticides. There are other amendments; there are fertilisers being used; there are other inputs that go into the agriculture system as well. I think a reasonable target should be to try and reduce it as much as we can, it in a responsible way. Let's balance the profit ratio and the productivity ratio for the grower as well, and set those reasonable targets. But go on very consciously working towards those targets.

A: Alison Bentley

Great question, Niamh. It's good to see you hitting the hard questions. I think from the perspective of fertilisers, the current Russia–Ukraine situation shows us that the lack of availability of fertiliser components is placing additional pressure on productivity in agriculture. And I think, as Neena points out, it is going to be necessary to work out how we can maintain productivity with reduced inputs, and I think that's the reality for the short term at least, working out how we can produce at least the same amount with a lot less, before we look at how we can produce more with even less. I think it's a gradual scale, but we will see that being forced – in this case with fertilisers due to externalities – but also the environmental concerns and other factors over time.

Chair

Thank you. I'll bring this session to a close. I would like us all to show our thanks to our panellists for sharing their excitement about their work, their expertise and their different journeys. It has been a very interesting afternoon. I would also like to thank the audience for your interesting and diverse questions.

A CONVERSATION FROM OUTSIDE AGRICULTURE

Looking to the future

Allan Gyngell[1] AO FAIIA, Kylie Walker[2], Dr Robert Glasser[3]

Moderator: The Hon John Anderson AC

1 National President of the Australian Institute of International Affairs
2 CEO, Australian Academy of Technology and Engineering (ATSE)
3 Australian Strategic Policy Institute, Climate and Security Policy Centre, ANU

Moderator: John Anderson

This conversation promises to be a very interesting session. It will follow a pattern used in my own podcast series of conversations with people who are outstanding in their fields: I will simply try and trigger a stream of consciousness from each of these three guests so that they can say the things that they think are most relevant and important.

I am going start the conversation by reflecting, Allan, on your enormous global experience over many years. You told me over afternoon tea that you have been very interested in hearing what has been said here: the importance of the work that is done; the significance of international agricultural research; of extension; of lifting people into better living planes around the world. I think it's fair to say that all of that has been possible since the end of the Second World War because of the relatively enlightened leadership of the United Nations, particularly headed up by America. Broadly speaking, our friends may irritate us at times, but they have been playing good cop, opening trade routes, keeping them open, globalisation if you like, ending the days when nations squabbled, refused to export their own oil. Andrew Campbell mentioned that a good policy might include encouraging countries not to export their food, but up until the Second World War many countries put bans on the export of their oil – and there were terrible results from that. In short, America has played the good cop but they are now under great challenge from without and from within. How important do you think their role has been, and is, and will they continue it?

Allan Gyngell

Today's discussion really has been wonderfully revealing and rich. It has been very interesting hearing about the challenges facing the Crawford Fund, ACIAR and the other organisations.

About the United States: we were fortunate at the end of the Second World War when the 'right' side won. The 'right' side, remarkably, had a series of brilliant diplomats and political leaders and statesmen, some of them Australian, who recognised that it was important to learn the lessons of the post-World War I era. The first lesson was that the United States needed to remain involved in the world. Lesson 2 was not to humiliate the defeated powers but help them grow again. And lesson 3 was to set in place a global structure which was universal in its membership of the United Nations but still took cognisance of power through the structure of the Security Council. It was liberal in its value system – the

convention on the Universal Declaration of Human Rights, for example. That is, traditional liberalism infused with liberalism in the economic sense as well – free and open trade. And the US could do it because in 1946 it controlled about 50% of global GDP. So, no argument. It had the resources to encourage countries to join the system and abide by it, and to itself take on major responsibilities for tending the global commons. The result was what we have seen.

Think back to Jenny Gordon's slides today – the one (her Figure 3) that showed from the 1500s onwards a series of absolutely flat lines and then suddenly, at the time of the industrial revolution, the world discovers the whole new idea of 'prosperity', and the lines start going up. Then, after World War II, we see a huge climb. At that time, Australian GDP per capita in constant dollar terms rose from $20,000 to $60,000, and world GDP rose from about $3000 to $15,000. A number of the other human indicators went up also, such as life expectancy, which went up by 20 years in the least developed countries as well as the developed countries. That was excellent.

If you had given an Australian audience a blank sheet of paper in 1947 and asked them to design a system that would suit us perfectly, you would have come up with something exactly like this, where our closest ally was the most powerful state on earth, and the system which that ally supported and underpinned enabled us to draw on our deep economic complementarity with North Asia to grow our economic relationships, first with Japan – it's worth noting Sir John Crawford's role with John McEwan in the Commerce Treaty with Japan – and with South Korea, and then China.

But this was too good to go on, in some ways. Things happened, and you can argue about precisely what those things were, but the way I think of it is that around the time of the global financial crisis, the two countries of most importance to us – United States and China – both ceased to be status quo powers. They both decided at around the same time that something needed to change.

For the Americans it was a recognition that after a long haul they were not getting the returns they thought they deserved on the investment they had put into the international system. Donald Trump was the manifestation of this, but not just Trump alone: you can see it in some of the policies of President Obama and in President Biden's 'foreign policy for the middle classes'.

On China's side, there was the election of Xi Jinping and their feeling that they were now the second largest economy in the world, no longer satisfied to be a stakeholder in someone else's system; wanting a greater say in how the world operates.

That is where we are at the moment, and it is immensely difficult. I don't believe this is a more dangerous time than any other in Australia's history: there were parts of the Cold War that were very dangerous as well. But it is certainly a more complicated time than any other, and the Crawford scholars here today – who will be the decision-makers in industry and the country in 20 years' time – are going to have a much harder time of it. People like me were operating in the early 1990s, and that was an easy time. The Cold War had ended, and globalisation was in full swing. Not hard. Now it's hard.

Moderator: John Anderson

Thanks, Allan.
I want to make an observation to the young scholars who are so important to our future: Broaden your horizons whenever you can, and remember Churchill made the observation that *'All you need to know about statecraft can be learned from history'.* We undervalue history. Allan has just given this snapshot of why it is so important to understand the background, so that we know what is worth defending and seeking to preserve.

Now a question to Kylie. I think we have all been a bit gobsmacked by the reality of the enormity of the challenges before us, including in maintaining and taking forward research and development in agriculture. Do you have a stream of consciousness you would like to share with us, on what research and development for the future should look like, given that so many of the issues confronting us now are not industry-specific or short-term, but rather look to be much longer term.

Kylie Walker

I think we're facing multiple system challenges at the moment. It is not just climate change; it is not just the changing geopolitical forces. There are also questions of infrastructure transformation. We've got questions of skills and workforce development, which is becoming a growing problem, not just in Australia but around the world. And, of course, our investment system – certainly our government investment system, and also our private investment system for R&D – is probably not where it needs to be right now to support us to grow and to really innovate for a future-focused transformation that's sustainable and nurturing for our society, both domestically and globally. So yes, just a few things to tackle there at once!

Those multiple challenges present an opportunity to think in very different ways about how we configure our systems – our systems of funding, of skills development, of R&D, of infrastructure – and to think about integrating the way in which we arrange those things.

We might, for example, look at weaning ourselves off the short-term political funding cycle for government-funded research, because really there is no reason why we cannot commit to 10- or 20-year research programs and give that stability to our system, where we know that we are losing so many excellent people because they don't have job security. They are spending up to a third of their working year applying for grants and justifying their existence. What a phenomenal waste! I think we can think differently about that.

There is an opportunity for a visionary government to lay out a 'moonshot', if you like, for the next 10 or 20 years and say they are going to significantly 'shift the dial', on R&D generally, and on food sustainability and nutrition sustainability particularly, because that is a fundamental basis for society and a fundamental human right as well, and if we don't get that right then none of the rest of really matters.

The other thing that I am thinking about a lot at the moment is: how do we bring together the threads of R&D from across a whole range of different sectors and disciplines, and coalesce

them into something that looks strategically sensible? For example, think about the circular economy principles of zero waste – not just in food production and freight and retail but also in how to build those principles of sustainability and zero waste into the research that is happening and the support that is provided on-farm. How do we look at our supply chains in that sense? How do we think about embedding better GPS data or systems for those supply chains and on-farm production? We now have phenomenal capabilities to provide real-time data streams – from our extraordinary satellite network and now also a data cube managed by Geoscience Australia – to provide that real-time feedback on-farm and lift our technological capability. How do we do that in a way that is integrated and self-evident, so that farmers, food-producers, are highly motivated – financially and from an efficiency perspective – to jump into that system?

When it comes to research in particular, I think the biggest shame that we have in this country is that we are actively discouraging people who don't, if I'm frank, who don't look like white men, from being active participants and successful long-term participants in our R&D system. We are not good at nurturing their careers. We are not good at providing them with training opportunities, with job security, with incentives. There are plenty of incredibly clever people with a strong will to problem-solve who, I think, would bring a lot of new solutions. We know that diversity brings stability. If you look at the biological system, it does not work without that diversity. So why wouldn't we nurture ourselves to thrive as a diverse and incredibly proactive R&D system?

I could go on.

Moderator: John Anderson

We can come back, Kylie.
Robert, at ASPI, your particular field relates to the interplay between climate change and geopolitical security and stability. What should we understand? What can we know?
I put the hypothesis to you that we know the science on climate change is very real but, as I understand, the modelling cannot yet tell us terribly accurately what is likely to happen region by region. In rough terms, we are swimming in tank of a fair bit of uncertainty.
What observations would you make, as of being of primary importance?

Robert Glasser

Let me start by further elaborating on what the science can and cannot tell us. I think one of the things that science has a hard time with is the impacts of climate change, partly because of the difficulty of considering climate change as a whole system change. People think of it as meaning a particular hazard or a natural disaster that strikes. Even the UN IPCC assessments, when they examine, say, the impact of climate on agriculture, might look at extreme temperature and what impact that has on a crop. They might weave in a few other variables, but not drought, fires, population displacement, stronger cyclones and hurricanes … all those things that are essentially happening virtually at the same time as the climate warms. One problem is that it is extremely complex to see these simultaneous events and how they cascade in society.

I should add that we are seeing this now globally in many different ways. In France, the drought is causing challenges with their nuclear energy because they cannot cool the reactors. In Australia, during Black Summer (2019–2020), we had record drought and record temperatures that triggered record fires so intense that they generated their own weather and, according to the Royal Commission, burned over 20 million hectares. It was an economic catastrophe; it was a biodiversity catastrophe; it was an air quality catastrophe; and it very nearly became a water supply and water security crisis for Sydney because, as you may recall, at the height of those fires the Warragamba Dam was threatened – the major supplier of Sydney's water.

We talk about geopolitical manoeuvering. A way of thinking about that is as China, say, and the United States being like the pieces on the chessboard moving around. But climate change is upending the chessboard itself. The other element that I think the modelling has difficulty with – in relation to your point, John, about regional impacts – is the resolution of the models. For society to act on a lot of the climate impacts predicted, communities need reliable information about what's going on at reasonably small scale – small areas, where cities or communities or even watersheds are located. Right now, a big effort is underway to increase that resolution, and there is a lot of progress happening on that.

The dimensions with security are fundamental, and food is absolutely at the centre of the concern about climate and security. The same UN assessments are already detecting simultaneous climate impacts on multiple bread-baskets around the world, and the science suggests that those impacts are going to increase and become more severe. In Australia, the current government, as some of you may be aware, has just asked the head of the Office of National Intelligence, Andrew Shearer, to lead the development of Australia's first climate and security risk assessment. That work is underway now across government departments and it will be looking at the range of ways the systemic change is affecting Australia's security interests – and they are very serious ways. For example, competition and cooperation with China. Climate change is affecting the South China Sea, which is, as you may already know, a climate and security hotspot: fish are moving to cooler waters; maritime boundaries are shifting as a result of sea level rise. This will exacerbate tensions between great powers, and between regional powers as well: for instance in the Mekong, where upstream countries – mainly China in this case – control through dams the water that flows to downstream countries, there are some major security issues. But those are narrow security issues.

There are broader ones: for example, if we in Australia struggled to manage Black Summer, imagine how a country like Indonesia, 200 km from Australia at the closest point, will cope, with 275 million people mostly located along coasts and in island archipelagos where sea-level is rising at least four times faster than the global average, where 1-in-100-year extreme flooding events will become annual events in a matter of a couple of decades. Imagine these systemic climate impacts happening, not individually but collectively one right after the other, and in a region that is already the most geologically active region in the world – the Ring of Fire, where Indonesia and the Philippines alone account for something like 80% of global volcanic risk. That's just looking at the physical impacts. Then if you overlay the lack of social safety nets, the large informal sector, the ethnic separatist movements, the Islamic extremism, transnational crime and disasters, and the spaces this will create for those actors to gain

influence and to operate successfully, to expand their operations, and the displacement of people on large scales … you can get a flavour of why the government is now looking at this as a security issue. You can understand why the Australian chief of the defence forces has described it as a major security issue, and why even two weeks ago when the chiefs of almost all (China wasn't there) the defence forces of the Indo-Pacific convened in Sydney, the number one item on their agenda was climate and security.

Moderator: John Anderson

Well, if we weren't sober before, I'm sure we are now.
Allan, can we come back to you. As we have all acknowledged here, this is a global problem. In Australia it strikes me that much of the debate is focused on what we do, without a realistic understanding of how it might fit into the global architecture. I am deeply troubled by the reality that there are hundreds of new coal-fired power stations being built around the world: 172 new ones, as I understand it, being built in China right now as we sit here; 56 in Indonesia, I think it is; 46 in India; quite a few in Vietnam have reopened, and across Europe, and so on. Can you give us a feel for where those countries that are still rapidly increasing emissions really sit on this issue? Forget the things that they have said publicly at the COP meetings and in the Paris Agreement, and elsewhere. Where does China, for example, really sit on this issue? Is it prepared to be a global citizen or is the Chinese Communist Party (CCP) in the end simply more interested in its own power?

Allan Gyngell

I think the CCP is most interested in its own power, but one of those interests must be to ensure that economic livelihoods of China's people remain viable into the future. The degree of environmental stress in China is very high. Water, for example, is severely limited. So I actually do take the Chinese at face value when they say they want to do something about this – and then the question becomes: How do you do it; and how do you manage transitions, from where you are now, to where you are going? Robert probably has a much more granular understanding of this than I do.

Robert Glasser

I'm not a China expert, but I think they have multiple interests and objectives, and we see that play out and the objectives change, given the time and the context, as well. The hydropower on the Mekong, for example: first, that helps them with their energy security because they have created hydroelectricity. Second, they control the water, so that's good for their water security. They are investing in hydroelectricity and renewable energy globally, and they control critical supply chains of those technologies, so there is an economic interest as well. Third, if you control the upstream water, it gives you leverage over downstream states that you can exercise if you want to. We saw disputes with Japan recently where China cut off supplies of rare earth minerals to Japan in the midst of the crisis, demonstrating they are willing to use that leverage, at least in that instance. And fourth, I think they are genuinely concerned about climate change. They are the largest emitter of greenhouse gases and funder of new coal but we need to put that in perspective; it's really no surprise, given their path of development. What matters is, how quickly are they switching to renewables? The coal plants will be there

for a while, many years, but the share of renewable energy that is making up their total energy is growing phenomenally fast, faster than anywhere else in the world. I think that doesn't mean we should be complacent from a security perspective, but just that they have a variety of objectives that they can meet simultaneously.

Robert Glasser, Kylie Walker, John Anderson, Allan Gyngell.

Moderator: John Anderson

Kylie, it's my view that agriculture can provide some of the answers, particularly in terms of Australia being, if you like, recyclers of carbon if we can just capture and hold some more of it. Many people have done a lot of thinking about this, and while some are excited others are highly cynical – there's no other way of putting it – and that includes people with a lot of knowledge. Do you have any thoughts on where the 'lowest-hanging fruit' and some of the obtainable fruit might be, in agriculture, given that agriculture is a serious contributor to greenhouse emissions?

Kylie Walker

Well, obviously, there has been a lot of discussion about the future of protein, and that is something that I think we should be vigorously pursuing – looking at plant-based protein. Carbon capture and storage, as you observe, is quite controversial, even among the fellowship of the Academy of Technological Sciences and Engineering. Our fellows are leaders across those disciplines in Australia and internationally, and they are divided about the relative merits there. But I think that we are at the point where we have to pursue all potentially viable options. Agriculture can be a positive net contributor to our emissions status, or it can be a negative net contributor. That is a choice both for individual producers and also for investors, governments, infrastructure and R&D.

It is not as simple as planting a lot of trees, obviously. What we can do is look at multiple uses of land. For example, Australia ought to be a clean energy leader globally, given the circumstances in which we geographically find ourselves: being an enormous landmass; being abundant in natural energy sources; and being reasonably technologically savvy by world

standards with a fairly high success rate in terms of our research and the hit-rate that we get for all the traditional impact metrics around publishing and adoption, etc.

We do have some lessons, I think, that we can work on in conjunction with a place like China, because we both have large landmasses; we both have challenges with flood and drought; we both – although obviously the populations are not comparable – have strong incentives, I think, to build sovereign capacity as well, for very different reasons. We saw some of the challenges, obviously, with global supply chains over the last few years with the advent of the pandemic. That is not going to go away, because climate change will continue to exacerbate that accessibility and that potential for continuity of freight. But we can take advantage of that and become a net exporter of clean energy as well.

I think, as well, there are some very interesting things being done in R&D in Australia for carbon capture and storage: not on-farm necessarily, but in green concrete, for example, where carbon from the air becomes a resource for us to use. Some Australian innovations have done very well at the recent COP meeting and been flagged as something to watch for the future. Green concrete is an Australian innovation – the result of collaboration between a private company, the New South Wales Government and a university. It has been used to reclaim land in Singapore and build new suburbs. The process is a net extractor of carbon from the atmosphere, rather than the normal concrete production process which is a high producer of carbon emissions.

So I think there are lots of interesting opportunities for us to explore, but it needs the will, the investment and the long-term vision.

Moderator: John Anderson

Now the panel is open to questions from the floor. Who will be first?

Q: Natasha Chabbra, Australian Council for International Development

I really appreciated your comments, Dr Glasser, about the reasons to act in the region and the high level of exposure to climate change. We are doing a fair amount of work at the moment on humanitarian crises in Africa and the Middle East, and the rising food insecurity and the threat of famine as well. I am interested to hear your thoughts, and those of anyone else on the panel, about what the reasons to act are in those regions. For Australia specifically, we have seen great focus on the Indo-Pacific, but for some of these countries in Africa and the Middle East food insecurity is a really grave issue, and drought trends in the Middle East as well will continue to compound that.

Robert Glasser

The term 'humanitarian' used to be in the aid program. That was the one clear objective. That was actually the term used, I think in the white paper that developed the Australian aid policy, or established the policy many years ago. The one clear objective was that we were not going to confuse our economic interests or our diplomatic interests with our humanitarian interests. Unfortunately, I think the trends that we are seeing, particularly with climate change, will make it even harder to justify aid interventions that are not seen as more narrowly in

Australia's interests. I will give you one illustration. With climate change, we are having big disasters in Australia, national-scale disasters, that we are just beginning to see now. At the same time, we are having dreadful humanitarian disasters: the food security crisis that is evolving now, with another La Niña in train, could become extremely serious within a year. I remember when we came back from Switzerland, from Geneva, and I was working with the UN, it was in the midst of the big drought. When it came time for our Qantas flight to land, the cabin crew, instead of passing around envelopes for change for good for UNICEF, were passing around envelopes to help our drought-stressed farmers. It was a very interesting moment for me because I realised that as disasters begin affecting us domestically it is harder to justify sending money outside Australia for whatever the humanitarian need is, when there's a huge and growing need in Australia.

Sadly, I think the argument we have to make is that human security, even in our immediate region, is a bit like forward defence for Australia: that we have to support agricultural research, drought-resistant crops, the range of issues that will mean that when these hazards strike, people are able to cope. If they are not able to cope, they are going to move. Most of them will move internally, which will create its own problems, but many will also do what they can to survive, including moving to other countries, which will then trigger other problems. So, unfortunately, I think we will increasingly need to make that connection more narrowly in terms of Australia's national interests.

Kylie Walker

If I can add on that, I think that there is a really strong case to be made for building mutually beneficial relationships, where it is not just about investing one way, it is not just about giving something and building capacity somewhere else. It is about building relationships, learning from each other, and together growing collaborations that are mutually beneficial.

The Sir John Crawford Address that we heard last night was very interesting. The idea that grabbed me was that there is an opportunity in this global region to lead the way internationally in terms of integrating traditional knowledge systems – and what they can teach us about sustainability – with modern science and technology. And if now is not the time to do it, then I don't know when is, because it is existentially urgent that we have a more sustainable approach to food production and to living as part of the natural world.

Robert Glasser

I agree, and I did not mean to paint such a bleak picture, because there are a lot of innovations in Australia that are not particularly expensive to share as well, that can have a big impact. In fact, we need to identify these initiatives, because the money is always scarce. Knowledge can leverage a big change that can be helpful for other countries dealing with these impacts.

Moderator: John Anderson

In the Crawford Fund we have always acknowledged the extraordinary value of being in step with research and development efforts elsewhere, because as we export our knowledge we can import knowledge gained by interacting with others around the world.

Q: Nicki Duncan, Charles Sturt University, a conference scholar

Kylie, something you said reflected conversations I have had with others here today, which is that there seems to be a recognition that we are in crisis, that something needs to happen. There is obviously so much research and development going on; innovations in so many different sectors are 'out there'; they exist. But there seems to be a gap in how to translate innovations into policy outcomes; how we can cement this, from the field into practice, into widespread practice. You mentioned integrated and self-evident systems, where we are motivated to do the right thing, I think? I welcome comments from anybody here in the panel to tell us how we do that. How do we bridge the gap from innovation to practice, especially under this climate imperative, this existential problem that we find ourselves in?

Moderator: John Anderson

Clearly the uptake of research, which were talking about over afternoon tea.

Kylie Walker

Yes. This is something that Australia has struggled with for a long time, and we have done it better at times in the past. We have also done it worse at times in the past, and we could certainly do it better now. I think that there is a range of different ideas that you could apply there, but the simplest thing is funding sources to connect the research with the development and the widespread implementation, and that also includes public awareness – which is crucial. Organisations like mine put a lot of energy into bringing expert advice, the advice of researchers and developers and innovators, to decision-makers. That is also crucial, because you can't leverage off an innovation if you don't know it exists.

But let's think a little bit more creatively about that right now, and think about how we might potentially embed primary producers into R&D programs, or vice versa. Let's use the knowledge that the people on the land and at the farm gate are harnessing themselves. Often that is generational knowledge that they have. Let's integrate that more effectively into the way that we do R&D. Let's harness those data. I spoke about the potential and the reams of data that we have coming in already. The amounts of data are exploding, just as – thankfully – the computing power is starting to catch up; and there is lot of hope with quantum computing as well. But let's harness those data more effectively and ensure that we are building systems that are able to analyse them in real time and then feed information back to people on the ground, so that they are empowered to continue to innovate from week to week, from month to month.

I think that's going to become increasingly important with climate uncertainty and extreme events, because, as Robert mentioned, the modelling is reliable to a certain point. We have very sophisticated modelling, but the systems are not behaving the way that we have always expected them to. So we need to have that two-way relationship between the data generator and the data user, and that line becomes increasingly blurred.

Allan Gyngell

I want to add to that. This is also fundamentally the job of public policy. When I was working in the public service and, for a while, up in Parliament House, I would frequently encounter

academics in my area (and I am sure the academics here today are all totally different!) who would say to me, 'Oh, I know so much about this matter. I have all these answers. But do the ministers ever telephone me? No, no. I just sit here in my office over at the ANU.' And I would have to tell them, 'It's never going to happen. Ministers like John Anderson are never going to think to themselves: "I really should call up someone at the ANU and ask the answer to this".' Part of the solution to how we bridge the gap is what Kylie was just saying: it's for your organisations to recognise the need to communicate to get research into practice. But also, you, as academics, do have to be active participants in the public debate, and willing to go around and to knock on doors and to tell people that you have answers which will be helpful to the country.

Moderator: John Anderson

Engagement is so important. We live in the age of disengagement right across the Western world. I don't think I mentioned this in any of my broader remarks, but I was fascinated to talk to a former Supreme Court judge in the UK on a podcast the other day, and he made the observation that in Britain – and this is paralleled everywhere, including in this country – in the 1950s and 1960s the British Labour Party had 1.1 million regular members, rank and file, and the Tories had 1.9 million: that's 3 million in total. Today, the British Royal Society of Birdwatchers has more members than the current numbers in the political parties combined.

Decisions are made by those who turn up. Young scholars, your country needs you to be involved in more than just your academic research!

Robert Glasser

I want to comment on this as well, because in my experience in CARE and NGOs I have seen so many projects that demonstrate remarkable results, and simply become a report that sits on a shelf. It's very important to keep in mind that virtually anyone who has some issue that they care about can demonstrate, with data, that investing another $5 in that issue will return $150 million. The real question, as Allan I think was hinting at, is how do you get heard?

Why does 'that' issue get accepted when 'others' aren't? They all have data about the return on the investment. It's not that the accepted issue demonstrates a principle, though it is essential to do that. And it's not just that you can demonstrate that your issue is a good investment. Assuming those two things are in place, the challenge is: 'How do you win the political debate?'.

An approach that I have seen succeed is to engage, as part of the pilot, with the local government, for a community-level project, so that the government is an active participant. That way, you begin developing the ownership, the government's ownership, while you're advocating at a national level as well, to try and bring those two pieces together. That way, the government is already basically committing to expand the project once you have demonstrated the results to wider districts or provinces and the like.

Kylie Walker

If I could jump in here, I am a long-term communication professional and I have empowered many scientists and technologists to communicate better, so I am always going to say you

need more capability in that respect, and that more communication is better. I think that the days are long gone where a scientist can afford to say that communicating their work to a broad audience is not part of their core job. Your scientific findings have to be something that you advocate for at the local level, and at the public level, and at the political and investment levels, and if you can't do it yourself then hook-up with a science communicator or an organisation that can do it well. The market for funds and adoption is a crowded space. There are probably more than 400 registered lobbyists in this town, and there are 'big bucks' going into creating very sleek well-thought-out presentations to convince politicians to make funding decisions and investments and policy decisions. You have to compete in that market!

I am not suggesting that every scientist ought to be an advocate. Of course that will not be everyone's comfort zone or skill set. But you must be thinking about the end uses for your work, particularly when you are talking about agricultural research, which is very practically focused. How is this going to benefit Australia, and the world? How can it be rolled out in a practical sense at a local, national or international level? Who do I need to be connecting with, collaborating with, influencing, in order for that to happen? Or who can help me with that?

I think that you're abrogating your responsibility if you simply produce the research findings, publish them in a paper, and consider the job done.

Moderator: John Anderson

Kylie, I agree with that and I want to add a little to what has just been said, because I think it is important. Allan, I think, alluded to it.

One of the problems we now have – following the great financial crisis, which was a debt crisis solved by more debt; following COVID, where nations threw everything they had at trying to keep their economies basically intact; and now with other global shocks, supply chain inflation and what have you – is that every government that has any degree of responsibility around the world is deeply conscious that they must look for savings.

Why do I mention that? Because it's an added and very real problem globally, including in China. And because it's also critical.

If you want to reach governments, the sophisticated and true and honest line to run is to differentiate between simple demands for more recurrent expenditure, and investment in wealth creation and a better tomorrow. Some forms of further borrowing are actually net positive: high quality research, like high quality infrastructure – and I stress *high quality* infrastructure – very much fits into that category. The message needs to be: *'Minister, this is not just going to be money out of the door that goes onto the bottom line. This will help solve your future debt.'*

That is a big hint for you, young scholars, when you start knocking on doors for funding.

Q: Tony Fischer, The Crawford Fund

I want to take us back to the comment about where the low-hanging fruit is in agriculture, and I am taking a global view rather than an Australian view. In sub-Saharan Africa, crop yields are

probably one-third of what they could be in that location just using today's technology, without any new innovations or new research. That region is importing more and more food every year. It's not developing rapidly economically. The population growth is over 2% per annum. There will be over 2 billion people in sub-Saharan Africa before the end of the century – there are 1 billion at the moment. However, we have an example from sub-Saharan Africa where improvement has happened. I don't know who got through to the president of Ethiopia, President Meles Zenawi – who unfortunately passed away a few years ago – but Ethiopia's statistics are very good. You can believe them, I think. I have checked them. In the last 20 years, Ethiopia has increased food production across all its crops at about 3% per annum. That's better than the rate during the Green Revolution.

How has it happened? They have invested 15% of their budget in agriculture – far more than the other countries in sub-Saharan Africa, which invest only around 1% or 2%. Ethiopia has invested in the sort of agricultural extension we heard about from David McGill this afternoon: farmer extension. The technology was there, on the shelf: some had come from the international crop centers and some came from local research institutes.

To me, this example is a bright spark in a difficult part of the world. Whether it's relevant to Australia, I don't know, but it's relevant to Europe, because that is where a lot of the refugees are coming from.

Moderator: John Anderson

That was not so much a question as a very pertinent observation. Thank you, Tony.

Comment from Andrew Campbell

We [ACIAR] have a fantastic program in Ethiopia and it's notable that the Agriculture Minister there has a PhD in agricultural science, as does the head of his ministry, and a very competent innovation system.

Moderator: John Anderson

Ladies and gentlemen, I think our three panellists have given us gold content, and I'd love you to show your appreciation.

Allan Gyngell AO has had an extensive career in Australian international affairs. He was appointed the National President of the Australian Institute of International Affairs (AIIA) in September 2017. He is an honorary professor with the Australian National University's College of Asia and the Pacific, and a director of China Matters. He was the Director-General of the Australian Office of National Assessments from 2009 to 2013. Prior to leading the ONA, he was the founding Executive Director of the Lowy Institute for International Policy from 2003 to 2009. Additionally, he has worked at the Department of Foreign Affairs and Trade and the Department of the Prime Minister and Cabinet, serving as an Australian diplomat in Rangoon, Singapore and Washington. He was Senior Adviser (International) to Prime Minister Paul Keating between 1993 and 1996. Mr Gyngell was appointed as an Officer in the Order of Australia in 2009 for services to international relations. In 2007, he co-authored *Making Australian Foreign Policy*. *Fear of Abandonment: Australia in the World Since 1942* was released in 2021 and he is the co-presenter of the 'Australia in the World' podcast.

Kylie Walker is the Chief Executive Officer of the Australian Academy of Technology and Engineering (ATSE), where she works with expert Fellows to lead crucial national conversations and strategy towards a thriving, healthy and connected Australia supported by technology. She specialises in connecting technologists, engineers and scientists with governments, business, media and society – skills built over many years in senior federal communication and advocacy roles in the science, technology and health sectors. As the immediate past CEO of Science & Technology Australia, Kylie led campaigns to increase investment in Australian research and development, and created the acclaimed Superstars of STEM program, championing Australian women in science, technology, engineering and mathematics. Kylie is also a visiting Fellow at the Australian National Centre for the Public Awareness of Science. She was Chair of the Australian National Commission for UNESCO, and in 2019 she was named in the 100 Women of Influence list by the *Australian Financial Review*, for her work on improving equity, diversity and inclusion in STEM.

Robert Glasser is the Head of the Climate and Security Policy Centre at the Australian Strategic Policy Institute (ASPI). He was previously the United Nations Special Representative of the Secretary General for Disaster Risk Reduction and Head of the United Nations Office of Disaster Risk Reduction (UNISDR). He was a member of the Secretary General's Senior Management Group and the Deputy Secretary General's Climate Principals Group. Dr Glasser has over 30 years of experience as a practitioner, advocate and policy maker in the areas of climate change, sustainable development and disaster response. Before joining the UN, he was the Secretary General of CARE International, one of the world's largest non-governmental humanitarian organisations, with annual income of about $1 billion and over 10,000 staff active in some 80 countries. From 2003 to 2007, Dr Glasser was the Chief Executive of CARE Australia. Prior to joining CARE, he was Assistant Director General at the Australian Government aid agency (AusAID) where his responsibilities ranged from Southeast Asia programs to Corporate Policy and Infrastructure and Environment. He has also worked on energy and climate change science and policy for the US Department of Energy (Los Alamos National Laboratory – Center for National Security Studies) and on peace and conflict issues at a variety of institutions, including the Geneva Centre for Security Policy, the Cornell University Peace Studies Program, the Strategic and Defence Studies Centre at the Australian National University, and the Centre for International and Strategic Affairs at the University of California. Dr Glasser is on the board of WaterAid Australia, the Queensland Reconstruction Authority and Inclusivo (Santiago, Chile). He was previously the Inaugural Board Chairman of the CHS International Alliance, a new organisation resulting from the merger of People in Aid and the Humanitarian Accountability Partnership. He was also previously the Chair of the Steering Committee for Humanitarian Response (an organisation comprising the CEOs/Secretary Generals of the largest NGOs/international organisations involved in disaster response). Dr Glasser was an Advisory Panel member of the Climate Vulnerability Monitor, a member of the Principals Steering Group of the United Nations Transformative Agenda for Humanitarian Action; and a member of the Project Steering Group for the World Economic Forum project on The Future Role of Civil Society. An Australian national, he has published on several topics, including climate change and disaster risk, peace and conflict, and humanitarian and development policy.

SUMMING UP, AND THE WAY FORWARD

Dr Colin Chartres

CEO, The Crawford Fund

This year I have volunteered to summarise the conference, and as I have sat here making notes and then condensing them I have realised that it is very difficult to do justice to all the speakers and all the matters raised. One risks forgetting points, forgetting people, and forgetting nuances. Therefore, this summary merely pulls out a few key themes that have emerged from today's talks for me. It is a personal and idiosyncratic summary, and the take-home messages for others of you may be different.

We started by acknowledging that it is the Crawford Fund's 35th anniversary and the 40th anniversary for ACIAR. That means we have had a good many years of making very sound progress in dealing with food insecurity around the world. Two papers today have given an overview of progress through work that the Crawford Fund and ACIAR have done, with returns in the order of $10 for every $1 invested. Similarly, we heard of a total benefit coming from the CGIAR of $600 billion from $60 billion investment, which makes a very positive argument that money invested in international agricultural research is well spent.

In the years from 1960 to 2000, the focus was mainly on productivity, and there were phenomenal numbers of new crop varieties, from which not only has the developing world benefited but also US farmers, Australian farmers and the world's consumers – an overall outstanding success. The world's population in about 1950 was between 2 billion and 3 billion people. It is now close to 8 billion, and yet farmers and agriculture in general have managed to feed those increasing numbers of mouths reasonably, over that period.

Nevertheless, we know that even over the last 30 years one in every nine people is still hungry, largely, as I think John Anderson said, because of inequalities in access to food, because of conflict and so on. I suspect that as the world population rises to 10 billion – which it is projected to reach before it declines – we will still be able to feed most of the people, although there will be increasing externalities. Some of these externalities are the critical things we've been grappling with since at least the year 2000 and perhaps before that.

Externalities

Tony Fischer made the point, at the end of the Conversation 'Looking to the future' session, about Africa being a focus of concern. The data show that while there was a fourfold increase in value of agricultural production in 1980–2016 around the globe, the increase was much smaller in Africa, where the value of production went from 5.7% to 7.5%. Yet sub-Saharan Africa has the greatest rate of population growth in the world. Africa is going to be one of the hotspots that international agricultural research will need to continue to focus on in the future. However, there is light there, as Tony said, from the successes in Ethiopia.

Another major concern, which has come up several times today, is that in spite of all the phenomenal success in agricultural production, women are still disadvantaged in many countries, even though it has often been women who have driven agricultural productivity in many of the countries we have been talking about. There is still much work to do on that issue.

Today's talks have also shown that the types of challenges we are facing are changing. My first job was doing a soil survey in part of Somalia. It was quite a simple scientific task. These days, the tasks are much more complex, as we have heard. Now researchers face both continuing biophysical challenges as well as much more complex transactional challenges – about how we do research, how it's funded, how we get the research adopted. There are many people who are questioning what to me seems to be highly valuable research – into fortification of rice, GM work, and so on. Although that work seems to add tremendous value, it is questioned, and we have to deal with that when interacting with other members of the community.

Another critical challenge for us, from my understanding, is climate change. I was in National Water Commission back in 2004–2007 when we commissioned CSIRO to do some work on the expected impacts of climate change on the Murray-Darling Basin and eastern Australia. That was 16 years ago, and they predicted higher incidences of heavy rain in northern NSW and southern Queensland. We are seeing that now. They said that flows into the southern Murray-Darling were going to be at least 11% less, on average. We are seeing that now. In other words, there has been the capability of modelling climate change for some considerable time. I think it is important that we do not just throw our hands in the air and say we don't know what to do. There are good models. We know they are not precise, but they show the direction the climate is moving in. So, to me, the challenge of climate change is critical. Another challenge is water scarcity, which is becoming increasingly serious. The reduced flows we have seen in the Murray-Darling Basin are being repeated in major river catchments around the world. For example, Lake Mead on the Colorado River is a shadow of its former self, and many other rivers around the world are facing the same closure of their basins, with very limited water flowing out to sea.

The world is faced with ongoing biosecurity threats, which are probably getting worse because of the increased ease of travel, particularly after the lull caused by COVID-19, and it has been pointed out that there are likely to be new types of zoonotic diseases every five or eight years. Although we don't know exactly what they will be, we know they are likely to affect agriculture and human health – in many cases, both at the same time.

We are seeing the linear model of adoption of international agricultural research is changing, becoming much more participatory, involving the kinds of partnerships that Andrew Campbell talked about. In these, we do not just go into a country and say, 'We'd like to do this research in an area here'. Instead, we ask about the types of problems people are experiencing, and whether we have collective experience and knowledge that can tackle them jointly. Many of those problems overseas will teach us how to tackle similar problems in Australia.

Another aspect of researchers' increasing awareness was touched on by the participants in the Conversation 'Looking to the future', following similar points made by earlier speakers including Ravi Khetarpal, Regina Bi Nukundj and David McGill: namely, that we can no longer

work in a country without a strong understanding of the local policy framework, and how our science fits with it. Who do we need to influence, and how? Although some scientists will have the luxury of working free of those constraints, it is up to the research leaders to make sure that we are understanding that need, and that we do have a good theory of change, and that we do know who to approach, whether it's the local communities, whether it's the Minister, etc. Whilst high quality science depends on peer-reviewed papers in good quality journals, it also has to be about impact on people and making their lives better.

More traditional foci

Another key point from today is that, alongside all the emerging challenges, we must not forget about maintaining and increasing spending on crop varieties, the new germplasm, which will be so vital in tackling some of the future diseases, and helping deal with increasing temperatures and aridity, or the opposite. That is vital, and therefore it needs a bigger slice of the investment pie – which was big in, say, 1980 but is not anymore.

I was fascinated by the talk on biopesticides – a real innovation and surely more acceptable than some of the pesticides that we are already using that are causing major problems among insect and bird populations. The possibility of climate change mitigation in rice is another fascinating topic, as is the ongoing challenge of improving nutrition – something we all should look at. And another vital topic is how to sustainably intensify agriculture with no net loss of natural capital.

Talking about this with Shaun Coffey earlier today, we agreed this is not just about not developing land that isn't yet under agriculture. That may have to be done as climate change impacts affect current agricultural land. Consequently, we need to think about land that may go out of agriculture, and about restoring it for other natural and ecological-service purposes.

This is a complex and challenging area and we need to think about that very carefully. Combined with that are issues around water use, water reuse, and also the reuse of human waste, animal manure and compost, which can help sustain agriculture into the future.

Someone mentioned the loss of water in food thrown into landfill in Australia. About ten years ago, Jan Lundqvist from the Stockholm International Water Institute calculated that globally, in about 2010, we were throwing away 1300 cubic kilometres of water in wasted food. That was water that could have been used to expand agriculture if we hadn't wasted it. I know we cannot capture it all back, but this is a real and large issue, in terms both of food wastage and of wastage of other resources with the food.

There is also the role of uncertainty. We probably live in much less certain times now than when I was undertaking research 45 years ago, and the discussion during the Conversation, 'Looking to the future' has reinforced the message that these are challenging times. Clearly, the declining global role of the West and the USA and the potential breakdown of the liberal rules-based order is going to have profound implications on trade, on fertilisers and on food security. We are already seeing the food crisis arising from the Ukraine–Russia conflict. Ongoing geopolitical uncertainty could have profound effects on food security and the world's

poor. Increasing fertiliser costs are associated with the current energy crisis, and that will make the sustainable use of wastes even more important, I suspect.

I am also concerned about advanced policies relating to meat production and organic agriculture, developed recently particularly in Europe, and the European Union's wish to impose them on other countries. We touched briefly on this, in Andrew Campbell's Q&A early today, in relation to the keeping and eating of animals. As was said then, there is a big difference between large feedlots in Europe and a small family somewhere in Africa with only a few animals. We need to make sure that the solutions we are looking at will be fit for purpose, and not imposing Western standards on other cultures.

And I want to reinforce a very key point made in the Conversation session, about the time wasted by researchers in having continually to reapply for funds every few years. I think we need a better model, which allows for longer-term research, for the longer-term problems that many of you are dealing with.

Dr Colin Chartres

Recognising the importance of social understanding

Linked to the opportunities and challenges I have mentioned already, is the incorporation of socio-economic research – not just on gender but on the whole gamut of issues around how communities respond and behave; how we look at economic development as well as physical development. I think these issues are critical.

When I was at IWMI [International Water Management Institute; formerly IIMI, International Irrigation Management Institute], at least a third of the staff were socio-economists. That was probably not enough, because water issues, such as water pricing, involve tremendous debate about how they are taken up, and their impacts on people. In a conversation I had with the head of the irrigation department in Sri Lanka, to do with the Mahaweli scheme – a very large irrigation scheme in the 1970s–1990s in Sri Lanka – he said, 'We have the best engineers in the world in Sri Lanka. They can build dams just as good as you've got in Australia, in Europe and in the US. We don't need any advice on building dams.' But initially they had not put any

investment into the socio-economics; into making sure that the new models of delivering water and the use of water were understood by the populations they were serving. So, there was water running to waste from the scheme, and the farmers were relying on their own wells and tanks that had been there since time immemorial, because the authorities had not invested appropriately in the uptake of the new irrigation technology.

Understanding the sociology is vital: spending time understanding how people will respond to innovations, and involving them in the research from the very beginning. I think that is one of the most vital messages that has come out of today's meeting.

Way ahead for the Crawford Fund, and thanks

All this information sets some challenges for the Crawford Fund, to make sure we can incorporate much of what we have discussed today into our training and capacity-building programs. We are doing our best to do this around sustainable intensification, in terms of leadership and management, but there will be other areas we need more focus on, including the gender equity issues that were raised, and some of the other socio-economic areas, as well as maintaining interest in the more traditional areas of agricultural science, which we must not overlook.

The other challenge for the Crawford Fund is that – being a not-for-profit organisation and not part of government – we have the opportunity to lobby strongly for increasing some of the funding in this area. There has been excellent evidence presented during this conference and coming also from recent revisions to our report 'Doing well by doing good', and we will be using that information over the next year or so to try and at least compete with some of the very skilful lobbyists in Canberra and in the state capitals. We need to make sure that people understand the value they are getting out of investment in international agricultural research. As John Anderson said today, it is the type of investment which clearly is for a better tomorrow, both for poor people overseas and for their economies, and also for Australia and our economy, through improved access to varieties and yields.

Today's talks have been incredibly stimulating and they have all been of very high quality. They have raised a range of very important topics that we need to think about, absorb, distil and build into the Crawford Fund's programs, and we will certainly be doing that.

I want to end by thanking all the speakers and Chairs for leading us through such an interesting and dynamic exercise. Particular thanks also to the sponsors who make it possible to hold this conference.

The Crawford Fund's organising committee ensures these conferences present topics in order and that they flow well from speaker to speaker, and that takes much thought. Tony Gregson leads the organising committee, which includes Gabrielle Vivian-Smith, Tristan Armstrong, Shaun Coffey, Dan Walker, Tim Reeves, Cathy Reade and myself. For this year's conference, we were gambling that COVID-19 would not prevent it, and fortunately infection numbers are now going down, but there was always the risk of cancellation. The organising team have done a wonderful job: Cathy and Larissa ably abetted by Sarah and Sue, from the Crawford Fund, assisted by the Conference Solutions team.

Finally, I want to thank the audience for your attention and stimulating questions. I hope you, like me, go away with a lot of food for thought, and keen to pass on to your colleagues some of what we have heard and learnt today. I short, to everyone who has contributed, thank you very much indeed.

Dr Colin Chartres has had a long and successful career in the private sector, academia and government roles. Before joining the Crawford Fund in 2014 he was Director General of the International Water Management Institute (IWMI), a CGIAR Research Centre headquartered in Colombo, Sri Lanka, from 2007 to 2012. Previously, he was Chief Science Adviser to the National Water Commission and held senior management roles in the Bureau of Rural Sciences and Geoscience Australia. He worked with CSIRO Division of Soils from 1984 to 1997 where he focused *inter alia* on soil acidity, soil structure and salinity issues and their impacts on agriculture, and from 2002 to 2004 in the Land and Water Division, where he was involved in business development and international science linkages. Colin has a strong interest in the key nexus between science and policy and, through his work with IWMI, specialist interest in water scarcity and its impact on global food security and on science leadership and management best practice. Colin currently Chairs the Expert Review Panel for the Australian Water Partnership and is an Honorary Professor in the Crawford School of Public Policy at ANU.

Conference participants 2022, in person and online

*indicates Crawford Fund conference scholars for 2022.
Some acronyms are listed on the last page.

Abbott, Lynette	The Crawford Fund WA
Abdissa, Tola	Wollega University, Ethiopia
Abdullahi, Ahamed Tijjani	Flour Mills of Nigeria
Ahmad, Israr	Hazara University Mansehra, Pakistan
Akbari, Mona	DAFF (Dept of Agriculture, Fisheries and Forestry)
Alaneme, Boniface	Bon Global Integrated Technology (Publishers of Afriscitech Digest)
Alatise Tusa, Sharydia Sera	Scientific Organization of Samoa
*Anagnostis, Mikali	The University of Sydney
Anderson AC, John	The Crawford Fund
Angleton, Alison	La Trobe University
Angus, John	Charles Sturt University
*Armati, Eleanor	The University of Sydney
Armstrong, Tristan	DFAT (Dept of Foreign Affairs and Trade)
Armstrong, Matt	ACIAR (Australian Centre for International Agricultural Research)
Arnold AO, Lynn	The Crawford Fund
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Acronyms

ACIAR	Australian Centre for International Agricultural Research
ANU	Australian National University
CABI	Centre for Agriculture and Bioscience International
CEAT	Centre for Entrepreneurial Agri-Technology (at ANU)
CIMMYT	International Maize and Wheat Improvement Center
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFF	Australian Government Department of Agriculture, Fisheries and Forestry
DFAT	Australian Government Department of Foreign Affairs and Trade
QAAFI	Queensland Alliance for Agriculture and Food Innovation (at The University of Queensland)
RAID	Researchers in Agriculture for International Development

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